U.S. Army Corps of Engineers Louisville District

Environmental Flows Workshop Recommendations Report: Licking River and Cave Run Lake

Sustainable Rivers Program

Licking River, Cave Run Dam and Lake (USACE photo)

U.S. Army Corps of Engineers and The Nature Conservancy

June 2025

Contents

Introduction

The Nature Conservancy (TNC) and the U.S. Army Corps of Engineers (USACE) have partnered to form the Sustainable Rivers Program (SRP) to explore opportunities for optimizing reservoir releases and river flows to benefit river ecology while maintaining the federal mandates of reservoir systems across the United States. The mission of SRP is to enhance the health and life of rivers by modifying water infrastructure operations to restore and protect ecosystems, while maintaining or improving other project benefits.

A primary objective of the SRP is the implementation of environmental flows (e-flows), defined as the quantity, timing, and quality of water flows necessary to sustain ecosystems. These flows are managed through decisions that manipulate water and land-water interactions to achieve ecological goals. The SRP complements other reservoir-centric water resource projects by demonstrating that a strategic, science-based approach can maintain or enhance benefits provided to the nation.

In 2024, the USACE Louisville District proposed adding the Licking River to the SRP. This river was selected due to its exceptional biodiversity, declines in ecosystem health near the Cave Run Lake Dam, and the opportunity for e-flows to support ongoing state initiatives to enhance and reestablish mussel populations. The Licking River supports a vibrant ecosystem, including at least five federally threatened and endangered mussel species, 55 native mussel species overall, and 111 native fish species. Thirteen of these fish species are classified as Species of Greatest Conservation Need in Kentucky's Wildlife Action Plan.

Stakeholder Coordination

Throughout the SRP initiative, coordination with stakeholders was critical to align goals and leverage expertise (Table 1).

Table 1. Key participants in the Licking River Sustainable Rivers Program initiative.

Name	Agency / Organization*	Title / Role / Specialty
Matt Thomas	KDFWR	Ichthyologist & Program Director
David Cravens	KDFWR	Nongame Ichthyologist
Thomas Timmerman	KDFWR	Regional Fisheries Biologist
Monte McGregor	KDFWR	Aquatic Scientist / Malacologist
Emily Lawson	KDFWR	Biologist
Michaela Lambert	KDOW	Nonpoint Source & Basin Team Supervisor
Brian Storz	KDOW	Licking River Basin Coordinator
David Eisenhour	Morehead State University	Professor, Biology

Name	Agency / Organization*	Title / Role / Specialty
Christina Wampler	NRCS	State Biologist
Mike Compton	OKNP	Aquatic Zoologist
Kathryn Schulz	OKNP	Aquatic Biologist
Becca Winterringer	The Nature Conservancy	Project Advisor, SRP
Zac Wolf	USACE	Limnologist
Kristin Berger	USACE	Biologist
Steele McFadden	USACE	Wildlife Biologist
Jeff Hawkins	USACE	Wildlife Biologist
Jonathan Matthews	USACE	Biologist
Melanie Babin	USACE	Hydraulic Engineer
Thomas Jackson	USACE	Cave Run Lake Manager
Kristi Dobra	USACE	Biologist
Taylor Fagin	U.S. Fish and Wildlife Service	Biologist
Wendell Haag	U.S. Forest Service	Research Fisheries Biologist
Pete Cinotto	U.S. Geological Survey	Branch Chief of Operations

*KDFWR = Kentucky Department of Fish and Wildlife Resources; KDOW = Kentucky Division of Water; NRCS = Natural Resources Conservation Service; OKNP = Office of Kentucky Nature Preserves; USACE = United States Army Corps of Engineers.

Workshop Process and Goals

Stakeholder Meetings: Initial consultations to introduce the Licking River and Green River Basin SRP efforts were held with the first meeting taking place on 30 September 2024. These meetings also served to gather regional insights and outline shared goals.

