Recovery Plan for the False Spike
(*Fusconaia mitchelli*)

Photo from Mussels of Texas Database

U.S. Fish and Wildlife Service
Southwest Region
Austin Ecological Services Field Office
Austin, Texas
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PURPOSE AND DISCLAIMER

This document presents the U.S. Fish and Wildlife Service's (USFWS) plan for the conservation of False Spike. The recovery plan is the second part of the USFWS's 3-part recovery planning framework and includes the statutorily required elements pursuant to section 4 of the Endangered Species Act (ESA). This recovery plan is informed by the first part of the framework, a Species Status Assessment (SSA). The SSA report delivers foundational science for informing decisions related to the ESA and includes an analysis of the best available scientific and commercial information regarding a species' life history, biology, and current and future conditions that characterizes the species' viability (i.e., ability to sustain populations in the wild over time) and extinction risk. We also will prepare a Recovery Implementation Strategy (RIS), the third part of the framework. The RIS is an easily updateable operational plan that is separate and complimentary to the recovery plan that details the on-the-ground recovery activities needed to complete the recovery actions contained in the recovery plan.

Recovery plans describe the envisioned recovered state for a listed species (when it should no longer meet the ESA's definitions of a threatened species or endangered species) and include a recovery strategy, recovery criteria, recovery actions, and the estimates of time and cost needed to achieve these objectives. Recovery plans are published by the USFWS and are often prepared with the assistance of recovery teams, contractors, State agencies, and others. Recovery plans do not necessarily represent the views, official positions, or approval of any individuals or agencies involved in plan formulation, other than the USFWS. They represent the official position of the USFWS only after they have been signed by the Regional Director as approved. Recovery plans are guiding and planning documents only; identification of an action to be implemented by any public or private party does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Approved recovery plans are subject to modification as dictated by new findings, changes in species status.

ACKNOWLEDGEMENTS

This recovery plan has benefitted from the advice and assistance of many individuals, agencies, and organizations. The USFWS Austin Ecological Services Field Office acknowledges and greatly appreciates the careful review of draft versions of this recovery plan, resulting in a more robust and well-reasoned document.

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RECOMMENDED CITATION AND ELECTRONIC AVAILABILITY

U.S. Fish and Wildlife Service. 2026. Recovery Plan for False Spike (*Fusconaia mitchelli*). U.S. Fish and Wildlife Service, Southwest Region, Albuquerque, New Mexico, USA. 39 pp.

An electronic copy of this Recovery Plan will be made available on the False Spike ECOS webpage.

Approved: KRISTIN MADDEN Digitally signed by KRISTIN MADDEN Date: 2026.08.25 08:14:18 -06'00'

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1. INTRODUCTION

This recovery plan describes criteria for determining when the False Spike should be considered for downlisting and delisting, lists site-specific actions that will be necessary to meet those criteria, and estimates the time and cost to achieve recovery. Additionally, a brief summary of information on the species' biology and status are included, along with a brief discussion of factors limiting its populations. A detailed discussion of these and other topics pertinent to the recovery of False Spike can be found in the Species Status Assessment report (SSA). Detailed, on-the-ground activities implementing recovery actions will be available in the Recovery Implementation Strategy (RIS). These supplemental documents are or will be available at False Spike species webpage. The RIS and SSA are finalized separately from the Recovery Plan and will be updated on a routine basis.

Species Overview

Species Conservation Status

The False Spike (*Fusconaia mitchelli*) was proposed for listing as endangered under the Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. 1531 et seq.) on August 26, 2021 (86 FR 47916). Critical habitat for the species was proposed concurrently with the proposed listing. The False Spike final listing rule was published on June 4, 2024 (89 FR 48034), listing the species as endangered under the ESA and designating 143.6 river miles (rmi) (231 river kilometers (rkm)) of critical habitat in the Guadalupe River basin.

The False Spike has been assigned a recovery priority number of 5, indicating that the species faces a high degree of threat and has low recovery potential. The threats to the species are high due to ongoing sources of increased stream sedimentation, changes in water quality (i.e., degradation), altered hydrology in the form of loss of flow and scour of substrate, predation, collection, and barriers to fish movement. Recovery will require intensive management to lessen or alleviate these threats, particularly within the context of projections for continued drought, extreme precipitation events, and elevated air and water temperatures.

Species Description and Life History

The False Spike is observed to be a medium-sized freshwater mussel (to 132 mm) that exhibits sexual dimorphism and has a yellow-green to brown, to black, elongate shell, sometimes with greenish rays".

The False Spike is a broadcast spawner that likely breeds and likely brood eggs and larvae from early spring to late summer (Pfeiffer et al. 2016). Males release sperm into the water column, which are taken in by females through their incurrent siphons. The sperm fertilize the eggs, which remain in the gills of the female mussel until they mature and are ready for release as glochidia (i.e., parasitic larvae. The female releases the glochidia, which attach to the gills, head, or fins of fishes (Vaughn and Taylor 1999; Barnhart et al. 2008). Glochidia encyst on a host fish's tissues, draw nutrients from the fish, and develop into juvenile mussels over a period of weeks or months (Arey 1932, pp. 214-215). Juveniles excyst (i.e., drop) from the fish and drop onto the substrate. The juvenile mussels burrow into interstitial substrates and grow to a size that is less susceptible to predation and to displacement from high-flow events (Yeager et al. 1994, p.

220). Adult mussels typically remain within the same general location where they dropped from their host fish as juveniles.

Species Distribution and Condition

Historically, False Spike occurred throughout the Guadalupe River basin and occupied much of the Guadalupe River from Victoria County to Kerr County, in addition to the San Marcos River (Howells 2014; Figure 1). Now, the species exists as a single population in the lower and middle Guadalupe River (USFWS 2022; GBRA 2024). The total current distribution of False Spike summed across the Guadalupe River population is about 167 rmi (269 rkm).

The remaining population in the middle and lower Guadalupe River is considered moderately healthy (USFWS 2022). Although portions of this reach of the Guadalupe River may experience low water levels, this reach of the river does not experience the extended periods of no flow or dry conditions that are experienced in other portions of the basin.

Given that there is only one remaining population, representation and redundancy of the species is limited, reducing the overall viability of the species.

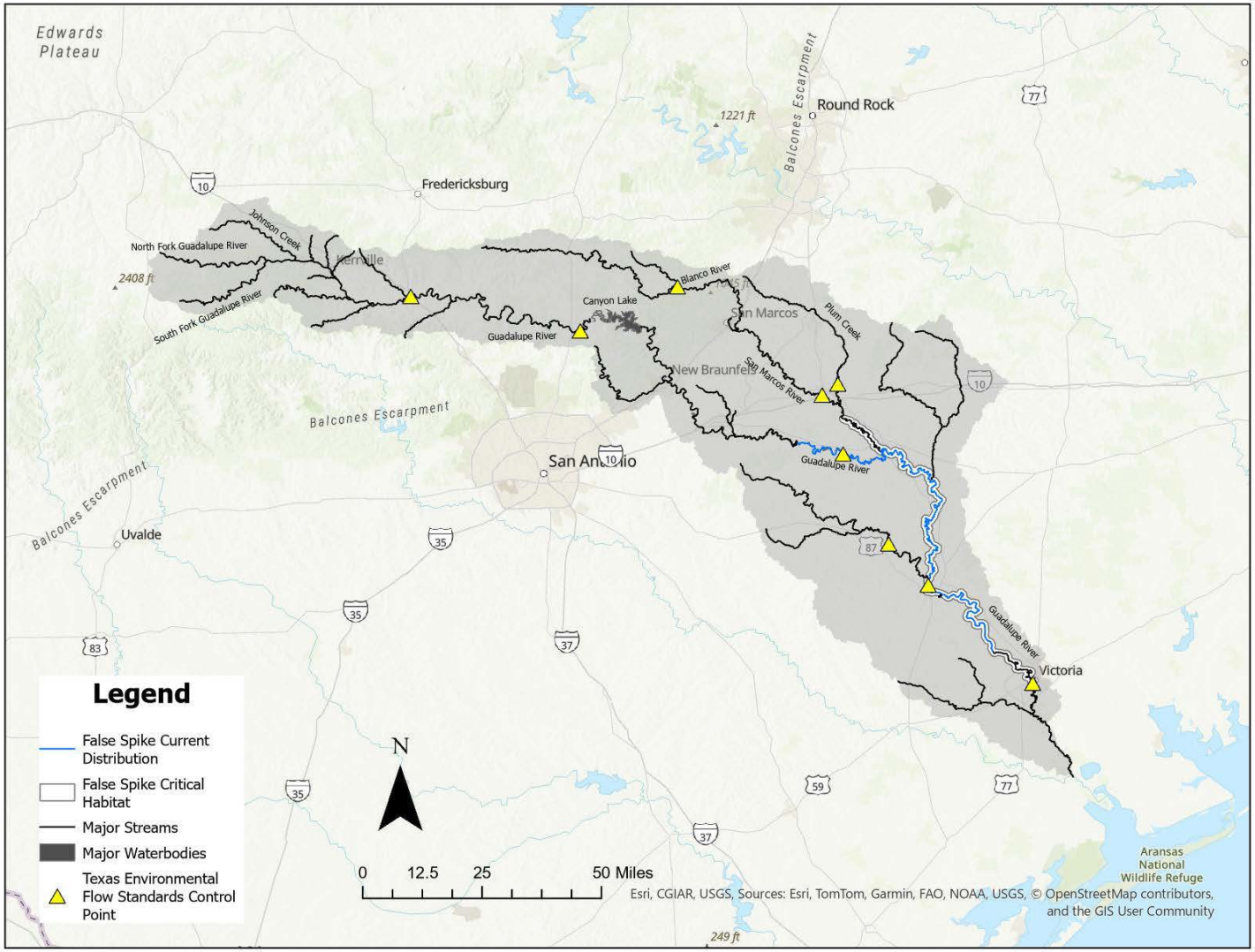

Figure 1. False Spike current distribution adapted from the Central Texas Mussels SSA report (USFWS 2022) and critical habitat (89 FR 48034). Note that the width of critical habitat displayed on this map is not to scale. Critical habitat is designated as the ordinary bank-full height, which is enlarged on this map for easier viewing.

