US ARMY CORPS OF ENGINEERS
NASHVILLE DISTRICT

Assessing Management Alternatives to Enhance Lake Sturgeon Spawning Habitat

Caney Fork River and Center Hill Dam (USACE photo)

Sustainable Rivers Program

Prepared By
US Army Corps of Engineers
Nashville District

2025

Table of Contents

Abstract 3
Introduction 3
Project Objectives 4
Modeling Results 4
Monitoring 13
Future Work 13
Conclusion 17
Acknowledgements 18
Literature Cited 18

Abstract

Following near extirpation due to commercial harvest and habitat modification, lake sturgeon are now being reintroduced to Tennessee. As part of these restoration efforts, hydraulic modeling has been used to identify dam release strategies that may support spawning below Center Hill Dam on the Caney Fork River. Considering the most suitable conditions for spawning based on scientific literature, modeling indicates that flow from the hydropower turbine Unit 1 produces the most consistent downstream conditions along the riprap wall. After a potential aggregation was found in the Caney Fork River, 15 lake sturgeon were tagged during summer of 2024 and spring of 2025 to be further monitored for variability in movement behavior. During sampling on May 6th, 2025, biologists tagged a large female lake sturgeon and noted the presence of fully developed eggs in her abdominal cavity. This fish was estimated to be 17.1 years of age and is the first documented sexually matured female lake sturgeon in the Cumberland River system since restoration efforts began. There is some indication that lake sturgeon present near Old Hickory Reservoir on the mainstem Cumberland display spring upstream migrations and return back in summer to early fall. Plans to tag additional fish this fall and next spring will allow for continued monitoring of their movement over the life of the transmitters. This report serves as the 2025 summary of the cooperation between the Tennessee Wildlife Resource Agency (TWRA) and the U.S. Army Corps of Engineers (USACE) to better understand lake sturgeon behavior and to identify operational changes to support lake sturgeon spawning below Center Hill Dam.

Introduction

Center Hill Dam is at river mile 26.6 on the Caney Fork River, about 50 miles east of Nashville, TN. Center Hill is operated by the U.S. Army Corps of Engineers Nashville District (LRN) and was initially authorized to provide flood control and hydropower. Water supply, recreation, fish and wildlife, and water quality have all been authorized as project purposes since completion of the dam.

The lake sturgeon (Acipenser fulvescens) is a relatively unique species due to its prehistoric origins, longevity, and size. Lake sturgeon can reach 2.4 meters (m) or 8 feet (ft) in length, weigh over 136 kilogram (kg) or 300 pounds (lbs), and live 150 years. Lake sturgeon are included in TWRA's Threatened and Endangered Species List. In 2025, TWRA reclassified lake sturgeon from "endangered" to "threatened". The lake sturgeon has been subject to an extensive reintroduction effort by the TWRA since the early 2000s. Previous studies in the St. Louis District have demonstrated that water temperature, time of year, flow velocity, and substrate are impactful to spawning (MVS 2021a; MVS 2021b; Swearingin and Errett 2023; Swearingin, Chen, and Peper 2024; Swearingin et al. 2025). Sturgeon spawning is benefited by higher flows and therefore occurs during the April/May time of year which is hydrologically wet. During this period, releases from Center Hill Dam are normally elevated providing opportunities to promote sturgeon spawning below the dam.

TWRA has recently documented aggregations of lake sturgeon below Center Hill Dam during the last four spawning seasons (2022-2025). On May 6th, 2023, TWRA received video evidence of a potential spawning aggregation of lake sturgeon on the Caney Fork River below Center Hill Dam on the left descending bank below the generator powerhouse. On May 11th, 2024, TWRA investigated and documented an aggregation of 19 sexually mature male lake sturgeon for the first time in the Cumberland River watershed since restoration began. That summer, TWRA initiated a project to begin characterizing seasonal movement patterns of lake sturgeon in the Caney Fork River and downstream into Old Hickory Reservoir on the Cumberland.

This project seeks to identify how LRN can utilize operations under the recently updated Water Control Manual (WCM) for lake sturgeon by 1) investigating river flows resulting from water management operations and 2) collaboratively monitoring lake sturgeon activity/response to varying releases made through turbine operations.

Project Objectives

1) Establish baseline flow conditions by developing a river hydraulics model and simulating prior year flow conditions
2) Tagging and tracking sturgeon and monitoring spawning

Modeling Results

The Hydrologic Engineering Center's River Analysis System (HEC-RAS) software, version 6.6, was used to simulate hydraulic conditions for this project. The study area focuses on an approximately 3.2 kilometer (2 mile) stretch of the Caney Fork River immediately downstream of Center Hill Dam as shown in Figure 1. Model results were evaluated for consistency and accuracy based on the data collected in June 2025.

In February 2025, bathymetric data were collected on the Caney Fork River in the immediate tailwater of Center Hill Dam. Water surface elevations and flow velocities were collected along the riprap embankment on the left bank in June 2025. Terrain modifications were made to produce more accurate results, such as adding the turbine wall and cutting a channel to approximately match the flow area of the Caney Fork River.