Literature Review: *The Science and Concepts for Environmental Flows, Licking River and Cave Run Lake* literature review document (USACE 2025) includes analyses of historical and current data on the Licking River and Cave Run Lake, including detailed flow, water quality, and biological data, with a focus on flow-ecology science and ecological impacts and flow alterations that have occurred since Cave Run Dam was constructed. The literature review also compiled species-specific life history data to be considered during the workshop. This report was shared with stakeholders on 7 March 2025.

Workshop Kickoff: The Licking River SRP project workshop was held over two days on 10-11 March 2025. The goal of the workshop was to facilitate a collaborative discussion to refine problem statements, identify priorities, and develop actionable recommendations for water management of the Licking River.

Summary of Key Findings from the Literature Review

The following streamflow alterations, as outlined in the Science and Concepts report (USACE 2025), are related to the operation of Cave Run Lake Dam and are thought to significantly impact stream ecology:

- Reduced frequency of high flows in the winter/spring.
- Reduced magnitude of high flows in the winter/spring.
- Elimination of low flows in fall, particularly in August, September, and October.
- Decrease in summer water temperatures below normal, particularly June through mid-July.
- Increase in fall/winter water temperatures above normal, particularly mid-October through January.
- Although dissolved oxygen concentrations regularly meet state standards, there is potential for dissolved oxygen saturation levels within the tailwater to be insufficient for fish and mussel recruitment.

Environmental Flows Workshop Outcomes

A preliminary list of target species was developed through consultations with experts to ensure that life history requirements—such as spawning, recruitment, and habitat needs—were considered when proposing flow alterations. All target species and data considered during the workshop are detailed in the Science and Concepts report (USACE 2025).

Fish Working Group Notes

- There is very little benthic habitat until the confluence of Triplett Creek where sediment begins to be introduced to the system. From there upstream to the dam most sediment has been scoured out and it is all bedrock bottom.
- Spawning occurs from late March to July. Periods of stable flow are important to allow for success. High flows should mimic the natural hydrograph as much as possible during this time.
- Once the lake stratifies (~May), high flows that eliminate the ability to release water that is the correct temperature should be avoided as much as possible.
- In fall, maintain low flows as much as possible. There is no reproduction this time of year but young-of-year fish are foraging and growing in preparation for upcoming low food availability in winter.

- Early spring pulses could serve as a cue for the fish to prepare for spawning. It is not clear the number or frequency of pulses necessary. These pulses should have peaks with short durations and magnitudes that are derived from historical data. It is ideal to have stable, low flows in between pulses to allow spawning activities to occur undisturbed (roughly one week of stability before the next pulse).
- For drawdown we recommend extending the drawdown period from 45 days to 60 days so that it could be done with lower releases that are temperature controlled and postponing any rapid drawdown until after the lake has gone through mixing/turnover in late October or November. This would help to avoid any large unnatural fall pulses. Would it be possible to extend the winter pool target date in December or to the end of December? This would allow for a more gradual temperature-controlled drawdown starting 15 October not to exceed 250 cubic feet per second (cfs).
- In late spring if water conditions require a large release this should be done as early as possible before the lake stratifies to avoid hypolimnetic (cold) releases, and to avoid washing out the system during spawning. If pulses are required for water management, they should be as quick/short as possible and return to normal flow as fast as possible.
- During the summer season it is important to keep temperature within the normal range and to keep flows stable, try to avoid going over 500 cfs as much as possible to maintain temperature control. If pulses are required for water management, they should be limited in duration to return to normal flow as fast as possible.
- KDFWR is open to moving the June trout stocking to March. There is not much angler pressure on trout, and it should be possible to remove trout stocking in June which will eliminate the need to keep outflow temperatures unseasonably low during that time. Similarly, October stockings could possibly be shifted to November.
- Muskellunge fishing is good in the tailwater. Really high flows are detrimental to fishing, but moderate flows are okay.