Habitat Requirements

Habitat requirements have been identified for the species through species-specific studies, congener studies, or studies of other common freshwater mussel species. Habitat requirements of individual False Spike include:

- Flowing water and protection from low flow dewatering events (Khan 2018; Mitchell et al. 2018);
- Water quality sufficient for False Spike and their fish hosts to meet life history needs at all stages of development (e.g. suspended solids, pollutants and xenobiotics are not present at harmful levels); basic needed water chemistry includes (USFWS 2022):
    - Dissolved oxygen > 4 milligrams/liter (mg/L);
    - Salinity < 2 parts per thousand (ppt) (Blakeslee et al. 2013);
    - Chronic Total Ammonia Nitrogen < 0.47 mg/L at pH 8.2 and 23 degrees Celsius (°C) per 2013 US EPA guidance (EPA 2013); and,
    - Water temperatures within or near the streambed <82 degrees Fahrenheit (°F) (<28 °C) (Goldsmith et al. 2022), with acute temperatures rarely exceeding 93 °F (34 °C).
- Protection from high-flow, scour events (Howells 2010; Cushway et al. 2024);
- Firm and stable substrate (i.e., substrates of mud, sand, gravel, and cobble; occasionally fine sediment deposited in bedrock crevices and fissures) (Bonner et al. 2018);
- Nutrition and food supply (i.e., course particulate organic matter and associated bacteria and fungi); and,
- Fish hosts, including blacktail shiner (*Cyprinella venusta*) and red shiner (*C. lutrensis*) (Dudding et al. 2019), but other host fish species likely exist (USFWS 2022).

Influences on Viability

Section 4(a) of the ESA describes five factors that may lead to endangered or threatened status for a species. These include A) the present or threatened destruction, modification, or curtailment of its habitat or range; B) overutilization for commercial, recreational, scientific, or educational purposes; C) disease or predation; D) the inadequacy of existing regulatory mechanisms; or E) other natural or manmade factors affecting its continued existence.

Stressors affecting the viability of the False Spike, discussed in Chapter 6 of the SSA (USFWS 2022), include increased fine sediment (Factor A), changes in water quality (Factors A and E), altered hydrology – inundation (Factors A and E), altered hydrology – flow loss and scour (Factors A and E), predation (Factor C), collection (Factors B and D), disease (Factor C), invasive species (Factor E), barriers to fish movement (Factors A and E), and environmental change (Factors A and E). Additionally, the current state of the species, including reduced abundances and distribution, exacerbates other threats and has a negative effect on the viability of the species (Factor E).

Increased Fine Sediment and Changes in Water Quality

Juvenile and adult False Spike inhabit microsites that have abundant interstitial spaces, or small openings in an otherwise closed matrix of substrate, created by gravel, cobble, boulders, bedrock crevices, tree roots, and other vegetation, with some amount of fine sediment (i.e., clay and silt) necessary to provide appropriate shelter (USFWS 2022). However, excessive amounts of fine

sediments can reduce the number of appropriate microsites in an otherwise suitable mussel bed, by filling in these interstitial spaces and can smother mussels in place (Factor A).

Under a natural flow regime, a river or stream is in equilibrium in the context of sediment load, when sediments are naturally washed away from one microsite to another and the amount of sediment is relatively stable across reaches within the river or stream (Poff et al. 1997). Current and past human activities result in enhanced sedimentation in river systems and legacy sediment. These sediment deposits, resulting from past land disturbance and reservoir construction, continue to persist and influence river processes and sediment dynamics (Wohl 2015), leading to degradation of mussel habitats. Fine sediments accumulate on the streambed and in crevices during low flow events, and much of the sediment is washed downstream during high flow events (also known as cleansing flows) and deposited elsewhere. However, increased frequency of low flow events (from groundwater extraction, instream surface flow diversions, and drought) combined with a decrease in cleansing flows (from reservoir management and drought) causes sediment to accumulate and can lead to a curtailment of occupiable habitat.

Water of sufficient quality is necessary to maintain suitable conditions for the False Spike (Factor A). Impairments can arise from the introduction of contaminants or the alteration of basic water chemistry and have minor, short-term effects like altering nutrient dynamics or more serious long-term impacts to survival, growth or reproduction. Dissolved oxygen levels may be reduced by increased nutrients in the water column from agricultural runoff, the discharge of wastewater effluents, and waste from livestock operations. Increased water temperature from environmental change and extended low flow conditions can lead to changes in life history (e.g. timing of spawning or glochidia release (Patterson et al. 2025) and behavioral responses (e.g. burrowing to seek cooler temperatures in deeper substrates, valve opening, and foot extension (Block et al. 2013)). Additionally, extended periods of low flow conditions can lead to increased water temperatures and push individual False Spike mussels beyond their critical thermal limits and exacerbate low dissolved oxygen levels in the habitats they occupy, especially when reduced flows strand individuals in isolated pools. The toxicity of many pollutants increases at higher temperatures, becoming more acutely toxic to organisms that are already under metabolic stress. Land use activities that affect water quality include irrigated cropland, concentrated animal feeding operations, oil and gas operations, industrial manufacturing, municipal wastewater effluents, landfill leachates, and stormwater runoff from urban and other developed areas (Factor E).

Altered Hydrology

The False Spike is primarily adapted to flowing water (i.e., lotic habitats) rather than standing water (i.e., lentic habitats) and requires free-flowing water to survive. Low flow events (e.g., stream drying) and inundation can eliminate appropriate habitat for the species, and while the species can survive these events for a very short duration, populations that experience prolonged drying events or repeated drying events will not persist.

Inundation has primarily occurred upstream of dams. This includes large dams, such as those at Canyon Lake and other major flood control and water supply reservoirs, like the run of the river dams in the Guadalupe River downstream of New Braunfels, Comal County, Texas. It also includes small dams, such as low water crossings and diversion dams typical of the tributaries and occurring usually on privately owned lands. Inundation causes an increase in sediment

deposition, covering the substrates that False Spike might inhabit. Inundation also includes the effects of reservoir releases in which frequent variation in surface water elevation acts to make habitats unsuitable for False Spike. Additionally, deep water reservoirs with bottom release operations (like Canyon Reservoir, which supports a recreational rainbow and brown trout fishery) can affect water temperatures several miles downriver. The water temperature remains below 70.0 °F (21.1 °C) for the first 3.9 mi (6.3 km) of the 13.8 mi (22.2 km) Canyon Reservoir tailrace (TPWD 2007). Decreased temperatures, like those experienced downstream of Canyon Reservoir, can disrupt freshwater mussel growth and reproductive timing.

Extreme high-flow events can lead to physical removal, transport, and burial of freshwater mussels and their habitats, significantly altering the health, abundances, and distribution of freshwater mussel communities (Cushway et al. 2024). During these rare events, large volumes of instream substrates can be mobilized and redistributed throughout a stream reach in a matter of hours, leading to significant channel alteration and large-scale displacement of the resident mussel community (Hastie et al. 2001). If these rare, extreme events occur more regularly or on multiple occasions during the typical life span of an individual mussel (generally from 3 to 30 years), the effects of these events can start to be observed at the population or community level. These effects can be realized through the alteration of species distribution within a basin, the extirpation of species that do not tolerate frequent disturbances, and the alteration of mussel community structures away from species with periodic or equilibrium life history strategies that require more stable habitats to those that exhibit an opportunistic life history strategy and tolerate frequent disturbance (Randklev et al. 2019). The effects of high flow events can be mediated by the presence of flow refuges, where shear stress is relatively low and where sediments are relatively stable. Thus, mussels must either tolerate high-frequency disturbances or colonize areas that remain stable during high flow events between disturbances (Strayer 1999). As environmental change occurs, the riverine environments in Central Texas are anticipated to experience increased frequency and scale of both drought and flood conditions in coming decades (Wootten et al. 2023). It is likely that changing flow conditions, leading to increased temperatures, lowered dissolved oxygen, exposed instream habitats, increased scour, and substrate aggradation, will negatively influence the False Spike in the basin.

Very low water levels can also be detrimental to False Spike populations. Droughts that have occurred in the recent past have led to extremely low flows in several Central Texas rivers and are anticipated to be more frequent and longer in duration (Wootten et al. 2023). Many Central Texas rivers have some resiliency to drought because they are spring fed, such as the Guadalupe River, but drought in combination with increased groundwater pumping may lead to lower river flows of longer duration than have been recorded in the past. Reservoir releases can be managed to some extent during drought conditions to prevent complete dewatering below many major reservoirs, but extended drought can reduce reservoir capacity and limit downstream water management options. Additionally, as spring flows decline due to drought or groundwater lowering from pumping, habitat for mussels in the tributary streams where managed releases are not available can become reduced and could eventually cease to exist. While mussels may survive short periods of low flow, as low flows persist, mussels face oxygen deprivation, increased water temperature, and, ultimately, stranding, thereby reducing survivorship, reproduction, and recruitment in the population (Gagnon et al. 2011).

Other Influences
While other influences are understood to potentialimpact False Spike viability, including disease, barriers to fish movement, and overcollection, these factors are not expected to have the same level of influence as those described above. In some instances, such as overcollection, these factors are an exacerbating threat to already depleted populations rather than the cause of the population's decline. Chapter 6 of the SSA provides additional discussion on how these factors and potential resulting management actions affect False Spike viability.

2. RECOVERY STRATEGY

The recovery strategy provides a concise overview of the envisioned recovered state for the False Spike, describes the USFWS's chosen approach to achieve it, and includes the rationale for why the approach was chosen. Specifically, the recovery strategy articulates how the plan's statutory elements (recovery criteria, recovery actions, and estimates of time and cost) will work together to achieve False Spike recovery.

The recovery strategy is to ensure the long-term viability of the species by supporting and enhancing abundant populations and mitigating current and future threats the species faces until the protections afforded by the Endangered Species Act are no longer required. The recovered state of the False Spike is for the species to exist as multiple, self-sustaining populations throughout its historical range that provide sufficient resiliency, redundancy, and representation to persist through the foreseeable future.

The anticipated recovery approach to meet this recovery goal will include:

1. Improve the resiliency of existing population and its associated habitats in the middle and lower Guadalupe River and its tributaries.
2. Reduce habitat degradation in occupied stream reaches and improve habitat quality in historically occupied river segments that have the highest potential to accommodate future reintroductions of the species.
3. Augment and monitor the existing False Spike population in the middle and lower Guadalupe River, reintroduce the species into the upper Guadalupe, San Marcos, and Blanco rivers to improve species redundancy and representation.
4. Foster cooperative/collaborative implementation of recovery actions to ensure that self-sustaining populations persist across the species' historical distribution into the future.

Reducing threats to populations is essential to increasing and supporting the resiliency of the populations of False Spike. Effective threat reduction can be achieved through collaborative efforts conducted at a watershed scale to protect, enhance, and restore habitat integrity and water quality of stream reaches that currently support or could support the species. Specifically, the loss and degradation of False Spike habitat resulting from impacts associated with land development, oil and gas extraction and transportation, water supply development and withdrawals, and other land and water disturbing activities may be avoided or alleviated through such collaborative efforts.

Population augmentation will require careful planning to manage genetic diversity, ensure compatibility with the local habitat, and mitigate threats to the species. If successful,

augmentation efforts can increase the resiliency of the existing False Spike population in the Guadalupe River basin. The USFWS will support captive propagation efforts by federal, state, or other entities focused on restoring robust populations of False Spike throughout its historical range, while maintaining genetic diversity within the basin. These augmented and reintroduced populations will be monitored to ensure that the stressors contributing to declines or extirpation in the past have been sufficiently alleviated, allowing the populations to become self-sustaining.

