Addendum to the Roosevelt Lake Habitat Conservation Plan, Gila and Maricopa Counties, Arizona

Submitted to:

U.S. Fish and Wildlife Service

Submitted by:

Salt River Project Agricultural Improvement and Power District

Prepared by:

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Addendum to the Roosevelt Lake Habitat Conservation Plan, Gila and Maricopa Counties, Arizona

SUBMITTED PURSUANT TO
SECTION 10(A)(1)(B) OF THE ENDANGERED SPECIES ACT

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Preface

The Salt River Project Agricultural Improvement and Power District (SRP) prepared the Roosevelt Lake Habitat Conservation Plan (RHCP) in December 2002 (herein called the "original RHCP"). In February 2003, the U.S. Fish and Wildlife Service (FWS) issued an Incidental Take Permit (ITP; Permit Number TE62371D-0) to SRP associated with and conditioned on implementation of the original RHCP. The ITP has an expiration date of February 27, 2053, unless otherwise amended or renewed prior to that date. Approximately 30 years of ITP authorization remain prior to this stated expiration date.

The original RHCP and ITP addressed SRP's continued operation of Modified Roosevelt Dam and Lake (Modified Roosevelt) within the designated conservation space (CS) of Roosevelt Lake. The CS is the space around Roosevelt Lake up to the 2,150.78-foot elevation contour (herein, approximated by the 2,151-foot elevation contour) where SRP may store water, and is also the permit area of the original RHCP and ITP. The ITP authorized incidental take of four bird species resulting from SRP's operation of Modified Roosevelt within the CS: southwestern willow flycatcher (flycatcher, *Empidonax traillii extimus*), western distinct population segment of yellow-billed cuckoo (cuckoo, *Coccyzus americanus*), Yuma Ridgway's rail[1] (rail, *Rallus obsoletus yumanensis*), and the bald eagle (*Haliaeetus leucocephalus*). Through this addendum and corresponding proposed amendments to the ITP, SRP seeks to expand incidental take coverage to include one newly listed species, SRP's operations of Modified Roosevelt within the flood control space (FCS), and additional permit areas, as outlined below. Under this addendum, SRP will continue to implement all of the conservation measures described in the original RHCP, as well as the measures prescribed by previous Endangered Species Act (ESA) Section 7 consultations between the U.S. Bureau of Reclamation (Reclamation) and the FWS that pertain to ongoing commitments adopted by the original RHCP.

Additionally, in this addendum, SRP seeks to restate and clarify the amount and extent of incidental take of bald eagles previously exempted or permitted through ESA Section 7 consultations associated with Reclamation's modifications of the original Roosevelt Dam, which included raising the dam 77 feet from 1989 to 1996. The incidental take authorized by these consultations, along with offsetting measures to conserve the species, were incorporated into the original RHCP analysis and its associated conservation program. However, the bald eagle is delisted and no longer protected by the ESA (FWS 2007a). The FWS also determined that the Sonoran Desert population of bald eagles is not a distinct population segment (FWS 2012a) and, thus, is not a listable taxonomic entity under the ESA. The bald eagle remains protected by the Bald and Golden Eagle Protection Act (BGEPA). Since approval of the original RHCP in 2003, the BGEPA implementing regulations have changed by, among other things, defining "disturb" and providing for incidental take permits (FWS 2007b, 2009, 2016a). The BGEPA implementing regulations provide that incidental take authorization under Section 10 of the ESA satisfies the permitting requirements of BGEPA (50 Code of Federal Regulations [CFR] 22.10[a]). Through this addendum, SRP seeks to restate and clarify the amount and extent of incidental take of bald eagles authorized under the original RHCP and ITP, consistent with the subsequently adopted regulatory definition of take under BGEPA. This addendum revises and consolidates the surrogate metrics that SRP and FWS will use to estimate and track incidental take of bald eagles arising from the covered activities, as expanded, for the remaining duration of the ITP. The revised surrogate metrics for incidental take of bald eagles address individual eagles, eggs, and eagle nests under BGEPA and the ESA (should the bald eagle become listed under the ESA in the future).

[1] After publication of the original RHCP, the rail species' name changed from Yuma clapper rail (*Rallus longirostris yumanensis*) to Yuma Ridgway's rail (*Rallus obsoletus yumanensis*) (FWS 2021f).

History of Roosevelt Dam Operations and Modifications

Reclamation completed construction of the original Roosevelt Dam in 1911. Water was first stored in the original conservation space (elevation 2,136 feet and below) in 1910. In an agreement with the Salt River Valley Water Users' Association (Association) dated September 6, 1917 (the 1917 contract), the United States turned over to and vested in the Association the authority to care for, operate, and maintain SRP facilities, of which Roosevelt Dam is an integral component. SRP continues to operate Roosevelt Dam, including subsequent modifications to the dam, pursuant to the 1917 contract and subsequent agreements with the United States.

From 1989 through early 1996, Reclamation undertook significant modifications to Roosevelt Dam to provide additional conservation storage capacity and to address flood control and concerns identified under the Reclamation Safety of Dams Act of 1978. The modified dam and lake (Modified Roosevelt) provided for additional water conservation, dam safety, and, for the first time, designated flood control space. SRP is responsible for operation of Modified Roosevelt, which involves the CS as well as the FCS. The FCS is the space between the top of the CS and the 2,174.87-foot elevation contour (herein, approximated by the 2,175-foot elevation contour). SRP's operation of Modified Roosevelt within the FCS is subject to criteria imposed by a 1997 Water Control Manual (WCM) issued by the U.S. Army Corps of Engineers (Corps) and a 1996 Water Control Agreement among the Corps, Reclamation, and SRP.

The original RHCP and ITP did not include SRP's operation of the FCS as a covered activity and did not include the FCS in the permit area. In 2003, at the time the ITP was issued, the FCS had not yet been used. Further, Reclamation's 1982, 1989, 1992, and 1995 Biological Assessments (Reclamation 1982, 1989, 1992; Reclamation and SWCA Environmental Consultants [SWCA] 1995) and associated Biological Opinions by FWS (FWS 1983, 1990a, 1993, 1996a) had already analyzed the effects of the development of the FCS, and its subsequent operation by SRP as prescribed by the 1997 WCM, on the listed species that were eventually covered by the RHCP. Because there were no new actions to analyze and no newly listed species or critical habitat in the FCS, additional incidental take coverage was not needed, and SRP elected not to include the FCS or FCS operations in the original RHCP. Consequently, in 2003, the activities covered in the original RHCP and ITP, and the associated permit area, were limited to the CS.

Unless expressly stated, the abbreviations, acronyms, and other defined terms used in the original RHCP have the same meaning in this addendum.

What this Addendum Covers

With this addendum, SRP amends the original RHCP and seeks a corresponding amendment of the ITP from the FWS. SRP proposes the following RHCP amendments that expand or restate and clarify the coverage of the ITP:

1. **Add the northern Mexican gartersnake (*Thamnophis eques megalops*; gartersnake) as a covered species.** The gartersnake became listed under the ESA as a threatened species in 2014, and is known to occur at Roosevelt Lake and along lower Tonto Creek (FWS 2014a). The gartersnake is likely to be incidentally taken by SRP's continued operation of Modified Roosevelt.
2. **Add SRP's current operation of the Modified Roosevelt FCS following the 1997 WCM as a covered activity.** Flood control operations occur when Roosevelt Lake elevations exceed the elevation of the CS and water enters the FCS. Estimates of Roosevelt Lake elevations suggest that flood control operations may become more frequent than observed in the past. These estimates are based on 106 years of historic inflow data and account for current operational parameters and

anticipated climate-related changes to regional precipitation and temperature (i.e., SRP's "Reservoir Planning Model"). Further, since 1995, when Reclamation issued its Biological Assessment addressing FCS operations, FWS has listed additional species and designated critical habitat for listed species within the FCS. This addendum evaluates the effects of FCS operations on these species and critical habitats.

3. **Add SRP's operation of the FCS under a planned deviation from the WCM as a covered activity.** SRP seeks a short-term exception to the WCM that would lengthen the time within which SRP must evacuate Roosevelt Lake from a portion of the FCS. While approval of the planned deviation requires federal action and take of listed species could be fully addressed through interagency consultation, SRP desires the regulatory assurances that are associated with incidental take permits. Consequently, SRP has included Modified Roosevelt FCS operations under the planned deviation in this addendum and seeks incidental take authorization through the ITP. This addendum evaluates the effects of implementing the deviation on all listed species covered by the RHCP.
4. **Add the FCS and a segment of lower Tonto Creek to the permit area of the RHCP.** The addition of new species and activities to the original RHCP expands the area in which incidental take may occur and where effects on listed species and designated critical habitats might occur.
5. **Restate and clarify the amount and extent of incidental take of bald eagles previously exempted or permitted at Modified Roosevelt.** The restatement of incidental take revises and consolidates the surrogate metrics that SRP and FWS will use to estimate and track incidental take of bald eagles arising from the covered activities, as expanded, for the remaining duration of the ITP. SRP has designed the revised surrogate metrics for incidental take of bald eagles to address both individuals and nests (i.e., unlike the ESA, the BGEPA extends protections directly to both individual eagles and eagle nests).

This addendum provides new or updated information, analysis, and commitments that are necessary to expand the coverage of the ITP as indicated above. Herein, SRP evaluates:

1. the effects of conservation storage operations in the CS on the gartersnake;
2. the effects of current flood control operations in the FCS on:
    a. the gartersnake and gartersnake critical habitat,
    b. the cuckoo and cuckoo critical habitat,
    c. the flycatcher and flycatcher critical habitat,
    d. the rail (this species lacks a critical habitat designation),
    e. the bald eagle, and
    f. unoccupied spikedace (*Meda fulgida*) critical habitat on Tonto Creek and Greenback Creek;
3. the effects of a planned deviation of flood control operations on all RHCP covered species and designated critical habitats overlapping the FCS; and
4. the effects on gartersnakes in lower Tonto Creek, upstream of the FCS, due to predation, competition, and wounding by nonnative predatory fish related to conservation storage and flood control operations.

The content of this addendum is presented in the order shown below. Where appropriate, subchapters (not shown here) address separately the content that is specific to each relevant combination of covered activity, permit area component, and species or critical habitat unit.

Chapter 1: Permit Areas and Covered Activities

Chapter 1 describes the covered activities and permit areas added to the original RHCP. Chapter 1 also includes important context for understanding the nature and extent of SRP's role and responsibility for the effects of nonnative predatory fish on the gartersnake.

Chapter 2: Species and Critical Habitats

Chapter 2 provides background and baseline information on the gartersnake for the entire permit area, and updated baseline information regarding the other covered species and designated critical habitats in the FCS and lower Tonto Creek.

Chapter 3: Effects of the Covered Activities

Chapter 3 evaluates the effects of the actions covered by this addendum, as described above.

Chapter 4: Incidental Take and Impacts of Take

Chapter 4 estimates the amount of incidental take and the impacts of the taking on the gartersnake arising from the covered activities using habitat surrogate metrics tailored to each part of the permit area (i.e., the CS, the FCS, and lower Tonto Creek). Chapter 4 also estimates take and the impacts of the taking on the flycatcher and cuckoo arising from the added covered activities for flood control operations, including current operations and operations under the planned deviation. SRP adapted the metrics used in the original RHCP for estimating take of the flycatcher and cuckoo to its flood control operations in the FCS. For the bald eagle, SRP established a set of surrogate metrics for incidental take that restate and clarify the amount and extent of take associated with the operation of Modified Roosevelt for the remainder of the ITP term.