Mussel Working Group Notes

- The reservoir undergoes turnover during drawdown, typically in late October or November.
- Recommendations for temperature visualization include plotting pre- and post-dam temperature data with a vertical line marking dam construction.
- Air temperature impacts water temperature, raising questions about whether changes are due to climate change or dam effects.
- Winter releases are primarily from the bottom of the reservoir, with retention times of ~73 days (2024) and ~68 days (2023).

- A rapid drawdown to winter pool post-turnover is preferable as temperature is the primary concern. Flow levels of 2,000–5,000 cfs have similar effects on mussels.
- Juvenile Growth Flow Recommendation: Maximize low-flow duration between June and September/October to promote juvenile mussel growth and glochidia release. Flow targets should vary to match natural inflows instead of holding at the same flow.
- Temperature Management: Maintain juvenile growth temperatures at 23°C (15 June–15 September). Temperature thresholds should be guided by historical data and percentile-based targets.
- High-flow duration influences temperature, fish movement, and habitat stability. Shorter duration high flows are preferred.
- Considerations for flow prescriptions indicate little difference between short-term and long-term brooder species.
- Dissolved Oxygen (DO): Mussels require high oxygen levels (>90% saturation). Low oxygen is rare in Kentucky streams, but additional data collection is recommended. DO targets should aim for 100% saturation where feasible. Continuous monitoring from May–October is recommended.
- Simulate natural inflows as much as feasible to mimic the hydrograph, especially from April to October.
- Simulate the natural temperature profile to better align with pre-dam conditions.
- The rate of water level decline can influence bank erosion. Recommendations include aligning drawdown rates with natural recession slopes.
- Reports of bank erosion along Daniel Boone National Forest support the need for drone-based monitoring before and after flow adjustments.
- Sediment Transport Considerations: The dam traps sediment, altering transport dynamics. Mimicking historical flow patterns may not fully address sediment movement issues.
- We have limited ability to influence sediment flow through the system and it is not considered the greatest factor impacting mussel populations.
- Downstream mussel habitats appear suitable, suggesting other factors (e.g., temperature, flow, DO) may be more critical.
- Mussel populations are doing well in many areas of the Licking River, especially further downstream from Cave Run Lake. However, species composition has changed over time.
- Declining mussel populations closer to the dam may be due to temperature impacts, as no recruitment has been observed in these areas.
- Seasonal flow management prioritization: April – October is the most important period for mimicking natural conditions.

- Avoid sustaining high-flow events (3,000–5,000 cfs) for long periods.
- Fall Drawdown Strategy: Begin releasing 250 cfs, managing for water temperature, then make a higher release to rapidly drawdown to winter pool post-turnover.
- Use pre-dam data to compute water recession slope to limit bank erosion and better mimic natural flows.

Overall Flow Recommendations

Flow Stability & Seasonal Adjustments:

- Maintain stable flows during the fish spawning season (March–July) to support reproductive success.
- Minimize unnatural high flows in summer to avoid disrupting temperature regulation and aquatic species.
- Use short-duration, historically informed flow pulses in early spring to cue fish for spawning.
- Avoid prolonged high-flow events (3,000–5,000 cfs), which negatively impact habitat stability for both fish and mussels.

Temperature Management:

- Match temperature guide curve as much as possible.
- Maintain juvenile mussel growth temperatures at a minimum of 23°C (15 June–15 September).
- Avoid high summer flows (>500 cfs) that disrupt temperature regulation and water quality.
- Adjust trout stocking from June to March to eliminate the need for unseasonably low outflow temperatures.

Drawdown Strategy:

- Extend the fall drawdown period from 45 to 60 days for a gradual, temperature-controlled release.
- Postpone rapid drawdowns until after lake turnover in late October/November.
- Release 250 cfs in fall before transitioning to a rapid drawdown to winter pool and only transition to a rapid drawdown if necessary.

Mimicking Natural Conditions:

- Simulate natural inflows as much as feasible, particularly from April–October, to align with historical hydrographs.