We expect the recovery of the False Spike to require long-term human intervention to alleviate threats, strengthen existing populations, and establish and maintain new populations. Planning and implementation of conservation activities to recover the species would benefit from a broader effort to conserve water resources and the native aquatic fauna in the Guadalupe River basin. As much of the basin is privately owned, these efforts will require close coordination through partnerships with federal, state, tribal, and local agencies, including river authorities, private landowners, and non-governmental organizations. The engagement and dedication of these conservation partners will be needed to efficiently and effectively recover the False Spike. Adjusting recovery activities through adaptive management will be necessary to respond to new information about the species' life history or habitat needs identified via research, in-situ observation, identification of new threats, or changing habitat conditions.

3. RECOVERY CRITERIA

Objective, measurable recovery criteria are statutorily required by Section 4 of the ESA. Recovery criteria describe the conditions of resiliency, redundancy, representation, and threat abatement that indicate when the False Spike may no longer meet the ESA definitions of an endangered or threatened species. Recovery criteria present our best understanding of a species' recovered condition at the time of recovery plan development. Changes in available information, technologies, and our understanding of the species over time might mean that the recovered state envisioned by the recovery criteria differs from our assessment in a later status determination.

Management Units

To foster freshwater mussel recovery in Texas, we identified sub-basin level management units (MUs) across each of the major river basins currently or historically occupied by listed mussel species. We delineated MUs based on a combination of major tributary confluence points and Texas Commission on Environmental Quality (TCEQ) river segments. We standardized Management Unit locations and areas across listed mussel species in Texas to simplify recovery documentation and avoid confusion when referencing recovery actions for multiple species within a single stream reach (e.g. the Middle Guadalupe River MU for one species overlapping stream segments in the Lower Guadalupe River MU for another species). Due to standardizing the MUs across listed mussel species in Texas, portions of individual MUs may include some stream reaches or tributaries that 1) do not include current or historical records of a listed species, 2) contain widely variable instream habitat types across the MU, or 3) do not contain suitable instream habitats throughout all portions of the MU identified for an individual species. As such, recovery efforts within an identified MU will focus on appropriate instream habitats that are currently or historically occupied by the covered species and contain the necessary habitat characteristics to support that species and those recovery activities.

Based on the current and historical ranges of the False Spike (Figure 2), four Management Units

are relevant to the species' recovery. Each MU provides at least some elements needed for False Spike survival and all provide adequate stream length considered necessary for successful reproduction and recruitment. We consider each MU to support, or potentially support, a separate population. The purpose of identifying MUs in this recovery plan is to:

1. Identify separate units across the species' range to foster site-specific recovery actions; and,
2. Promote local, targeted watershed partnerships to improve delivery, efficiency, and communication of recovery activities and promote flexibility of adaptive management.

Major stream units are listed below for each MU and provided as a reference for potential stream segments that could be occupied by False Spike. However, there is no guarantee that presented stream segments contain instream habitats that are suitable for the species or that habitat restoration to achieve suitability is required for any given segment. These stream units are identified using TCEQ's Surface Water Quality Stream Segment ID numbers. These ID numbers are at times updated and those presented in this recovery plan reflect the numbers used in August 2026. Current TCEQ Surface Water Quality Stream Segment IDs, delineations, and descriptions can be found at Surface Water Quality Segments Viewer. Described measurement points (Control Points) from the Texas Environmental Flow Standards for Surface Water (30 Tex. Admin. Code § 298.380, 2012) present within each MU are also listed as a point of reference for locations where future criterion monitoring could occur.

Live False Spike presence does not need to be limited to these defined streams or stream segments for the MU to be considered occupied. Occupancy of different or additional tributaries and streams located within these sub-basins would also constitute occupancy of the overall MU.

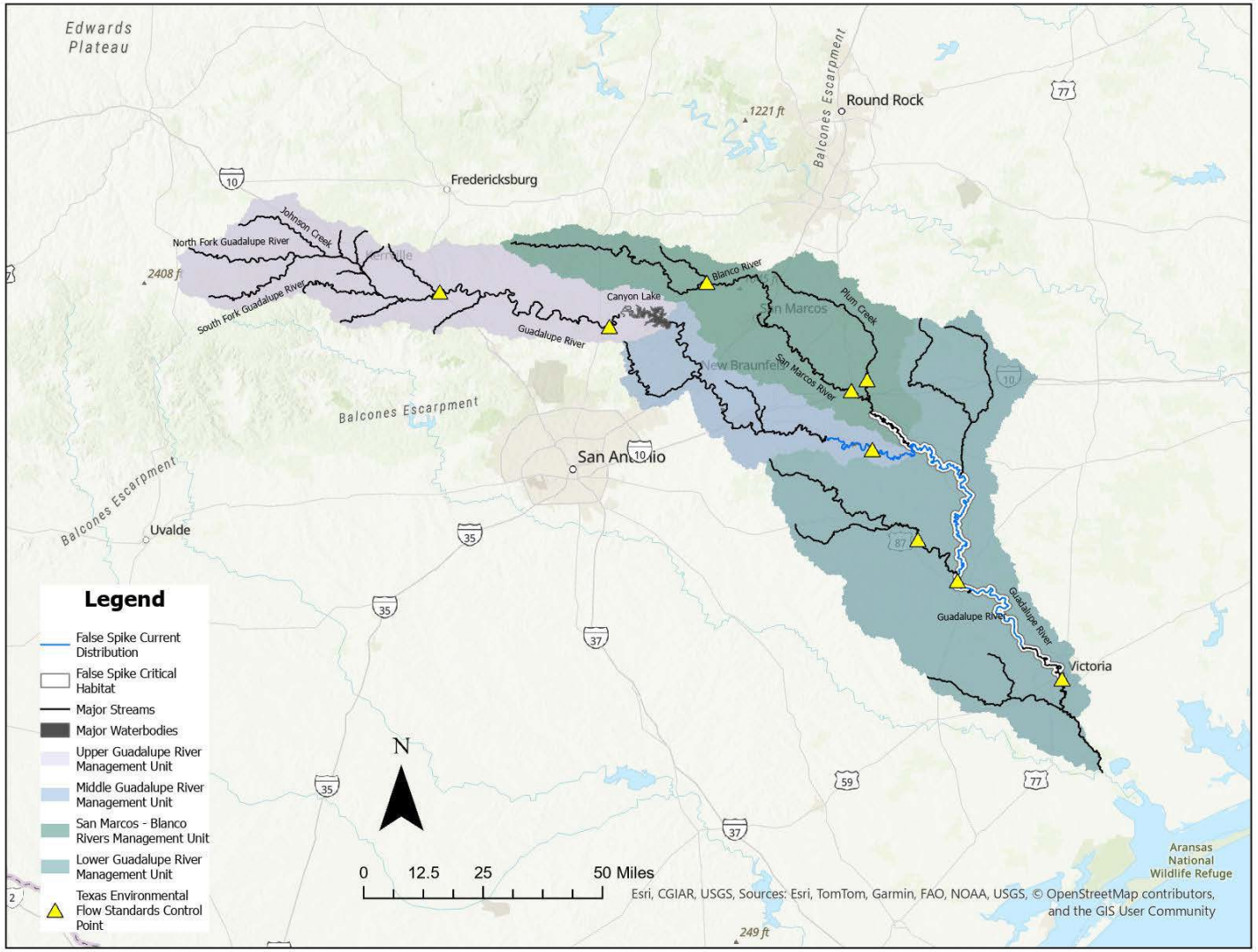

Figure 2. Four recovery planning Management Units and river sub-basins for the federally endangered False Spike.

Middle Guadalupe River Management Unit

Live False Spike mussels have been observed in this MU as recently as 2023 (Table 2; Figure 4). Our strategy in this unit is to work with partners to curtail the decline of the species and its habitat by developing strategic delivery of environmental flows necessary to support False Spike, monitoring the species to assess its status, augment the existing individuals with the intention of establishing a resilient population within the MU, and implementing additional research as necessary to ensure recovery actions are effective into the future.

This MU contains 1 Control Point described as part of the Environmental Flow Standards; Guadalupe River at Gonzales, Texas.

Table 1. Summary of stream reaches within the Middle Guadalupe River Management Unit.

TCEQ Segment No.	Segment Name	Segment Length mi (km)	Currently Occupied?
1812	Guadalupe River below Canyon Dam	23 (37)	No
1804	Guadalupe River below Comal River	101 (163)	Yes
N/A	Bear Creek (tributary of Guadalupe River upstream of New Braunfels)	5 (8)	No