Chapter 5: Northern Mexican Gartersnake Conservation Measures

Chapter 5 describes a conservation program for the gartersnake that seeks to suppress the abundance of nonnative fish in select, permanent pool habitat in lower Tonto Creek and to increase the availability of native gartersnake prey. Native gartersnake prey to be stocked into areas where nonnative fish have been suppressed may include appropriate native fish species and may also include native lowland leopard frogs, depending on availability of hatchery-reared species. The gartersnake conservation program is expected to fully offset the impacts of incidental take for each of the covered activities (i.e., conservation storage operations, current flood control operations, and the planned deviation of flood control operations) by addressing the primary threats to the species.

Chapter 6: Monitoring, Reporting, and Adaptive Management

Chapter 6 describes monitoring, reporting, and adaptive management measures for the gartersnake. The monitoring and reporting measures will help SRP and the FWS ensure that take has not been exceeded and that conservation measures are implemented as proposed. Adaptive management will involve annual coordination with the FWS to refine annual management decisions and propose responses to identified adaptive management triggers. In this chapter, SRP also revises its bald eagle monitoring and reporting activities.

Chapter 7: Changed Circumstances

Chapter 7 identifies three Changed Circumstances related to the gartersnake and describes appropriate responsive actions. Chapter 7 also identifies Changed Circumstances related to the bald eagle and describes appropriate responsive actions. SRP must implement the responsive actions when a Changed Circumstance is triggered to maintain the assurances provided by the No Surprises Rule (FWS and National Marine Fisheries Service [NMFS] 1998).

Chapter 8: Budget Estimates

Chapter 8 describes the funds and labor needed to implement the conservation measures; monitoring, reporting, and adaptive management measures; and Changed Circumstances described in this addendum, with a reasonable allowance for contingencies.

Chapter 9: Alternatives to the Taking

Chapter 9 incorporates by reference the original RHCP's detailed explanation of the reasons why a modification to existing conservation storage operations was rejected as an alternative to the taking. Chapter 9 also describes why modifying current flood control operations and why not pursuing the planned deviation of flood control operations are rejected as alternatives to the taking.

Chapter 10: Permit and Implementing Agreement Amendments

Chapter 10 outlines the proposed changes to the ITP and Implementing Agreement.

Chapter 11: Literature Cited

Chapter 11 lists the scientific and technical information sources referenced in this addendum.

What this Addendum Does Not Cover

This addendum is supplemental to the original content of the RHCP and does not replace any of the original RHCP content unless expressly stated herein. SRP is not seeking to amend any aspect of its current ITP authorizations for the flycatcher, cuckoo, or rail that arise from its operations of Modified Roosevelt in the CS. The effects of operations in the CS on the flycatcher, cuckoo, and rail are fully addressed by the original RHCP and ITP. SRP has been implementing the conservation program of the RHCP and abiding by the terms and conditions of the ITP since issuance in 2003. Given this track record and assuming that SRP continues to faithfully implement the RHCP and ITP for the remainder of the ITP permit term, SRP expects to rely on the regulatory assurances of the No Surprises Rule (50 CFR 17.22(b)(5) and 17.32(b)(5)) with respect to incidental take of the covered bird species, including the bald eagle, arising from operations in the CS. These assurances are set forth, in their entirety, in the ITP.

SRP's implementation of the planned deviation of FCS operations is conditioned upon and requires the prior approval of the Corps. The request for deviation shall be made by SRP after consultation with Reclamation.[2] The Corps' decision whether to approve or deny SRP's request for a planned deviation is a federal agency action subject to consultation with the FWS pursuant to ESA Section 7(a)(2). This addendum does not address the Corps' decision, which will be evaluated in the context of a consultation under Section 7(a)(2). Rather, this addendum (and the proposed ITP amendment) would cover the incidental taking of listed species resulting from SRP's implementation of the planned deviation, only in the event approval is granted. If approval is not granted, SRP will not implement the deviation.

[2] 1996 Water Control Agreement, Paragraph 7 ("Any deviations from the approved Water Control Plan other than for emergencies, as stated above, shall be approved by the COE [U.S. Army Corps of Engineers] prior to the action being taken. The request for deviation shall be made by SRP after consultation with the USBR [U.S. Bureau of Reclamation]."). See also WCM, paragraph 7-14c (Prior approval for planned deviations "must be obtained from the COE." [U.S. Army Corps of Engineers 1997]).

List of Acronyms and Abbreviations Used in this Document

Term, Abbreviation, or Acronym	**Definition or Word or Phrase**
°C	degrees Celsius
°F	degrees Fahrenheit
ADEQ	Arizona Department of Environmental Quality
AGFD	Arizona Game and Fish Department
amsl	above mean sea level
Association	Salt River Valley Water Users' Association
BGEPA	Bald and Golden Eagle Protection Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm	centimeter(s)
Corps	U.S. Army Corps of Engineers
current flood control operations	Salt River Project's operation of the Modified Roosevelt flood control space following the 1997 Water Control Manual
conservation space	Roosevelt Lake basin up to 2,151 feet amsl elevation
covered activities	conservation storage operations; current flood control space operations following the Water Control Manual; planned deviation of flood control space operations
CS	conservation space (Roosevelt Lake basin up to 2,151 feet amsl elevation)
cuckoo	yellow-billed cuckoo (*Coccyzus americanus*)
EcoPlan	EcoPlan Associates, Inc.
ERO	ERO Resources Corporation
ESA	Endangered Species Act
FCS	flood control space (Roosevelt Lake basin between 2,151 and 2,175 feet amsl elevation)
flycatcher	southwestern willow flycatcher (*Empidonax traillii extimus*)
FWS	U.S. Fish and Wildlife Service
gartersnake	northern Mexican gartersnake (*Thamnophis eques megalops*)
GEI	GEI Consultants, Inc.
HCP	Habitat Conservation Plan
HCP Handbook	*Habitat Conservation Planning and Incidental Take Permit Processing Handbook* (FWS and NMFS 2016)

Term, Abbreviation, or Acronym	**Definition or Word or Phrase**
ITP	Incidental Take Permit
lake	Roosevelt Lake
lake elevation	water surface elevation of Roosevelt Lake
m	meter(s)
mm	millimeter(s)
Modified Roosevelt	Roosevelt Dam and Lake as modified by construction in the 1990s
NAD	North American Datum
NAIP	National Agriculture Imagery Program
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
PBF	physical or biological feature
PCE	primary constituent element
rail	Yuma Ridgway's rail (*Rallus obsoletus yumanensis*)
Reclamation	U.S. Bureau of Reclamation
RPM	Reservoir Planning Model
RHCP	Roosevelt Lake Habitat Conservation Plan
Salt Arm	Salt River arm of Roosevelt Lake
SFRA	Dingell-Johnson Sport Fish Restoration Act of 1950
SRP	Salt River Project Agricultural Improvement and Power District
SRPSIM	Salt River Project Simulation Model
SWCA	SWCA Environmental Consultants
Tonto Arm	Tonto Creek arm of Roosevelt Lake
USC	United States Code
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
Verde Reservoirs	Horseshoe and Bartlett Reservoirs on the Verde River
VES	visual encounter survey
WCM	Water Control Manual
WSFR	Wildlife and Sport Fish Restoration Program

Table of Contents

Appendices

Figures

Tables

Chapter 1. Permit Areas and Covered Activities

This chapter describes the permit areas and covered activities added to Salt River Project Agricultural Improvement and Power District's (SRP's) Roosevelt Lake Habitat Conservation Plan (RHCP). This chapter also describes SRP's Reservoir Planning Model and contains important context for understanding the nature and extent of SRP's role and responsibility for the effects of nonnative predatory fish on the northern Mexican gartersnake (*Thamnophis eques megalops*; gartersnake).

As described in the original RHCP (SRP 2002) and for general background context, SRP optimizes the operation of the Modified Roosevelt Dam and Lake (Modified Roosevelt) consistent with its original purpose as a water storage and power generation facility. SRP operates Modified Roosevelt in accordance with the September 6, 1917 Agreement between SRP and the United States, and the Modified Roosevelt Dam Operating Agreement among SRP, U.S. Bureau of Reclamation (Reclamation), Flood Control District of Maricopa County, and various Arizona cities, dated December 14, 1993 (Modified Roosevelt Dam Operating Agreement).[3] SRP operations, within the Roosevelt Lake flood control space (FCS) and Safety of Dams surcharge space,[4] are performed in accordance with the 1996 Water Control Agreement among the U.S. Army Corps of Engineers (Corps), Reclamation, and SRP, and the Water Control Manual for Modified Theodore Roosevelt Dam (WCM) issued by the Corps in 1997 (Corps 1997). SRP, Reclamation, and the Corps entered into a Water Control Agreement dated November 5, 1996, under which these parties agreed that SRP, while operating Modified Roosevelt, would comply with the flood control operating criteria contained in the WCM. The Modified Roosevelt Dam Operating Agreement is intended to minimize the spill of water past Granite Reef Diversion Dam and (together with the WCM and Water Control Agreement, further described in Subchapter 1.D) aims to minimize downstream flood damage from the Salt and Verde Rivers.

While Roosevelt Lake elevations rise within the conservation space (CS) and water physically occupies the FCS, SRP is operating the Salt River reservoir system under spill conditions as described in the Modified Roosevelt Dam Operating Agreement (see Sections 7.4 and 7.6 of the Modified Roosevelt Dam Operating Agreement). During spill conditions, water may or may not physically spill over Granite Reef Diversion Dam or from spillways on the Salt River dams, depending on whether inflows on the Verde River and the lower Salt River reservoirs (Saguaro Lake, Canyon Lake, and Apache Lake) exceed available storage and SRP deliveries at Granite Reef Diversion Dam.

A. Expanded Permit Area

The original RHCP permit area included only the CS, which includes the "SRP Conservation Storage" and the "New Conservation Storage" zones shown on Figure 1. The upper elevation of the CS is at elevation 2,150.78 feet above mean sea level (amsl).[5] For the purposes of discussion in this addendum, the top of the CS is simplified to 2,151 feet amsl. This addendum expands the original RHCP permit area to also include 1) the Roosevelt Lake FCS, and 2) a portion of lower Tonto Creek from the top of the FCS upstream to the crossing of East del Chi Drive. Figure 2 depicts the boundaries of the CS, the FCS, and the lower Tonto Creek permit areas.

[3] These agreements are summarized in detail in the original RHCP, pp. 13–16, and in Appendix D to this addendum.

[4] The storage space at Roosevelt Dam above 2,175 feet amsl to top of dam (2,218 feet amsl) is commonly referred to as Safety of Dams space, as shown in Figure 1. Above elevation 2,175 feet amsl, dam safety becomes the prime objective and operations shift to passing as much water as possible from the surcharge pool. This space is referred to as surcharge space within the WCM and other documents and will therefore be referenced as surcharge space going forward within this document.

[5] The actual CS elevation contour is the 2,150.78-foot elevation contour and the actual FCS elevation contour is the 2,174.87-foot elevation contour; however, for the purposes of this addendum and for simplicity, they are referred to as 2,151 and 2,175 feet, respectively, throughout this document and in the analysis.