- Model flow targets on inflow percentiles rather than fixed cfs values to reflect natural variability.
- Maintain dissolved oxygen (DO) at >90% saturation, with continuously monitoring from May to October.

Sediment & Habitat Considerations:

- Acknowledge limited ability to influence sediment transport due to dam impacts and monitor downstream habitats.
- Continue assessing mussel populations, particularly near the dam, where recruitment has declined.
- Conduct drone-based monitoring of bank erosion along the Daniel Boone National Forest boundary.
- Match flow attenuation rate with natural rates to reduce bank sloughing and erosion.

Optimizing Large Releases:

- If large releases are necessary in late spring, conduct them early before lake stratification to prevent hypolimnetic releases.
- Keep any required pulses for water management short and return to normal flow as quickly as possible.

These recommendations aim to balance ecological health with operational constraints while preserving critical aquatic habitats.

Immediately Actionable Changes

The workshop resulted in an array of changes that could be started without formal changes to the Cave Run Lake Water Control Manual (WCM). Additionally, some desired operations changes that are not approved in the current WCM could be permitted through deviation requests that would need to be reviewed and approved on a year-to-year basis. Otherwise, feasible operational actions that can be implemented will be reviewed and executed to the greatest extent possible beginning in Fiscal Year 2026. The immediate next steps to be taken by USACE include:

> Coordination with Tom Timmerman (Regional Fisheries Biologist, KDFWR) on the adjustment of trout stocking dates from June to March in the Licking River tailwater. This will eliminate the need for unseasonably cold water to be released in the summer, while also maintaining a recreational trout fishery in the Licking River.

A review of spring and summer outflow needs and operations, with the intent of determining the potential to implement flow recommendations, including avoiding prolonged high flows to the extent possible, implementing spring pulse flows, maintaining stable flows throughout the spawning season to the extent possible, and avoiding high flows after lake stratification. These actions would help regulate temperatures throughout the spawning season as well as foster stable water conditions that would allow for a successful spawn.

Fall drawdown operations have been initially reviewed by USACE water managers with the intent of reducing unnaturally high flows in October and November, as outlined in the flow recommendations above. It is possible to delay drawdown until November 1st and maintain a temperature-controlled release of 250 cfs until a rapid drawdown begins on November 21st and lasts until November 29th, which more closely simulates a natural flood event (Figure 1). Delaying high outflows until November 21st will mean that the lake will have mixed, which means that temperature would not be impacted by the higher release. This proposed drawdown method would provide more time for young of the year to become established and prepared for winter conditions. Key elements to the delayed drawdown for Water Managers are:

- Release the maximum bypass capacity starting on Oct 15 to drawdown as much of the pool as possible while still maintaining temperature control
- Transition to higher releases using the main gates slowly over days or weeks to create a temperature ramp that is not shocking to the downstream system
- Target the maximum release at the mid-point of the drawdown to offset the delayed schedule and simulate a natural event
- Slowly reduce releases on the descending limb of the drawdown hydrograph to prevent potential bank sloughing

