Photograph of Nimrod Dam (USACE photo).

Fourche La Fave River and Lake Nimrod, Arkansas Pool Level Management and Flow Recommendations Workshop Summary

Sustainable Rivers Program 2025

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The Nature Conservancy

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Introduction

In 2021, the Fourche La Fave River was added to the Sustainable Rivers Program (SRP) and together with partners from Arkansas Department of Agriculture Natural Resources Division (ANRD) and U.S. Fish and Wildlife Service (USFWS), a state of the science report was completed in April 2024. The state of the science report detailed the current available data and literature for the Fourche La Fave River to identify flow-dependent fish, mussels, and other species in the river; examined changes in these species over time; and looked at alterations in the streamflow regime that potentially could have caused these changes (Hart et al., 2024).

In July 2024, an environmental flows and environmental pool management workshop was held to develop streamflow and pool level management recommendations. The workshop and resulting recommendations aimed to restore eco-hydrological function by examining possibilities for reservoir management modifications within the range of authorized reservoir releases to create streamflows and in-pool water levels beneficial to the Fourche La Fave River and Nimrod Lake ecosystem and its biota. This report details the outcomes and recommendations from that environmental flows and environmental pool management workshop.

Background

An objective of the Fourche La Fave SRP project is to determine the ecological goals for streamflows upstream and downstream of Nimrod Dam. Considerations include re-establishing physical processes that create and connect in-channel and off-channel habitats, recruiting and maintaining floodplain vegetation, providing alligator gar spawning habitat, conserving other Species of Greatest Conservation Need (SGCN), and mitigating thermal impacts of the dam releases.

The Ouachita Mountains Ecoregion, the ecoregion that the majority of the Fourche La Fave River watershed lies within, is home to 48 endemic species with more than one-third of the species being aquatic (TNC, 2003). The aquatic systems are stressed from land use conversion from forest to agriculture, commercial timber, and development. These land use changes lead to increased sedimentation and runoff and other nonpoint source pollution (TNC, 2003). Dams, among other anthropogenic activities (altering land use, water withdrawals, etc.), can cause hydrologic alterations that reduce peaks, prolong baseflows, smooth the hydrograph, produce unseasonably high flows, and impact water quality, in particular, water temperature and dissolved oxygen (DO; Hart et al., 2024).

Environmental streamflows have been defined by TNC as “scientific prescriptions for the timing, quantity and quality of water flow that must occur downstream and upstream of dams in order to revive and sustain critical ecological functions and habitat for species” (TNC, 2020). There is little information regarding environmental flows in the Fourche La Fave River and surrounding streams, necessitating the need to develop and compile such information, therefore, necessitating the need for an environmental flow recommendations and environmental pool management workshop.

Fourche La Fave River

The Fourche La Fave River, located entirely in western Arkansas, is a major tributary to the Arkansas River (Figure 1. Map of the study area.). The Fourche La Fave River (herein also referred to as simply “the Fourche La Fave”) is impounded by Nimrod Dam to form Nimrod Lake. The Fourche La Fave headwaters arise in Scott County about 45 miles south of Fort Smith, Arkansas, and flow toward Nimrod Dam approximately 65 miles to the east through Scott, Yell, and Perry counties. Throughout this reach, the basin is relatively steep, long, and narrow with only one main stem fed by numerous short tributaries.

After leaving Nimrod Dam, the Fourche La Fave widens into a broad flood plain with low terraces and is characterized as gently sloping and deep (Hart et al., 2024). The South Fourche La Fave River enters the Fourche La Fave approximately 10 river miles below the dam and is its largest tributary.

Nimrod Dam is in Perry County, Arkansas, 62.6 miles upstream of its confluence with the Arkansas River. Nimrod Lake is one in a group of projects authorized for flood control on the Arkansas River. Nimrod Dam regulates flow from 680 square miles of the total 1,110 square miles of the Fourche La Fave watershed and a permanent pool is provided for betterment of fish and wildlife, recreation, and water supply. The conservation pool extends approximately 6 miles upstream of the dam and lies within Yell and Perry counties. The reservoir has a storage capacity of 29,000 acre-feet, provides 77 miles of shoreline, and drains approximately 680 square miles at a conservation pool elevation of 342 feet. Regulation of flows in the Fourche La Fave River aids in controlling floods on the Arkansas River by reducing tributary streamflow coincident with peak discharge, and by increasing valley storage on the lower Fourche La Fave River to further modify Arkansas River floods.

The climate for the Fourche La Fave watershed (Figure 1) is predominantly influenced by its proximity to the Gulf of Mexico. At Nimrod Lake, the reservoir averages 4.5 inches of rainfall monthly, receiving more than the monthly average in spring and averaging 54.43 inches, annually. The reservoir's average precipitation is distributed over 92 days per year in the form of rain and snow, sleet, or hail (approximately 2.8 inches, annually, of frozen precipitation; Hart et al., 2024).

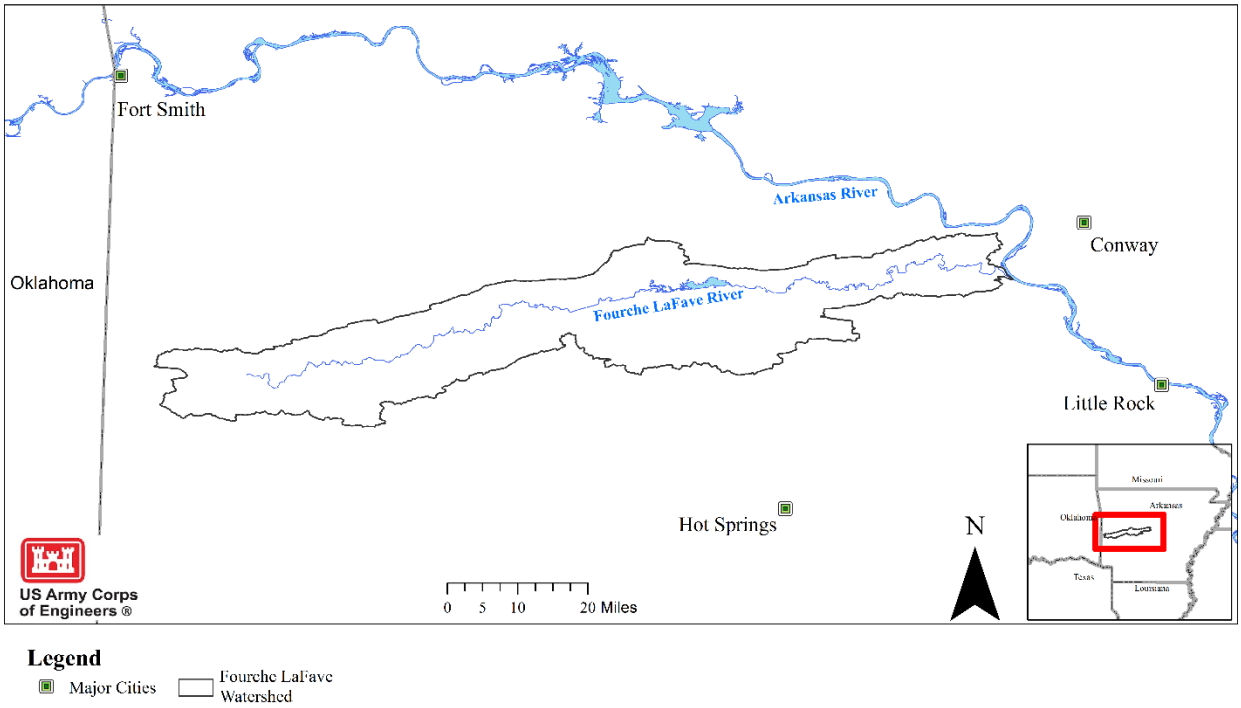

Figure 1. Map of the study area.

Environmental Flow and Pool Level Management Workshop

An environmental flow recommendations and environmental pool management workshop was held in Conway, Arkansas, for the Fourche La Fave and Nimrod Lake. There were 23 attendees with representatives from TNC (North America), Arkansas Game and Fish Commission (AGFC), USFWS, University of Central Arkansas (UCA), Arkansas Natural Heritage Commission (ANHC), ANRD, Arkansas Department of Transportation (ARDOT), and the U.S. Army Corps of Engineers (USACE; Appendix A). After brief introductions and technical presentations were given by the USACE and TNC, the group was divided into two groups based on areas of concern: Nimrod Lake and the Fourche La Fave below the dam (Appendix B). Each group was asked to identify flow needs or pool level management for their SGCN, the floodplain, or in-pool portions of the Fourche La Fave and Nimrod Lake.

For each breakout group, a facilitator and an individual who ran the Regime Prescription Tool (HEC-RPT) were provided. The RPT software (http://www.hec.usace.army.mil/software/hec-rpt/) allows for the group to view hydrologic information and create flow recommendations on the spot. Hydrologic information was provided as daily streamflow in cubic feet per second (cfs). Nimrod Lake inflow data was the unaltered streamflow data and used for comparison with the altered, observed streamflow data measured downstream of the dam. The altered streamflow is represented by the observed streamflow for both the Nimrod and Aplin U.S. Geological Survey (USGS) streamflow gaging sites (refer to https://maps.waterdata.usgs.gov/mapper/index.html for locations). For visual comparison purposes only, the observed streamflow data was not adjusted for the Aplin site (Figure 2). Also provided in RPT were reservoir elevations; these were important for developing flow recommendations for the reach above Nimrod Lake. During the workshop, it became apparent that RPT would not capture the intents of the workshop because most of the ecohydrology data was unknown. Instead, a table was developed by each group identifying the environmental target, the purpose for developing the target, recommendation and justification for the environmental action, data gaps/needs and whether the action was implementable (Appendix C).

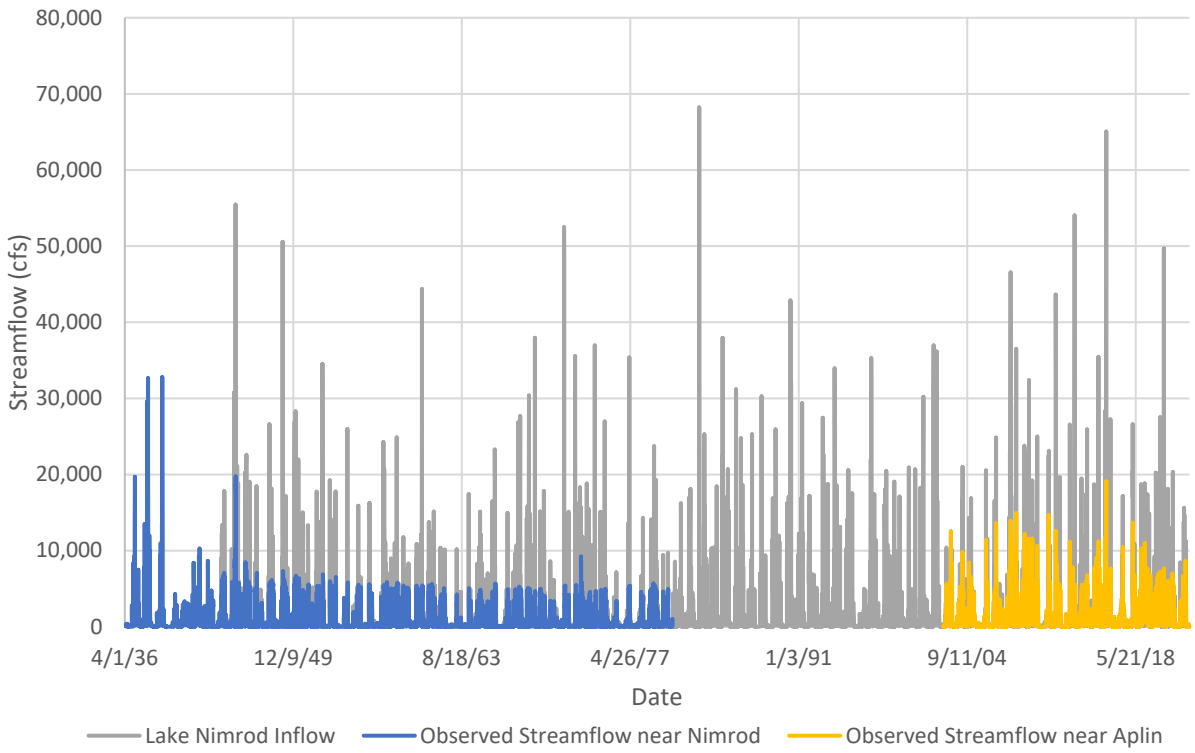

Figure 2. Unaltered Lake Nimrod inflow compared to the observed, altered streamflow data for both the USGS Fourche La Fave near Nimrod, AR, and Fourche La Fave near Aplin, AR, sites.