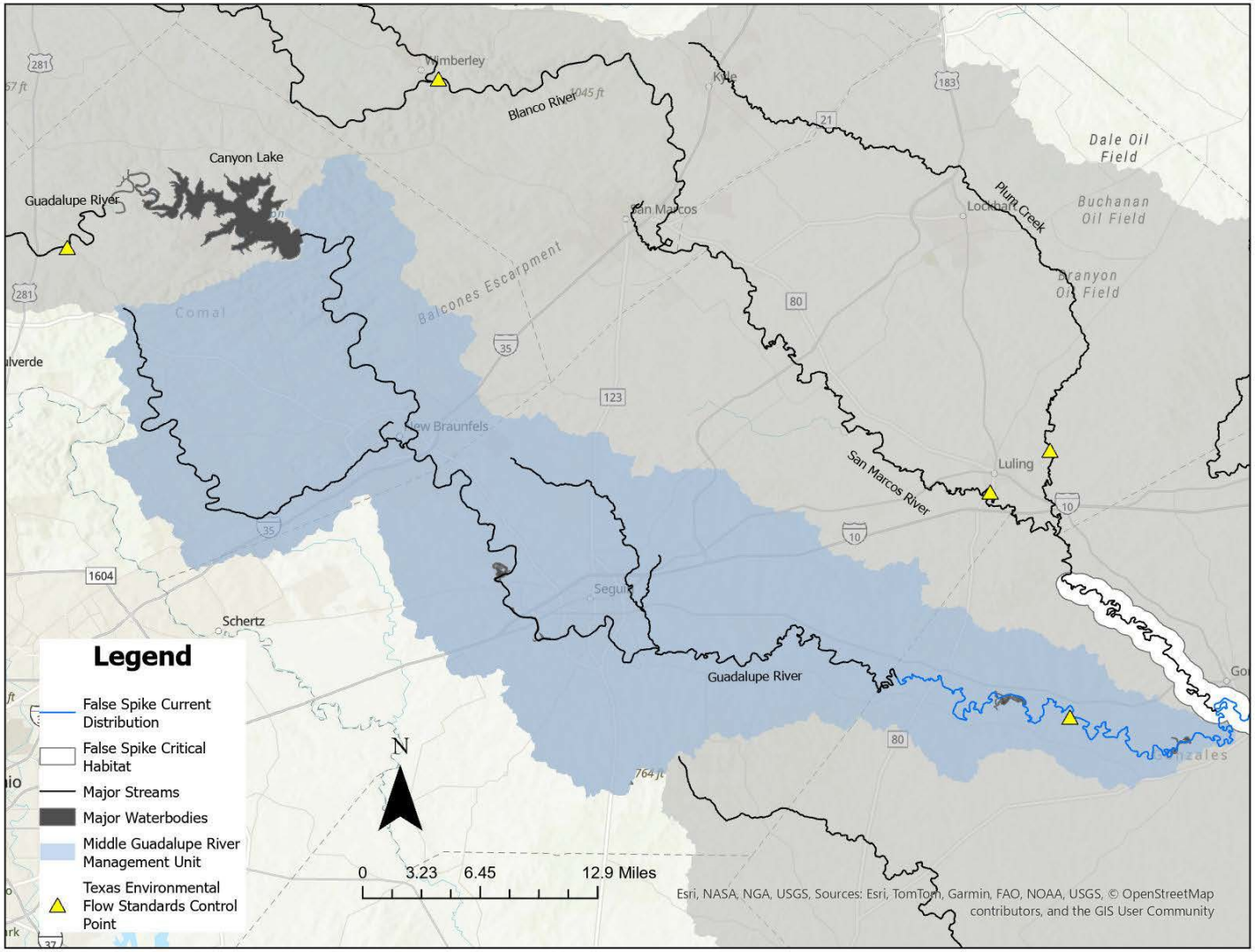

Figure 4. Stream reaches and sub-basins included within the Middle Guadalupe River Management Unit.

Lower Guadalupe River Management Unit

Live False Spike mussels have been observed in this MU as recently as 2024 (Table 4; Figure 6). Our strategy in this unit is to work with partners to curtail the decline of the species and its habitat by developing strategic delivery of environmental flows necessary to support False Spike, monitoring the species to assess its status, augmenting the population as appropriate via hatchery produced juveniles, and implementing additional research as necessary to ensure recovery actions are effective into the future.

This MU contains 4 Control Points described as part of the Environmental Flow Standards; Guadalupe River at Gonzales, Texas, Sandies Creek near Westhoff, Texas, Guadalupe River at Cuero, Texas, and Guadalupe River at Victoria, Texas.

Table 2. Summary of stream reaches within the Lower Guadalupe River Management Unit.

TCEQ Segment No.	Segment Name	Segment Length mi (km)	Currently Occupied?
1803	Guadalupe River below San Marcos River	169 (272)	Yes
1803b	Sandies Creek	65 (105)	No

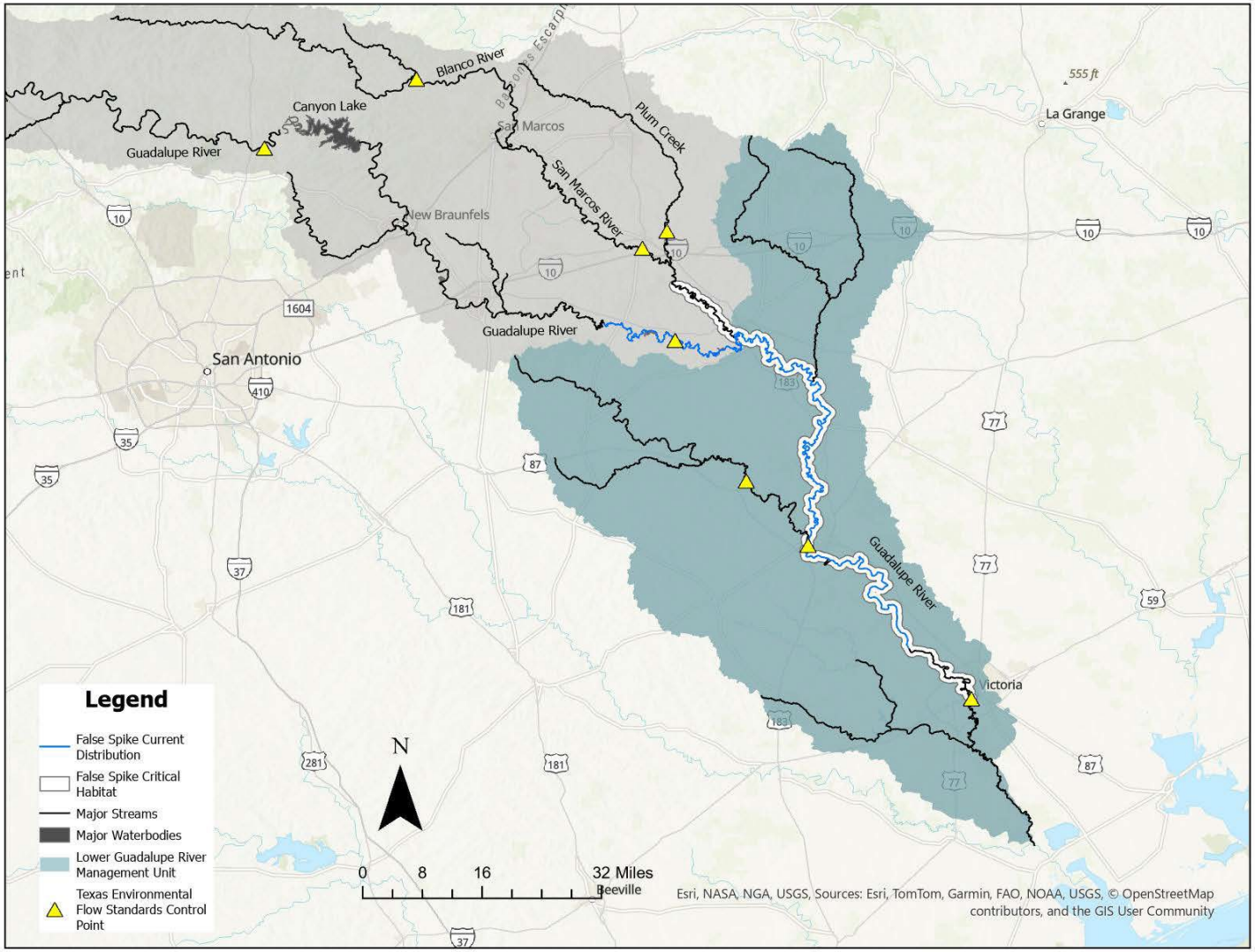

Figure 6. Stream reaches and sub-basins included within the Lower Guadalupe River Management Unit.

Upper Guadalupe River Management Unit

No live False Spike mussels have been observed in this MU in recent decades (Table 3; Figure 5). However, there are historical records for the species at multiple locations in the Guadalupe River upstream of Canyon Lake. As there are no contemporary observations of the species, and it is believed to be extirpated from this portion of the Guadalupe River basin, recovery efforts for the species in this MU will require reestablishment of a population. Therefore, our strategy in this unit is to reintroduce a population of False Spike with the intention of establishing a resilient populations within MU, work with partners to develop strategic delivery of environmental flows necessary to support False Spike, monitor the species to assess its status, and implement additional research as necessary to ensure recovery actions are effective into the future.

This MU contains 2 Control Points described as part of the Environmental Flow Standards; Guadalupe River at Comfort, Texas and Guadalupe River near Spring Branch, Texas.

Table 3. Summary of stream reaches within the Upper Guadalupe River MU.

TCEQ Segment No.	Segment Name	Segment Length mi (km)	Currently Occupied?
1806	Guadalupe River above Canyon Lake	103 (166)	No
1806F	Turtle Creek	26 (42)	No
1816	Johnson Creek	21 (34)	No
1817	North Fork Guadalupe River	29 (47)	No
1818	South Fork Guadalupe River	27 (44)	No

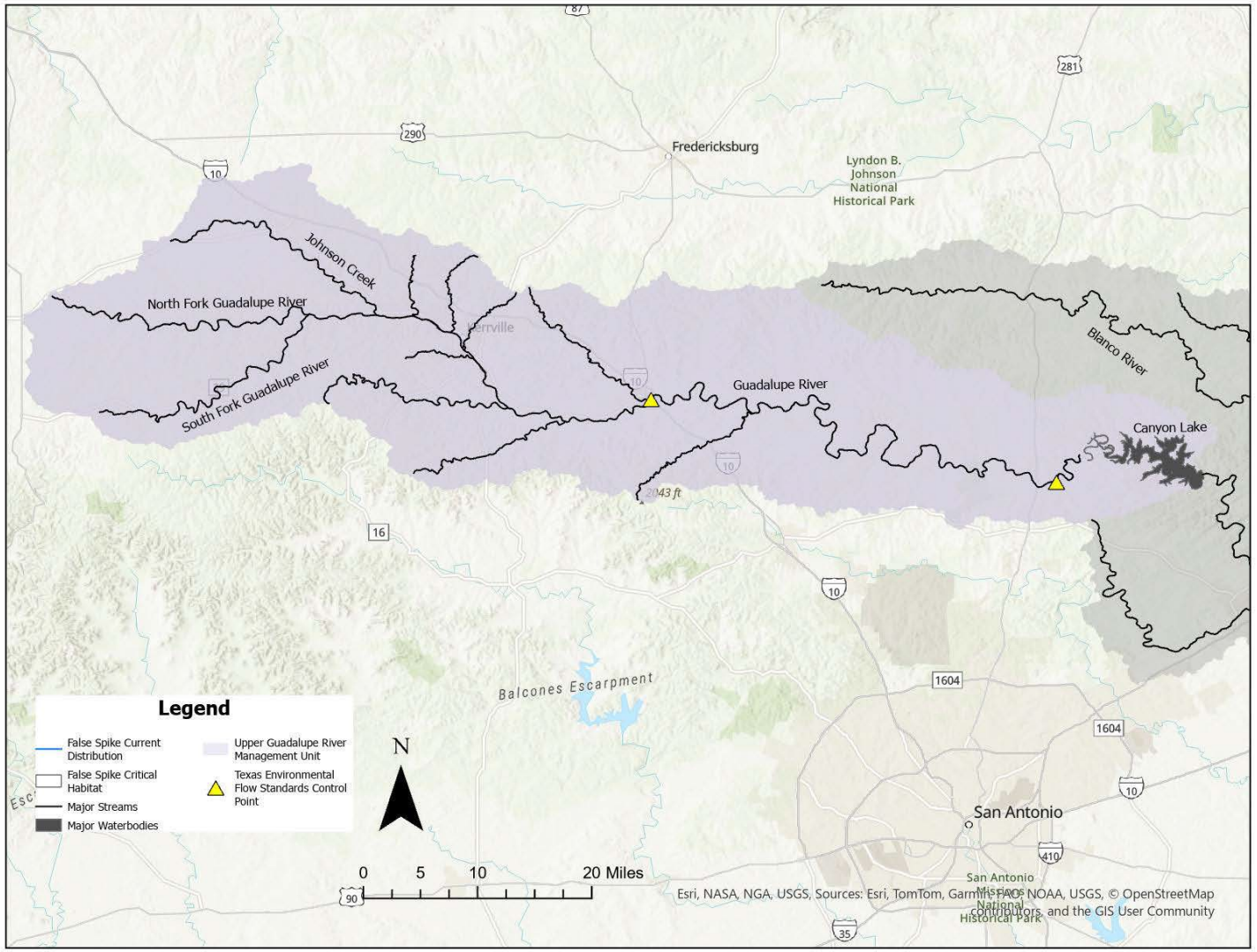

Figure 3. Stream reaches and sub-basins included within the Upper Guadalupe River Management Unit.