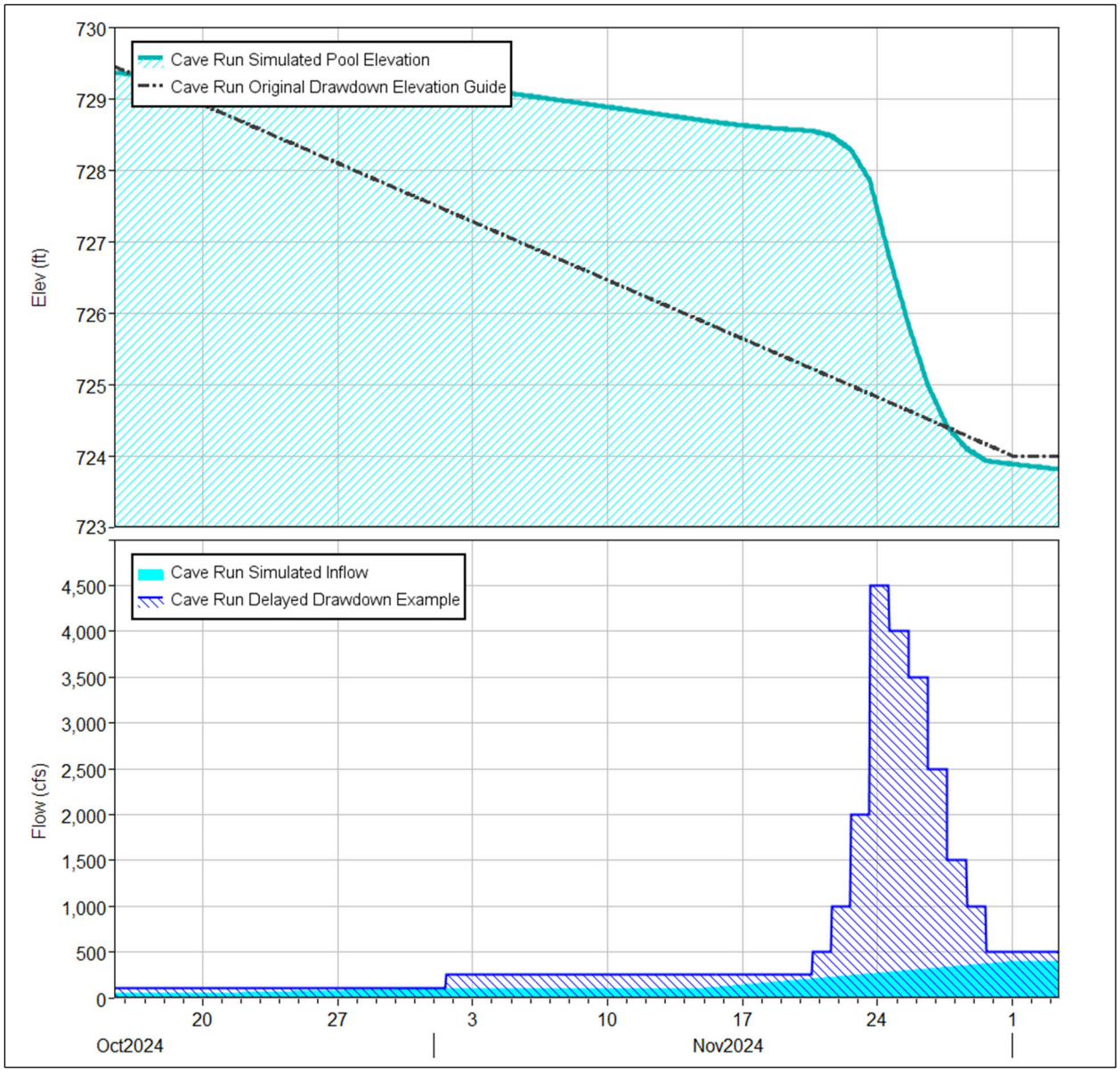

Figure 1. Proposed Cave Run Lake drawdown schedule.

A review of flow attenuation rates based on attenuation rates of natural high-water events to determine if water levels are adjusted on an appropriate temporal scale. This action would ensure USACE operations are, to the best of operational abilities, reducing the potential for unnecessary bank erosion and sedimentation.

Monitoring

The need for monitoring was discussed to be of high importance for this effort. Given the lack of funding for monitoring provided by SRP, it was determined that monitoring would need to be conducted by partners in coordination with the Louisville District Water Quality Team. The Water Quality Team has begun reaching out to partners to form a working group and develop a monitoring plan. The central question to frame the monitoring plan is "are our e-flows implementations having a positive/negative impact on downstream aquatic communities?" which requires solid baseline data before implementations occur and several years of data after. The plans include monitoring fish and mussel populations downstream of the dam, with potentially other types of monitoring such as macroinvertebrates. Methods are to be designed to minimize error and provide robust datasets to optimize statistical inferences.