Workshop Results

Environmental Flows

To set specific restoration targets, understanding the relationship between changes in the streamflow regime and ecological response are needed. Several animal and plant species of conservation concern exist within the instream, riparian, and floodplain portions of the Fourche La Fave River corridor. Described below are the species and/or habitats of conservation concern that were discussed by workshop attendees.

Fish

A total of 24 fish families are represented in the Ouachita Mountains Ecoregion, with most species located within the minnow (*Cyprinidae*), perch (*Percidae*), sucker (*Catistomidae*), sunfish (*Centrarchidae*), and catfish (*Ictaluridae*) families. Around 60 species of fish from 14 families have been documented in the Fourche La Fave watershed (D. Lynch, ANHC, personal communication, 2023). Additionally, the Ouachita Mountains host a total of 8 endemic fish species, most of which are limited in geographic range within the ecoregion and are located primarily in the Ouachita/Little River systems (TNC, 2003).

Two fish species are of concern within the Fourche La Fave River below Nimrod Lake: Alligator gar (*Atractosteus spatula*) and longnose darter (*Percina nasuta*). Alligator gar populations are declining throughout their range, which includes the Fourche La Fave River below Nimrod Dam. Decline is

attributed to overharvest and widespread habitat alteration resulting in the loss of connectivity between rivers and floodplain habitats (Kluender et al., 2016). The alligator gar is a periodically reproducing species that relies on flood pulses to connect main channel rivers to floodplain habitats (Winemiller and Rose, 1992, as cited in Kluender et al., 2016) and the Fourche La Fave is a known spawning ground for the alligator gar. The alligator gar is listed as a species of greatest conservation need by AGFC (AGFC, 2015).

Longnose darter has been historically reported from Nimrod Lake in low numbers but has not been detected since 1984 and is likely extirpated (USFWS, 2023b). Additionally, the species' historical range likely included the Fourche La Fave below Nimrod Dam because of its presence in the lake and its current presence within the South Fourche La Fave River (USFWS, 2023b). There is little information about spawning habitat and behavior for the longnose darter, but they probably spawn from March to May and may be triggered by water temperature and possibly increased streamflow. Longnose darter is currently under review for potential listing under the Endangered Species Act.

Alligator Gar

The environmental flows recommendations developed during the workshop targeted life history support for the alligator gar for spawning, recruitment success, and stranding. Recommendations, justification, and purpose for each life history event are provided in detail in the following sections.

Spawning

Studies have shown that for alligator gar spawning success, they need access to inundated floodplain tributaries at optimal temperatures (Adams et al., 2012; Kluender et al., 2016; Robison and Buchanan, 2020); therefore, the purpose of the recommendation for spawning is to sustain floodplain tributary inundation for sufficient periods of time to encourage and maintain successful spawning efforts. Direct observations by experts indicated that the Arkansas River influence of the downstream sections of the Fourche La Fave provide the supporting conditions for alligator gar; however, receding Arkansas River levels are often too fast. Supplementing the river recession with Nimrod outflows would help sustain needed inundation for spawning conditions. Previous studies conducted by Inebnit (2009) demonstrated that the optimal environmental conditions for spawning and recruitment of the alligator gar in the Fourche La Fave were a mid-May to mid-June spawning season that generally corresponded with rising water levels (mostly due to back flooding from the Arkansas River) and increased water temperatures. Therefore, the recommendation is to sustain the downstream inundation by manipulating outflows from Nimrod from 15 May to 15 June. It was determined through RAS modeling efforts (explained below) that this could be possible under the right circumstances. However, to make this recommendation possible, a deeper understanding is needed of the hydraulic connections between outflows from Nimrod and Arkansas River flow with respect to the extent of Nimrod release travel times associated with first effect and full effect at documented spawning sites.

Recruitment Success

Not only is the occurrence of flooding critical for recruitment, but the duration of flooding is also key; therefore, the purpose of the recommendation for recruitment success is to enable and maintain supporting recruitment conditions post spawn. The recommendation is to sustain the downstream inundation by manipulating outflows from Nimrod for 7 to 10 days, at least one time during 15 May to 30 June. To make this recommendation successful, it was suggested that real-time water quality monitoring, particularly temperature, occur at the Houston and Aplin gages and near Perryville. The purpose of the water temperature monitoring is due to the fry being heavily dependent on water temperatures of at least 20 degrees Celsius (°C) for survival. This recommendation could possibly be implementable if temperature monitoring was realized, weather patterns fully understood, and water conditions were met

(especially following and tracking floods i.e., the high-water events on the Arkansas River) May through October. It would then be possible to look for the best opportunities to assist in maintaining inundation from Nimrod outflows.

Stranding

Experts have observed adults trapped in oxbows, backwater connections, and shallow areas that dry out with fast water recessions of the Arkansas River affecting the lower Fourche La Fave throughout the year. Therefore, the recommendation is to use Fourche La Fave outflows to mitigate adult stranding during dry and average years. However, a study is needed to identify where, and the conditions when, areas utilized by alligator gar are dry and to identify under what hydrologic conditions this occurs. Additionally, the collection of telemetry data to track alligator gar movement patterns and link these patterns to observed flow regimes under varying conditions both spatially and temporally would also be needed.

Longnose Darter

A better understanding of longnose darter distribution is needed to fully develop flow recommendations for this SGCN. Distribution of the longnose darter within the mainstem Fourche La Fave is generally unknown and undocumented. However, there are documented sightings of the longnose darter in the Fourche La Fave and the South Fork Fourche La Fave, but the longnose darter has only been documented once above the dam in 1984 (Robison and Buchanan, 2020). Furthermore, longnose darters may be above Aplin but survey conditions preclude good data (snorkeling is the primary method of detection and low turbidity conditions are required).

Habitat occupancy in spring months is typically riffle/runs with coarse substrates (cobble and boulder), and pools with larger substrates (boulder) in the summer. Spawning occurs mid-April to June in the higher flow areas of pools and raceways. Workshop experts requested possible coordination with USACE staff that may be on-site to report on when favorable survey conditions are present to allow for data collection and to expand database and presence records. It was noted that in April to May, low flow conditions should be targeted to support spawning in areas of more flow, i.e., raceways of pools. Eggs likely attach to substrates, but reproductive behavior is relatively unknown. Furthermore, experts also requested an evaluation to identify the times of year when essential flow components, specifically, timing and magnitude of spring flows, occur from the period of record. Specific environmental flow components to evaluate whether spawning conditions have existed (i.e., lower flows during the spawning period) include: the number of annual occurrences of low pulse events (events below the 25th percentile), the average number of events greater than the 75th percentile, the magnitude of minimum flows, and the duration of high flows. If evaluation of these flow components determine that lower flows exist during the spawning period and if longnose darter are present, then their required habitat and flow needs should currently exist. However, if the conditions do not currently exist, it is recommended that flow targets mimic the essential flow components, i.e., mimic unaltered flows, that are key to the species survival.

Mussels

The scaleshell mussel is a federally endangered mussel that reaches lengths of 1 to 4 inches. It is a long-term brooder. They begin brooding glochidia after fertilization occurs (late September through the end of October), infest host fish (i.e., Freshwater Drum) during the March to May period and then glochidia fall off their host. Scaleshell are often found in stable sand in clear runs, riffles or fast-moving currents. The recommendations developed are like other long-term brooders found in the Ouachita Mountain streams and were determined during the 2023 SRP Cossatot River and Gillham Lake flow recommendations workshop (Hart et al., 2023). For long-term brooder fertilization, maintaining flows at or above 105 cfs is ideal, along with 2 to 4 low-flow pulses of at least an increase of 50 cfs, but not more than an increase of 150 cfs, during the long low-flow periods. This low-flow period typically coincides with the long-term

brooder fertilization period (late September through the end of October). These low-flow pulses need to last for 2 to 3 days to help these long-term brooders in successful reproduction. Long-term brooder host infestation can occur as early as March through mid-May or when water temperatures reach approximately 16 °C. During this period, the duration of lower flows is more important than a high peak of a short duration with a short recession. Glochidia of long-term brooders typically excyst from host fish on average 20 days after infestation, and for scaleshell in Arkansas, this typically occurs from mid-March to the end of May. The excystment period is the most critical period for mussel survival, e.g., too high of flows can displace newly transformed juveniles into unsuitable habitat.

Riparian and Floodplain

Floodplain connectivity is essential for the exchange of water, nutrients, sediments and organisms between the riparian environment and river (van der Most and Hudson, 2018). They also support high levels of biodiversity and some of the most productive ecosystems on Earth (Opperman et al., 2010).

Bottomland Hardwood Forests

Harris Brake Green Tree Reservoir (GTR) is a significant Wildlife Management Area (WMA) for AGFC, providing recreation opportunities and beneficial habitat for game species (waterfowl and other wildlife). It is also an important recreational fishery. Therefore, to maintain conditions at Harris Brake, outflows from Nimrod should be released as not to impact this GTR. If possible, USACE has been asked to protect, sustain, and maintain existing conditions and to support conditions needed to promote bottomland hardwood tree growth on the higher elevations within the area (i.e., terraces). There is also a need to explore if Nimrod operations and Harris Brake could work together to provide mitigating conditions to avoid prolonged inundation. Furthermore, there is a need to explore the GTR regulations and review when the Arkansas River incurs prolonged flooding and an understanding of the hydraulic connections between outflows from Nimrod and Arkansas River flow, particularly with respect to the extent of Nimrod release travel times associated with first effect and full effect at Harris Brake.

Sediment Mitigation

Agricultural run-off and lack of transition zones between agricultural land and the river compound bank failure. If Nimrod Dam releases could recede slower during extended periods of saturation, then bank sediments and floodplains could drain with reduction in bank failure. There is a need to address bank failure through restoration of riparian areas to mitigate sediment loading and bank loss. This could be accomplished through a more gradual reduction in Nimrod Lake releases after an extended period of flood evacuation releases to reduce the rate of bank sloughing incurred by prolonged saturation of riverbanks. This recommendation could be implementable within the right conditions and after potential evaluation of the rate of change of releases from Nimrod, as well as the timing, magnitude, and duration. Furthermore, hydraulic modeling could be used to identify when and where and under what hydrologic conditions bank failure is exacerbated by prolonged saturation on the floodplain.

Herbaceous Vegetation

No specific recommendation was provided for herbaceous vegetation that would enable supporting growth conditions. However, this environmental target would likely be a secondary positive response from the recommendations developed for the bottomland hardwood forests and alligator gar and would meet the desire for conditions that support a long-term herbaceous community in the lower reaches of the Fourche La Fave.

Water Quality

The Fourche La Fave has been designated as suitable for the propagation of fish and wildlife, primary and secondary contact recreation, and public, industrial, and agricultural water supplies (ADEQ, 2016).

Elevated turbidity values within one reach of the Fourche La Fave have been documented, as well as other reaches have been listed because of low dissolved oxygen concentrations (ADEQ, 2016). Therefore, to support the Clean Water Act beneficial uses for aquatic life, particularly for DO and temperature, it is recommended that three to four pulses of 300 to 500 cfs occur over a three-to-five-day period when water temperatures are greater than 22 °C. Pulses might not be needed during above average precipitation years during the summer months. However, pulses should occur during dry years, which could potentially be possible with the managed nature of the system. If this recommendation was realized, water quality standards could potentially be met and bring the Fourche La Fave into attainment. Monitoring data is needed, and experts suggest adding continuous monitoring data at Houston gage and possibly Perryville to evaluate efficacy of recommendation.

Other Recommendations

Other recommendations were made for commercial and sport fisheries, the alligator snapping turtle, and for fish passage. Recommendations for commercial and sport fisheries and the alligator snapping turtle include creating suitable conditions for the alligator gar. Therefore, if conditions were met for the alligator gar, commercial and sport fisheries and the alligator snapping turtle would be a secondary or tertiary benefits of implementation of alligator gar targets. Recommendations for fish passage, which includes passage for the American eel and the Ohio River shrimp, include restoring the native ranges and the ecosystem services each of these species provides. However, no other specific recommendations were provided.

Environmental Pool Management

Environmental pool management (EPM) was considered during the Fourche La Fave River and Nimrod Lake workshop.