San Marcos – Blanco Rivers Management Unit

No live False Spike mussels have been observed in this MU in recent decades (Table 3; Figure 5). However, there are historical records for the species at multiple locations in the lower San Marcos River. Recovery efforts for the species in this MU will require reestablishment of a population. Therefore, our strategy in this unit is to reintroduce a population of False Spike with the intention of expanding the species distribution throughout the MU, work with partners to develop strategic delivery of environmental flows necessary to support False Spike, monitor the species to assess its status, and implement additional research as necessary to ensure recovery actions are effective into the future.

This MU contains 3 Control Points described as part of the Environmental Flow Standards; Blanco River at Wimberley, Texas, San Marcos River at Luling, Texas, and Plum Creek near Luling, Texas.

Table 4. Summary of stream reaches within the San Marcos – Blanco Rivers Management Unit.

TCEQ Segment No.	Segment Name	Segment Length mi (km)	Currently Occupied?
1808	Lower San Marcos River	70 (113)	No
1814	Upper San Marcos River	5 (8)	No
1809	Lower Blanco River	16 (26)	No
1815	Cypress Creek	16 (26)	No
1813	Upper Blanco River	71 (114)	No
1810	Plum Creek	52 (84)	No

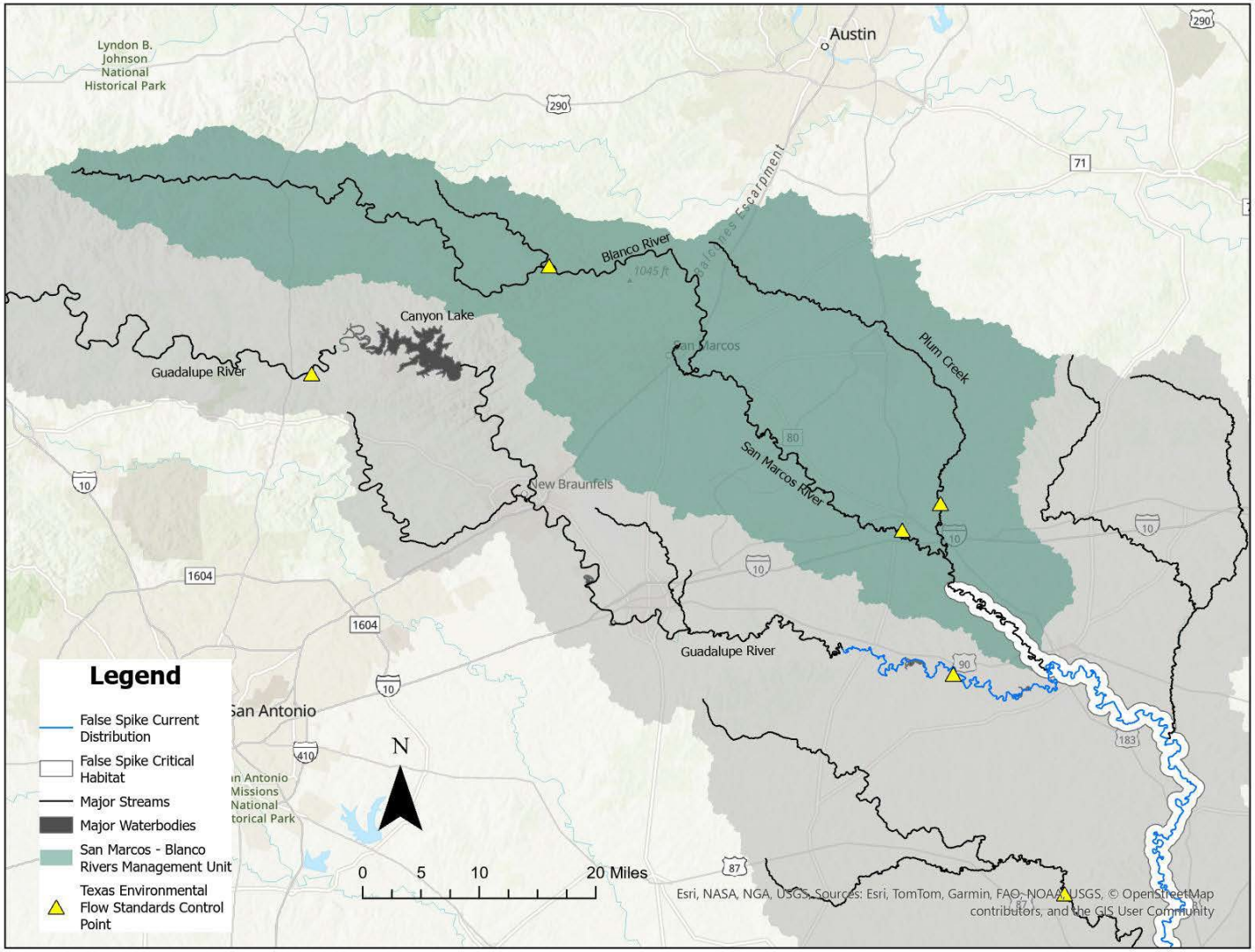

Figure 5. Stream reaches and sub-basins included within the San Marcos - Blanco Rivers Management Unit.

RECOVERY CRITERIA

This section provides objective, measurable downlisting and delisting criteria and the rationale for each. These criteria are designed to be met through implementation of the recovery actions in this recovery plan. Criteria in this recovery plan are divided into two sets: those that meet demographic (population) needs, and those that address habitat, including flow recommendations necessary to support populations into the future. The SSA analyzed the projected future condition of the False Spike 10, 25, and 50-years into the future (USFWS 2022). Our projections of stream flow and habitat quality to support the species are based upon projections 25 years into the future.

A 25-year projection timeline was selected to balance a long enough time frame that habitat management or restoration activities could be implemented, but a short enough time frame that the plan could account for changing threats or management and habitat responses. Demographic (i.e., population) goals may require another 15 - 25 years to become established once habitat and flow trends are suitable, as identified in Criteria 2 and 3. The False Spike may be considered for downlisting from endangered to threatened or removal from the List of Endangered and Threatened Wildlife (i.e., delisting) when the following criteria are met:

Downlisting Criteria: The False Spike may be considered for downlisting to threatened when the following criteria are met.

Criterion 1 – At least one resilient, self-sustaining False Spike population greater than 50 mi (80 rkm) in length occurs in three separate MUs (i.e., three of Upper Guadalupe River, Middle Guadalupe River, San Marcos-Blanco River, or Lower Guadalupe River). Populations are considered self-sustaining when the following demographic conditions are satisfied:

- Observed density of approximately 0.5 live False Spike / square meter (m^2) (approx. 0.05 live False Spike / square foot (ft^2)) per every 100 m^2 (1,076 ft^2) of sampled habitat where the species is present (i.e., a mussel bed);
- Presence of gravid females at 50% or more of sampled sites during the breeding season; and,
- Documented presence of multiple age classes, as evidenced by the presence of adult and sub-adult individuals (i.e., naturally recruited individuals <35 mm), at 50% or more of sampled locations over 15 or more years.

Additional occupied stream reaches across any combination of MUs downstream of Canyon Lake must total at least 100 rmi (161 rkm) of occupied streams. Populations occupying these additional stream reaches do not have to meet the demographic conditions described above. This provides for a cumulative occupied stream total of 250 rmi (402 rkm).

Criterion 1 Justification: Criterion 1 addresses the establishment of resilient populations and the ability of these populations to persist following the negative effects of periodic stochastic events (e.g. severe drought, floods, chemical spills, etc.). The spatial distribution of these multiple, resilient populations across different portions of the Guadalupe River basin increases the species representation by preserving the species genetic and behavioral variability across its range. The establishment, maintenance, and distribution of these populations across multiple MUs also

addresses species redundancy by allowing the species to persist if an entire population is lost to a catastrophic event.

Criterion 1 relates to the Population Factors identified and described in the SSA (USFWS 2022) that influence species resiliency and were used to assess the health of individual populations of the False Spike. The Occupied Stream Length factor is a measure of a population's ability to withstand localized disturbances that may lead to high mortality rates over a restricted area. The Abundance factor is a measure of a population's ability to survive stochastic events over large areas by having sufficient reproductive adult animals survive a mortality event across an entire population. The Reproduction factor is a measure of a population's ability to sustain itself over time through the successful recruitment of juvenile mussels into the population.

Criterion 2 - Stream flows and river connectivity targets throughout the occupied MUs are sufficient to support life history needs of juvenile, sub-adult, and adult False Spike, dispersal of glochidia, and movement and persistence of host fish. Achievement of Criterion 2 will be measured via:

Achievement of appropriate subsistence (i.e. low flows maintained during a time of drought) and base (i.e. "average" or "normal" flow conditions in the absence of significant precipitation or runoff events) environmental flows (similar to, but not necessarily those as defined by TCEQ; 30 Tex. Admin. Code § 298.380, 2012) in occupied MUs, at Control Points in/near Comfort, Spring Branch, Gonzales, Cuero, and Victoria, Texas in the Guadalupe River, Wimberley, Texas in the Blanco River, and Luling, Texas in the San Marcos River or through methods derived via future basin- or reach-level research.

- Meeting subsistence flow standards at Control Points within occupied MUs necessary to maintain adequate river connectivity, enabling recovery and achievement of Criterion 2. We acknowledge that future, targeted research may elucidate flow needs appropriate for the False Spike and its habitats, and future adjustments to and definition of subsistence flow needs may prove appropriate to maintain wetted instream habitats during low flow conditions and enable species recovery.

- Due to naturally occurring annual variability in hydrologic conditions (e.g. dry, average, or wet years) across the Guadalupe River basin and within occupied MUs and the need for additional data related to species-specific responses to variation in instream flow conditions and the instream flow conditions necessary to create and maintain suitable instream habitats, the appropriate frequency and duration of base flows that must be met to consider Criterion 2 achievement will be derived through future basin- or reach-level research.