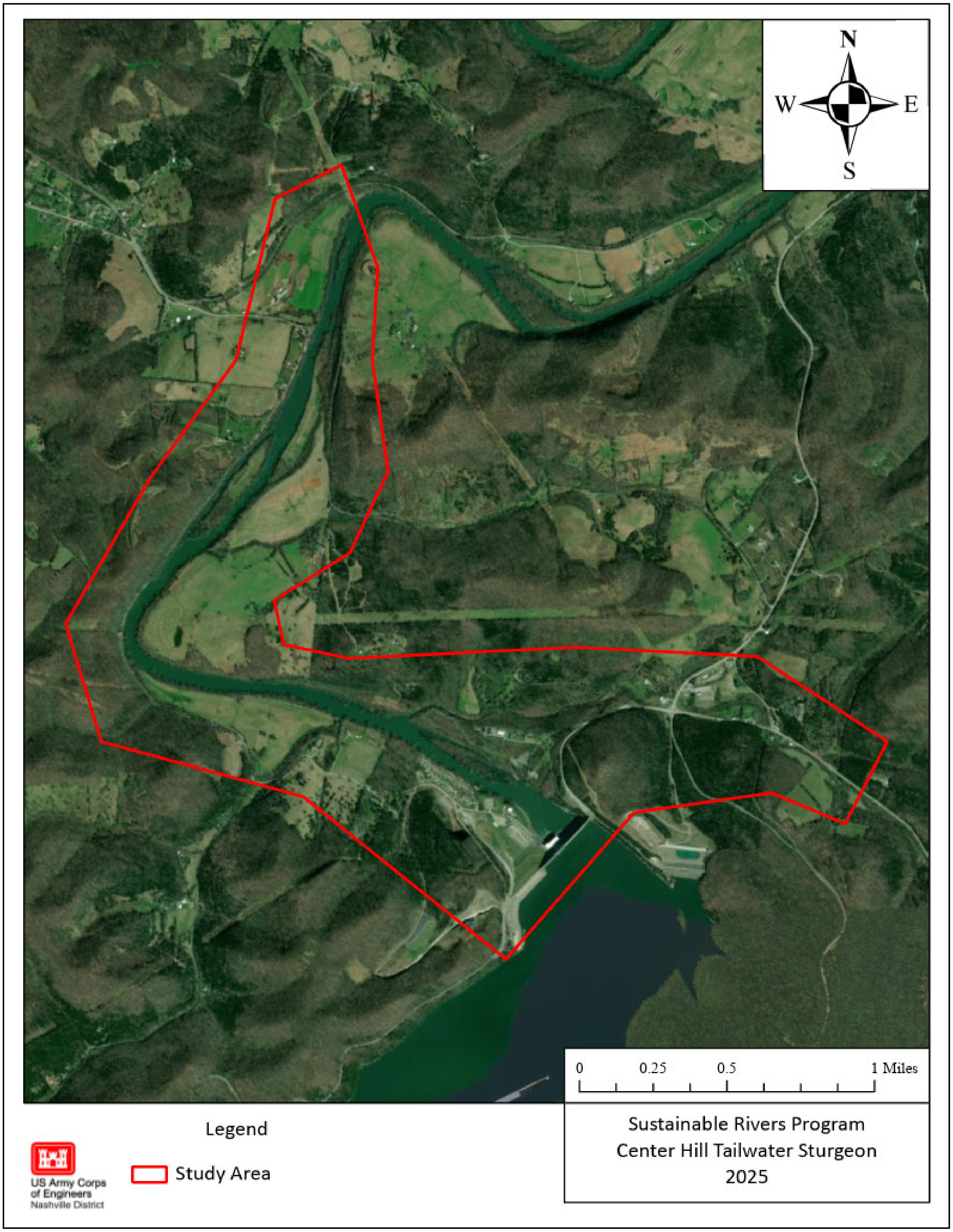


Figure 1: Project study area.

Turbine discharge was simulated using a flow hydrograph that ramps up to flow value of 106 cubic meters per second (cms) or 3,750 cubic feet per second (cfs). An unsteady flow plan was developed to simulate the turbine outflow from the three different hydropower units, Unit 1, Unit 2, and Unit 3 (Figure 2). During generation with one unit, the hydraulic model produces water surface elevations within 0.03 m (0.1 ft) of the surveyed water surface elevation, indicating that the model accurately represents the volume of the channel and the roughness of the substrate.

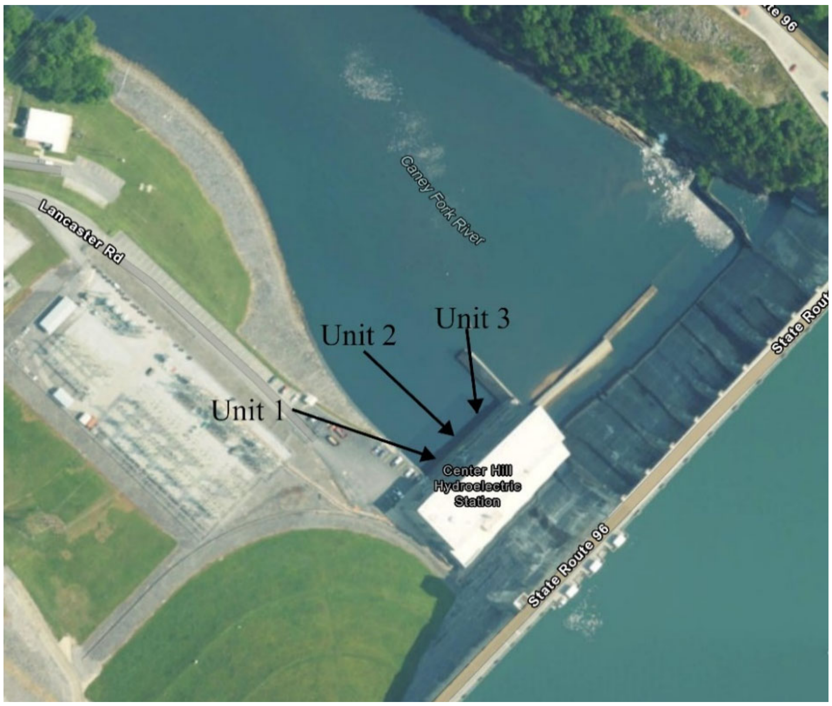


Figure 2: Hydropower units, hydroelectric station, Center Hill Dam.

The velocity data collected during the June 2025 survey was also used to determine the accuracy of the hydraulic model. The velocity results in the hydraulic model generally match the velocity data collected during the June 2025 survey, though the survey data is only point data collected at discrete points in the tailwater.

Velocities along the riprap on the left bank are commonly 0.2-0.6 m/second (0.5-2.0 ft/s), with the highest velocities near Location 3 and Location 4. This is likely a result of the turbine outflow becoming more laminar as it travels downstream and is directed by the riprap wall. The velocities at Location 7 and Location 8 were near zero as those locations are protected from the strongest flow by the bend in the left bank. This is shown clearly in Figure 3. The Unit 2 and Unit 3 velocity results show a relatively large eddy formed immediately downstream of the tailwater as shown in Figure 4 and Figure 5. As a result of this eddy, Unit 1 creates the most consistent downstream flow along the riprap wall that has the most suitable substrate for sturgeon habitat.

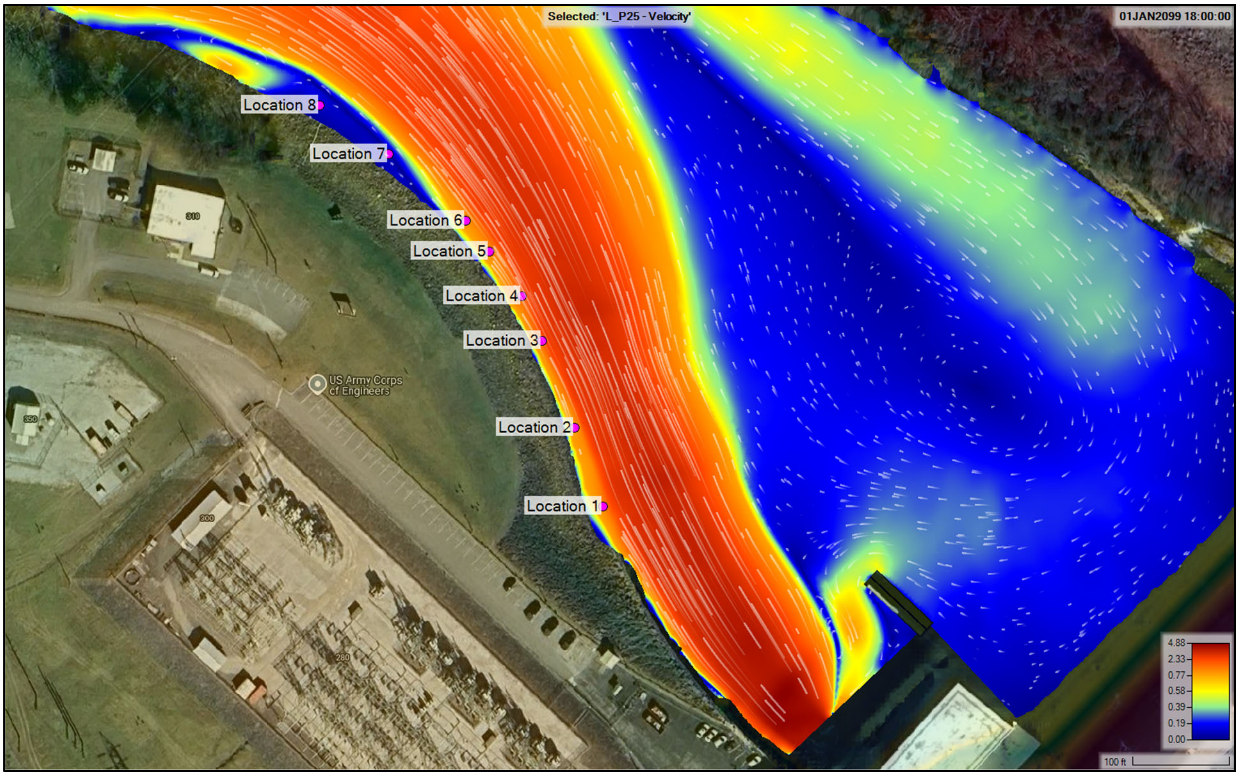


Figure 3: Simulated water velocities with outflow from Unit 1 (106 cms; 3,750 cfs).