Bottomland Hardwood Forests

A unique feature to Nimrod Lake is the Lloyd Millwood WMA, managed by the AGFC. This area is a 1,125-acre GTR, a seasonal wetland that uses a system of levees and water control structures to flood the surrounding forest, providing migrating waterfowl (and other species) shelter, food, and mating opportunities from late fall through early spring (Hart et al., 2024). The Lloyd Millwood and Harris Brake GTRs contain some of the few remaining bottomland hardwood forests. The management and sustainability of these bottomland hardwood forests (see recommendations for the Harris Brake GTR in the “Bottomland Hardwood Forests” section under “Environmental Flows”) is of particular concern because of the rarity of bottomland hardwood forests in western Arkansas (AGFC, 2023).

The purpose of EPM for bottomland hardwood forests is to evacuate water quickly from the trees during the springtime (defined as the end of February through March – currently, this date is dependent on waterfowl migration patterns). The quick water evacuation is to encourage success of the red oak species for waterfowl habitat. This species is being replaced with more water-tolerant species and, overall, bottomland red oak forests are disappearing. Therefore, the recommendation is to allow maximum allowable releases to lower the lake level to remove any unnecessary water during the nondormant season. However, to make this recommendation effective, the lake level needs to be below the second, bottom stoplog and this elevation is currently unknown.

This unique forest and habitat contributes to the mosaic of the landscape benefitting many species and could potentially help endangered bat species (particularly Indiana) and, therefore, need to be preserved. It is desired that flow pulses occur during a period when the water has been evacuated from the GTR. These pulses are important for oxygenation of the trees and to promote growth and can occur any time of

the year. These pulses could happen through a combination of GTR structure openings and closings and EPM. However, a rating curve should be developed to determine the volume of water leaving the GTR and how much the downstream system can take at varying water levels within the GTR. Furthermore, it is recommended that DO be measured in the GTR, during all times of the year, and determinations on how long it takes the DO to go from low to high and vice versa need to be made.

To make the recommendation successful, several data gaps need to be addressed, particularly determining at what elevation the white oaks and red oaks are dying and at what elevation red oak and white oak recruitment/regeneration is occurring. This information would be needed to make strong recommendations for water level management in Nimrod Lake. Additionally, age-class for each species would also be beneficial. As stated by Bender (2008), age-class-structure in trees strongly influences population dynamics through effects on fertility and fecundity rates, timing and length of breeding seasons, population-level productivity, total population-level mortality, and sensitivity to population regulating mechanisms such as density dependence.

This recommendation can be implementable dependent on how much water there is within Nimrod Lake and the GTR. There needs to be some water downstream (in-pool) to keep the GTR structures from being destroyed. Furthermore, dependent on how much water is downstream (in-pool) of the GTR, limits how much the structures can be opened. The downstream regulating stage may need to be raised in order to maximize releases to remove the water and, in doing so, could potentially flood downstream farmers.

Shoreline Vegetation Drawdown

Currently, within the Water Control Manual (WCM), a drawdown that occurs approximately once every 4 years is being implemented to allow AGFC to seed the shoreline for vegetation to promote sport fisheries through the planting of grasses or the recruitment of native grasses. The vegetation clears up water allowing for less turbidity, the decaying vegetation provides nutrient input and remnant vegetation promotes the next year's young of the year (yoy). Furthermore, the seeding from the grasses helps waterfowl foraging and provides a macrohabitat boost. The subsequent drawdown crowds predatory fish, increasing their foraging capability, and providing for a good fishery.

The recommendation is instead of an every 4-year drawdown to move it to every 5 years. The drawdown historically occurs over 6 weeks, but a 2-week drawdown is being considered to keep soil moisture conditions adequate. This allows for more germination of the aerially applied seed. Additionally, the quicker drawdown would be beneficial for anglers extending their season, as well as for recreation. However, shorter drawdown makes coordination with the pilots more difficult, and a longer drawdown would allow for more native vegetation to take.

The justification for the above recommendation is to improve fisheries for anglers and enhance the in-pool ecosystem. However, although this recommendation is already being implemented, changing it to a 5-year drawdown, permanently, would require a change in the WCM. It has been noted that what is currently in the WCM has been working. However, a lot has been dependent on the big floods and when those events do not occur, the specified drawdown helps, but a 5-year drawdown is expected to be more beneficial.

To make this recommendation successful, several questions need to be addressed and are listed under "Data Gaps". To make any determinations, a wetland biologist would need to be consulted.

Shoreline Vegetation Refill After Drawdown

Currently, the WCM states that the pool should fill beginning 15 September from an elevation of 337 feet to 342 feet and could happen over any length of period. However, it was recommended that a slower,

stepped fill should occur 1 October to 1 January. The purpose of this recommendation is to allow the vegetation to be maintained along the shoreline, which also benefits waterfowl. The longer duration also benefits the fishery by providing more foraging opportunities.

To make this recommendation successful, several questions need to be addressed and are listed under "Data Gaps". Furthermore, a slower, stepped fill might require a deviation and could potentially be tested this fall (2024) and, eventually, be requested as an addition to the WCM.

RAS Modeling Effort

To improve our understanding of effects from Nimrod Dam's flow releases both upstream and downstream on the Fourche La Fave, a hydraulic model was developed using the Hydrologic Engineering Center's River Analysis System (HEC-RAS) model version 6.4.1. The model aims to address key concerns such as sustaining inundation to support alligator gar spawning and mitigating rapid drops in water surface elevations downstream to prevent stranding aquatic wildlife. Influential variables extend beyond Nimrod Dam's flow release and include Arkansas River flows, Nimrod Dam's pool elevation, local rainfall, and the timing of these factors. Due to the complexities in predicting these variables, historical events representing unique variations of each were used to facilitate discussions and refine strategies for addressing these concerns. The analysis follows a process that precedes hypothesis testing: water temperatures need to be near 20°C during the spawning season and the Arkansas River must have sufficiently high flows to cause backwater up the Fourche La Fave, raising the Houston gage to approximately 261 to 262 feet elevation (21 to 22 feet stage) or higher, which provides alligator gar access to their spawning sites. If these conditions are met, the hypothesis posits that Nimrod Dam can extend the inundation period at spawning sites to seven days or more.

Model Layout

The HEC-RAS model was fully two-dimensional for the river systems with a one-dimensional storage area representing Nimrod Lake. The model included Pool 7 (Toad Suck Ferry Lock and Dam (LD 8 on Figure 3) to Murray Lock and Dam (LD 7, not referenced in Figure 3) along with the Fourche La Fave River up to Nimrod Dam. Key locations of the model are shown in Figure 3.

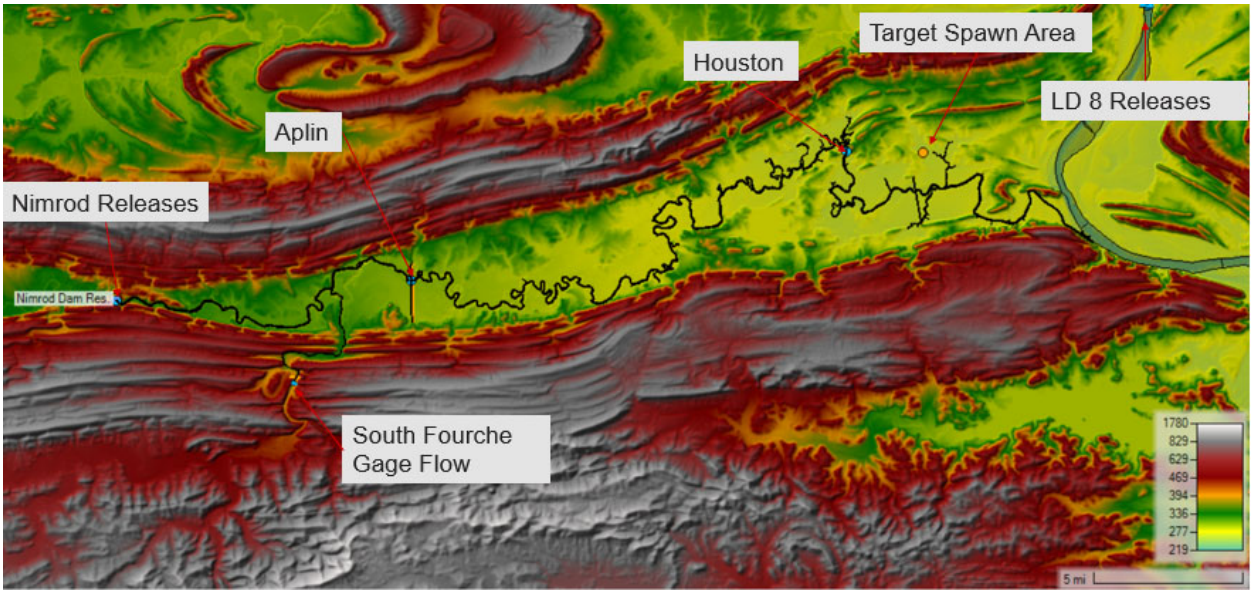

Figure 3. HEC-RAS model layout for the Fourche La Fave River, color bar is elevation in feet.

Additionally, the model included precipitation and hydrologic losses. The hydrologic losses were determined by average initial and infiltration rates based upon soil classifications. These losses were not adjusted by each respective event to calibrate – rather the results and gages were checked for reasonableness in timing and peak values.

Historical Events

A well-documented successful spawn of alligator gar was reported in June of 2007, and a failed spawn event was reported in May 2010. These two events along with the addition of a May 2007 event were analyzed and modeled. Figure 4 depicts the May to June 2007 event. This event was successful and driven by the backwater of the Arkansas River. Eggs were noticed on 17 June 2007 when the Houston Gage was at an approximate elevation of 262 feet. Nimrod was releasing very little flow and had little to no flood storage to evacuate. The sustained higher flows on the Arkansas River were a result of the Tulsa District Flood Risk Management Reservoirs having a high percentage of their flood storage utilized. A high flow on the Arkansas River during the month of May that was of a shorter duration was noticed and thus included in the analysis to understand possible improvements to the abrupt drops in water surface elevations along the river. Local rainfall during this time frame was not substantial.

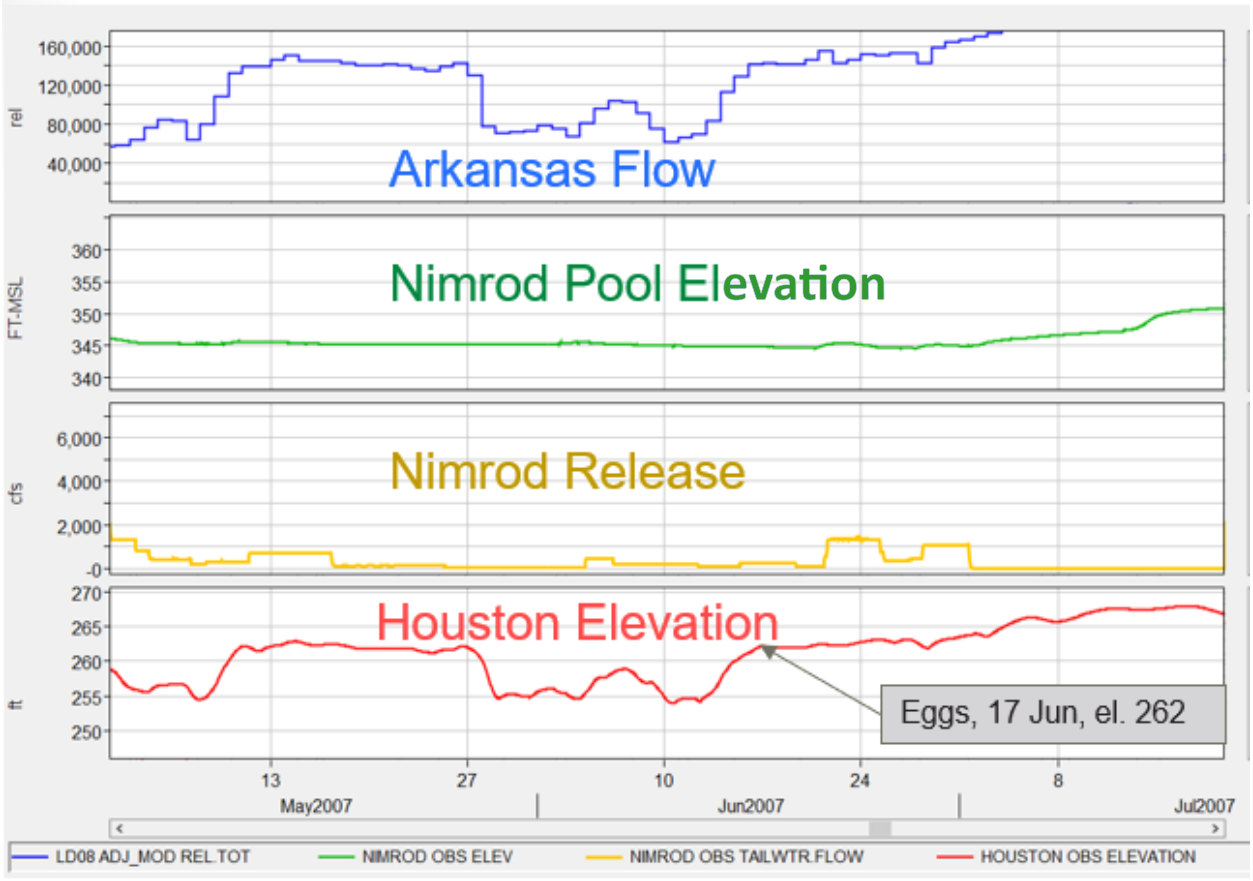

Figure 4. May to June 2007 event data, representing a time of successful alligator gar spawning (eggs observed 17 Jun 2007 when the Houston gage was at an elevation of 262 feet).