Achievement of these appropriate environmental flows should be measured at United States Geological Survey (USGS) gage(s) or using other methods for ungauged sites. Appropriate flows should be present to support life history needs of all life-stages of False Spike in MUs occupied by populations for the time period considered for satisfying Criterion 1.

Criterion 3 – Water quality (e.g. temperature, dissolved oxygen, turbidity, conductivity, ammonia concentrations, nutrients, pollutant load, pesticides, trace metals, pharmaceuticals, or

other xenobiotics, etc.) and substrate (e.g. substrate composition, percent fine sediment, embeddedness, oxygen levels, etc.) conditions present within occupied MUs result in habitats suitable for the recruitment of juvenile False Spike mussels into the populations, survival of sub-adults through adulthood, and persistence of host fishes. Additional research and analysis may be required to identify the specific range of these conditions within portions or across entire MUs that are required to facilitate the creation and maintenance of suitable habitats. Until such information is available, the following criteria apply:

- Necessary water quality and substrate quality conditions, as identified below or through additional, targeted species- or genus-level research actions, are generally achieved to create instream habitats sufficiently present within each occupied MU to allow occupation levels described in Criterion 1. Due to the constantly changing nature of riverine systems, it is not anticipated that all habitats within a MU will meet all of the following water quality criteria at all times and these criteria are not presented as thresholds that must be attained as such. The following water quality criteria are intended to demonstrate suitable conditions:

    - Dissolved oxygen (DO) > 4 mg/L;
    - Water temperatures within or near the streambed < 82 °F (<28 °C) (Goldsmith et al. 2022) with acute temperatures rarely exceeding 93 °F (34 °C);
    - Salinity < 2 ppt (Blakeslee et al. 2013);
    - Chronic Total Ammonia Nitrogen < 0.47 mg/L at pH 8.2 and 23 °C per 2013 US EPA guidance (EPA 2013); and,
    - Total phosphorous sufficiently low to prevent degradation of mussel habitat.
- Appropriate water quality should be present to support life history needs of all life-stages of False Spike in MUs occupied by populations for the time period considered for satisfying Criterion 1.

Criteria 2 and 3 Justification: Criteria 2 and 3 address the establishment and maintenance of instream habitats that are critical to the long-term persistence of the False Spike. Once necessary instream flows are attained to create adequate habitat quantity and quality, these flows must persist or improve, and wetted habitats must maintain appropriate water quality and substrate quality to support the survival of mussels (i.e., all life stages from glochidia through adulthood) and their fish hosts.

The determination of appropriate base and subsistence flow needs described as part of Criterion 2 should be completed through future research efforts focusing on the instream conditions needed to support the long-term persistence of False Spike populations and their habitats. Similar efforts have been completed for other faunal groups within the Guadalupe River basin as part of the Texas Instream Flows Program, known as the Senate Bill 2, established by the 77th Texas Legislature in 2001, and the Statewide Environmental Flows process, also known as Senate Bill 3, established by the 80th Texas Legislature in 2007. Although the impacts of the target flow thresholds on the health and persistence of freshwater mussels, specifically the False Spike, was not evaluated as part of these programs and processes, it is estimated that the identified environmental flow standards would benefit host fishes and could also potentially benefit mussels themselves (Guadalupe BBEST, 2011). However, it is stated in several subsequent reports (San Antonio River Authority et al., 2015 and 2017) as part of the Statewide

Environmental Flows process that flow needs for freshwater mussels were unavailable at that time and future evaluations of freshwater mussel responses to subsistence and base flow targets should be pursued. As such, the USFWS supports the position that additional research should be pursued to identify the appropriate subsistence and base flow needs of freshwater mussels and their habitats in the Guadalupe River basin, specifically the False Spike. Additionally, the USFWS acknowledges that adjustments to these criteria may be appropriate in the future, following completion of this additional research and the determination of appropriate stream flows needs and connectivity recovery targets.

The water quality criteria identified as part of these criteria were included in the Central Texas Mussels SSA report (USFWS 2022) and are based upon values that have either been determined through species-specific research or through existing criteria that have been documented to be generally protective of freshwater mussel species. For example, the total ammonia nitrogen criterion noted in this plan is based on the 2013 U.S. Environmental Protection Agency's (EPA) Criterion Continuous Concentration (CCC) chronic threshold of 1.9 mg TAN/L (at pH 7, 68 °F (20 °C)). Ammonia toxicity is influenced by water chemistry, namely pH and temperature. Therefore, the ammonia criterion cited in this recovery plan has been adjusted to local conditions at pH 8.2 and 73 °F (23 °C) (which more accurately reflect conditions in the Guadalupe River basin that the False Spike are likely to experience). The EPA ammonia criterion was developed using multiple taxa, including freshwater mussels, and should generally be protective of the False Spike; however, these parameters are not all-inclusive (e.g., other harmful pollutants exist) and should be updated if additional research in the future identifies species-specific thresholds or other pollutants that are limiting recovery.

Criteria 2 and 3 are also related to identified Habitat Elements that Influence Resiliency identified in the SSA (USFWS 2022). Specifically, Criterion 2 addresses the Flowing Water factor (USFWS 2022), and Criterion 3 addresses the Substrate and Water Quality factors (USFWS 2022). The criteria described in the SSA have been identified as those that are necessary for instream habitats to support healthy, persistent populations of the False Spike. Creating or maintaining instream habitats that meet this plan's criteria, or others through species-specific research, are critical to the recovery of the False Spike. Because multiple water users affect river flows and no single water user is wholly responsible for instream flows, the USFWS acknowledges that long-term, collaborative partnerships and watershed level coordination are imperative to maintaining instream flows that are adequate to support the long-term persistence of False Spike populations and their habitats.

Delisting Criteria: The False Spike may be considered for removal from the List of Endangered and Threatened Wildlife (delisted), when *all* downlisting criteria above are met *and* the following delisting criterion is met.

Criterion 4 - Four self-sustaining False Spike populations, occupying at least 50 rmi (80 rkm) each, occur in separate MUs, and meet demographic criteria described in Criterion 1. Additional occupied stream reaches across any combination of MUs downstream of Canyon Lake must total at least 100 rmi (402 rkm) of occupied streams across the species' range. Populations occupying these additional stream reaches do not have to meet the demographic criteria described in Criterion 1. This provides for a cumulative occupied stream total of 300 rmi (483 rkm). All populations, regardless of length, must also meet stream connectivity and habitat quality criteria,

as defined by downlisting Criterion 2 and 3, above.

Criterion 4 Justification: Criterion 4 further reinforces the resiliency and redundancy of the False Spike created through implementation of Criteria 1 through 4, resulting in the establishment of more widely distributed and robust populations that allow for greater adaptive capacity to respond to environmental stressors.

Progress toward meeting down- and delisting criteria should be measured throughout implementation of this recovery plan. Careful planning and consideration of the timing of surveys and the ongoing implementation of propagation and population augmentation or re-establishment efforts will be instrumental in addressing essential habitat and recovery criteria at the time delisting may be considered.

4. RECOVERY ACTIONS

Recovery actions are statutorily required, site-specific management actions needed to achieve recovery criteria, as described in section 4 of the ESA. The USFWS assigns recovery action priority numbers (1-3) to rank recovery actions. The assignment of priorities does not imply that some recovery actions are of low importance but instead implies that lower priority items may be deferred while higher priority items are being implemented. Recovery action priority numbers are based on the following:

> Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.
>
> Priority 2: An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.
>
> Priority 3: All other actions necessary to provide for full recovery of the species.

Table 5. Recovery actions for the False Spike, including: Recovery Action Numbers, Recovery Criteria Addressed, Recovery Action Priority Numbers, Recovery Actions, and Recovery Action Descriptions.

Recovery Action Number	Recovery Criteria Addressed	Recovery Action Priority Number	Recovery Action	Recovery Action Description
1	2,3	2	Improve understanding of the water quantity and instream flow recommendations needed to maintain healthy False Spike populations, fish host populations, and instream habitats across the species' ranges, and establish a stream flow monitoring program as necessary to protect and recover the False Spike.	Reduced stream flows and high flow events and the resulting effects on water quantity, water quality, and sediment transport influence availability of instream habitats for recruitment and survival of juvenile and adult False Spike, and their host fishes. As Texas experiences droughts of increasing frequency, intensity, and duration, as well as flood events, it is crucial to understand the effects of hydrologic conditions (e.g. subsistence and base flows) on the False Spike populations, the creation and maintenance of instream habitats, and how these factors affect species recovery. For example, these stated flow recommendations could be explored through incorporating an evaluation of freshwater mussel's needs into the Texas Instream Flow Studies Program implemented by Texas Parks and Wildlife Department, Texas Water Development Board and Texas Commission on Environmental Quality and described in the Study Design and Biology portions of the 2008 Texas Instream Flow Studies: Technical Overview.
2	2,3	2	Improve understanding of the nature, extent, and role of water quality degradation in the decline of the species across its range and establish a water quality monitoring program as necessary to protect and recover the False Spike	Many land use activities and their resultant discharges (both point and non-point source) have the potential to affect the False Spike and its habitats. Since much of the water quality research completed for freshwater mussels to date has been developed using species endemic to other regions of the United States, the impacts of various activities and water quality factors, including release of ammonia, phosphorous, and xenobiotics (e.g. pesticides, heavy metals, pharmaceuticals, etc.), that affect water quality and their effect on False Spike populations and all of their life stages are not well understood and should be examined further.
3	1,2,3,4	2	Continue to develop knowledge of the species' life history, ecology, habitat requirements, health, and behavior and apply that knowledge to restore and protect False Spike populations and appropriate habitats range-wide.	Perpetuation of the False Spike in the wild depends on a thorough knowledge of the species' life history, ecology, habitat requirements and behavior, and application of that knowledge to restore and protect appropriate habitats.
4	1,2,3,4	2	Improve understanding of environmental change effects to river flows, water quality, and species viability throughout the Guadalupe River basin.	Continue to learn and utilize new tools as they become available to help better understand future climate projections and related tools on how those projections will affect hydrology, habitat, water quality, and species viability in the Guadalupe River basin.
5	1,2,3,4	1	Develop and implement water management strategies across stream reaches occupied by False Spike populations.	Water management strategies will consider the variety of stream flows needed to support the False Spike and its host fishes' life histories (e.g. subsistence and base flows) in stream reaches currently occupied by the False Spike. These flows are necessary for the establishment and maintenance of a seasonally stable wetted channel that promotes the creation and existence of False Spike habitats (baseflows) and for obtaining and maintaining water quality necessary to support the recruitment of juvenile False Spike and persistence of adult False Spike (subsistence). Appropriate water management strategies should account for necessary sediment transport conditions to maintain substrate quality and condition needed to support populations of the False Spike and its host fishes. This effort will involve supporting and working with stakeholders or a workgroup to implement water management/use practices to maximize natural flow regimes, as well as implementing water releases from reservoirs and optimizing water uses where possible. As additional data becomes available through the completion of Recovery Actions 1, 2, and 4, these plans should be updated and adapted to incorporate this improved understanding of stream flows, water quality, and the effects of environmental change.