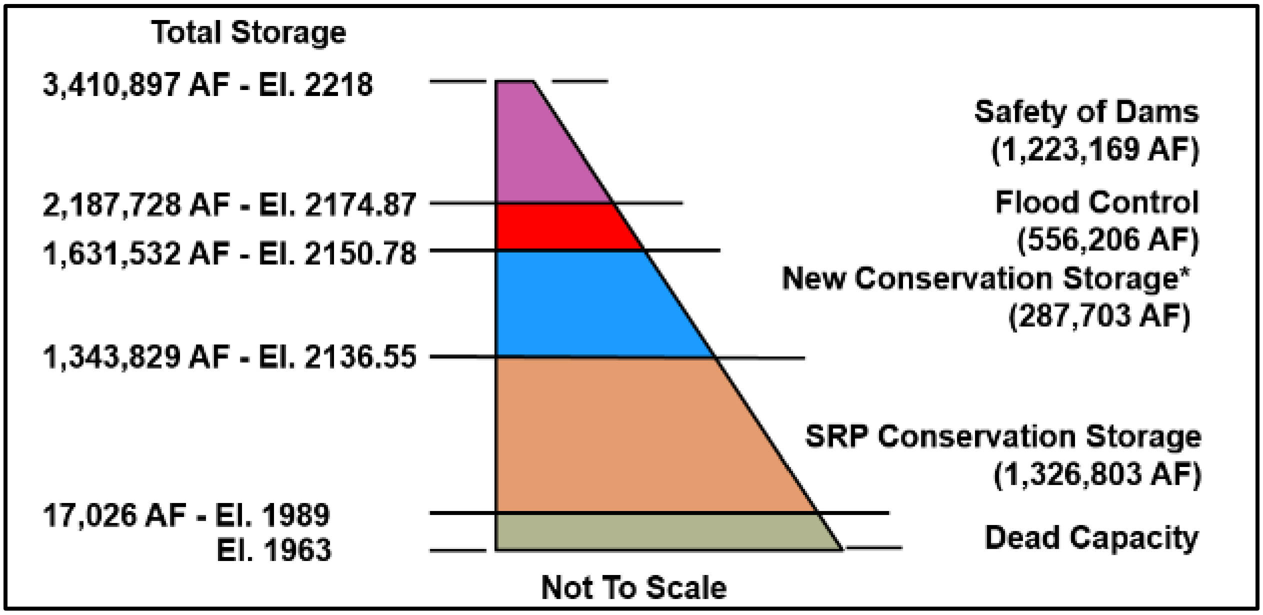

Figure 1. Delineated storage spaces within the Roosevelt Lake basin by elevation in feet amsl. The elevation limits bounding each storage space are rounded to the nearest whole foot in the text for simplicity. Also shown are the storage capacities of each storage area in acre-feet (AF).

The FCS is the zone around Roosevelt Lake that includes the area between the 2,151-foot elevation contour to the 2,174.87-foot elevation contour (see Figure 1). For simplicity, the top of the FCS is referenced as 2,175 feet amsl. The FCS covers an elevation change of approximately 24 vertical feet and a planar area of approximately 3,595.9 acres. SRP's flood control operations, which may occur more frequently than previously estimated in the original RHCP, temporarily inundate some or all of the FCS. Additional detail regarding flood control operations is provided in Subchapter 1.D.

The Safety of Dams surcharge space for Roosevelt Lake includes the elevations from 2,175 to 2,218 feet (see Figure 1) and is reserved for spillway surcharge with the prime objective of dam safety.[6]
The surcharge space is not included in the expanded RHCP permit area, except where it overlaps with lower Tonto Creek as described in the following paragraph.

[6] The storage space at Roosevelt Dam above 2,175 feet amsl to top of dam (2,218 feet amsl) is commonly referred to as Safety of Dams space, also referred to as surcharge space within the WCM and other documents and will therefore be referenced as surcharge space going forward within this document (see footnote #4).

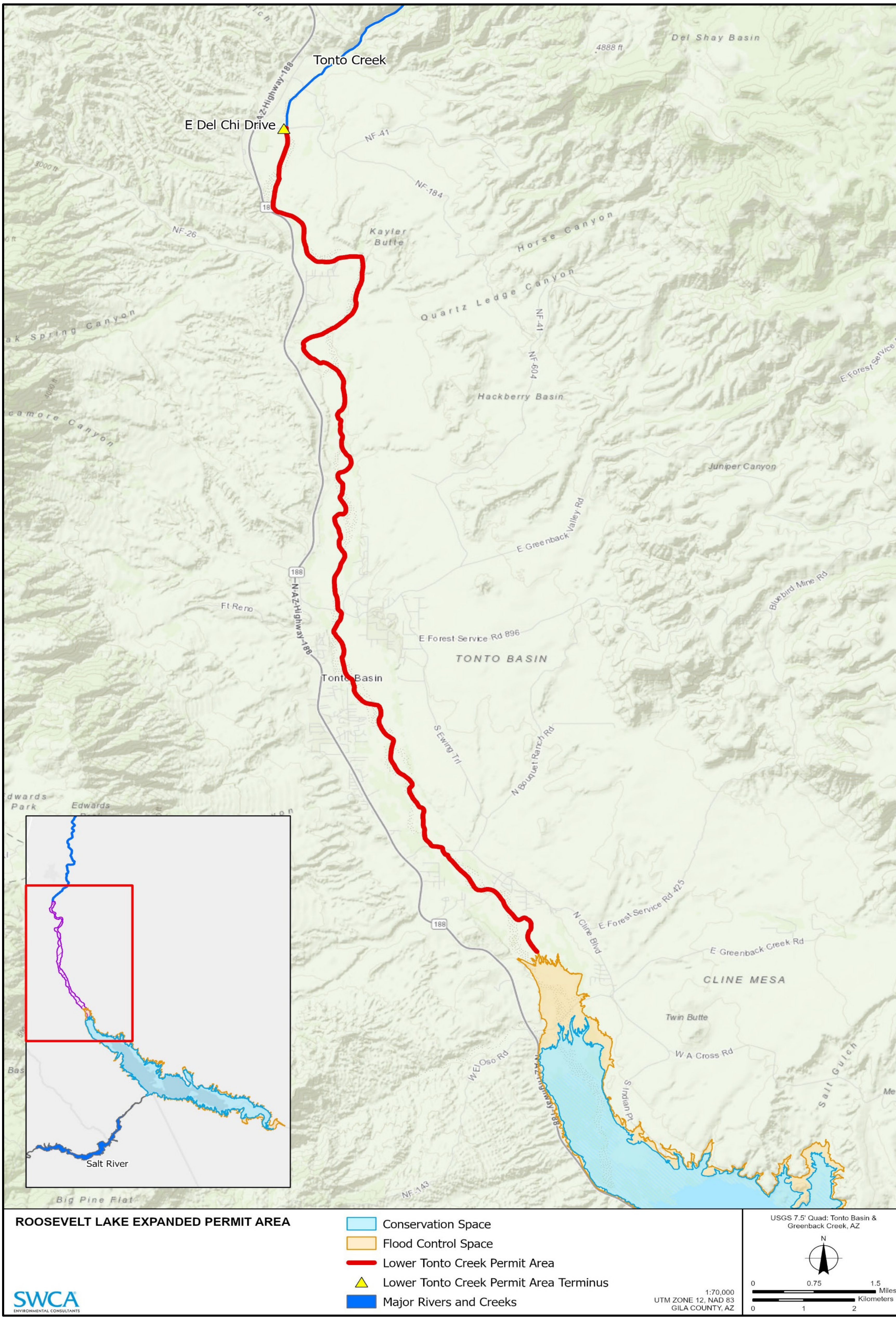

Figure 2. Geographical boundaries of the CS, the FCS, and the lower Tonto Creek permit area.

The lower Tonto Creek portion of the permit area extends approximately 14.1 river miles upstream from the top of the FCS. The lower Tonto Creek permit area extension is only connected to SRP's covered activities involving conservation storage operations at Modified Roosevelt, which occur within the CS. The lower Tonto Creek permit area extension is not related to SRP's covered activities involving flood control operations in the FCS, under current operations or under the planned deviation. SRP's storage of water in the CS provides consistent aquatic habitat for nonnative fish to persist in Roosevelt Lake. Unlike conservation storage operations, SRP's flood control operations involve actions that release water from Modified Roosevelt and not actions that store water. Therefore, SRP's flood control operations in the FCS, whether under current operations or the planned deviation, do not create or contribute to the presence of consistent aquatic habitat for nonnative fish in the FCS, as Roosevelt Lake is only temporarily in the FCS. Regardless of flood control operations, nonnative fish may enter the FCS as a result of Tonto Creek flow, which is a condition not attributable to SRP's actions; creek flows are not controlled by SRP. Outside of the CS and FCS, SRP's covered activities are not reasonably certain to take any listed species besides the gartersnake. Therefore, the lower Tonto Creek extension of the permit area is defined in relation to the portion of lower Tonto Creek that is likely to be affected by SRP's conservation storage activities within the CS.

B. Reservoir Planning Model

SRP maintains a record of monthly and daily inflows to Roosevelt Lake that covers an approximate 106-year time span from 1914 to 2019. SRP uses this historic inflow data to simulate Roosevelt Lake elevations that help plan for future operations. For the purpose of this RHCP addendum, SRP combined the historic inflow data with 1) operational parameters for storing and releasing water from Modified Roosevelt, and 2) adjustments for climate-related changes to regional precipitation and temperature, to create a 106-year scenario of lake elevations that approximates the range of potential future conditions (the "Reservoir Planning Model"; SRP 2022; Appendix A). SRP's Reservoir Planning Model estimates Roosevelt Lake elevations for conservation storage operations and flood control operations. In 2016, SRP's Reservoir Planning Model replaced the Salt River Project Simulation Model (SRPSIM) model as SRP's main operational planning tool for estimating future reservoir conditions. Because of this, the SRP Reservoir Planning Model is used for the analysis in this addendum. The Reservoir Planning Model uses the same assumptions and methods for modeling Roosevelt Lake as the previous SRPSIM model but is updated with modern coding/software, user interface, and current operations.

SRP generated two scenarios using the Reservoir Planning Model: one that addresses current FCS operations following the WCM, and another that addresses the increased 120-day evacuation period of the planned deviation for flood control operations. In both scenarios, the model outputs for the CS are the same; only the simulated lake elevations in the FCS differ based on the prescriptions for evacuating water from the FCS. The Reservoir Planning Model is run on a daily timestep to ensure accuracy of estimates within the FCS due to the shorter duration of flood control operations (<20 days). The daily output of the model represents the best available information with which to estimate Roosevelt Lake elevations within the CS and FCS. For the purposes of habitat modeling and other analysis for the RHCP addendum, the daily outputs from the Reservoir Planning Model were also consolidated to monthly values using the end-of-month daily value for the CS and the maximum-of-month daily value for the FCS. Appendix B provides the monthly estimates of peak lake elevation under each scenario and a summary of estimated lake elevations in June of each model year. SRP applies the monthly data to describing the effects of flood operations and the yearly June data to describing the effects of CS operations.

The Reservoir Planning Model provides a basis for estimating the frequency, magnitude, duration, and timing of changes to the elevation of Roosevelt Lake resulting from SRP's continued operation of Modified Roosevelt.