Figure 5 depicts the unsuccessful alligator gar spawn event in May 2010. Eggs were documented on 23 May when the Houston Gage rose to an approximate elevation of 267 feet (3 feet above the regulating

stage and 2 feet above the National Weather Service flood stage). Eggs were noted as dried on 24 May when the Houston gage fell abruptly to elevation 263 feet. For this event (May 2010), the abrupt rise was a combination of Arkansas River backwater and significant local rainfall. The abrupt fall was a combination of shut backs at Nimrod and recession of local rainfall. This event was further analyzed to mitigate the abrupt drop in water surface elevation.

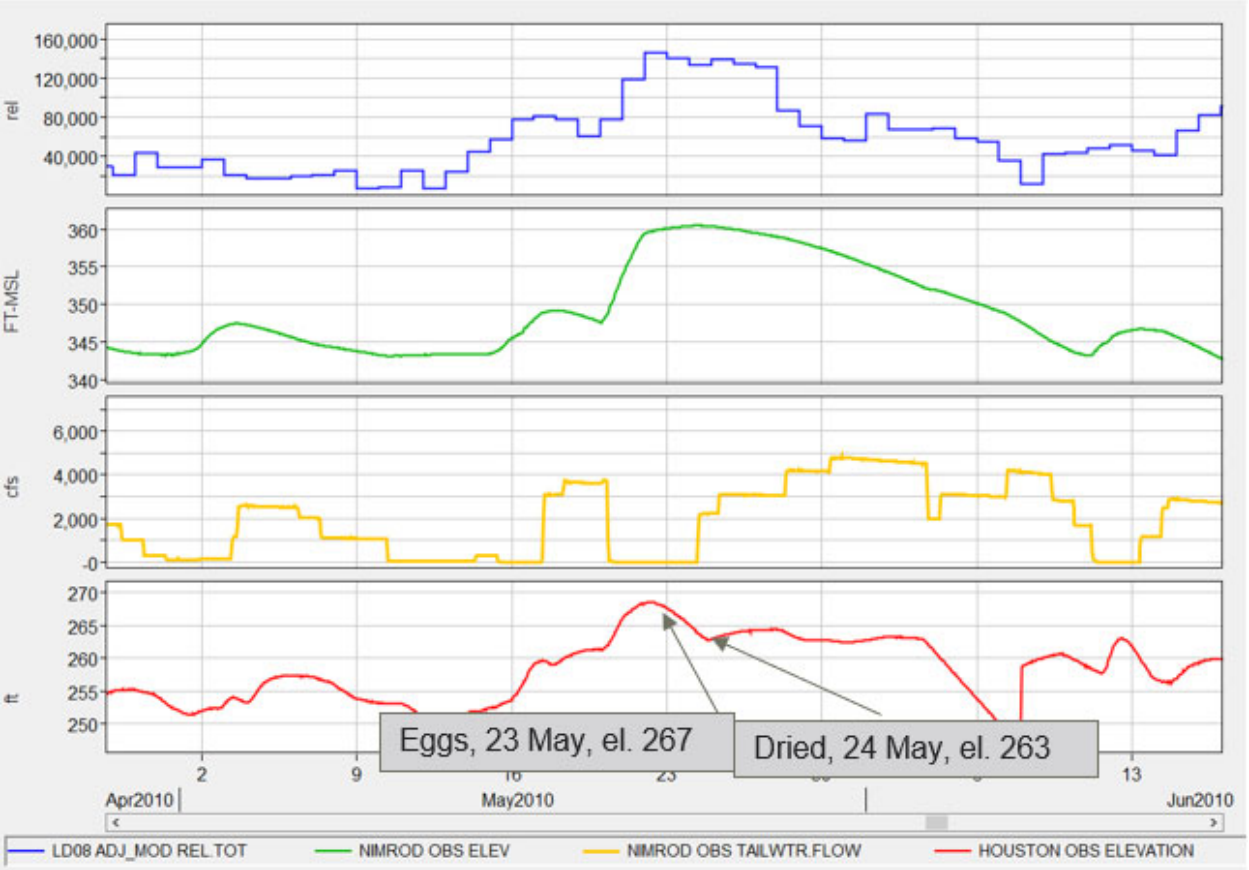

Figure 5. May 2010 event data, representing a time of unsuccessful alligator gar spawning, color scheme is the same as in Figure 4.

Model Results

The observed events previously described were not perfectly replicated with the river hydraulics model; however, the calibrated results predicted the stage-flow relationships for the gage ratings well, with the imperfection of the replications being mostly due to hydrologic variables. And, given that the objective of the study is subject to hydrologic variation, differences in the observed and calibrated events are acceptable to still draw conclusions. The following sections describe adjustments to Nimrod's operations for different hydrologic events to target a more successful alligator gar spawn. The calibrated results are referred to as "base" and adjustments to operations as "modified".

May 2010

Local rainfall and backwater from the Arkansas River caused the Houston gage to peak at an elevation higher than the regulating stage and flood stage. This increase in elevation led to more area inundated in the floodplain during the spawn; however, that additional area, being so influenced by local rainfall, was

not sustainable for a long enough duration to support successful spawning. The modeling effort investigated cutting releases back prior to the peak at Houston to determine if Nimrod's operations would sustain a lower peak longer. Additionally, because the peak elevation at Houston was higher than the regulating and flood stages, Nimrod's flows were shut back during the time of heavy rainfall to allow water to recede before releasing more water. The modeling effort investigated releasing from Nimrod sooner to mitigate the abrupt drop in water surface elevation in the spawning area. The subsequent figures (Figures 6 to 9) describe the results of the model at different key locations.

Figure 6 shows results from the adjusted releases from Nimrod for May 2010 as well as the base conditions at Nimrod Dam. Nimrod's releases were cut in half prior to the peak at Houston on 16 May 2010 and then opened up 2 days sooner on 21 May 2010 to attempt to mitigate the drop in water surface elevation at the Houston Gage.

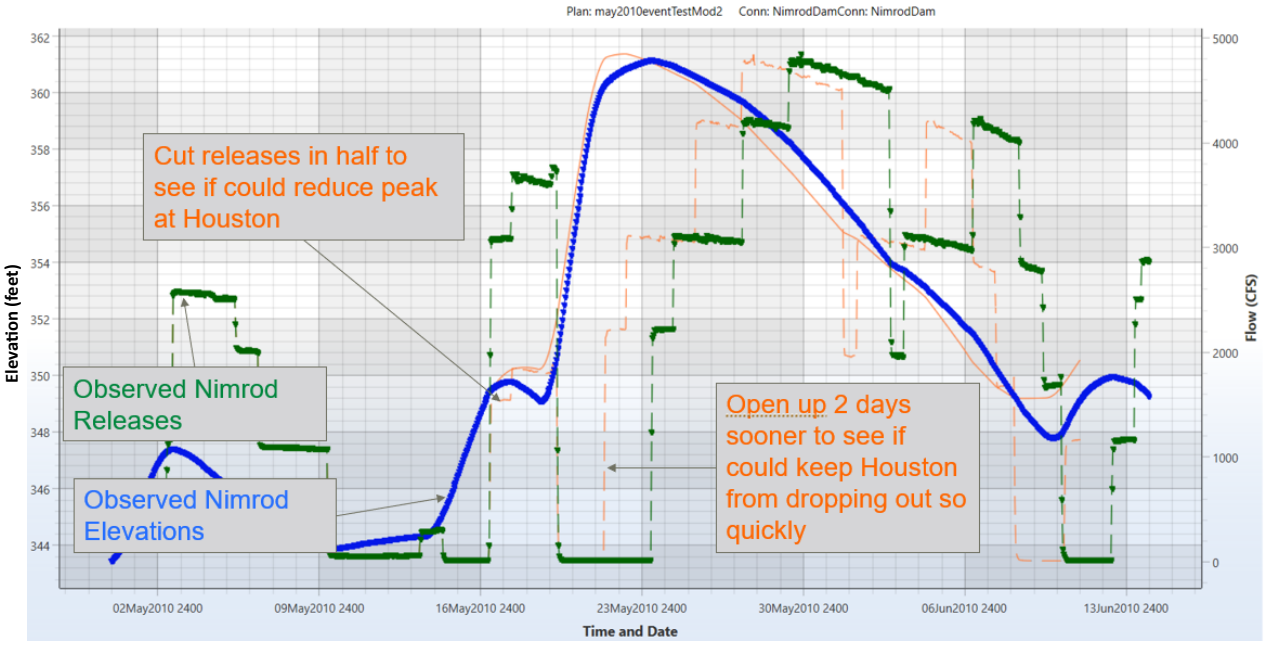

Figure 6. May 2010 base (blue/green) and modified (orange) results for Nimrod Dam to target a more successful alligator gar spawn.

Figure 7 shows the results from the adjusted releases from Nimrod for May 2010 as well as the base conditions at the Aplin Gage. The adjusted releases at Nimrod did not violate the "not-to-exceed" value of approximately 6,000 cfs or a 14-foot stage at Aplin. The period that is above the 6,000 cfs mark is influenced by local rainfall-runoff.

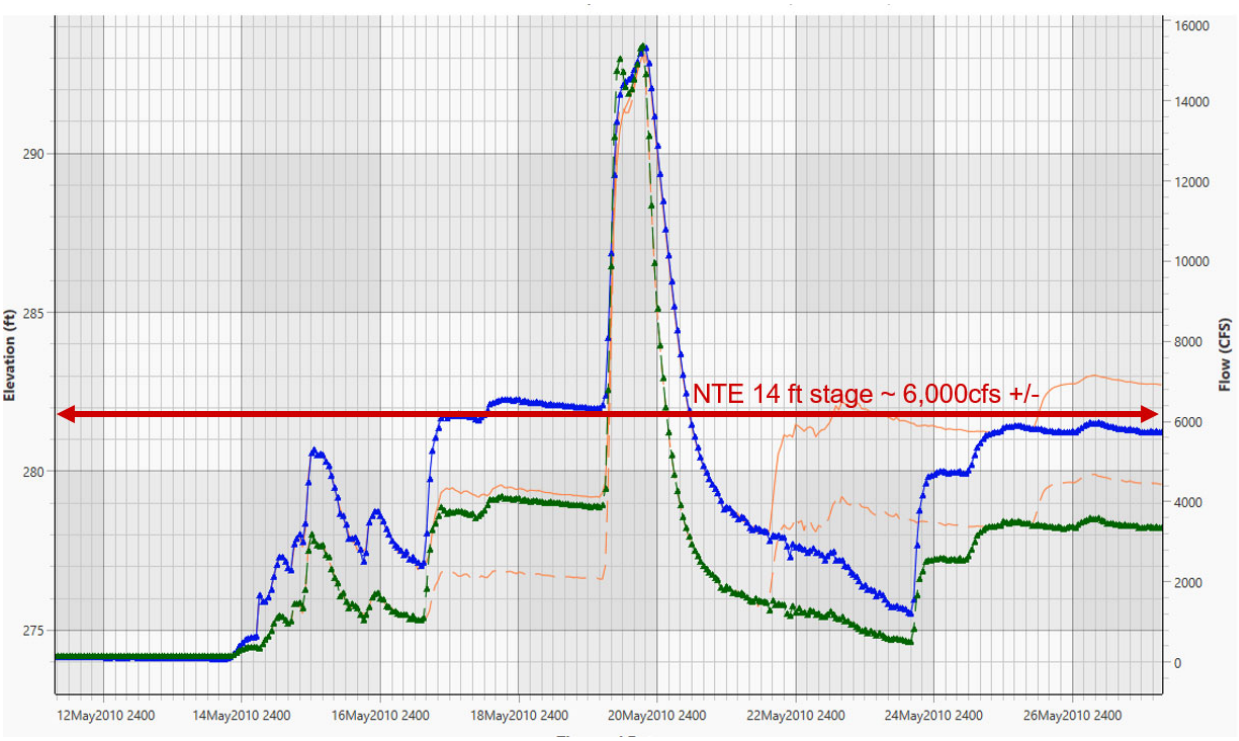

Figure 7. May 2010 base (blue/green) and modified (orange) results for Aplin gage to target a more successful alligator gar spawn.