Table 5 (continued). Recovery actions for the False Spike, including: Recovery Action Numbers, Recovery Criteria Addressed, Recovery Action Priority Numbers, Recovery Actions, and Recovery Action Descriptions.

Recovery Action Number	Recovery Criteria Addressed	Recovery Action Priority Number	Recovery Action	Recovery Action Description
6	1,4	2	Evaluate previously occupied stream segments (Guadalupe River (upstream of Canyon Lake)) and develop priorities for False Spike augmentations/reintroductions.	These stream segments each have the potential to support False Spike populations but may first require some level of habitat and/or flow modification and management. Prioritization will be based on the potential for successful False Spike augmentations/reintroductions and will account for current and future habitat conditions, level of needed management actions (if any) to accommodate reintroductions, and the ability of partners to provide the resources needed for such reintroductions.
7	1,2,3,4	2	Develop and implement water management strategies for the previously occupied stream segments (where possible) identified through implementation of Recovery Action 6 above.	After priorities from Recovery Action 6 have been developed, historically occupied stream segments will be selected for False Spike reintroduction. For reintroductions to be successful, water management strategies, similar to those developed as part of Recovery Action 5, will be developed in collaboration with stakeholders or a workgroup and will consider a range of flow conditions; e.g. subsistence and base, flows, needed to accommodate the False Spike's life history, maintain necessary water quality conditions, and establish and maintain channel width and complexity necessary to support False Spike populations into the future.
8	1,2,3,4	2	Implement long-term management commitments or conservation agreements across the species' range to ensure water and habitat quality and quantity are sufficient (occur within >150 miles (241 kilometers) of stream length) to support self-sustaining populations of False Spike.	Additional research is required to determine the necessary water and habitat quality and quantity parameters required by the False Spike. Based on these findings, specific management commitments or conservation agreements should then be implemented to the greatest extent possible. These commitments must be robust and with such high certainty of implementation that their continued benefit to the species is reasonably expected to continue.
9	2,3	3	Implement a range-wide habitat monitoring program.	Working with State and River Authority partners, the USFWS will participate in and conduct monitoring for habitat quality and threats to existing or re-established populations. Additional reporting and coordination between the USFWS, TPWD, and river authorities will be necessary to ensure standard protocols are consistent and implemented such that results can be used to address Recovery Criteria 2 and 3.
10	1,4	1	Establish and maintain a captive propagation program.	Captive propagation of wild caught False Spike and the augmentation of currently occupied streams will improve the resiliency of existing populations. Reintroduction of captively produced juveniles into historically occupied stream reaches will address limited redundancy of the species. The number of individuals used for broodstock, their genetic structure, and effectiveness of the captive breeding program should be monitored in accordance with a Captive Propagation Plan (CPP) that has been developed to guide the captive maintenance and breeding program for the False Spike. Goals of the captive propagation portion of the CPP will be to guide collection targets, outline the steps necessary to provide a representation of the genetic characteristics of wild populations, and ensure that wild reproductive potential is not hindered by broodstock collections. The CPP will also develop criteria based upon the viability of False Spike populations in the basin detailing when propagation, augmentation, and reintroduction efforts should cease, and the program conclude. The CPP will be developed in coordination with agencies or other entities likely to be involved with the propagation efforts.

Table 5 (continued). Recovery actions for the False Spike, including: Recovery Action Numbers, Recovery Criteria Addressed, Recovery Action Priority Numbers, Recovery Actions, and Recovery Action Descriptions.

Recovery Action Number	Recovery Criteria Addressed	Recovery Action Priority Number	Recovery Action	Recovery Action Description
11	1,4	1	Research drought mitigation strategies and develop appropriate and implementable emergency drought/catastrophic event plan.	Work with Partners to research drought mitigation strategies, which may include the development an emergency salvage and refugia plan to temporarily bring False Spike mussels into hatchery facilities in the event of prolonged drought or catastrophic event (e.g. chemical spill). This plan will identify monitoring efforts to identify instream conditions necessary to activate the plan, thresholds to identify when salvage efforts are necessary to move animals to deeper waters and when necessary to move animals to a hatchery stetting, identify costs, and develop handling and possible holding procedures for live False Spike in temporary holding facilities, and criteria for when temporary refugia efforts are no longer necessary and animals can be returned to the wild.
12	1,4	2	Develop and implement Reintroduction Plans.	Develop and implement plans that outline parameters for the release of captive-bred individuals into currently and historically occupied stream reaches. This plan shall also include guidance on requisite stocking densities and frequency. This plan will be informed by Recovery Action 10 above.
13	1,4	1	Augment existing populations of False Spike.	Augment existing populations of False Spike through captive-rearing techniques in accordance with propagation plans with considerations for genetics and disease identified in the CPP (Recovery Action 10). Augmentation will continue until density, recruitment, and reproductive measures detailed in Recovery Criteria 1 and 4 are met.
14	1,4	2	Restore historical populations of False Spike.	Restore historical populations, as feasible, through reintroductions (e.g., using captive-bred individuals and/or translocation of wild individuals) in accordance with propagation plans, as appropriate, with considerations for genetics and disease identified in the CPP (Recovery Action 10). Restoration will continue until distribution, density, recruitment, and reproductive measures detailed in Recovery Criteria 1 and 4 are met.
15	1,4	3	Implement a range-wide population monitoring program.	Working with State and River Authority partners, the USFWS will participate in and conduct monitoring for False Spike to further delineate the current status and distribution of the False Spike and monitor population health and threats to existing or re-established populations. Additional reporting and coordination between the USFWS, TPWD, and river authorities will be necessary to ensure standard protocols are consistent and being implemented such that results can be used to address Recovery Criteria 1 and 4.
16	1,2,3,4	2	Identify key partners for each stream segment.	Identify key partners in each of the currently occupied and historically occupied stream segments. Partners will include tribes, private landowners, municipalities, non-government organizations, state, and federal agencies.
17	1,2,3,4	3	Develop and implement a communications plan to enhance collaboration with partners.	Develop a plan that outlines how collaboration among partners identified in Recovery Action 16 will be implemented. The plan will include a process on how to best share information and how frequently that information will be shared.
18	1,2,3,4	2	Integrate existing conservation plans.	Evaluate and integrate existing plans from state, federal, and non-government organizations to identify common goals and assist with recovery actions.
19	1,2,3,4	3	Develop and implement an outreach and communication plan for the False Spike.	A comprehensive outreach and communications plan will be developed jointly by the USFWS and its partners. Some basic considerations and ideas for such a plan include identifying key audiences, key messages, and methods of disseminating information such as regular meetings, social media, USFWS webpages, news outlets, etc.

Table 6. Threats summary table for the False Spike, including: Recovery Action Numbers, Recovery Criteria Addressed, Recovery Action Priority Numbers, Recovery Actions, and Recovery Action Descriptions.

Recovery Action Number	Recovery Criteria Addressed	4(a)(1) Factor(s)	Threats Description	Recovery Action
1	2,3	Factors A, D, and E	Degraded Water Quality, Reduced Water Quantity, Fish Passage, Environmental change	Improve understanding of the nature, extent, and role of water quality degradation in the decline of the species across its range, as well as the water quality standards necessary for its protection and recovery.
2	2,3	Factors A, D, and E	Degraded Water Quality, Environmental change	Improve understanding of the nature, extent, and role of water quality degradation in the decline of the species across its range, as well as the water quality standards necessary for its protection and recovery.
3	1,2,3,4	Factors A and C	Reduced Range and Abundance	Continue to develop knowledge of the species' life history, ecology, habitat requirements, health, and behavior and apply that knowledge to restore and protect populations and appropriate habitats range-wide.
4	1,2,3,4	Factor A and E	Degraded Water Quality, Reduced Water Quantity, Environmental change	Improve understanding of environmental change effects to river flows, water quality, and species viability throughout the Guadalupe River basin.
5	1,2,4	Factors A, C, D, and E	Degraded Water Quality, Reduced Water Quantity, Environmental change	Develop and implement water management strategies across stream reaches occupied by False Spike populations.
6	1,4	Factors A and E	Reduced Range and Abundance	Evaluate previously occupied stream segments (Guadalupe River (upstream of Canyon Lake)) and develop priorities for False Spike augmentations/reintroductions.
7	1,2,4	Factors A, D, and E	Degraded Water Quality, Reduced Water Quantity, Environmental change	Develop and implement water management strategies for the previously occupied stream segments (where possible) identified through implementation of Action 5 above.
8	1,2,3,4	Factors A, B, and E	Degraded Water Quality, Reduced Water Quantity, Environmental change	Implement long-term management commitments or conservation agreements across the species' range to ensure water and habitat quality and quantity are sufficient (within >150 miles (241 kilometers) of stream length) to support at least three self-sustaining populations of False Spike.
9	2,3	Factors A and E	Reduced Range and Abundance	Implement a range-wide habitat monitoring program.
10	1,4	Factors A, C, and E	Reduced Range and Abundance	Establish and maintain a captive propagation program.
11	1,4	Factors A, C, and E	Reduced Range and Abundance	Develop emergency drought/catastrophic event salvage and refugia plan.
12	1,4	Factors A and E	Reduced Range and Abundance	Develop and implement Reintroduction Plans.
13	1,4	Factors A, C, and E	Reduced Range and Abundance	Augment existing populations of False Spike.
14	1,4	Factors A, C, and E	Reduced Range and Abundance	Restore historical populations of False Spike.
15	1,4	Factors A and E	Reduced Range and Abundance	Implement a range-wide population monitoring program.
16	1,2,3,4	Factors B and E	Degraded Water Quality, Reduced Water Quantity, Environmental change, Fish Passage, Overcollection; Disease	Identify key partners for each stream segment.
17	1,2,3,4	Factors B and E	Degraded Water Quality, Reduced Water Quantity, Environmental change, Fish Passage, Overcollection; Disease	Develop and implement a communications plan to enhance collaboration with partners.
18	1,2,3,4	Factors B and E	Degraded Water Quality, Reduced Water Quantity, Environmental change, Fish Passage, Overcollection; Disease	Integrate existing conservation plans.
19	1,2,3,4	Factors B and E	Degraded Water Quality, Reduced Water Quantity, Environmental change, Fish Passage, Overcollection; Disease	Develop and implement an outreach and communication plan for the False Spike.