C. Conservation Storage Operations

SRP is not proposing any changes to its conservation storage operations at Modified Roosevelt. Conservation storage operations are described in the original RHCP, as are the effects of conservation storage operations on the original set of covered species (SRP 2002). SRP is amending the original RHCP to address the effects of conservation storage operations on the gartersnake, which was listed after SRP entered into the RHCP. A summary of conservation storage operations potentially affecting the gartersnake is included here for context.

As described in the original RHCP, SRP implements conservation storage activities in accordance with the Modified Roosevelt Dam Operating Agreement, which specifies the following priorities (in order of priority):

1. Maintain the safety and integrity of the dam.
2. Maintain sufficient SRP storage to meet SRP water delivery obligations.
3. Optimize Roosevelt Lake storage for SRP use within the SRP reservoir system.
4. Maintain adequate SRP carryover storage for following years in case of low runoff.
5. Conjunctively manage groundwater pumping given Roosevelt Lake storage and projected runoff and demand.
6. Maximize hydrogeneration.
7. Operate to permit necessary facility maintenance.

SRP's conservation storage activities change the elevation of Roosevelt Lake within the CS, such that the lake elevation is continuously rising or falling. The lake elevation typically rises between November and April and typically falls between May and October. There is variation in the timing and magnitude of rises and falls, with most variation seen during the months of April and May. Roosevelt Lake elevations may start declining as early as March following a dry winter or may continue to rise into May following a wet winter. The duration and magnitude of lake elevation rises are in part associated with snowmelt and rainfall runoff on the watershed and the transition of SRP water deliveries among its reservoir systems. The duration and magnitude of lake elevation falls are in part associated with SRP's water deliveries from Roosevelt Lake and evaporation.

The Reservoir Planning Model estimates Roosevelt Lake elevations under the conditions evaluated in the model. Figure 3 illustrates how lake elevation may change within a given model year. The typical timing of lake elevation changes described above is illustrated in the monthly output of the Reservoir Planning Model.

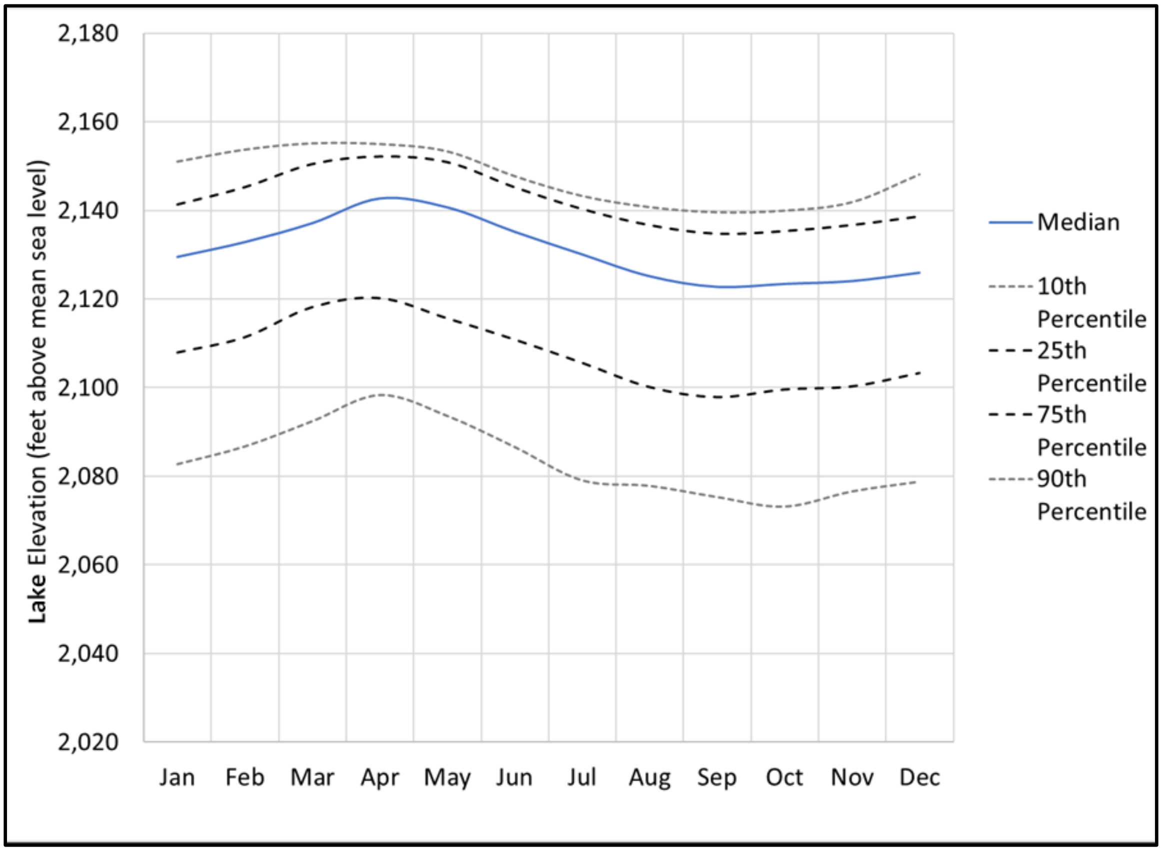

Figure 3. Estimated range of intra-annual lake elevation changes, by month.

Figure 4 shows the simulated year-to-year variation in lake elevations on June 30 of each model year (does not include any anticipated FCS operations). In June, the lake elevation has typically begun to decline from its winter peak. SRP chose June as the month with which to describe these changes to best coincide with the timing of other information pertinent to the analysis of effects on the gartersnake (see Subchapter 4.B.ii for more discussion).

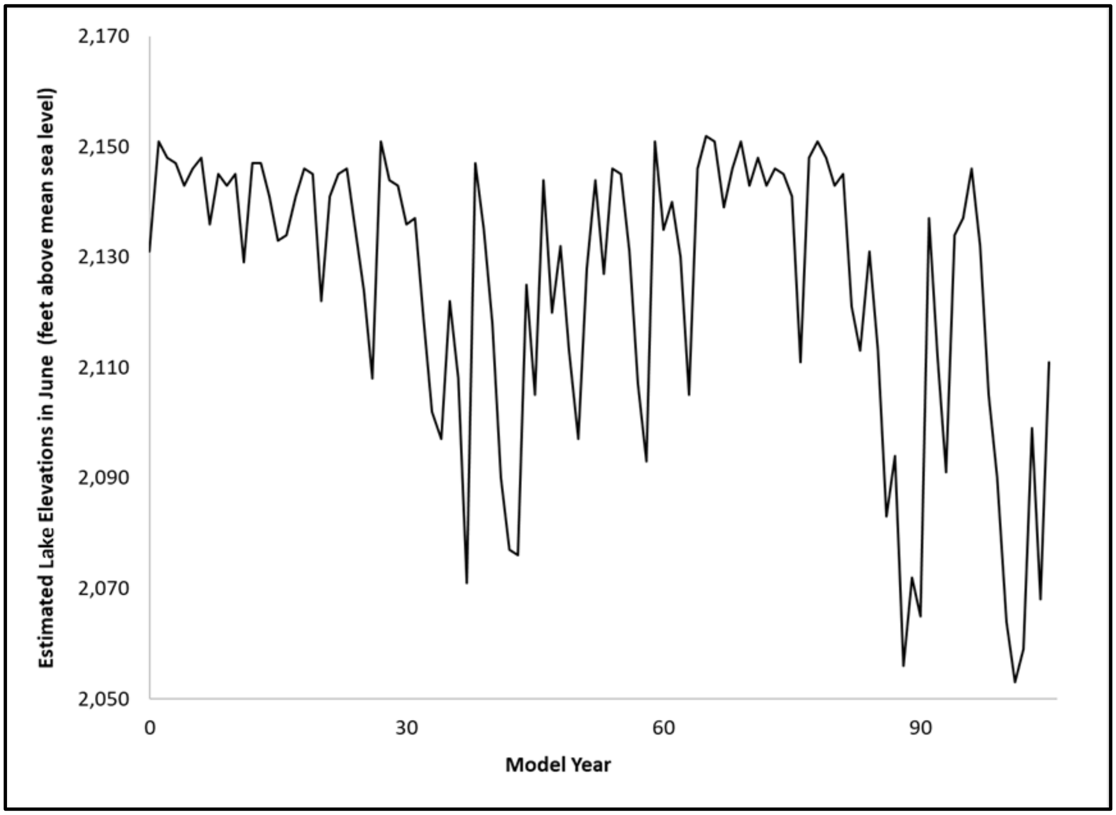

Figure 4. Year-to-year variation in lake elevations in each model year as of June 30.

The simulated variations in lake elevations can be categorized into changes that are typical, atypical, and extreme. Table 1 summarizes the estimated lake elevation changes that would occur in the CS within years (by month, represented by the end of the month value) and between years (using June 30 data as the basis for the annual elevation). The table shows the magnitude and duration of estimated lake elevation changes. The general categories—typical, atypical, and extreme—convey the frequency of occurrence of these categories of lake elevation changes, based on their percentiles in the Reservoir Planning Model.

Typical daily changes in estimated lake elevations are small (0.2 vertical foot per day; 25 horizontal feet per day or about 1 horizontal foot per hour). Over several months, the estimated lake elevation changes accumulate to result in moderate changes of approximately 20 to 30 vertical feet (see Figure 3 and Table 1). The 20-foot to 30-foot vertical change equates to approximately 3,000 to 4,500 feet of horizontal movement of the lake edge.

Estimated atypical lake elevation changes may occur that are of greater magnitude, exceeding 30 vertical feet, or have faster rates of change, as presented in Table 1. These atypical lake elevation changes occur at an estimated frequency of approximately once every 7 to 8 years. Atypical lake elevation changes are generally spread across several months within a calendar year, following the trends shown in Figure 3 and described in Table 1.

Table 1. General categories of estimated lake elevation changes based on their magnitude, duration, and frequency of occurrence.

		Rise			Fall		
Frequency of Occurrence		**Common (75th percentile)**	**Occasional (90th percentile)**	**Rare (99th percentile)**	**Common (75th percentile)**	**Occasional (90th percentile)**	**Rare (99th percentile)**
General Categories		**Typical**	**Atypical**	**Extreme**	**Typical**	**Atypical**	**Extreme**
Intra-annual	Magnitude (feet)	20	40	80	20	30	40
	Duration (months)	6–7	7	8–9	6	7	9–10
Interannual	Magnitude (feet)	30	50	80	20	30	40
	Duration (years)	1–2	1–2	2–3	1–3	3–4	4–5

Notes:

Interannual changes are based on the differences in lake elevations on December 31 of each model year.

Intra-annual changes reflect the fluctuation in lake elevations that occur over the course of the fill and delivery seasons.

"Duration" refers to the number of consecutive years or months with rising lake elevations, or consecutive years or months with falling lake elevations. Note that duration percentile statistics are calculated independently of magnitude percentile statistics; for example, the 99th percentile magnitude of interannual rise (80 feet) does not necessarily occur during the 99th percentile run of back-to-back years with increases in lake elevation (which lasts 4 to 5 years in duration).