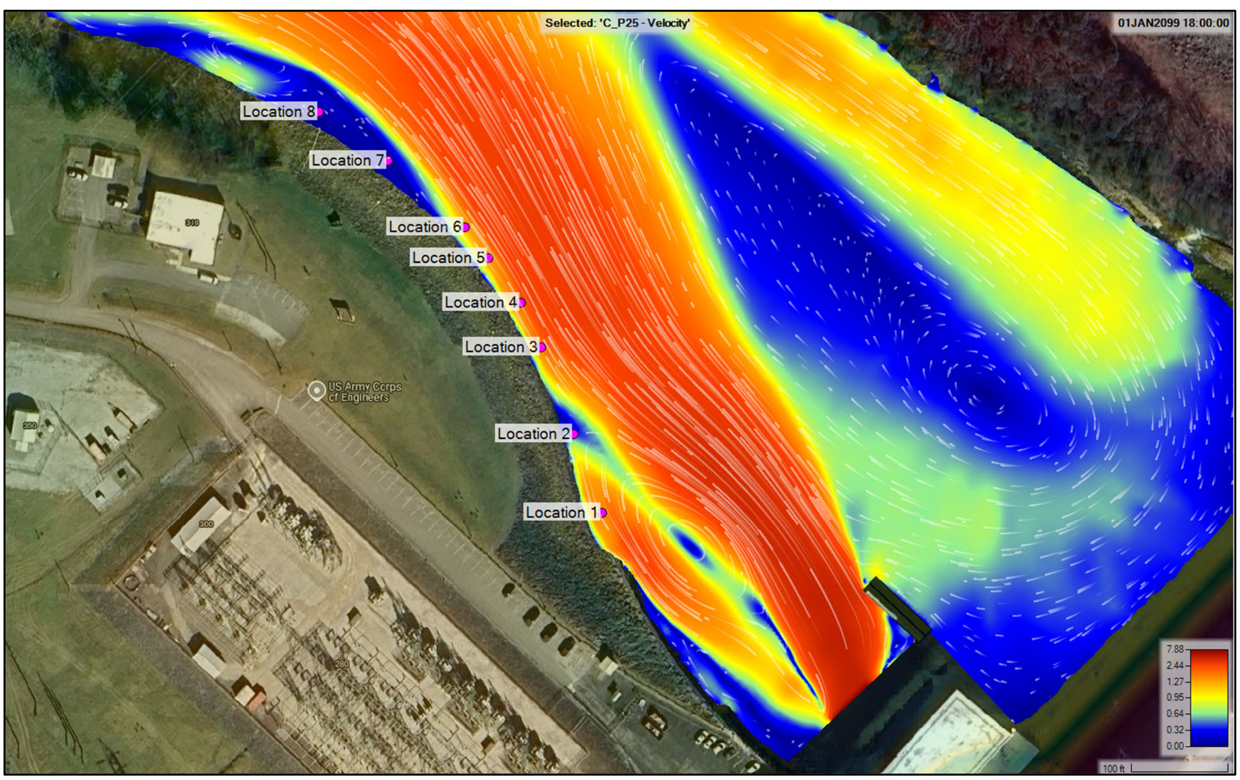


Figure 4: Simulated water velocities with outflow from Unit 2 (106 cms; 3,750 cfs).

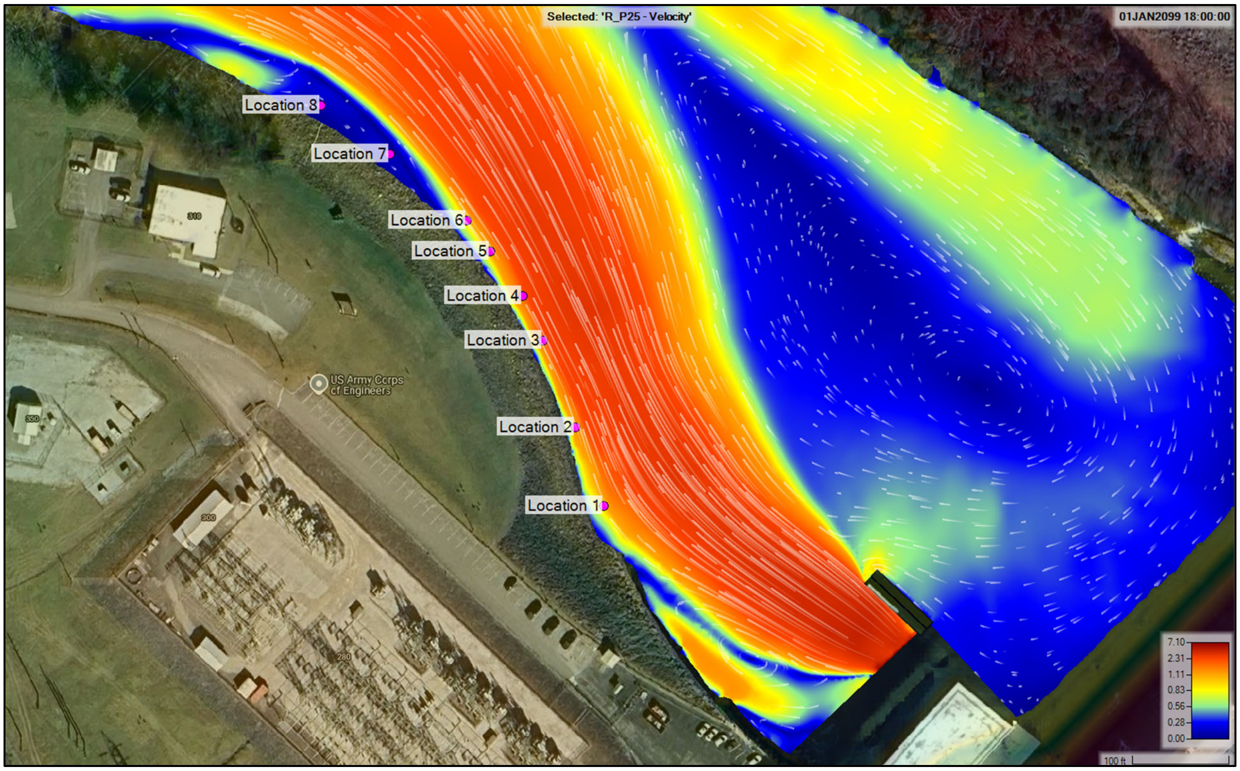


Figure 5: Simulated water velocities with outflow from Unit 3 (106 cms; 3,750 cfs).