5. ESTIMATED TIME AND COSTS TO ACHIEVE RECOVERY

Estimates of time and cost, as defined in section 4(f)(1)(B)(iii) of the ESA, must reflect, to the maximum extent practicable, the total amount of time and costs it will take to achieve the recovery (delisting) of False Spike. The cost estimates provided do not account for possible future inflation.

We estimate that the full implementation of the recovery actions would improve the status of False Spike so that it may be delisted within 25-30 years following the adoption of this recovery plan and cost approximately $29 million dollars. We note that the recovery program may change over time, or the timeframe estimated to implement the recovery actions to achieve recovery of the species may take longer than expected. We also note that some of the costs presented in Table 3 could be shared across multiple species, resulting in a lower total cost attributed to False Spike in that scenario. However, because it is unknown when recovery activities will be initiated for other overlapping species, the costs of the actions have been presented as solely associated with False Spike in this document. The recovery of False Spike will depend largely on the commitment and the ability of the USFWS and partners to implement the recovery actions necessary to achieve the recovery criteria.

Table 7. Recovery action time and cost table for the False Spike, including: Recovery Action Numbers, Recovery Action Descriptions, Estimated Annual Costs, Estimated Times to Completion, and Total Estimated Costs.

Recovery Action Number	Action Description	Estimated Annual Cost	Estimated Time (years)	Total Estimated Cost
1	Improve understanding of the water quantity and instream flow needs for the persistence of False Spike and host fish populations and instream habitats across the species' ranges, as well as the environmental flow needs and standards necessary for its protection and recovery.	$250,000	10	$2,500,000
2	Improve understanding of the nature, extent, and role of water quantity and water quality degradation in the decline of the species across its range, as well as the flow needs and water quality standards necessary for its protection and recovery.	$150,000	10	$1,500,000
3	Continue to develop knowledge of the species' life history, ecology, habitat requirements, health, and behavior and apply that knowledge to restore and protect populations and appropriate habitats range-wide.	$200,000	10	$2,000,000
4	Improve understanding of environmental change effects to river flows, water quality, and species viability throughout the Guadalupe River basin.	$150,000	10	$1,500,000
5	Develop and implement water management strategies across stream reaches occupied by False Spike populations.	$1,500,000	25	$37,500,000[1]
6	Evaluate previously occupied stream segments (Guadalupe River (upstream of Canyon Lake)) and develop priorities for False Spike augmentations/reintroductions.	$75,000	5	$375,000
7	Develop and implement water management strategies for the previously occupied stream segments (where possible) identified through implementation of Action 5 above.	$1,500,000	25	$37,500,000[1]
8	Implement long-term management commitments or conservation agreements across the species' range to ensure water and habitat quality and quantity are sufficient (within >150 mi (241 km) of stream length) to support self-sustaining populations of False Spike.	$350,000	25	$8,750,000
9	Implement a range-wide habitat monitoring program.	$100,000	25	$2,500,000
10	Establish and maintain a captive propagation program[2].	$150,000[3]	30	$2,000,000
11	Develop emergency drought/catastrophic event salvage and refugia plan.	$50,000	2	$100,000
12	Develop and implement Reintroduction Plans.	$50,000	5	$250,000
13	Augment existing populations of False Spike.	$150,000	15	$2,250,000
14	Restore historical populations of False Spike.	$150,000	25	$3,750,000
15	Implement a range-wide population monitoring program.	$50,000	25	$1,250,000
16	Identify key partners for each stream segment.	$10,000	5	$50,000
17	Develop and implement a communications plan to enhance collaboration with partners.	$10,000	25	$250,000
18	Integrate existing conservation plans.	$100,000	10	$1,000,000
19	Develop and implement an outreach and communication plan for the False Spike.	$25,000	25	$625,000
			Downlisting Total	**$26,900,000[4,5]**
			Total	**$30,650,000[4]**

[1] Associated recovery actions are difficult to calculate, as costs are anticipated to fluctuate with market rates, include possible donations, or may be accounted for through existing or anticipated partnerships.
[2] Costs associated with the completion of this recovery action can be shared across multiple species, and costs presented as part of this plan are likely an over-estimate of anticipated per-species cost.
[3] Estimated cost of $150,000 for the first 5 years to establish program and then $50,000 for remaining 25 years to maintain the program.
[4] Total cost only includes anticipated new costs that can be reasonably calculated and not those already associated with ongoing activities, potential future agreements that are anticipated to occur throughout the timeline of this plan, or costs that are anticipated to continually fluctuate according to changing market rates.
[5] Estimated total cost for downlisting does not include costs associated with re-establishing populations in previously occupied management units.

6. LITERATURE CITED

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APPENDIX A

Peer and Public Review Response

We received comments from three commentors (Texas A&M University, Texas State University, and the Guadalupe-Blanco River Authority) during the 60-day public comment period which ended on December 1, 2025. We received two of four requested peer reviews for the draft recovery plan. In general, commentors were supportive of this recovery plan. Several commentors requested more specific, measurable details be included in Criterion 2. We have revised this criterion and added text discussing the need for fauna-specific environmental flow studies to be completed for the False Spike to identify flow recommendations for specific locations throughout the species' range. The TPWD Instream Flow Program and the Texas Environmental Flow Standards for Surface Water Environmental Flow Standards were provided as examples of similar efforts completed for other fauna groups. We made additional edits as summarized below, and in some cases, additional language and/or citations were added for clarity and to support scientific findings. Comments and how we addressed them are summarized below and presented in order of appearance in the document.

Comment: We received multiple, minor, non-substantive changes and corrections throughout this document (e.g., typos, spelling errors, grammatical revisions) to revise the readability and clarity of the document.

> Response: We appreciate these comments and have incorporated them as appropriate. A full summary of such changes is not provided.

Comment: Multiple reviewers provided additional scientific studies to bolster the credibility and clarity of species tolerance and thresholds in the Habitat Requirements section of the document.

> Response: We appreciate these additions and have incorporated these new studies as appropriate (i.e., Mitchell et al. 2018, Blakeslee et al. 2013, Cushway et al. 2024).

Comment: One reviewer indicated that our total ammonia nitrogen (TAN) values were based on laboratory conditions at the EPA where the regulations were developed. Chronic toxicity values were derived by the EPA at a pH of 8.5 and temperature of 28 Celsius. When corrected for actual conditions in the Guadalupe River, these TAN toxicity values are different.

> Response: We agree with the reviewer and appreciate their thorough explanation of this methodological issue. Per their recommendations, we have updated the recovery plan's presentation of these values to reflect anticipated TAN values associated with observed instream conditions in the Guadalupe River.

Comment: Reviewers suggested we add additional information regarding stretches of river in the Guadalupe River basin that undergo frequent very low or no flow (dry) periods.

> Response: We agree this information is pertinent and have added this to the discussion of population health.

Comment: Multiple reviewers provided citations and requested our discussion in the Altered Hydrology section be revised. Specifically, these revisions should address extreme low and high flow conditions in which severe sediment deposition or bed scour occur. These events are likely to significantly impact mussel communities. Suggestions were also made to provide context of the duration and frequency of these conditions in relation to the species' generation time.

Response: This section has been revised to incorporate these recommendations, and updated scientific literature has been incorporated.

Comment: A reviewer requested we bolster the discussion surrounding limiting factors that will need to be addressed prior to population augmentation or translocations at specific management units.

Response: We added information where appropriate throughout the Management Unit section and elsewhere in the recovery plan.

Comment: Several reviewers questioned the methodology regarding how management units were delineated. More specifically, we received multiple comments regarding why tributaries or stream areas are included that have not been confirmed to historically support False Spike populations.

Response: The Management Units are defined using TCEQ river segments, which were developed prior to the development of this recovery plan and rightfully without consideration for our current usage of them. We utilize these existing TCEQ river segments given their standardization statewide. In an effort to standardize the MUs across listed mussel species in Texas with the goal of avoiding naming confusion across recovery plans, it is expected that portions of individual MUs may include some stream reaches or tributaries that 1) do not include current or historical records of a listed species, 2) contain widely variable instream habitat types across the MU, or 3) do not contain suitable instream habitats throughout all portions of the MU identified for an individual species. As such, recovery efforts within an identified MU will focus on appropriate instream habitats that are currently or historically occupied by the covered species and contain the necessary habitat characteristics to support that species and those recovery activities.

We have revised the text of the methodology section for the Management Units and hope to provide clarity.

Comment: A reviewer requested additional information for the rationale for the identified target observed density stated in Criterion 1; specifically, whether the target density was based on survey data for the species.

Response: Because targeted, quantitative freshwater surveys were not common for the False Spike prior to the listing of the species as state-threatened by the Texas Parks and Wildlife Department, no density information is available for a healthy population of the species. Therefore, the USFWS utilized survey data from stable populations of congener species, such as *Fusconaia askewi,* to identify density targets for this recovery plan.

Comment: A reviewer commented that, per Dudding et al. 2020, the sub-adult threshold of 35mm used in Criterion 1 may be too high and may more accurately represent individuals closer to 4 years in age.

Response: In the study referenced by the reviewer, the authors state “The earliest age of reproduction for *F. mitchelli* was 5 y (shell length of 42 mm) …” Based upon the

reviewer's thought that the stated sub-adult threshold may be too high, and this statement in the referenced study that suggests the stated threshold may be too low, the USFWS has elected to use a threshold between these two differing statements and leave the current sub-adult threshold in place, as originally presented.

Comment: Multiple reviewers had questions and concerns pertaining to Criterion 2 as written in the draft recovery plan. Specifically, there was significant concern that, as written, the draft criterion was not measurable and did not provide a stand-alone metric. Multiple reviewers suggested we revise this criterion.

Response: We appreciate these critiques and agree with reviewers that specific, measurable flow recommendations are needed for False Spike recovery. Unfortunately, species-specific studies have not been completed, and environmental flow recommendations do not currently exist.

We have updated language in Criterion 2 and the Criteria 2 and 3 Justification to note that subsistence and base-flow rates have been studied as part of the Senate Bill 2 and Senate Bill 3 processes. These flows were admittedly not studied specifically for freshwater mussels; and we note that similar studies should be completed for this group and have included recovery actions to address these research needs.

We have also included the control points (locations where flow standards were developed as part of the Senate Bill 3 process) in the corresponding Management Units for the species. We have included these locations as suggested control points for future work as we believe it would be prudent to develop flow recommendations at locations where the currently exists for other faunal groups in the Guadalupe River basin.

Comment: Recovery Action 11 description is unclear.

Response: We have revised the language throughout this action to provide better clarity and support out intent.

Comment: Based on reviewer experience conducting various research projects, specifically those focused on flow and water physicochemical tolerance testing, several recovery action time and cost estimates are potentially too low (i.e., Recovery Actions 1 and 4).

Response: We have revised the cost estimates for these recovery actions, per values suggested by the reviewer, and incorporated these edits into the overall cost of species recovery.