In even rarer instances (i.e., once every 18 to 19 years), the lake elevation may undergo an extreme change, exceeding 40 feet (see Table 1). These rare, extreme changes are more punctuated and are consequences of major weather events, such as exceptional precipitation events. Most of these extreme changes are the result of accumulated changes that take place over 4 to 10 months, though in some cases large increases can occur in just 1 to 2 months. These events tend to occur when the lake elevation is either exceptionally low (i.e., less than 2,100 feet amsl) or exceptionally high (i.e., 2,151 feet amsl). The lake elevation may also reach 2,151 feet amsl gradually through typical year-to-year accumulation, even though, within any year, the lake rises and falls following the annual pattern shown in Figure 3.

D. Flood Control Operations

i. Relevant Previous Consultation History

Previous consultation history related to Modified Roosevelt is summarized in Subchapters I.H, III.E.2.b, and III.C.2.b of the original RHCP (SRP 2002) and in the Reclamation-provided document entitled "Consultation History" (Appendix C).

ii. Current Flood Control Operations

SRP implements WCM prescriptions for releasing water from Modified Roosevelt when the lake elevation exceeds the limits of the CS. The purpose of flood control operations is to minimize downstream flood damages by reducing peak discharges that might otherwise occur during large flood events. The WCM specifies a schedule of minimum releases from Modified Roosevelt based on lake elevation and whether the lake elevation is rising or falling. The WCM requires that SRP manage releases such that the lake is returned to the limits of the CS within 20 days of first entering the FCS. Table 2 shows the minimum release rates at different lake elevation stages (in cubic feet per second [cfs], rounded to the nearest whole number), to meet the 20-day drawdown requirement when the lake is rising (inflows exceed outflows) and when it is falling (outflows exceed inflows). While the lake elevation is receding, additional minimum releases may be required to meet the 20-day drawdown requirement.

The WCM-prescribed releases (see Table 2) were designed by the Corps to evacuate the FCS within 20 days for a single event. In this reservoir system, however, there can be continued higher runoff from several back-to-back storms, or during peak snowmelt when inflows rise and fall daily. Such occurrences are not single inflow events, but multiple inflow events. Strict adherence to the prescriptions of the WCM for these scenarios creates circumstances where the lake elevation could remain within the FCS (at lower elevations within the FCS) for more than 20 days and/or only decrease to 2,152 feet at certain times before rising again. For these cases, SRP would use discretion (discretion-based operation) to release more than the prescribed minimum release identified by the WCM to draw down below FCS within 20 days. The decision to do this would be made on a case-by-case basis and would be dependent on runoff forecasts, time of year, and snowpack on the watershed, and would be used in most scenarios to meet the 20-day drawdown requirement.[7]

Table 2. Water Control Manual prescribed releases for Modified Roosevelt release plan (current flood control operations).

Lake Elevation—Rising (feet amsl)	Minimum Release Rate—Rising	Lake Elevation—Falling (feet amsl)	Minimum Release Rate—Falling
2,151–2,153	1,900 cfs	2,151–2,152	6,500 cfs
2,153–2,155	2,200 cfs		
2,155–2,157	6,500 cfs	2,152–2,157	12,200 cfs
2,157–2,162	12,200 cfs		
2,162–2,172	39,500 cfs	2,157–2,170	39,500 cfs
2,172–2,175	53,100 cfs	2,170–2,175	53,100 cfs

The original RHCP did not include SRP's flood control operations at Roosevelt Lake as a covered activity and did not include the FCS in the permit area. Reclamation's 1995 Biological Assessment (Reclamation and SWCA 1995) addressing the modifications to Roosevelt Dam considered the impact of flood control operations under the conditions ultimately imposed by the WCM. The 1995 Biological Assessment concluded that FCS operations for the 20-day period dictated by the WCM would not affect the southwestern willow flycatcher (flycatcher, *Empidonax traillii extimus*). The subsequent 1996 Biological Opinion (U.S. Fish and Wildlife Service [FWS] 1996a), which addressed Modified Roosevelt operations in their entirety, left undisturbed the 1995 Biological Assessment's conclusions regarding the effects of FCS operations on the flycatcher.

In 2003, at the time the Incidental Take Permit (ITP) was issued (FWS 2003), the FCS had not yet been used. Further, Reclamation's 1982, 1989, 1992, and 1995 Biological Assessments (Reclamation 1982, 1989, 1992; Reclamation and SWCA 1995) had already analyzed the effects of development of the FCS, and its subsequent operation by SRP, on the listed species eventually covered by the original RHCP. Because there were no new actions to analyze and no newly listed species or critical habitat in the FCS,

[7] In certain operational scenarios, SRP could seek Corps approval of an unplanned minor deviation to modify releases and/or extend beyond the 20-day drawdown period. Operational scenarios requiring an unplanned minor deviation could occur, for example, when: 1) a flood is being routed through the Horseshoe and Bartlett Reservoirs on the Verde River (Verde Reservoirs), and/or 2) local inflows on the Salt River below Roosevelt Dam are peaking and a minor deviation from the WCM would result in a reduction of the peak releases over Granite Reef Diversion Dam to protect resources downstream. Any such unplanned minor deviation scenarios are not included in this addendum, but, rather, would be based on analysis and subject to approval by the Corps at the time they occurred during actual FCS operations.

additional incidental take coverage was not needed, and SRP elected not to include the FCS or flood control operations in the original RHCP. The original RHCP covered activities and associated permit area, therefore, were limited to the CS.

Since then, the FWS listed two additional species that occupy portions of the FCS: the threatened yellow-billed cuckoo (cuckoo, *Coccyzus americanus*) and the threatened northern Mexican gartersnake. Additionally, the FWS has designated portions of the FCS as critical habitat for the flycatcher, the cuckoo, the gartersnake, and the endangered spikedace (*Meda fulgida*). The 1995 Biological Assessment (and the subsequent 1996 Biological Opinion [FWS 1996a]) did not address effects of flood control operations on these subsequently listed species and designated critical habitats.

Additionally, while the original RHCP Environmental Impact Statement (FWS 2002) described flood control operations as a federal responsibility subject to Endangered Species Act (ESA) Section 7, the Corp's 1997 WCM and the 1996 Water Control Agreement recognize that the responsibility for ongoing flood control operations has been delegated to SRP. With the issuance of the WCM, operation of the FCS was turned over to SRP, as prescribed by the 1996 Water Control Agreement, the 1917 contract, and subsequent agreements between SRP and Reclamation governing the operation of the Salt River Federal Reclamation Project and Modified Roosevelt. SRP continues to operate Modified Roosevelt, including the FCS, pursuant to the WCM and these agreements. Appendix D describes in greater detail the legal authorities governing operation of the FCS. This addendum incorporates into the RHCP an analysis of the effects of SRP's flood control operations under the WCM on listed species and designated critical habitats.

SRP also is responsible for surcharge space[4] (lake elevations between 2,175 and 2,218 feet amsl) operations under the 1997 WCM and the 1996 Water Control Agreement. SRP is not electing to include existing surcharge space operations as a covered activity because there is a low likelihood (1 in 10,000 for any given year) that such operations would occur over the remaining 30 years of the permit (see 1996 Environmental Assessment for the WCM [Reclamation 1996]; 1996 Biological Opinion [FWS 1996a]; 1995 Biological Assessment [Reclamation and SWCA 1995]). Further, SRP is not proposing any deviation or modification to existing operations of the surcharge space.

Since 2003,[8] Roosevelt Lake entered the FCS in two years: 2009 and 2010. Flood control operations occurred four times during these two years, with each event ending within 20 days of the lake entering the FCS. The lake did not rise more than 2 vertical feet into the FCS during these events, reaching a maximum elevation of 2,151.5 feet amsl in 2009 and 2,152.1 feet amsl in 2010. Figure 5 depicts the approximate change in lake elevation during FCS operations in 2009 and 2010.

[8] Roosevelt Lake entered the FCS on March 22, 2023, and increased up to an elevation of 2,155 feet amsl before beginning to decline with increased releases up to 6,500 cfs beginning at an elevation of 2,155 feet amsl in accordance with the WCM. At the time of this writing (March 30, 2023), Roosevelt Lake elevation was declining within the FCS in order to meet the 20-day drawdown period.

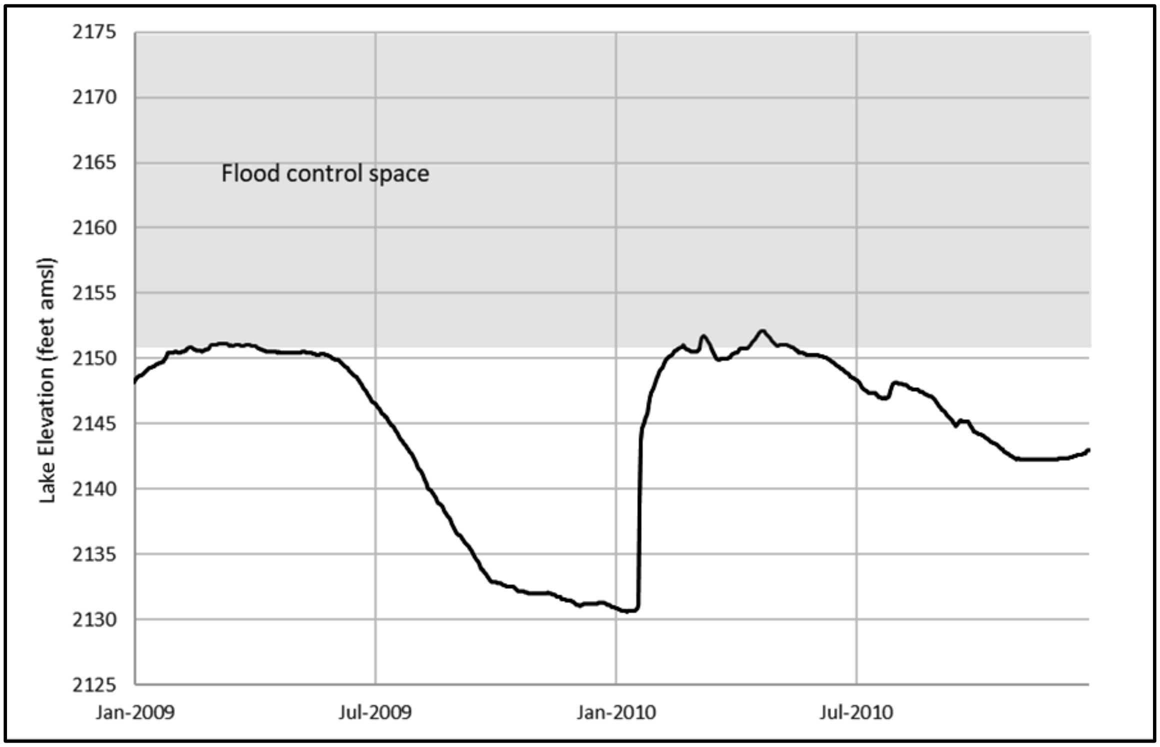

Figure 5. Actual Roosevelt Lake elevations in 2009–2010, with lake elevations entering the FCS.

The Reservoir Planning Model indicates that flood control operations may be more frequent in the future. The difference is due, in part, to the consideration of anticipated climate-related changes to regional precipitation and temperature, and in large part because modifications to Roosevelt Dam to add the FCS were only completed within the last 25 years, during a longer-term period of drought. The Reservoir Planning Model for current flood control operations indicates that the lake may enter the FCS in 37 of 106 years (35% of years in the Reservoir Planning Model) and require flood control operations in 143 of 1,272 months (11% of months in the Reservoir Planning Model). The hydrology of the Salt River occasionally results in multiple flood control operations in the same year, extending the duration in which the lake may be present in the FCS.