Simulated velocities and depths were exported from the river hydraulics model as geotiffs, which are raster image files that store geographic information. Velocity and depth results were exported for the final time step (when flow conditions had been at 106 cms (3,750 cfs) for the longest time) of the river hydraulics simulations for each of the three operational scenarios (i.e., outflows from units 1, 2, and 3). Geotiffs were converted into habitat maps and assessed for habitat provided and lake sturgeon spawning locations using the Ecosystem Functions Model (HEC-EFM) and its spatial accessory HEC-GeoEFM.

A Habitat Suitability Index (HSI) is a paired data set of habitat quality that ranges from 0 (wholly unsuitable) to 1 (perfectly suitable) and a corresponding habitat variable such as water velocity or depth. Indices are available for many species and life stages and are commonly used in ecological analyses. HSIs for lake sturgeon spawning velocity (Figure 6) and depth (Figure 7) were adapted from Baril et al. 2018 for use on the Caney Fork River.

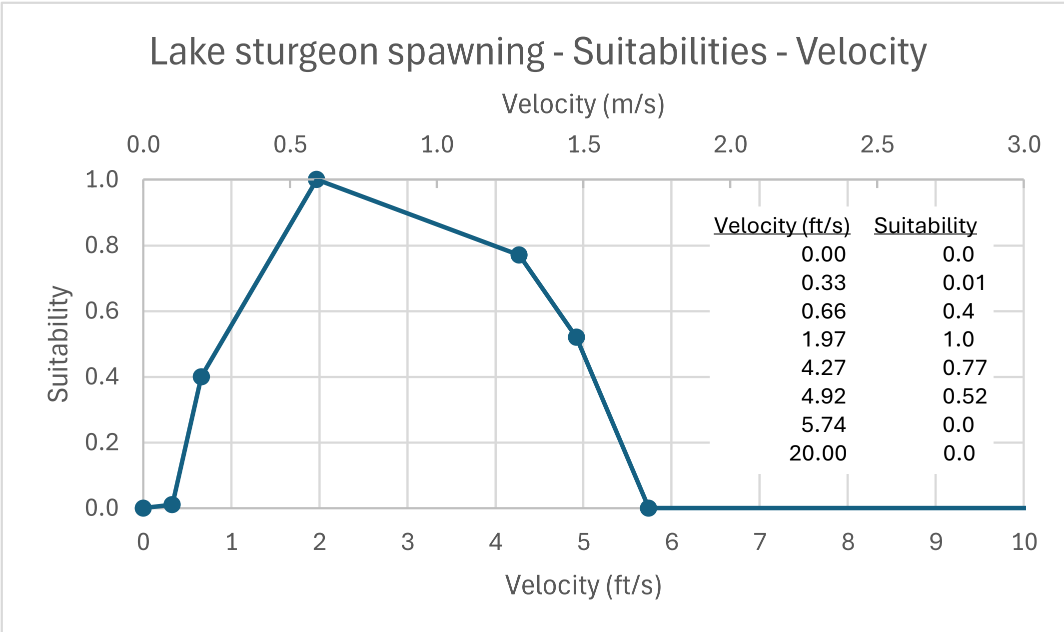


Figure 6: Habitat suitability as a function of water velocity for lake sturgeon spawning.

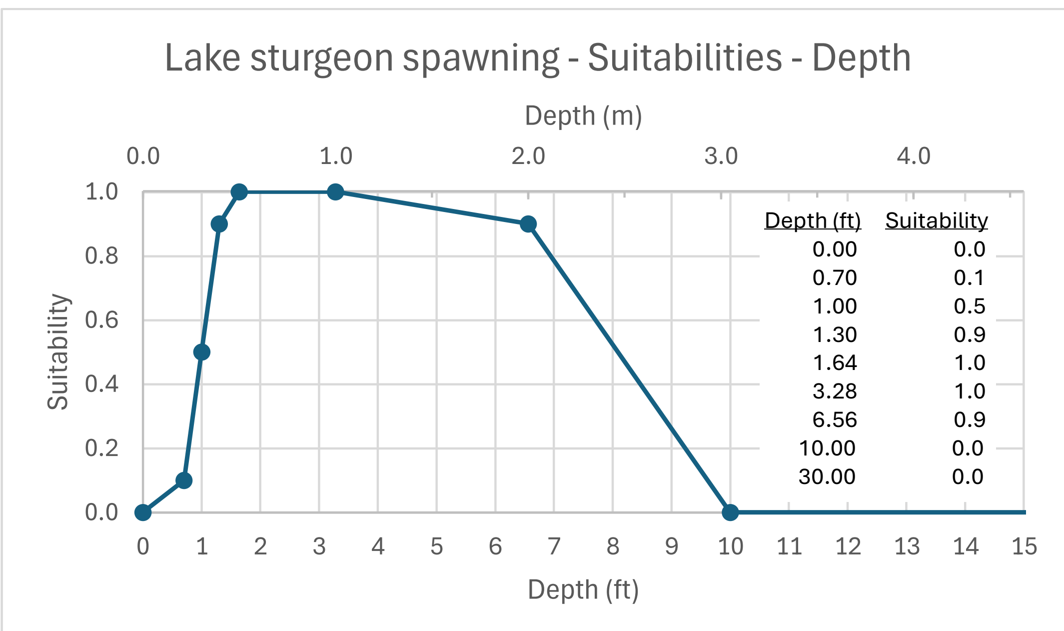


Figure 7: Habitat suitability as a function of water depth for lake sturgeon spawning.

Velocity and depth HSIs were applied to the corresponding geotiffs to generate maps of suitable habitat. This process had two steps. First, the velocity and depth HSIs were applied to the velocity and depth geotiffs independently, such that each geotiff was used to generate a habitat map based on one variable (e.g., the depth HSI was applied to the depth geotiff to produce a habitat map based only on depth). Second, the habitat maps for velocity and depth (produced in the first step) were combined into a single multivariate habitat map for each operational scenario. Multivariate habitat maps were generated by multiplying velocity and depth suitabilities and then taking the square root of that product (Figure 8). When an area was wholly unsuitable, it was removed from the habitat map, as shown in Figure 8 for areas of the river deeper than 3 m (10.0 ft).