The Water Quality Team is also planning to further monitor downstream impacts on temperature and dissolved oxygen which may include deploying series of data loggers to study longitudinal and temporal patterns of temperature and dissolved oxygen. Relevant questions to this monitoring include: "how far downstream does the dam have significant impacts on temperature and dissolved oxygen?"; "what is the magnitude of those impacts?"; and "how do specific operations affect water quality downstream?"

Long-term Goals

Water Control Manual Update

The Cave Run Lake WCM was last updated in 1982 (USACE 1982). USACE regulations require that these operational guidelines be revised as necessary to conform with changing requirements, technologies, scientific understanding, legislation, environmental conditions, and other relevant factors. Review of water control manuals and associated operating plans should occur no less than every 10 years (USACE 2016). When the next update begins, potential considerations for revision in the manual should include:

- Extending the drawdown period to allow more time for a low flow drawdown.
- Targeting a slightly lower summer pool elevation to allow for more control of the release of flood waters as well as less extreme drawdown needs.
- Having the ability to maintain pool levels slightly above the targeted pool for a period of time to allow for more controlled releases when discharging less significant rain events.

Stakeholders that were present at this workshop should be engaged in the WCM update as much as practicable.

Structural Modifications

There are limitations with the operation of Cave Run Lake that are caused by the original design of the infrastructure. It was discussed during the workshop that potential structural modifications be studied to determine if they could effectively increase the operational bandwidth for e-flows at Cave Run Lake. In particular, structural modifications for increased temperature control at higher flow releases, and increased oxygen in outflows were determined to be of potential high importance.

A selective withdrawal riser was proposed to be built for Cave Run Lake in 1986 to address concerns with releases of water from the hypolimnion in the fall months (Maynord and Tate 1986). The project was ultimately not recommended for construction due to high costs and a lack of understanding of the potential environmental benefits. With the increased understanding of how the Cave Run Lake Dam impacts the Licking River, and the need for increased operational control, we recommend that structural modifications be revisited.

Conclusion

The Environmental Flows Workshop for the Licking River represents a pivotal step in advancing the Sustainable Rivers Program's mission to enhance ecological health while balancing operational needs. The collaborative efforts of stakeholders and experts have yielded a set of science-based recommendations tailored to address the unique challenges of the Licking River below the Cave Run Lake Dam. These recommendations underscore the importance of adaptive water management strategies that prioritizes water quality and aquatic biodiversity.

The workshop outcomes provide actionable guidelines to optimize natural flow regimes, flow stability during critical life-history stages for fish and mussels, temperature regulation, and considerations for erosion. Immediate steps, such as revising trout stocking schedules and refining seasonal flow management practices, demonstrate a commitment to implementing practical solutions in the near term. Additionally, the emphasis on stakeholder coordination and ongoing monitoring ensures that adjustments will be informed by scientific data and collaborative input.

By aligning operational goals with ecological priorities, this initiative reaffirms the USACE value of integrated water resource management. The strategies outlined in this report not only aim to restore the ecological integrity of the Licking River but also serve as a model for sustainable reservoir and river management across the Ohio River Valley. Moving forward, the partnership between USACE, The Nature Conservancy, and other stakeholders will remain critical in advancing the shared vision of a resilient and thriving Licking River ecosystem.

References

Maynord, S. and C. Tate. 1986. *Technical Report HL-86-9: Selective withdrawal riser for Cave Run Lake.* Department of the Army, Waterways Experiment Station, Corps of Engineers.

U.S. Army Corps of Engineers (USACE). 1982. Cave Run Lake and Dam: Operational management plan. U.S. Army Corps of Engineers, Louisville District.

U.S. Army Corps of Engineers (USACE). 2016. Water control management. Engineer Regulation 1110-2-240. 70 p.

U.S. Army Corps of Engineers, Louisville District (USACE). 2025. *Science and concepts for environmental flows: Licking River and Cave Run Lake*. Sustainable Rivers Program. Available at: https://www.hec.usace.army.mil/sustainablerivers/publications/