In Reservoir Planning Model years with flood control operations, the lake elevation is within the FCS for an average of 3.8 months, with a range of 1 to 8 months. The WCM requires evacuation of the FCS within 20 days, so results showing multi-month durations of FCS operations under the existing WCM are the result of 1) the occurrence of multiple runoff events (storms or snowmelt) resulting in multiple 20-day flood control operations occurring within weeks of each other, and/or 2) a single 20-day event occurring at the end of a month and lasting into the start of the next month. For a single 20-day event that straddles 2 months, it is not expected that the lake elevation would remain in the FCS for the entirety of both months. Of the 106 years modeled, 18% of the years have consecutive storm events that could result in inundation lasting longer than 20 days. In these instances, discretion-based operation would be used to release more than the minimum defined by the WCM to meet the 20--day drawdown. When taking into consideration 1) that the Reservoir Planning Model programming logic does not incorporate the operator discretion to increase releases above the required minimum to draw Roosevelt Lake below FCS within 20 days, and 2) the type of events that would be appropriate for requesting an unplanned minor deviation, the 18% of modeled years is reduced to less than 2% when using discretion-based operation.

Approximately 45% of the months with modeled flood control operations are in April and May, and 41% are in January, February, or March. The lake elevation during flood control operations varies quickly, since the WCM requires the evacuation of the FCS within 20 days. In months with flood control operations, the peak monthly lake elevation averages 2,154 feet amsl. The majority of monthly lake elevation peaks (93% of months with predicted flood control operations) are within the first 10 vertical feet of the FCS, up to the 2,161-foot elevation contour. Table 3 summarizes the duration, timing, and magnitude of predicted flood control operations for model years in which they occur. Rates of fill in the FCS reach about 0.5 vertical foot per day (about 3 feet per hour horizontal movement) under atypical conditions (90th percentile), with extreme events (99th percentile) reaching 4 vertical feet per day (about 25 feet per hour horizontal movement).

Table 3. Duration, timing, and magnitude of estimated flood control operations for model years in which they occur.

Model Year*	Number of Months with FCS Operations	Range of Months with FCS Operations	Range of Peak Monthly Lake Elevations (feet amsl)	Range of Peak Monthly Lake Rise into FCS (feet)
2	5	February–June	2,151–2,156	<1–5
3	5	January–May	2,151–2,174	<1–23
4	5	January–May	2,153–2,155	2–4
6	4	April–August	2,152–2,153	1–2
7	8	October–May	2,151–2,165	<1–14
9	4	February–May	2,151–2,155	<1–4
11	5	December–April	2,151–2,156	<1–5
13	1	May	2,152	1
14	4	February–May	2,152–2,155	1–4
19	4	January–April	2,151–2,162	<1–11
23	2	April–May	2,152–2,153	1–2
24	4	February–May	2,151–2,157	<1–6
28	5	February–June	2,151–2,166	<1–15
29	5	January–May	2,151–2,152	<1–1
30	2	April–May	2,151	<1–1
39	2	April–May	2,154–2,155	4
47	1	April	2,151	<1
53	6	December–May	2,151–2,155	<1–4
55	3	March–May	2,151–2,154	<1–3
56	1	April	2,152	2
60	4	March–June	2,151–2,157	1–7
65	3	March–May	2,151–2,155	<1–4
66	7	December–June	2,152–2,163	1–12
67	6	January–June	2,151–2,165	<1–14
69	2	April–May	2,151	<1
70	6	January–June	2,151–2,157	<1–6
71	7	October–April	2,151–2,153	<1–2
72	6	December–May	2,154–2,157	3–6

Model Year*	Number of Months with FCS Operations	Range of Months with FCS Operations	Range of Peak Monthly Lake Elevations (feet amsl)	Range of Peak Monthly Lake Rise into FCS (feet)
73	2	March–April	2,154–2,155	3–4
74	3	March–May	2,151–2,154	<1–3
75	2	April–May	2,153	2
78	2	April–May	2,152	1
79	5	February–June	2,151–2,155	<1–4
80	6	December–May	2,153–2,169	2–18
81	1	April	2,151	<1
82	3	February–April	2,152–2,157	1–6
97	2	April–May	2,154	3

* Based on water year (October–September)

E. Planned Deviation of Flood Control Operations

The WCM identifies instances for deviations from its defined flood operating plans in Section 7-14c. Since the WCM was finalized in 1997, total surface water use in central Arizona has grown outside of SRP's water service area, primarily from use of Colorado River supplies provided by the Central Arizona Project canal. Regional growth in water use, combined with the likelihood of reductions in availability of Colorado River water resulting from shortage conditions on the Colorado River, requires careful management of the water supplies available to central Arizona, including spill waters provided by flood events on the Salt River. Spill conditions occur when 1) the SRP Conservation Storage is full and lake elevations in the New Conservation Storage are rising as inflows into Modified Roosevelt exceed SRP deliveries out of Stewart Mountain Dam (resulting in virtual spill); or 2) when water enters the FCS (resulting in physical spill). Prior to the modifications to Roosevelt Dam, this water would have either been delivered as spill water or would have physically spilled over Granite Reef Diversion Dam. Increased operational flexibility within the FCS would allow for increased beneficial use of floodwaters, when available, through direct use or underground recharge for recovery during times of drought and shortage.

SRP proposes to implement a planned deviation from current flood control operations under the WCM. Implementation of any deviation requires the prior approval of the Corps. Requests for approval of the deviation, "shall be made by SRP after consultation with the USBR" (1996 Water Control Agreement, paragraph 7). The planned deviation would allow SRP to extend the duration in which it must evacuate the FCS from 20 days to 120 days for a single flood control event in a year. This planned deviation would only apply to the first 5 vertical feet of the FCS—i.e., between elevation contours 2,151 feet amsl and 2,156 feet amsl; the "planned deviation space"—and only in 3 years within a defined 5-year period. The planned deviation would allow for use starting January 1, 2024, and ending December 31, 2028. Current flood control operations would apply when the lake is above the 2,156-foot elevation contour, when the deviation period has expired, or when SRP has implemented these alternate flood control measures in 3 of the 5 years. Inundation during the planned deviation operations on the Salt River arm of Roosevelt Lake (Salt Arm) and the Tonto Creek arm of Roosevelt Lake (Tonto Arm) are depicted on Figure 6 and Figure 7.

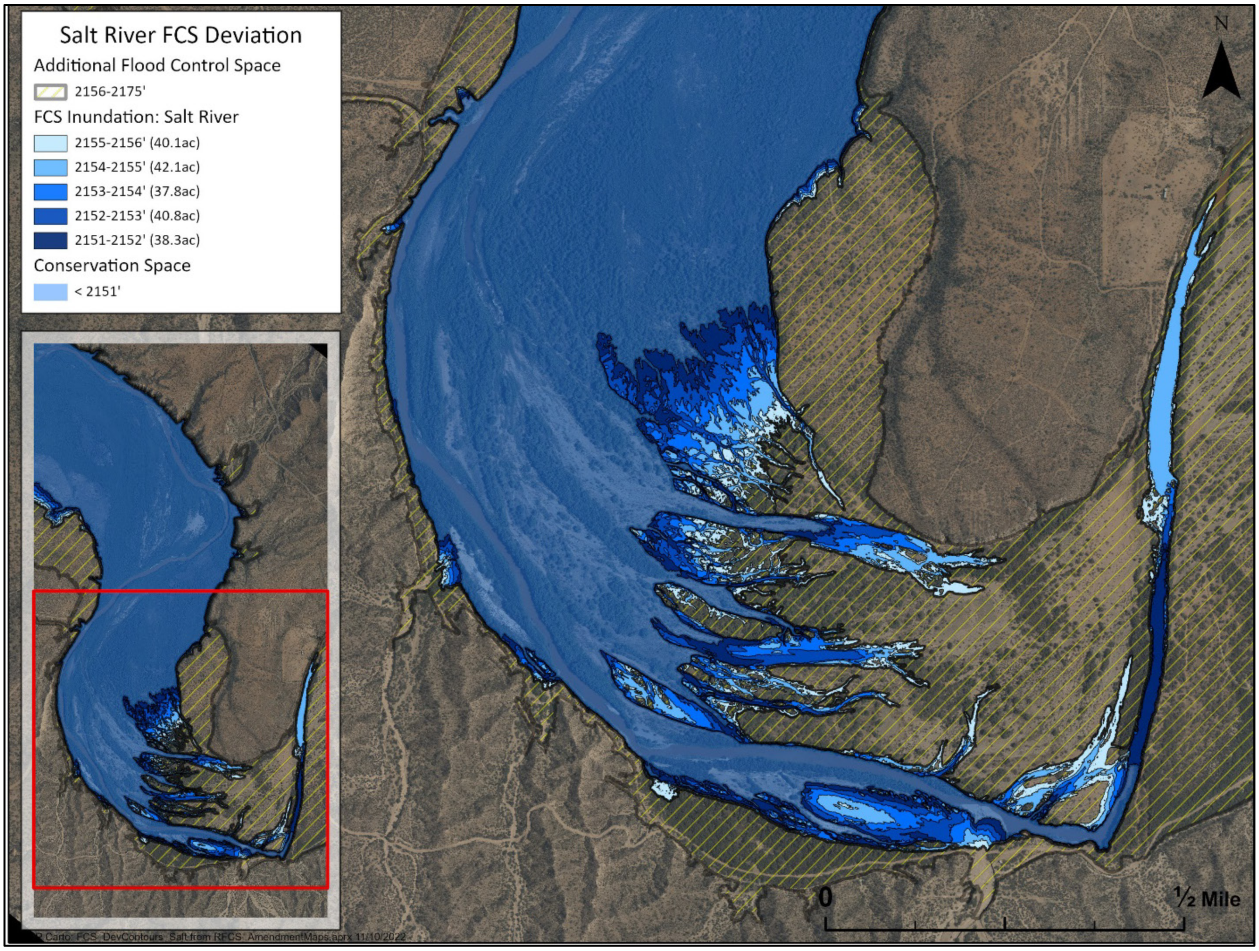

Figure 6. Inundation of the Salt Arm during planned deviation operations.