Figure 8 shows the results from the adjusted releases from Nimrod for May 2010 as well as the base condition at the Houston Gage. Reducing releases prior to the peak did not have any influence on the overall peak at Houston; however, releasing 2 days sooner after the peak at Houston did mitigate the drop in water surface elevation without violating the "not-to-exceed" stage of 24 feet.

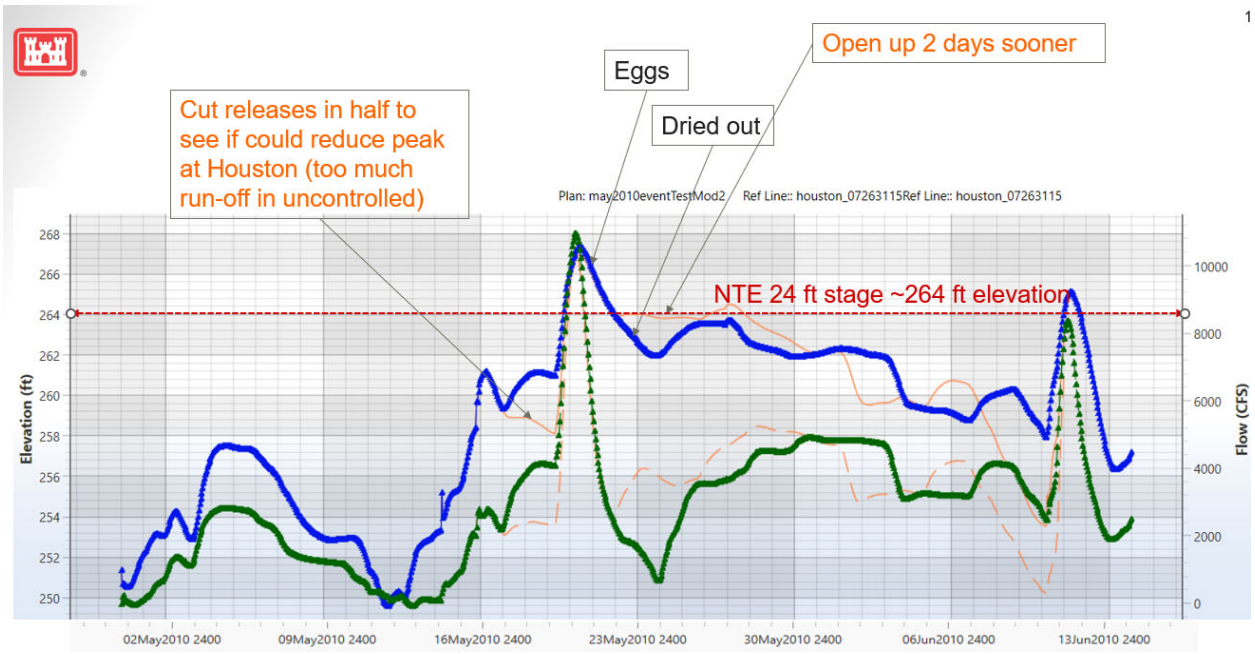

Figure 8. May 2010 base (blue/green) and modified (orange) results for the Houston gage to target a more successful alligator gar spawn.

Figure 9 shows the elevation differences and Figure 10 the inundation differences between the adjusted releases from Nimrod and base conditions at the ALG spawning site. The mitigated drop in water surface elevation results in significant more area for spawning to be inundated (Figure 10) and to remain available.

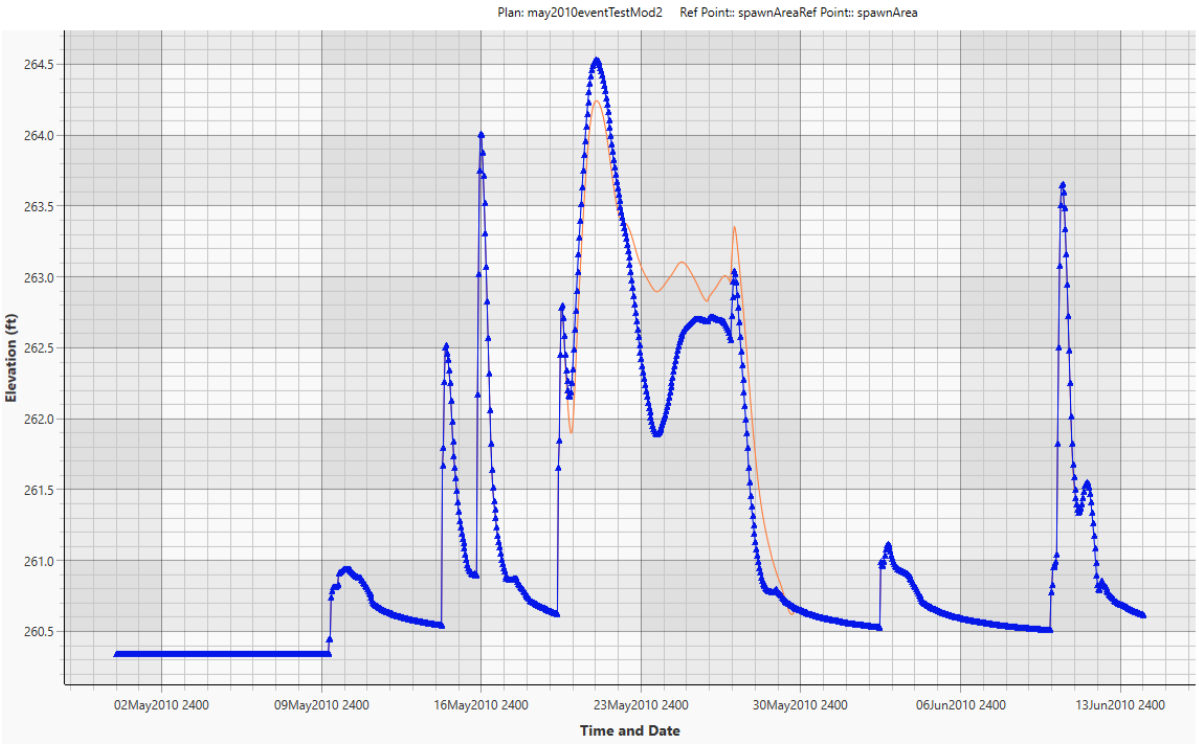

Figure 9. May 2010 base (blue) and modified (orange) results for the known alligator gar spawning area.

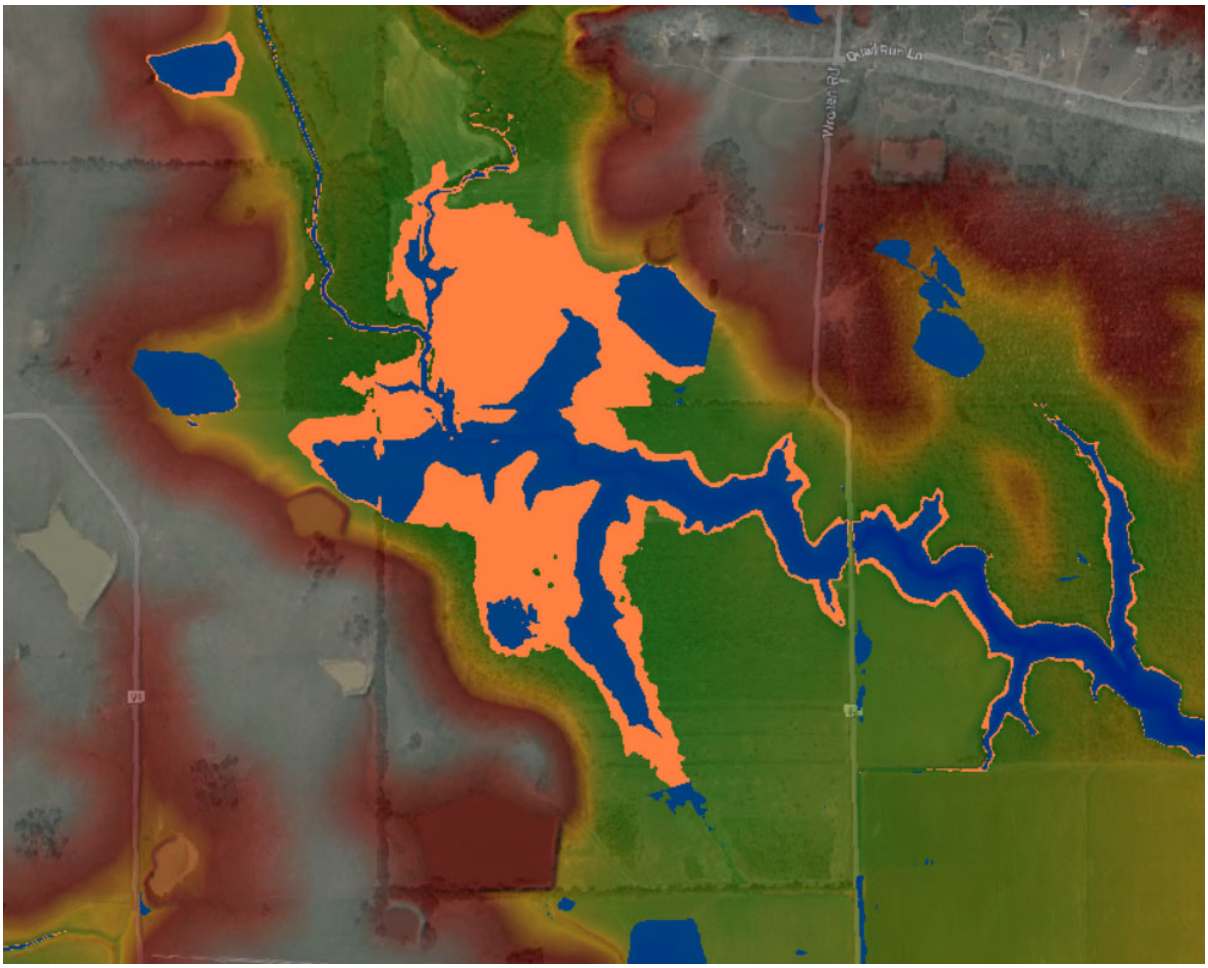

Figure 10. May 2010 base (blue) and modified (orange) inundation results for the known alligator gar spawning area.

May 2007

Prior to the successful spawning event in June 2007 (Inebnit, 2009), watershed conditions in May 2007 were also conducive to successful spawning, but conditions were characterized by different hydrologic circumstances from both June 2007 and May 2010. The percentage of flood storage in Tulsa District Flood Risk Management reservoirs on 15 May was 44 percent and decreased to 19 percent by 27 May; as the flood storage was evacuated, flow targets at Van Buren reduced from 150,000 cfs to 60,000 cfs and resulted in decreased mainstem Arkansas River flow and water surface elevation at Houston in late May and early June 2007. As such, the May 2007 event was investigated to determine if Nimrod releases could be modified to extend floodplain inundation durations at the spawning area.

The May 2007 test investigated whether Nimrod Dam releases could extend floodplain inundation at the Houston Gage and nearby spawning area beyond the water surface elevation drop near the end of the month (Figure 11). It should be noted that the May 2007 event itself had all the characteristics of a successful spawn and a documented successful spawn was noted by Inebnit (2009). However, the event was chosen for testing simply because the prevailing conditions were different than the June 2007 and May 2010 events, and therefore an interesting test case.