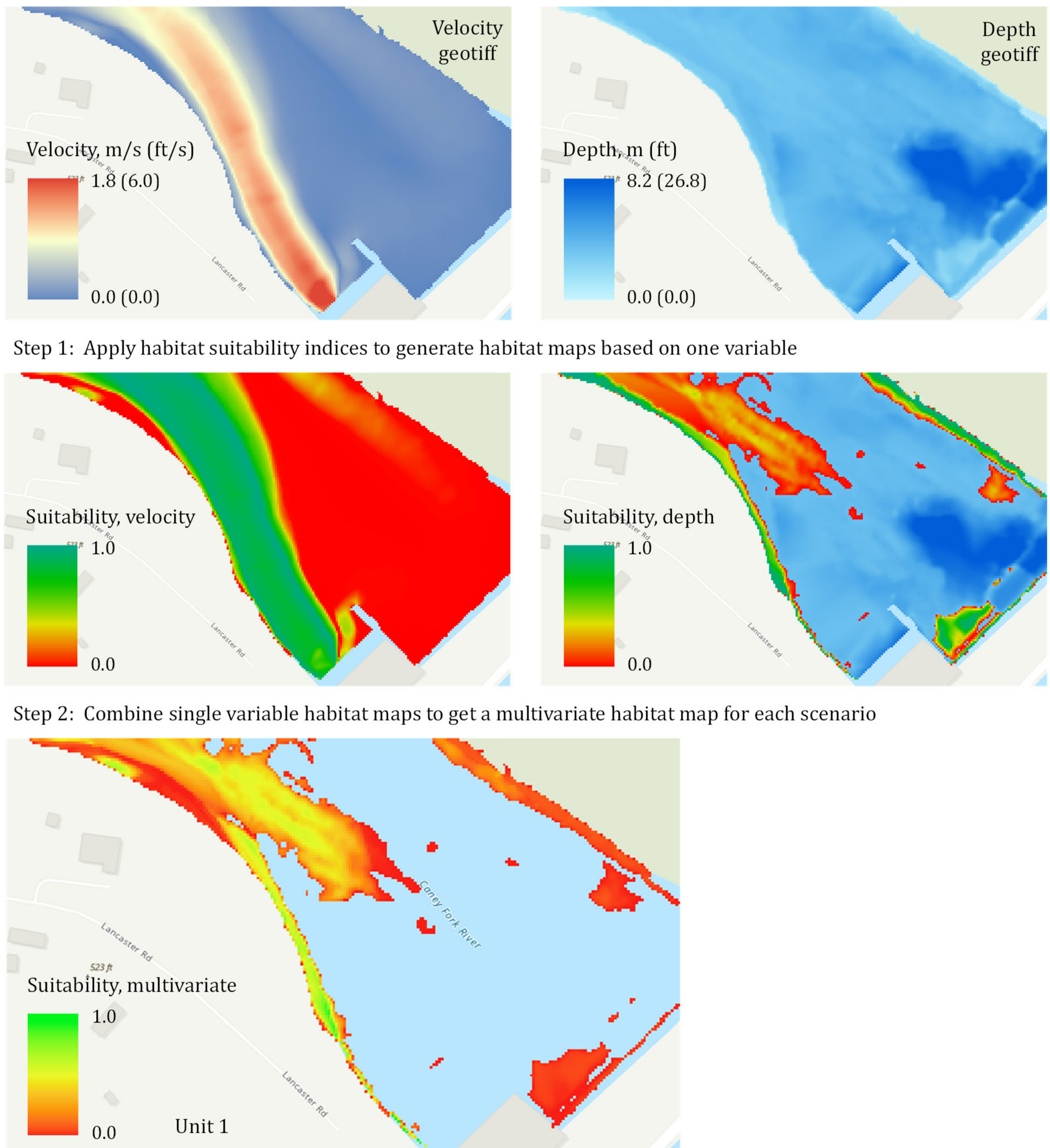
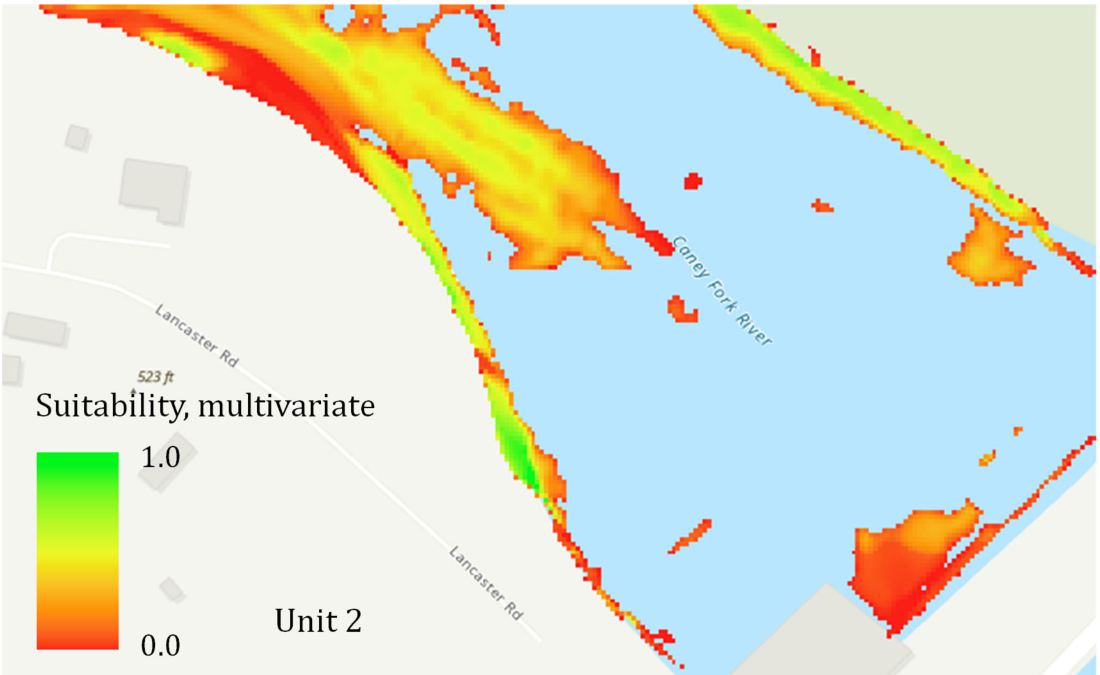


Figure 8: Process used to generate multivariate habitat maps. Unit 1 scenario shown.

This process was done for each operational scenario, independently (Figure 9). It is important to note that computations, for applying HSIs and generating multivariate habitat maps, were done spatially for each raster cell in the geotiffs.



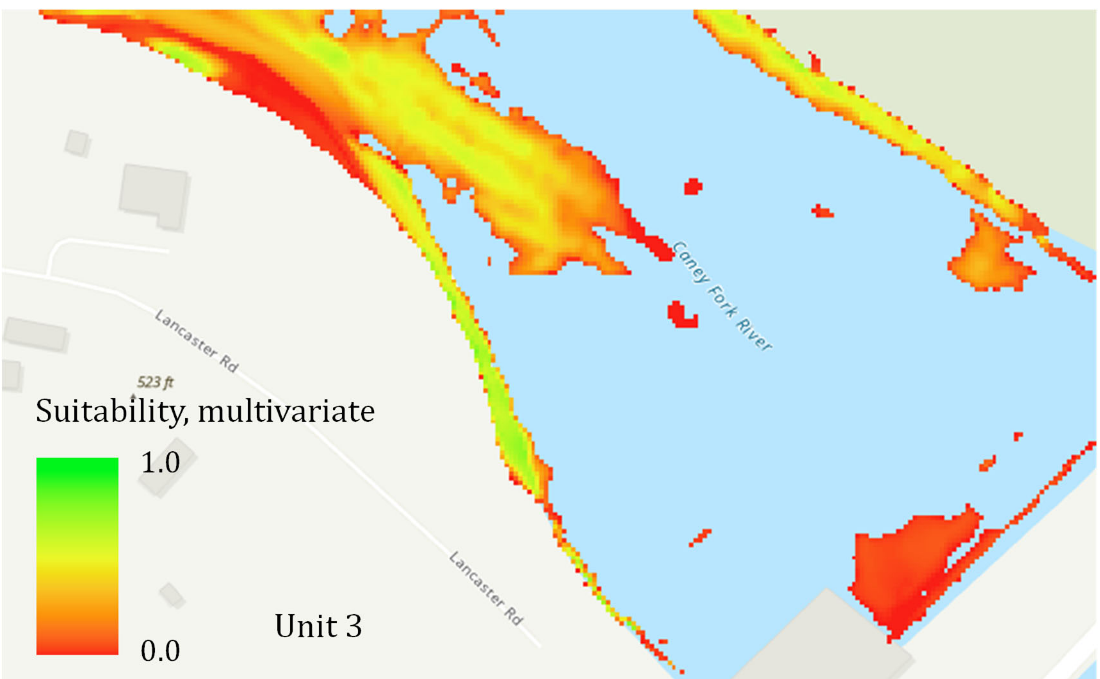


Figure 9: Multivariate habitat maps for Unit 2 (top) and Unit 3 (bottom) scenarios. Unit 1 scenario shown in Figure 8.