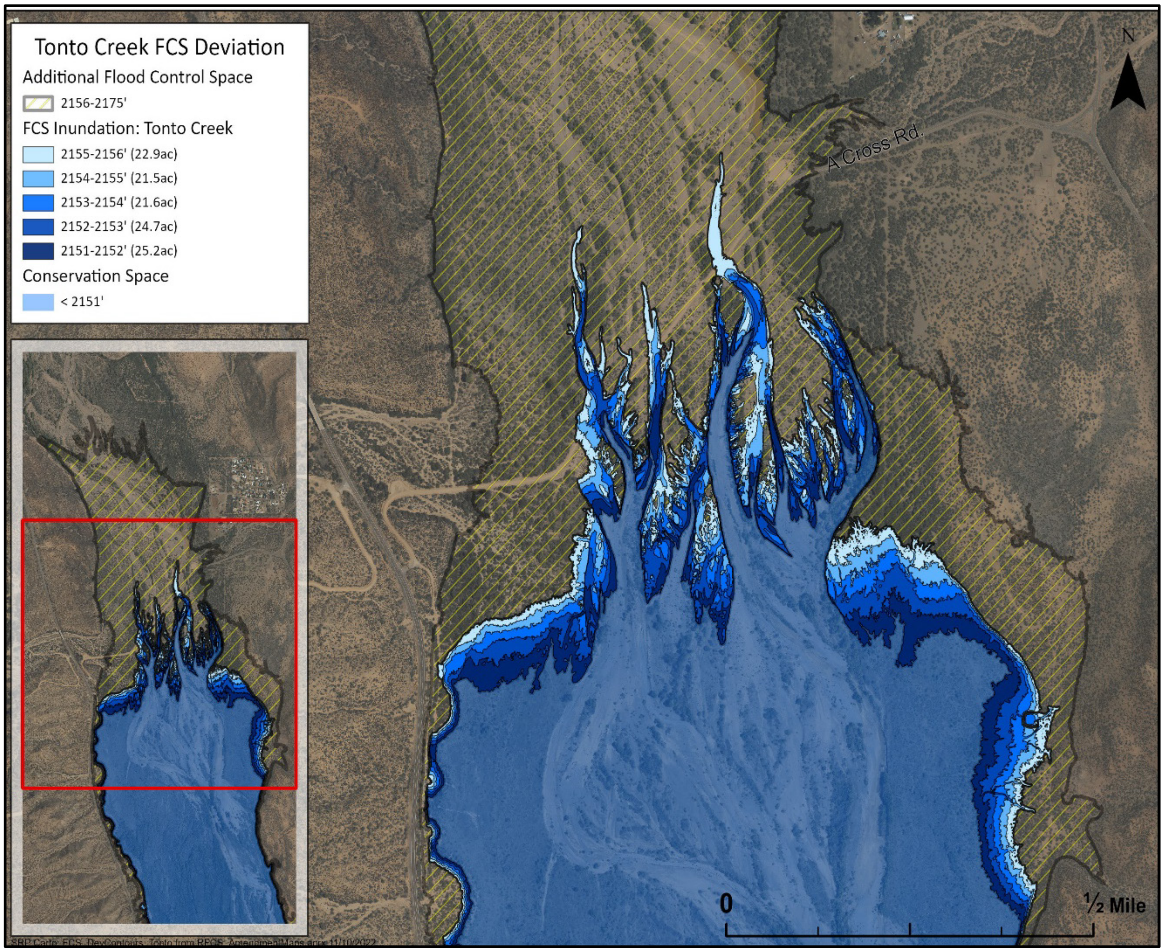

Figure 7. Inundation of the Tonto Arm during planned deviation operations.

Figure 8 is an illustration of an example water year (Water Year 2 of the Reservoir Planning Model simulation) showing the differences between operations in the FCS under the current WCM and under the planned deviation. Figure 9 is estimated Roosevelt Lake elevations for the same modeled events provided in Figure 8, but extended through the end of the calendar year. Figure 9 also includes an added time series that represents discretion-based operation (previously discussed in Subchapter 1.D.ii) that would be expected to be used to drawdown Roosevelt Lake below the FCS within 20 days during multiple back-to-back inflow events under the current WCM. The daily Reservoir Planning Model is programmed to operate Modified Roosevelt releases based on the WCM prescribed minimum release rates that are based on Roosevelt Lake elevations and whether the lake elevations are rising or falling while within the FCS (see Table 2), and does not account for operator discretion while in the FCS. However, the difference between the modeled WCM operations and discretion-based operations is minor. WCM operations typically cause Roosevelt Lake elevations to be a foot or two higher than discretion-based operations, and the difference is within the bottom 5 feet of the FCS. The discretion of the operator to increase releases above the stated WCM releases ensures that water is withdrawn from the FCS (below 2,150.78 feet) within the 20-day period prescribed under current operations. Similar illustrations for comparison of the current WCM and the planned deviation for the full 106-year period are provided in Appendix A, Sections 4.1 and 4.2.

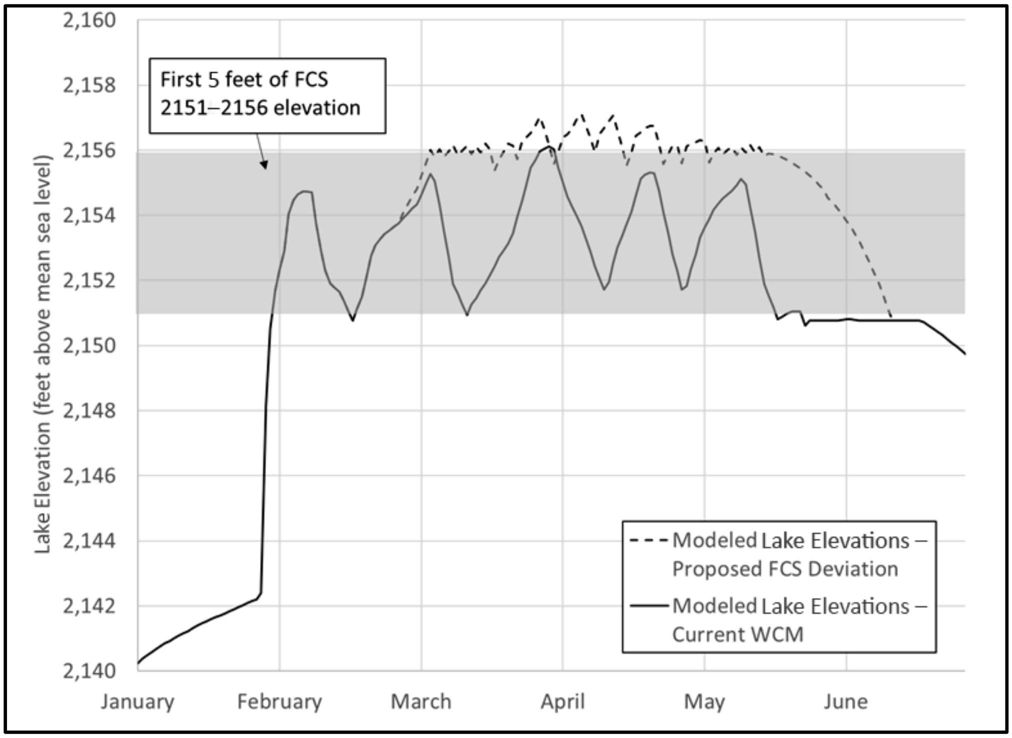

Figure 8. Example illustration of estimated Roosevelt Lake elevations under the current WCM and planned deviation for the planned deviation space.

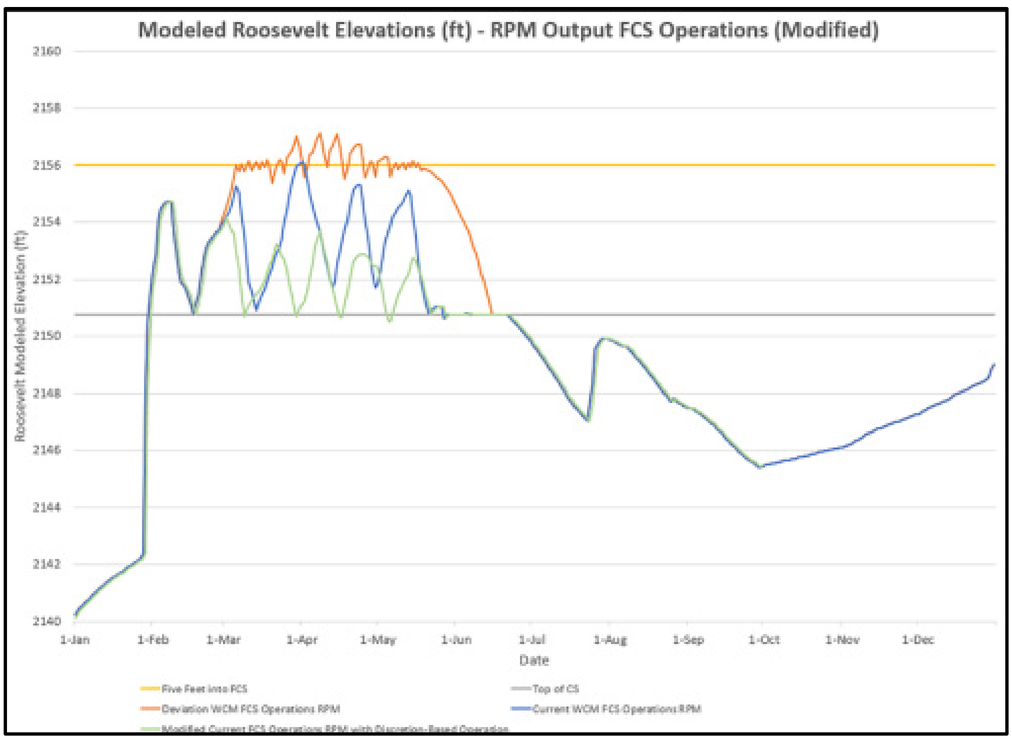

Figure 9. Example illustration of estimated Roosevelt Lake elevations under the current WCM and planned deviation for the planned deviation space, for the same modeled events provided in Figure 8 but extended through the end of the calendar year.

Lake elevations are estimated using the Reservoir Planning Model and are the same for operations within the CS regardless of whether the planned deviation is approved, since SRP's operational plans will not change within the CS. Once water enters the FCS, the lake elevations estimated using the Reservoir Planning Model differ between the two scenarios. For example, in the illustration, Roosevelt Lake elevations would be the same within the CS prior to entering into the FCS in early to mid-February and remain the same as inflows exceed the CS as per current FCS operations until the deviation is initiated (modeled as March 1).

Current flood control operations would be expected to return Roosevelt Lake elevations to the top of the CS within 20 days (early March), while the planned deviation would allow Roosevelt Lake elevations to remain in the planned deviation space for up to an additional 100 days for a single event in a calendar year when Roosevelt Lake inflows allow. Throughout March, April, and May, additional inflow events result in current operations entering the FCS three more times (nearly reaching 5 feet into the FCS before returning to the top of the CS, based on current WCM) while the planned deviation operations maintain lake elevations 5 feet into the FCS and show only a slight increase as releases are still operated per the current WCM above 2,156 feet amsl. In some instances, as shown by the end of the third and fourth inundation events in Figure 8 for the current WCM, a subsequent storm event may begin filling the FCS again before the end of the 20-day period, resulting in small bands within the FCS having some inundation that lasts longer than 20 days for the current operation model. The discretion-based operation time series on Figure 9 shows how release operation may occur using operator discretion for this example year. In this example, multiple back-to-back events occur, and inflows vary but remain high throughout the winter. Following the current WCM modeled release (see Table 2), a final decrease in release to 6,500 cfs occurs at 2,152 feet amsl. During peak snowmelt (or additional storms), inflows may exceed this release and the Reservoir Planning Model appropriately follows the WCM and switches to the rising elevation WCM release of 1,900 cfs at 2,152 feet amsl. This causes a further rise in lake elevation at 2,152 feet amsl rather than continuing to drawdown lake elevation (Figure 9, blue line). Using discretion-based operations, releases may be increased above the WCM as necessary to continue the drawdown of lake elevation below FCS within 20 days, before reentering the FCS again. For this example, the operator decides to maintain releases higher than those dictated by the WCM, to continue withdrawing from the FCS to below 2,150.78 feet amsl, before decreasing releases (Figure 9, green line).