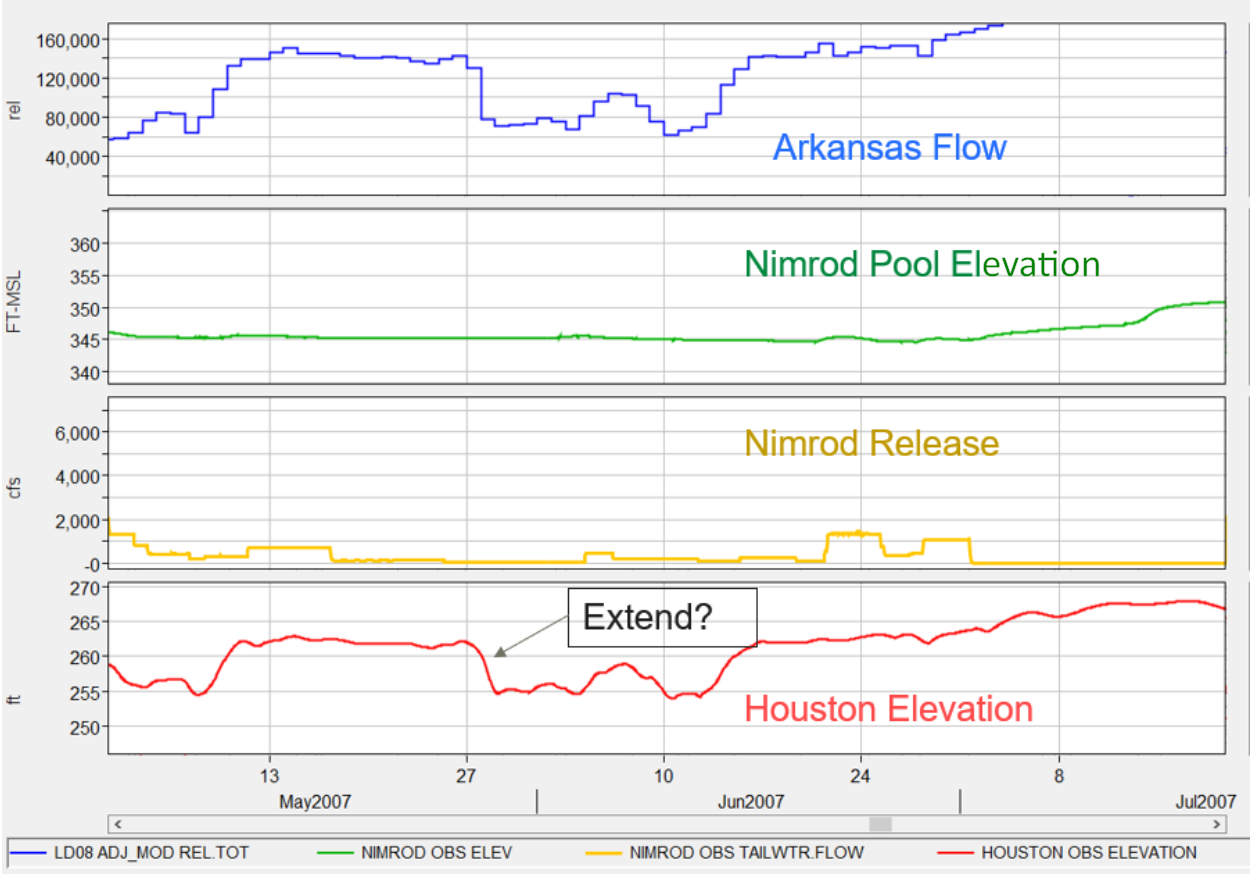

Figure 11. May 2007 event conditions to investigate if releases from Nimrod Dam could extend the floodplain inundation period for potential Alligator Spawn success.

Figure 12 depicts base conditions and modified outflows and corresponding pool elevations at Nimrod Dam in the May 2007 test case. Increasing outflows would have dropped Nimrod's pool to elevation 332 feet (i.e., more than 10 feet below conservation pool). This would not be a feasible operation and would be detrimental to upstream environmental conditions, but it does clearly depict the importance of Nimrod Dam needing to have storage available to be able to target flows for downstream spawning conditions.

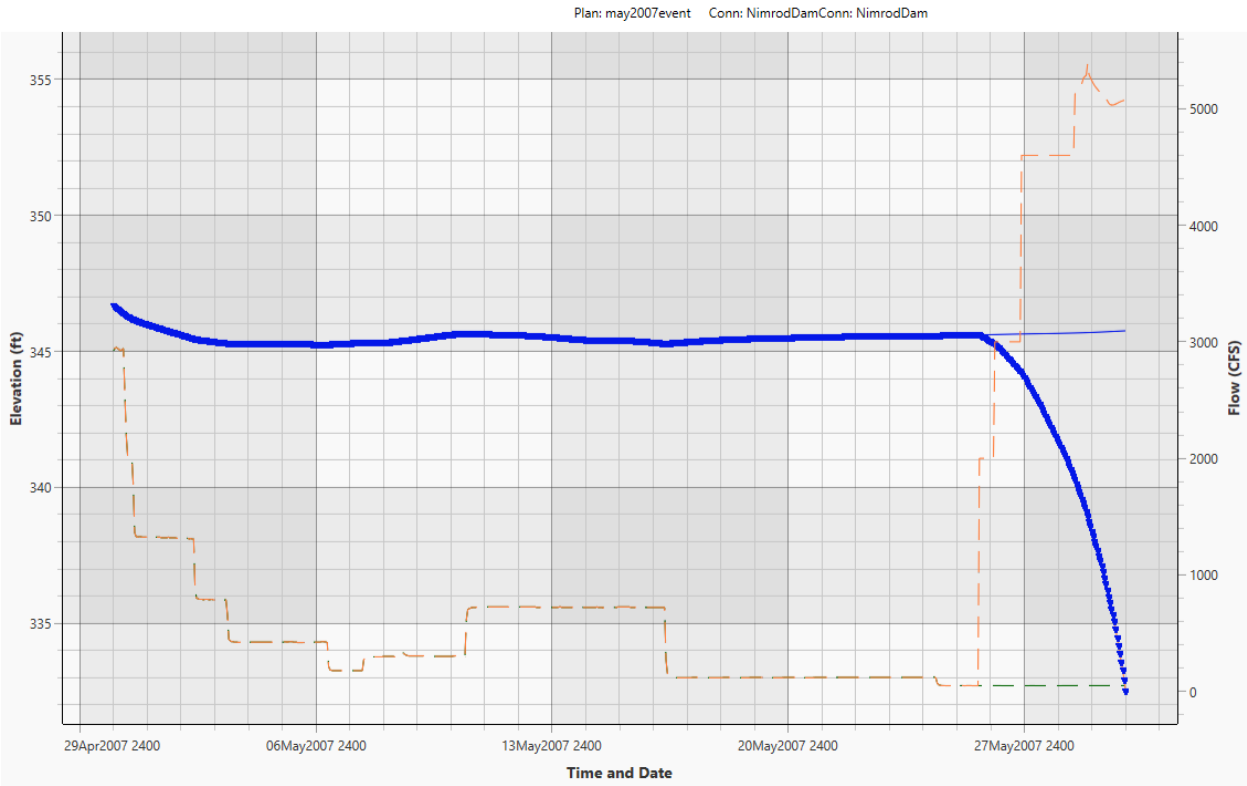

Figure 12. May 2007 base (blue/green) and modified (orange) results for Nimrod Dam to evaluate the results of producing successful May 2007 spawn conditions.

Figure 13 shows the resulting modified releases and base conditions at the Houston gage. This result, while still showing a "dip" in water surface elevation, conceptually shows the influence Nimrod's releases could have for downstream spawning areas. Additional simulations, to "smooth" the extension, were not performed because this event did not have enough storage in the reservoir to realistically be successful and in future situations, prevailing hydrologic conditions downstream would be unique to optimize the timing of releases should storage in Nimrod be available for these targeted environmental flows.

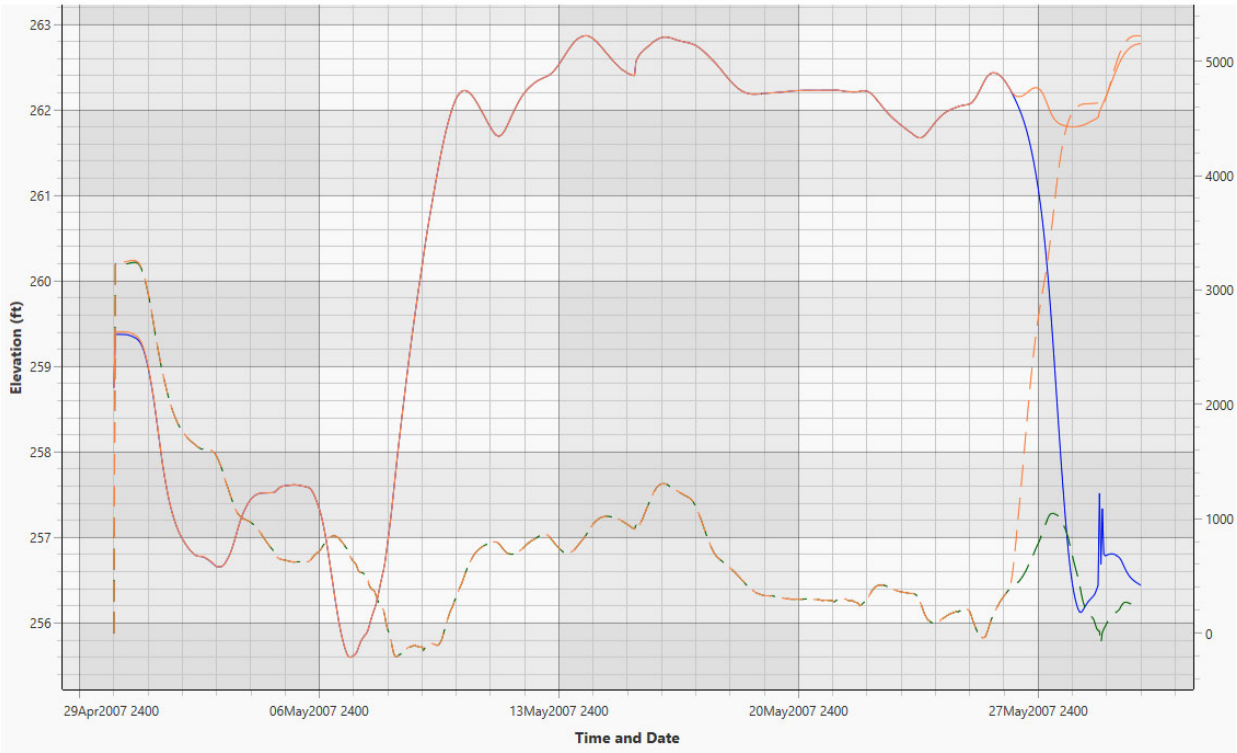

Figure 13. May 2007 base (blue/green) and modified (orange) results for the Houston gage to evaluate the results of producing successful May 2007 spawn conditions.

Model Limitations

The model analysis conducted to evaluate the hypothesis was strictly a comparison between the base scenario and the hypothesized scenario, without direct comparisons to observed events. The model's calibration to observed events was sufficient to draw conclusions about Nimrod Dam's potential impact on spawning sites, focusing mainly on timing and peak flows rather than volume. Detailed hydrologic calibration was deemed unnecessary, as future conditions will present unique variations. Channel bathymetry data was limited throughout the system, necessitating long interpolations between known gage sites; therefore, discrepancies may exist in the modeled transition between bankfull and floodplain flows at various locations. The model results are most reliable at or near the calibrated gage sites.

Model Conclusions

The analysis concluded that the successful spawn in June 2007 (Inebnit, 2009) was primarily due to the prolonged high flows of the Arkansas River, largely influenced by the percentage of flood storage in the Tulsa District Flood Risk Management reservoirs during a summer period with frequent runoff producing storm systems tracking through the basin. The percent of flood storage occupied in the Tulsa District reservoirs during the May 2007 event and the June 2007 event varied from 44 percent on 15 May to 19 percent on 27 May, and as additional rainfall runoff occurred in Oklahoma, storage increased to 27 percent by 1 June, followed by increases to 43 percent by 16 June, 63 percent by 28 June, and 102 percent by 1 July. A Tulsa District system flood storage of 35 to 50 percent in the spring and 45 to 60 percent during the summer can be expected to provide 7 to 10 days of sufficient inundation in the spawning area of the Fourche La Fave. The May 2007 event test acknowledges the fact that the duration of influence of the Arkansas River can be highly variable, and the event had the potential for success on its own;

however, the test demonstrates that no matter the duration of influence of the Arkansas River, extending the inundation period in the spawning area would have significantly drained Nimrod – highlighting the importance of scale. The unsuccessful spawn event in May 2010 saw local rainfall augmenting the backwater peak from the Arkansas River, leading to more extensive inundation. However, the receding inundation area that led to a poor spawn was due to local inflows draining out, causing the Houston Gage to drop below flood and regulating stages, rather than the Arkansas River flow receding. Opening Nimrod two days earlier in May 2010 may have improved spawning area conditions, but this would have required water managers to increase releases from the dam around the time of the Houston Gage peak, considering the 2- to 3-day travel time. Inaccurate rainfall forecasts or unexpected future rain could lead to "induced flooding" by adding water above the regulating stage rather than prolonging inundation. There is reasonable alignment between target elevations for the spawn and the existing water control manual, suggesting that meeting the environmental flow criteria for alligator gar could be more effectively met with a more accurate, specialized forecasting model to assess the risks of more aggressive releases from Nimrod. Additionally, a better understanding of the complex rating at the Houston Gage is needed (instrumentation is in place), and close coordination and communication between agencies regarding the spawn, water temperatures, and prevailing hydrologic conditions is critical for determining the best options quickly.