The left bank area immediately below the hydroelectric station was of particular interest because it is most directly influenced by choice of generating unit and because it is known to have substrate suitable for lake sturgeon spawning. This area was extracted from the multivariate habitat maps for each operational scenario for further analysis (Figure 10).

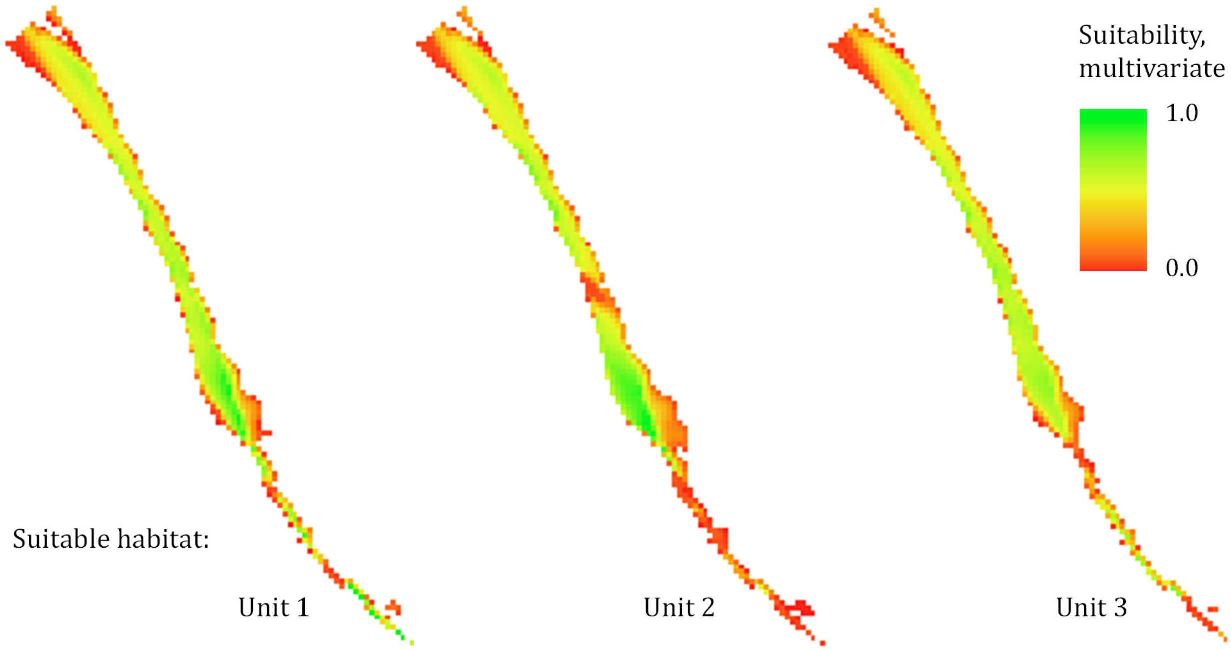


Figure 10: Suitable habitat within the left bank area for three operational scenarios.

Total and suitable habitat areas for the left bank extracts were tallied for each operational scenario (Table 1).

Table 1: Total and suitable habitat provided by different operational scenarios, left bank area. Areas in hectares (ha) and acres (ac).

	Unit 1		Unit 2			Unit 3		
Relationship	Suitable Area, ha (ac)	Total Area, ha (ac)	Suitable Area, ha (ac)	Total Area, ha (ac)	Change, Percentage	Suitable Area, ha (ac)	Total Area, ha (ac)	Change, Percentage
Lake sturgeon spawning	0.066 (0.164)	0.153 (0.379)	0.065 (0.161)	0.161 (0.397)	-2.11	0.062 (0.152)	0.149 (0.367)	-7.19

Suitable habitat was assessed for locations that could support potential lake sturgeon spawning aggregations for each operational scenario (Figure 11). The criteria for locations were an overall circular size with a radius of 3 m (10.0 ft) that contains habitat that is at least 50% suitable.

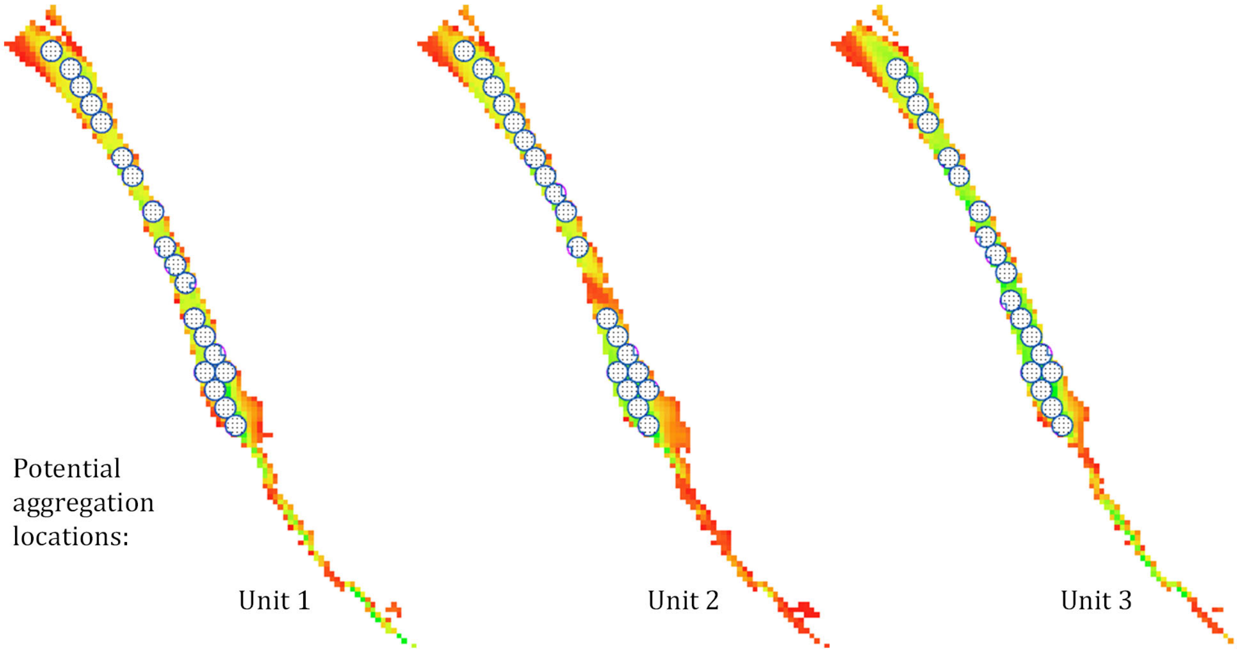


Figure 11: Potential lake sturgeon spawning aggregation locations within the left bank area for three operational scenarios.

Habitat comparisons of the operational scenarios showed only slight differences. Suitable habitat within the left bank area was highest when Unit 1 was generating. The other operational scenarios provided slightly less suitable habitat (-2% for Unit 2 and -7% for Unit 3). The Unit 2 scenario provided the most total area and the highest number (20) of potential aggregation sites (the Unit 1 and Unit 3 scenarios each had 19 sites). Again, differences were slight and supported identification of Unit 1 as the recommended operating unit during lake sturgeon spawning based on suitable habitat provided.