Overall Flow and Pool Level Management Recommendations

Overall flow recommendations include sustaining the downstream inundation by manipulating outflows from Nimrod from 15 May to 15 June with a duration of 7 to 10 days for alligator gar spawning and recruitment. For the longnose darter, it was recommended that low flow conditions should be targeted from April to May to support spawning. For scaleshell life-history support, 1 to 2 low flow pulses should occur late September through the end of October, between 100 to 300 cfs, and over 2 to 3 days. For the Harris Brake GTR, it was recommended that USACE protect, sustain, and maintain existing conditions that support conditions needed to promote bottomland hardwood tree growth, which include avoiding prolonged inundation. Finally, to support the Clean Water Act beneficial uses for aquatic life, particularly for DO and temperature, it is recommended that three to four pulses of 300 to 500 cfs occur over a three-to-five-day period, seasonally, when water temperatures are greater than 22 °C.

Overall pool level management recommendations for bottomland hardwood forests include evacuating water quickly from the trees during the springtime (defined as the end of February through March). Pool level management recommendations for shoreline vegetation and fill include changing the drawdown to occur every 5 years rather than 4 and that a slower, stepped fill occur during 1 October to 1 January.

Recommendations for Future Studies

For the alligator gar recommendations to be successful, it was suggested by AGFC that any modeling or information gathered during implementation be shared so that their monitoring data can be linked to the hydraulic information and river system operations to inform on their agency instream flow recommendations.

Data Gaps

Data gaps for specific recommendations were noted in each of the individual recommendations under “Workshop Results”. However, the largest data gaps are listed below for environmental flows and environmental pool management.

Environmental flows data gaps:

- Improve our understanding of the hydraulic connections between outflows from Nimrod and Arkansas River flow with respect to the extent of Nimrod release travel times associated with first effect and full effect at documented alligator gar spawning sites.
- Improve our understanding of alligator gar carrying capacity (in general and locally) and how river water temperatures relate with adjacent floodplain water temperatures and the influences on fry. Understanding fry temperature dependencies will help inform actionable implementation strategies for alligator gar recruitment success.
- Identify environmental and hydrologic conditions that lead to drying of alligator gar spawning sites. Improve our understanding of how flow regimes affect alligator gar movement patterns under varying conditions both spatially and temporally.
- Gain a better understanding of longnose darter distribution in the Fourche La Fave near the South Fork Fourche La Fave confluence and their seasonal use of the Fourche La Fave to inform flow recommendations for longnose darter.
- Add water temperature and DO continuous monitoring at Houston gage and possibly Perryville.
- Conduct mussel surveys for scaleshell near Aplin, a collection site of recent unconfirmed relic, to better understand distribution within the Fourche La Fave and inform flow recommendations.

Environmental pool management data gaps:

- Determine the topographic elevations where white oaks and red oaks are dying in the Lloyd Millwood GTR, as well as the topographic elevations that red oak and white oak recruitment/regeneration are occurring in order to better understand the conditions that are causing mortality and/or poor recruitment. These data will help determine the factors causing mortality such as time of year and/or duration of flooding, i.e. connect growth/recruitment elevations with water elevations. Additionally, determine age-classes for each species. These data can be defined by forest health assessments, which, currently (2024) do not exist.
- The topographic elevation for the second stop log, the bottommost water control structure within the Lloyd Millwood GTR, is 343 feet. A rating curve needs to be developed for 1-to-3-foot elevation changes for the water leaving the GTR, through this bottom most water-control structure, into Nimrod Lake and determine channel capacity for these different water levels. These data can help determine the water level rate of change. Moving water through larger and variable water control structures is what, ultimately, is needed to provide sheet flow, a key component to red oak survival.
- Determine best time of year and whether a 2-, 4-, or 6-week drawdown of Nimrod Lake is more beneficial for vegetation sprouting and growth. Considerations are that a longer drawdown would be better for birds and other wildlife. Additionally, the longer span will encourage a diverse stand of natives and could potentially be better for birds and other wildlife. However, a shorter span provides a better chance for a millet crop to properly start growing on the lakebed. The ideal situation might be a varied drawdown from drawdown cycle to drawdown cycle.
- Determine whether natural pool level rises greater than 342 feet during the Nimrod Lake fill affects vegetation establishment, fishery, and duck habitat. Furthermore, it is uncertain how best to manage the fill in responses to high inflow events triggered by natural precipitation. Stair stepping the fill would allow large precipitation events to pulse the system but also to pass through the system and not do more harm to the GTR. Additionally, based on aerial survey data, there, typically, is not a large population of Mallards until the first full week of December. Therefore, a “staggered” fill scenario may be best, allowing some forage available to dabblers,

but more so for divers. Finally, Nimrod Lake should be a part of AGFC's complex planning on flooding to ensure additional forage is available incrementally throughout winter.

Conclusions

Although there are several unknowns and data gaps, workshop participants and subsequent analyses identified flow and pool management recommendations that could be implemented within the next 1 to 3 years. After implementing the developed flow and pool management recommendations, it is suggested that the recommendations be incorporated into the Nimrod Lake Water Control Manual as an addendum or something similar. Additionally, annual follow-ups should occur to share whether the changes in management are working and which should be continued. The hopes are that this workshop summary and flow recommendations report will be used as a stepping point for the continued involvement of other organizations and stakeholders.

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Appendix A: Workshop Agenda

Fourche La Fave River and Nimrod Lake, Sustainable Rivers Program Environmental Flows and Pool Workshop

July 9-10, 2024

Conway Area Chamber of Commerce
900 Oak St, Conway, AR 72032
&
Fish and Wildlife Service
110 South Amity Road Suite 300, Conway, AR 72032

AGENDA

July 9, 2024

Location: **Conway Chamber of Commerce**

9:00 Welcome and introductions – *Rheannon Hart (USACE)*

9:30 Review of SRP process and discussion of meeting outcomes – *Becca Winterringer (TNC)*

9:45 Overview of Nimrod Lake Authorizations and Fourche La Fave Operations – *Mandy Edmondson (USACE)*

10:15 Hydrologic analysis and flow/ecology relationships as background for developing environmental flow recommendations – *Rheannon Hart (USACE) and Edmund Howe (USACE)*

11:00 Lunch (on your own)

12:15 Overview of Regime Prescription Tool software that will be used in Working Groups – *Becca Winterringer (TNC)*

12:30 Instructions for Working Groups – *Rheannon Hart (USACE)*

12:45 Breakout groups: Working Groups have been organized by leveraging individuals having specific expertise. The aim of these Working Groups is to identify flows or in-pool levels for each location designed to improve ecological conditions associated with each Group's focus area.

- Clarify hypotheses regarding flow-related issues and potential flow changes enhancements that could be made, or where the greatest opportunity is to enhance benefits via pool-level or flow manipulations related to the selected habitats or target species.

- Develop environmental flow hypotheses based on specific Environmental Flow Components (low flows, flood pulses, small floods, and large floods), understanding the existing flow prescriptions, and how existing flows could be modified.

- Determine target species for e-pool management, lake habitat types that support the target species, the sequence of pool level manipulation that supports habitat types beneficial for target species throughout a calendar year, and if the target species, habitat types, and sequence is lake specific or general.

- Groups should think about purpose, timing, magnitude, duration, frequencies, and rates of change for the e-flow components. Please also note any contingencies and uncertainties.

Working Groups break out:

Group #1 – Downstream of Nimrod Dam: Alligator Gar and Longnose Darter
Facilitator: *Jaysson Funkhouser (USACE)*
RPT: *Becca Winterrringer (TNC)*

Group #2 – Nimrod Lake: Green Tree Reservoir, Shoreline Vegetation, and Drawdown
Facilitator: *Nathaniel Keen (USACE)*
RPT: *Rheannon Hart (USACE)*

2:15 Break (15 min)

2:30 Resume working groups

3:30 Working group summarize findings for each breakout session

4:00 Group reconvenes to address “parking lot issues” and review tasks for July 10

4:30 Adjourn

July 10, 2024

Location: **Fish and Wildlife Service Office**

9:00 Working groups continue to define flow needs per locations

10:30 Break (15 min)

10:45 Working groups continue to define flow needs per group locations

11:45 Lunch (in house - TNC provided)

12:45 Each group presents its findings (~20 minutes each)

1:30 Unification of flow recommendations (~30 minutes per group)

2:30 Break (15 min)

2:45 SRP opportunities and success stories in e-flows and e-pools – *Becca Winterringer (TNC) and Rheannon Hart (USACE)*

3:15 Conclusion and parting discussion – Discussing uncertainties, parking lot issues, next steps, concluding thoughts

3:30 Adjourn

Appendix B: List of Workshop Attendees*

Environmental Flows Group

Chance Garrett	Arkansas Game and Fish Commission
Reid Adams	University of Central Arkansas
Lindsey Lewis	U.S. Fish and Wildlife Service
Tommy Inebnit	U.S. Fish and Wildlife Service
Tate Wentz	Arkansas Department of Agriculture – Natural Resource Division
Jennifer Sheehan	Arkansas Game and Fish Commission
Chris Davidson	U.S. Fish and Wildlife Service
Chelsea Gilliland	Arkansas Game and Fish Commission
Matthew Moix	U.S. Army Corps of Engineers
Edmond Howe	U.S. Army Corps of Engineers
Becca Winterringer	The Nature Conservancy
Matt Schramm**	Arkansas Department of Transportation
Katie Morris**	Arkansas Natural Heritage Commission

Environmental Pool Management Group

Nathanial Keen	U.S. Army Corps of Engineers
Jesse Palmer	U.S. Army Corps of Engineers
Jeremy Wells	U.S. Army Corps of Engineers
Cherrie Lee Phillip	U.S. Army Corps of Engineers
Amanda Edmondson	U.S. Army Corps of Engineers
Frank Leone	Arkansas Game and Fish Commission
Craig Davis	Arkansas Game and Fish Commission
Rheannon Hart	U.S. Army Corps of Engineers
Mark Green**	U.S. Army Corps of Engineers

* Photo 1

** Only attended the first day

Photo 1. Workshop participants from left to right: Cherrie-Lee Phillip, Matt Moix, Nathaniel Keen, Jeremy Wells, Becca Winterringer, Jesse Palmer, Mandy Edmondson, Craig Davis, Rheannon Hart, Jennifer Sheehan, Chelsea Gilliland, Chance Garrett, Lindsey Lewis, Edmund Howe, Tommy Inebnit, Tate Wentz, Chris Davidson, Reid Adams, and Frank Leone (USACE photo).

Appendix C: Environmental Pool Management and Environmental Flows Information Collected During Workshop (Tables C1 and C2)

Table C1. Environmental pool management information.

Target	Purpose	Recommendation	Justification	Data Gaps/Unknowns	Implementable	Prioritization	Limitations	Timing	Notes
Bottomland Hardwood Forests									
	Evacuate water quickly from trees during spring time (end of Feb - Mar -- this is dependent on waterfowl migration patterns); pulses during a period when the water has been evacuated are important for oxygenation of the trees to promote growth and can occur any time of the year; healthy forest could help endangered bat species (particularly Indiana); This unique forest contributes to the mosaic of the landscape benefitting many species (even bats).	Max releases to lower the lake level -- would need to be at a set level at the elevation	To encourage the success of the red oak species for waterfowl habitat -- the overall bottomland hardwood forests are disappearing these unique habitats need to be preserved	What elevation are the white oaks and red oaks dying? What elevation for red oak and white oak recruitment/regeneration? What are the year classes for each species? DO in the water in the GTR during all times of the year; how long does it take the DO to go from low to high or vice versa; need to know elevation of the second stop log, bottom structure; Rating curve -- How much water is leaving (volume) and how much it can take (capacity) the system at the different water levels? No water downstream versus at certain water levels below, i.e., 1-3 ft elevation difference	Depends on how much water there is, need some water downstream in order to keep structures from being destroyed limited to how much water downstream of GTR to how much the structures can be opened; The downstream regulating stage would need to be raised in order to maximize the releases to remove the water -- this would flood downstream farmers	high	Houston Gage for releases; Need to cross check with eflows recommendations to make sure the don't need to hold water back	All considerations should be made for all time of year unless specified	head differential for evacuation at elev 352 (elevation of the spillway);can't just close the levee to the GTR not allowing water to enter limits USACE space is needed for storage, plus would fill up anyway; trees are at or above at 345

Target	Purpose	Recommendation	Justification	Data Gaps/Unknowns	Implementable	Prioritization Limitations	Timing	Notes
Sport Fisheries								
	to increase sport fisheries	what is currently in the WCM works, a lot has been dependent on the big floods and when those haven't happened, the drawdown helps; but a 5-year drawdown might more beneficial	to increase sport fisheries	Shortening duration of the floods could negatively effect year class strength and growth of fish	currently being implemented			
Shoreline Vegetation (EPM)/Drawdown								
	Promote sport fisheries through the planting of grasses or the recruitment of native grasses clears up water for less turbidity; year after flooding the decaying provides nutrient input; remnant vegetation promotes next year yoy (young of the year) will use; the seeding from the grasses helps the waterfowl foraging; the seeding areas also provide a macrohabitat boost; drawdown crowds predatory fish which is good for fisheries and increases their foraging capability	preference would be every 5 years instead of 4; the drawdown is typically 6 weeks, but 2 week is being considered and would be the quickest in order to keep the most soil moisture in the ground as possible; the faster the ground dries out, the more desirables take; quicker drawdown would be beneficial for anglers extending the season, as well as for recreation; shorter drawdown makes coordination with the pilots more difficult; longer drawdown allow for more native vegetation to take; longer drawdown could potentially expose cultural resources to pilfering	improve the fisheries for anglers and increase the in-pool ecosystem	what would be more beneficial as far as the drawdown, 2, 4, 6 week? need to consult wetland biologist; Is July 1 a good ending date? Is the drawdowns going to attract T&E bird species?	already being implemented, changing it to 5 year would take extra work from the Corps side - change in WCM		large questions on the timing	
Sediment								
		drawdown helps turbidity		bank caving for a quicker drawdown? what amount would it take to cause issues?				
Shoreline Vegetation (EPM)/Filling								
	slower fill for waterfowl, so that the vegetation could be maintained along the shoreline; could benefit the fishery through longer duration providing more foraging capabilities	Oct 1 - Jan 1 fill -- slow fill; attempt to make it a linear; if it naturally	helps prolong the waterfowl stopover	If it naturally goes up above 342, is it okay to stay up/hold it or does it need to come down? How does the stair step need to look in relation to the natural precipitation. This relates to the 2 week drawdown question, how quick could it be brought down? Need to consult wetlands ecologist	might require a deviation and could potentially be tested this fall -- eventually could be requested to be a part of the WCM			

Table C2. Environmental flows information.

Target	Purpose	Recommendation	Justification	Data Gaps/Unknowns	Implementable	Prioritization	NOTES1	NOTES 2
Alligator Gar	Maintenance of existing conditions and enabling conditions in the lower reach of the Fourche La Fave to confluence with Arkansas River							
Spawning	Sustain floodplain inundation for longer and sufficient periods of time to encourage and maintain successful spawning efforts. Direct observations by experts indicated that the Arkansas River influence of the downstream sections of the FLF provide the supporting conditions for Alligator Gar; however, receding Arkansas River levels are often too fast. Supplementing the river recession with Nimrod outflows would help sustain needed inundation for spawning conditions.	Sustain the downstream inundation by manipulating outflows from Nimrod from 15 May - 15 June.	Life history support	Need deeper understanding of the hydraulic connects between outflows from Nimrod and Arkansas River flow with respect to the extent of Nimrod release travel times associated with first effect and full effect at documented spawning sites.	Yes, with conditions: need real-time in-situ observations at documented spawning sites during test of recommendation.	High	AGFC requests any modeling or information gathered during implementation be shared so that their monitoring data can be linked to the hydraulic information and river system operations to inform on their agency instream flow recommendations.	(Inebit, Spawning Ecology of Alligator Gar) The mid May to mid June spawning season observed for Alligator Gar in the FLR generally corresponded with rising water levels (mostly due to back flooding from the Arkansas River) and increased water temperatures, which has been demonstrated to provide optimal environmental conditions for successful spawning and recruitment in riverine fishes (Junk et al. 1989; Turner et al. 1994; Johnson and Noltie 1996; Snedden et al. 1999; King et al. 2003).
Recruitment Success	Enable and maintain supporting recruitment conditions post spawn.	Sustain the downstream inundation by manipulating outflows from Nimrod for 7-10 days, at least one time during 15 May - 30 June.	Life history support	Better understand carrying capacity of Alligator Gar (in general and locally), need to understand related river water temperature with adjacent floodplain water temperature influences on fry. Temperature dependencies of fry would help inform actionable implementation strategies of this target for Alligator Gar.	Need more supporting documentation. See above; if above implements then this target objective may be a secondary purpose (and response) and data collected would inform some unknowns for this recruitment target. Monitor temperature to understand uncertainties on temperature conditions and timing for when inundation support is needed in the downstream reach.	Medium, needs data	Fry are temperature dependent (20C) for a time period. Real-time water quality monitoring on the Houston and Aplin gages, and Perryville is requested.	Monitoring T, weather, and water conditions (esp. following and tracking floods, high water events on Arkansas River) May through October and look for opportunities for Nimrod outflows to assist in maintaining inundation.
Stranding	Experts have observed adults trapped in oxbows, backwater connections, and shallow areas that dry out with fast water recessions throughout the year.	Fourche outflows to mitigate adult stranding during dry and average years.	Life history support	Need a study to identify the conditions when areas utilized by Alligator Gar dry. Identify under what hydrologic conditions it occurs, collect telemetry data to track movement patterns and link to flow regimes observed/gaged under varying conditions spatially and temporally.	Yes, with conditions: with hydraulic information needs met, model locations that would be susceptible to Alligator Gar stranding.	Medium, needs data	This was observed one time but experts suspect it happens routinely under triggering conditions. How stranding may impact the distribution and success of species as a variable is of interest to stakeholders.	
Riparian/Floodplain Vegetation								
Bottomland Hardwood Forests	Maintain condition at Harris Brake (GTR)	Desire is for flows from Nimrod outflow not impact this GTR and to protect/sustain/maintain existing conditions. Potential for Nimrod outflows to mitigate over-inundation risks is also desired.	Harris Brake is a significant WMA for AGFC providing recreation opportunities, and provides beneficial habitat for game species (waterfowl, other wildlife). It is also an important recreational fishery.	Need understanding of the hydraulic connects between outflows from Nimrod and Arkansas River flow with respect to the extent of Nimrod release travel times associated with first effect and full effect at Harris Brake.		Medium-Low	See Alligator Gar targets and needs as recommendations and justifications are similar for BHF. The desire is to support conditions needed to promote hardwood tree growth on the higher elevations in the area (terraces).	Explore the GTR regulations, then review when the Arkansas River incurs prolonged flooding explore if Nimrod operations and Harris Brake could work together to provide mitigating conditions to avoid prolonged inundation. Bluegill, Redear Sunfish, Black Crappie, White Crappie, Channel Catfish, Largemouth Bass,
Herbaceous Vegetation	Enable supporting growth conditions	No specific recommendation provided; this target would likely be a secondary positive response from the recommendations for BHF and Alligator Gar and would meet the desire for conditions that support a long-term herbaceous community in the lower reaches of the Fourche La Fave.						
Longnose Darter								
	Flow regimes that support the essential flow components for Longnose Darter (life history support)	Desire is for Fourche La Fave flow regime to mimic unaltered flows and target increasing the number of events for the identified essential flow components identified as critical for Longnose Darter survival.	Increase the occurrences/events of the identified essential flow components for Longnose Darter.	Distribution of Longnose Darter within the mainstem Fourche La Fave is generally unknown and undocumented due to the needed survey conditions for surveying (snorkeling is primary method of detection, low turbidity conditions are required). The only known records of Longnose Darter are from the South Fork Fourche La Fave, downstream of Nimrod Dam and a record from 1984 within Nimrod Lake. Better understanding of their distribution is needed to fully develop flow recommendations for the Longnose Darter.	Yes, with conditions: Implementing flow targets to mimic the essential flow components that are key to species if species persists in mainstem.	Medium	Habitat occupancy in spring months is typically riffle/runs with coarse substrates (cobble and boulder), and pools with larger substrates (boulder) in the summer. Spawning occurs mid-April to June in the higher flow areas of pools and raceways. Longnose darters may be above Alpin but survey conditions preclude good data collection. Experts requested possible coordination with USACE staff that may be on-site to report on when favorable survey conditions are present to allow for data collection to expand database and presence records. Experts also requested an evaluation to identify times of year for when the essential flow components occur from the period of record. Evaluate timing and magnitude of spring flows to evaluate if spawning conditions are present (i.e., need lower flows for spawning); if Longnose Darter are present then their required habitat and flow needs exist.	In April - May, target low flow conditions that support spawning in areas of more flow, raceways of pools. Eggs likely attached to substrates but reproductive behavior is relatively unknown. EFC's: See paper and USFWS data 1. FL1 pulse events 2. Average # events >75th percentile 3. Magnitude of minimum flows 4. Duration of high flows

Target	Purpose	Recommendation	Justification	Data Gaps/Unknowns	Implementable	Prioritization	NOTES1	NOTES 2
General Aquatic Integrity								
	Enable conditions supportive of aquatic integrity.						General feedback was environmental flows to support and/or mitigate for persisting issues in watershed: bank stability, channel incision, sediment mitigation, water quality and water temperature, conductivity, spring inputs/influence evaluation	
Sediment Mitigation								
	Address bank failure through restoration of riparian areas to mitigate sediment loading and bank loss.	Reduce releases more gradually to reduce the rate of bank sloughing incurred by prolonged saturation or river banks.	Bank stabilizing actions that support integrity of the riparian zone and river bank slope.	Evaluate the rate of change of releases from Nimrod, timing, magnitude, and duration.	Yes, with conditions. Dependent upon the hydraulic modeling to identify when and where and under what hydrologic conditions bank failure is exacerbated by prolonged saturation on the floodplain.	Medium	Agricultural run-off and lack of transition zones between agricultural land and river compound bank failure. If Nimrod releases could be reduced more gradually after an extended flood evacuation period then bank sediments and flood plains could drain with reduced bank sloughing.	
Water Quality								
	Support Clean Water Act beneficial uses (aquatic life)	Three to four pulses 300-500 cfs over a three to five day period, seasonally when water temperatures are >22C	Meet Water Quality Standards and bring waterbody into attainment.	Monitoring data is needed. Experts suggest adding continuous monitoring data at Houston gage, and possibly Perryville to evaluate efficacy of recommendation.	Yes	Medium-High	Temperature and DO.	
Commercial/Sport Fisheries								
	Conditions that support commercial and sport fisheries	Similar/same as Alligator Gar		Harvest/ by-catch data	Unlikely, but would be a secondary or tertiary benefit of implementation of Alligator Gar targets.	Low	Evaluate any changes to ensure public access areas along the mainstem are not jeopardized.	
Fish Passage								
Eel	Restore native ranges and the ecosystem services species provides	None applicable to Fourche La Fave and Nimrod Lake mainstem actions			Unlikely	Low	There are 6-8 passages on Arkansas River and Atchafalaya, off the Red River. Future opportunities (outside the SWL likely) are Hist range Ft Smith, likely in Fourche, likely dom. Crustacean.	
Ohio River Shrimp	Restore native ranges and the ecosystem services species provides	None applicable to Fourche La Fave and Nimrod Lake mainstem actions			Unlikely	Low		
Fish (All)								
Access to Floodplains and Tributaries	See "Stranding" under Alligator Gar	See "Stranding" under Alligator Gar	Life history support	Stakeholders request a barrier assessment of watershed	Yes, with conditions: with hydraulic information needs met, model limitations of fish access incurred from operations at Nimrod Dam.	Medium - High	Perryville Down	
Harperella								
							Likely present in Nimrod Lake and no known occurrences in downstream reach; addressed sufficiently in pool level management group.	
Alligator Snapping Turtle								
	Life history support and habitat access and availability.	See recommendations (all targets) under Alligator Gar		Harvest/ by-catch data	Unlikely, but would be a secondary or tertiary benefit of implementation of Alligator Gar targets.		See AL Gar, bank stability for nesting - May 1 - Aug 30	
Scaleshell								
	Life history support	TBD	TBD	Distribution and presence data is unknown for mainstem Fourche La Fave. Recent shell record is unconfirmed but warrants an assessment to understand their occurrence in reach.	TBD	Medium	Scaleshell is a long-term brooder and releases glochidia March - April. Freshwater Drum is its host and habitat preference is stable sand. USFWS recommends similar flow recommendation construct as was applied to Cossatot mussel targets.	