Monitoring

Lake sturgeon monitoring below Center Hill Dam began in the summer of 2024 and spring of 2025 using common angling methods with gear currently reported being used during incidental captures – for example, medium to heavy action rods, circle- and j-hooks with non-artificial bait (i.e., night crawlers). Upon landing the fish, TWRA measured total length (TL), fork length, and total weight. Lake sturgeon were tagged with an individually numbered, laminated dart tag inserted below the dorsal fin and a PIT tag (BioMark) inserted below the first dorsal scute. Acoustic tags (Innovasea V16 51-85kHz; ~4-year tag life) were implanted in the ventral cavity of each fish via a 3-4 cm (1.2-1.6 in) incision; each tag emits a unique acoustic signal. All surgeries were performed using tagging protocol as described by Summerfelt and Smith (1990). Prior to incision, the surgical area, nonabsorbable nylon sutures, surgical equipment, and each tag were treated with a betadine solution. Incisions were closed with a series of three to four simple interrupted sutures and reinforced with a cyanoacrylate ester to bond tissue. Fish were allowed to recover and regain swimming mobility before being released in the approximate area of capture.

Post release movement characteristics of lake sturgeon were monitored through a combination of recapturing fish with dart and PIT tags in subsequent sampling efforts, recaptures by anglers, and tracking hydroacoustic-tagged fish via hydrophone and fixed station acoustic receivers (Innovasea VR2W-180kHz). In 2024, receivers were placed in the Caney Fork River and Old Hickory Reservoir (Figure 12). Each stationary receiver was attached to a permanently fixed object by a length of cable with a weight attached to the bottom (Old Hickory Reservoir) to prevent the receiver from being swept downstream during high flows or attached to a large stationary anchor and placed on the bottom of the river (Caney Fork River).

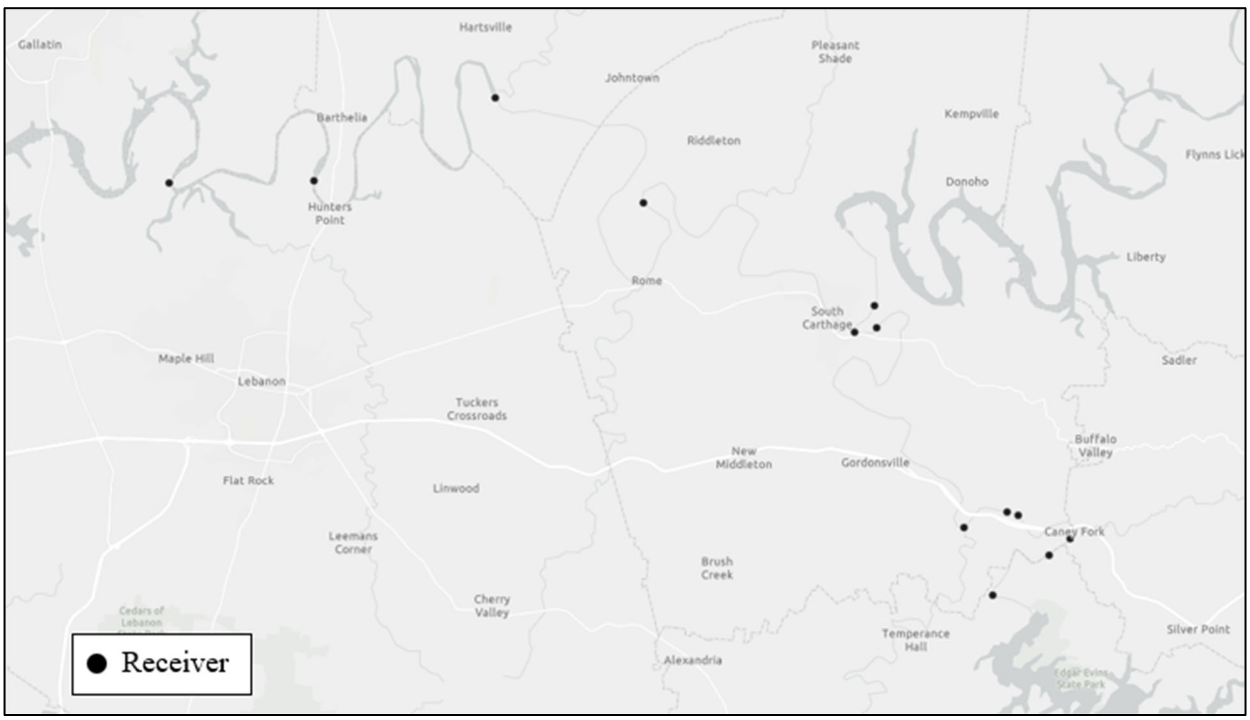


Figure 12: Map showing the locations of fixed acoustic receivers deployed in Old Hickory Reservoir and the Caney Fork River in 2024 (black).

Receivers were operated continuously and automatically logged any detection event. The tag's unique interval-tolerance combination, data, and time were recorded for each signal detected by the receiver. Receivers were checked for maintenance and data were downloaded directly to a laptop computer.

A total of 6 sampling days were conducted in the summer of 2024 on the Caney Fork River and 2 days in the spring of 2025. Fifteen individual lake sturgeon (Figure 13) were captured. Lake sturgeon ranged in size 87.7 to 144.5 cm (34.5 to 56.9 in) TL and weighed 3.0 to 20.8 kg (6.6 to 45.9 lbs; Table 2). TWRA and U.S. Fish and Wildlife Service staff conduct batch scute removals of fingerling lake sturgeon prior to stocking to identify year class. Based on scute removal patterns, fish captured ranged in estimated age from 5.2 to 17.1 years of age. During sampling on May 6th, 2025, TWRA biologists were tagging a large individual lake sturgeon (144.5 cm - 56.9 in TL; 17.76 kg - 39.2 lbs) and noted the presence of fully developed eggs in the abdominal cavity. This fish was estimated to be 17.1 years of age and is the first documented sexually mature female lake sturgeon in the Cumberland River system since restoration efforts began.

Figure 13: Map showing the locations of lake sturgeon captures in the Caney Fork River in 2024 (black) and 2025 (grey).

Table 2: Lake sturgeon capture information on the Caney Fork River as of August 11, 2025.

Capture Date	Acoustic Tag #	Total Length cm (inches)	Fork Length cm (inches)	Weight kg (lbs)
6/26/2024	ID50819	116.5 (45.9)	106.2 (41.8)	8.92 (19.7)
6/26/2024	ID50816	123.2 (48.5)	116.8 (46.0)	11.90 (26.2)
6/27/2024	ID50814	88.4 (34.8)	80.0 (31.5)	3.26 (7.2)
7/10/2024	ID50817	106.2 (48.1)	93.6 (36.9)	4.72 (10.4)
8/1/2024	ID50809	90.8 (35.7)	80.4 (31.7)	3.62 (8.0)
8/14/2024	ID50815	87.7 (34.5)	78.5 (30.9)	3.00 (6.6)
8/14/2024	ID50813	93.9 (37.0)	83.6 (32.9)	3.90 (8.6)
8/21/2024	ID50811	111.2 (43.8)	87.6 (34.5)	4.22 (9.3)
8/21/2024	ID50812	101.6 (40.0)	90.1 (35.5)	4.54 (10.0)
5/6/2025	ID50810	144.4 (56.9)	132.5 (52.2)	20.80 (45.9)
5/6/2025	ID50808	117.9 (46.4)	107.2 (42.2)	7.58 (16.7)
5/6/2025	ID50818	122.8 (48.3)	109.0 (42.9)	8.40 (18.5)
5/6/2025	ID50831	144.5 (56.9)	130.0 (51.2)	17.76 (39.2)
5/6/2025	ID50827	119.3 (47.0)	108.5 (42.7)	9.00 (19.8)
5/14/2025	ID50820	129.2 (50.9)	117.6 (46.3)	11.74 (25.9)

Movement of all 15 fish are being documented as part of the ongoing study by recaptures made by anglers, manual tracking with hydrophone, and fixed station acoustic receivers. To date, approximately 29,000 individual detections have been compiled across all receivers, 11 recaptures by anglers or by TWRA in subsequent collection efforts, and 22 manual detections with a hydrophone. Individual fish have been last detected from 11 to 367 days after release.

A total of 9 fish were captured and tagged in the summer and fall of 2024. Of these, a total of 6 fish outmigrated to Old Hickory Reservoir that year. The mean emigration date for these fish was October 25th 2024. Three other individuals tagged during this period remained residents throughout the year. Three of the six fish that emigrated from the Caney Fork River in 2024 returned the following year. Those fish reentered the river between March 27-April 1st, 2025. On average, they emigrated back to Old Hickory Reservoir by April 25th 2025. The fish tagged in 2024 ranged in age from 5.2 to 10.3 years of age, so they have likely not reached sexual maturity. Immature lake sturgeon have been shown to display variable movement patterns in other studies (Schulze 2017).

Lake sturgeon tagged in the first 2 weeks of May 2025 (n=6) displayed different movement patterns than the previous year's cohort. These fish were also significantly older and ranged in age from 12.1 to 17.1 years of age. Upon release, all 6 of these fish outmigrated to Old Hickory Reservoir with a mean date of June 5. Half had outmigrated by the end of May (including the sexually mature female). This likely represent the typical movement patterns of lake sturgeon during their spawning migrations in the Cumberland River system.

Movement patterns observed in the first two years of the study display variability in behavior among tagged fish. TWRA plans to tag additional fish this fall and next spring and will continue to monitor their movements over the life of the transmitters. Despite this variability, there is some indication that lake sturgeon in Old Hickory Reservoir display upstream migrations in spring and return in summer to early fall, which is consistent with expected movement related to spawning.

Future Work

The first year of this collaborative project applied a river hydraulics model to assess and compare how well flows through each of the three hydropower units of Center Hill Dam met the needs of sturgeon during spawning season. The project also monitored sturgeon by actively tagging them in the Center Hill tailwater.

LRN will continue to increase and expand the collaborative lake sturgeon monitoring efforts with TWRA to obtain a better understanding of sturgeon distribution, population dynamics, and spawning response to different flow regimes. TWRA is planning to deploy spawning mats in the spring of 2026 to detect if spawning is occurring in coordination with LRN dam releases. Water quality parameters such as dissolved oxygen and temperature below Center Hill Dam will also be collected to gain a better idea of the conditions in which sturgeon thrive.

Operational feasibility of the recommended release scenario identified this year, hydropower generation with Unit 1, will be assessed using HEC-ResSim. Center Hill is a heavily utilized project with high public use in both the reservoir and tailwater areas. Ensuring that operational conditions can meet the habitat needs of sturgeon is a top priority. Over the past four years, observed spawning aggregations have coincided with a period of increased rainfall and the seasonal transition from winter to summer pool levels. LRN is committed to balancing sturgeon habitat needs with all authorized project purposes, in alignment with the guide curve if and when potential exists. While we are optimistic that the necessary conditions can be met, past experiences with significant spring droughts suggest that in some years, support may be limited during dry conditions. Through evaluation of these conditions, additional future stakeholder meetings will be held to discuss proposed action plans.

Conclusion

Through collaboration between TWRA and LRN, the beginning stages of data collection and model development have been completed for the tailwater of Center Hill Dam. The river hydraulics model utilized water surface elevations, velocity data, and terrain modifications to build and verify accuracy of results, namely that releases through Unit 1 creates the most promising downstream conditions for sturgeon spawning habitat. Sturgeon movement was monitored by TWRA. An exciting discovery revealed via monitoring was the first known presence of a female sturgeon with fully developed eggs in the Cumberland River since sturgeon restoration efforts were started in the early 2000s. Future steps for the following fiscal year will include assessing feasibility of the generation plan using HEC-ResSim and continuation of monitoring lake sturgeon in the area of interest in hopes of documenting spawning.

Literature Cited

Baril, A. M., J. T, Buszkiewicz, P. M. Biron, Q. E. Phelps, and J. W. Grant. 2018. Lake sturgeon (Acipenser fulvescens) spawning habitat: a quantitative review. Canadian Journal of Fisheries and Aquatic Sciences: 75(6), 925-933.

MVS (St. Louis District). 2021a. Lake Sturgeon Spawning at Mel Price Locks and Dam. U.S. Army Corps and Engineers. Sustainable Rivers Program. 18 pp. https://www.hec.usace.army.mil/sustainablerivers/publications/docs/Mississippi%20-%20Lake%20sturgeon%20spawning%20summary.pdf

MVS (St. Louis District). 2021b. Mel Price Locks and Dam Hydraulic Assessment of Conditions Surrounding the 2015 Lake Sturgeon Spawn. U.S. Army Corps and Engineers. Sustainable Rivers Program. 30 pp. https://www.hec.usace.army.mil/sustainablerivers/publications/docs/Mississippi%20-%20Lake%20sturgeon%20spawning%20modeling.pdf

Schulze, J.C. 2017. Lake Sturgeon Movement After Upstream Passage of Two Hydroelectric Dams on the Menominee River, Wisconsin-Michigan. College of Natural Resources – University of Wisconsin.

Summerfelt, R. C., and L. S. Smith. 1990. Anesthesia, surgery, and related techniques. Pages 213-263 in C. B. Schreck and P. B. Moyle, editors. Methods for fish biology. American Fisheries Society, Bethesda, Maryland.

Swearingin, R., and R. Errett. 2023. 2022 Lake Sturgeon Spawning at Melvin Price Locks and Dam. U.S. Army Corps and Engineers. Sustainable Rivers Program. 18 pp. https://www.hec.usace.army.mil/sustainablerivers/publications/docs/Mississippi%20-%20Lake%20sturgeon%20spawning%20summary%20-%202022.pdf

Swearingin, R., C. Chen, and S. Peper. 2024. 2023 Lake Sturgeon Spawning at Melvin Price Locks and Dam - Mississippi River. U.S. Army Corps and Engineers and Missouri Department of Conservation. Sustainable Rivers Program. 26 pp. https://www.hec.usace.army.mil/sustainablerivers/publications/docs/Mississippi%20-%20Lake%20sturgeon%20spawning%20summary%20-%202023.pdf

Swearingin, R., K. Bales, S. Clark, S. Peper, and T. Moore. 2025. System Operations to Support Lake Sturgeon Spawning at Locks and Dams on the Mississippi River. U.S. Army Corps and Engineers and Missouri Department of Conservation. Sustainable Rivers Program. 14 pp. https://www.hec.usace.army.mil/sustainablerivers/publications/docs/Mississippi%20-%20System%20operations%20for%20lake%20sturgeon%20spawning.pdf