Following the winter/spring inflow events, current operations would maintain Roosevelt Lake elevations at the top of the CS (approximately 2,151 feet amsl) through May and June, while the deviation would gradually decrease within the top 5 feet of the FCS before returning to the top of the CS within 120 days from entry into the FCS (February to June). Following the 120-day period, Roosevelt Lake elevations would be consistent with elevations from current operations and remain the same following the deviation under normal operations within the CS.

Table 4 shows the minimum release rates proposed by SRP for the planned deviation, rounded to the nearest whole number (cfs), that would be used for the planned deviation to meet the drawdown requirements at different lake elevation stages when the lake is rising (inflows exceed outflows) and when it is falling (outflows exceed inflows). The proposed change to the release plan for the planned deviation considers one of the WCM's original goals—to make maximum use of water in the flood control pool for power generation. The planned deviation does this by 1) decreasing minimum release rates for elevations within the planned deviation space, and 2) not modifying existing release rates for lake elevations in the FCS that are higher than the planned deviation space (i.e., above 2,156 feet amsl). As identified in the WCM, additional minimum releases may be required while the lake is receding to meet the 20-day drawdown requirement above the planned deviation space.

Table 4. Modified Roosevelt release plan for the planned deviation.

Lake Elevation—Rising (feet amsl)	Minimum Release Rate—Rising	Lake Elevation—Falling (feet amsl)	Minimum Release Rate—Falling
2,151–2,156	460 cfs	2,151–2,156	460 cfs
2,153–2,156	460 cfs		
2,156–2,157	6,500 cfs	2,156–2,157	12,200 cfs
2,157–2,162	12,200 cfs		
2,162–2,172	39,500 cfs	2,157–2,170	39,500 cfs
2,172–2,175	53,100 cfs	2,170–2,175	53,100 cfs

SRP used the Reservoir Planning Model to evaluate the effects of the modified release plan made available by the planned deviation shown in Table 4. The analysis applies the modified release plan to each month of the 106-year period to evaluate the impact on expected lake elevations. As proposed in the planned deviation, the evacuation period is extended from 20 to 120 days for a single event in a year.

Additional months of FCS operations beyond what is created by a single 120-day event are a result of other runoff events (storms or snowmelt) that create a new flood control event. If an additional event occurs while within the 120 days of the planned deviation, the area of the FCS above elevation 2,156 feet amsl would be evacuated within 20 days and then the operations within the FCS would continue to operate under the release rates defined in Table 4 as allowed by the planned deviation. Table 5 shows the average number of consecutive days water remained in each 1-foot interval for model years when water entered the FCS using the planned deviation.

Table 5. Average number of consecutive days water remained in each 1-foot interval of the planned deviation space.

Number of Days	2,151–2,152 feet amsl	2,152–2,153 feet amsl	2,153–2,154 feet amsl	2,154–2,155 feet amsl	2,155–2,156 feet amsl	2,156 feet amsl
Average	95	86	79	70	60	39

Table 6 summarizes the duration, timing, and magnitude of predicted FCS operations under the planned deviation for model years in which they occur—that is, for all years within the 106-year period that are estimated to result in water entering the FCS. Table 6 shows the change in expected duration of inundation of the FCS that would occur with the planned deviation as compared to normal operations (see Table 3). Of the 37 years with flood control operations within the 106-year period, the average duration of months of FCS operations is expected to increase by 21 months if the planned deviation operations were allowed in all 106 years (from 143 months in the FCS to 164 months in the FCS under the planned deviation). This analysis is only provided for context, since the planned deviation is only proposed to allow for the modified release plan to be used in 3 out of 5 years of the deviation period.

Table 6. Comparison of the duration, timing, and magnitude of estimated FCS operations under the planned deviation for model years in which they occur.

Model Year*	Additional Number of Months with Water Levels in FCS Caused by Deviation (compare to Table 3)	Range of Months with FCS Operations	Range of Peak Monthly Lake Rise into FCS (feet amsl)	Range of Peak Monthly Lake Elevations (feet)
2	0	February–June	2,155–2,157	4–6
3	1	January–June	2,153–2,174	2–23
4	1	January–June	2,151–2,157	<1–6
6	0	April–August	2,152–2,153	1–2
7	1	October–June	2,151–2,165	<1–14
9	0	February–May	2,151–2,156	<1–5
11	1	December–May	2,151–2,156	<1–5
13	1	May–June	2,151–2,153	<1–2
14	1	February–June	2,151–2,156	<1–5
19	2	January–June	2,151–2,162	<1–11
23	0	April–May	2,153	3
24	0	February–May	2,153–2,158	2–7
28	0	February–June	2,152–2,169	1–18
29	0	January–May	2,151–2,154	<1–3
30	1	March–May	2,151–2,152	<1–1
39	1	April–June	2,153–2,156	2–5
47	1	April–May	2,151–2,152	<1–1
53	0	December–May	2,151–2,156	<1–5
55	1	March–June	2,151–2,156	1–5
56	2	March–May	2,151–2,153	<1–3
60	0	March–June	2,156–2,158	5–7
65	0	March–May	2,156	5–6
66	0	December–June	2,155–2,163	4–12
67	0	January–June	2,152–2,165	1–14
69	0	April–May	2,151–2,152	1
70	0	January–June	2,153–2,157	2–7
71	0	October–April	2,151–2,153	<1–3
72	1	December–June	2,153–2,158	2–7
73	1	March–May	2,154–2,156	3–5
74	1	March–June	2,151–2,156	<1–5
75	0	April–May	2,153–2,154	2–3
78	1	April–June	2,151–2,153	<1–2
79	0	February–June	2,152–2,156	1–5
80	1	December–June	2,153–2,168	2–17
81	0	April	2,151	<1

Model Year*	Additional Number of Months with Water Levels in FCS Caused by Deviation (compare to Table 3)	Range of Months with FCS Operations	Range of Peak Monthly Lake Rise into FCS (feet amsl)	Range of Peak Monthly Lake Elevations (feet)
82	1	February–May	2,154–2,158	3–7
97	1	April–June	2,151–2,155	<1–4

* Based on water year (October–September)

F. Historic and Ongoing Fish Stocking at Roosevelt Lake

This addendum addresses, among other impacts, the incidental take of gartersnakes attributable to predation by and competition with nonnative predatory fish that persist in the CS after being introduced in Roosevelt Lake by others. SRP's long-term storage of water in the CS is one factor that contributes to these predator-prey interactions, which FWS has identified as a primary threat to the conservation of the species. Other contributing actions, which have occurred in the past, are ongoing, and are anticipated to continue in the future, include the Arizona Game and Fish Department's (AGFD's) management of Roosevelt Lake as a sport fishery (including periodic stocking of the lake with nonnative predatory fish) and the funding of these stocking activities by FWS and others. This section provides important context for understanding SRP's role in and proportionate share of responsibility for the effects of nonnative predatory fish on gartersnakes, in relation to the roles and responsibilities of other actors. This section also describes the background and baseline conditions for gartersnake and its habitat in the permit area.

Modified Roosevelt is part of the Salt River Federal Reclamation Project, and is operated by SRP for water supply, flood control, and dam safety purposes, and to generate a moderate amount of hydroelectric power. Recreation and fishing are not legislatively authorized purposes of Modified Roosevelt and, consequently, SRP does not operate the dam to support recreation or fishing. Despite this fact, the lake has become a popular sport fishery because of past and ongoing stocking activities and funding support from the FWS's Wildlife and Sport Fish Restoration Program (WSFR) and the AGFD.

Starting in about 1930, the U.S. Bureau of Sport Fisheries (predecessor to the FWS) stocked several warmwater fish species in the lake to establish a warmwater sport fishery. In 1941, the AGFD began stocking and managing Roosevelt Lake as a sport fishery, and established multiple nonnative species, starting with threadfin shad (*Dorosoma petenense*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*), and bluegill (*Lepomis macrochirus*) in 1941, and black crappie (*Pomoxis nigromaculatus*) in 1949 (AGFD 2019). Currently, 19 species of nonnative fish inhabit Roosevelt Lake, which include populations of largemouth bass, smallmouth bass, green sunfish (*Lepomis cyanellus*), and flathead catfish (*Pylodictis* spp.).

Starting in about 2008, the AGFD reported a decline in the abundance and quality of largemouth bass and two other sportfish species at Roosevelt Lake (AGFD 2019).

In response to this reported decline, the AGFD in 2011 incorporated Roosevelt Lake into a proposed 10-year statewide plan (2011–2021) that called for stocking the lake with largemouth bass, bluegill, and black crappie (FWS 2011a). The stocking program was included in AGFD's request for federal funds under the authority of the Dingell-Johnson Sport Fish Restoration Act of 1950 (SFRA), as amended (16 United States Code [USC] 777) (FWS 2011a).

A continuation of this stocking plan was proposed in 2021. As part of this most recent 10-year statewide stocking plan, from 2021 to 2031, the AGFD proposed to stock largemouth bass, bluegill, and black crappie annually into Roosevelt Lake (FWS 2021a). Most of the bass historically stocked in Roosevelt

Lake and other Arizona waters are a northern strain of largemouth bass, but in the 1980s, the AGFD stocked the Florida strain on three occasions, and in 2014, began stocking this strain again (FWS 2021a). The 10-year proposal by the AGFD to stock fish in Roosevelt Lake from 2021 to 2031 would also use federal funds under the authority of SFRA.

The use of SFRA funds by the AGFD for stocking Roosevelt Lake is a federal action subject to Section 7 of the ESA. In 2021, the WSFR, in coordination with the AGFD, consulted with the FWS Arizona Ecological Services Office (FWS 2021a). The FWS Arizona Ecological Services Office 2021 Biological Opinion concluded that the proposed action "may affect, and is likely to adversely affect" the gartersnake and its designated critical habitat, but that it is not likely to jeopardize the continued existence of the gartersnake or destroy or adversely modify its critical habitat (FWS 2021b). The Biological Opinion identified conservation measures for Roosevelt Lake such that if fish are stocked, AGFD will remove all predatory nonnative fish in two of the larger pools in Tonto Creek between Roosevelt Lake and Gisela, following coordination with SRP, to benefit the gartersnake.

An Environmental Assessment also evaluated the potential effects of the WSFR funding to AGFD for the 10-year stocking program and determined a potential effect of incidental take in the form of harassment (competition for space and food) and harm (predation or injury) of neonatal and juvenile gartersnakes (AGFD and FWS 2021a). In a Finding of No Significant Impact (FONSI), the FWS found that the stocking program would have no significant impact on threatened or endangered species or other special-status species, and that any negative impacts would be reduced or offset below a level of significance by the implementation of conservation measures (AGFD and FWS 2021b).[9]

In summary, the AGFD, with federal funding support from SFRA, has supported sportfish stocking in Roosevelt Lake for over 80 years. Subsequent to 2031 and over the remaining life of the Roosevelt ITP, it is foreseeable that the AGFD will continue to request funding for sportfish stocking at Roosevelt Lake, either through the SFRA program or through state or private funding.

This addendum and proposed ITP amendment address incidental take of gartersnakes associated with SRP's continued conservation storage operations. This addendum and proposed ITP amendment do not address, minimize, or mitigate the effects of ongoing sportfish stocking actions of the FWS and AGFD at Modified Roosevelt. The AGFD and FWS undertook and completed ESA Section 7 consultation in 2021 to evaluate the effects of federal funding of AGFD's 10-year fish stocking program (FWS 2021a, 2021b). SRP has no involvement in, responsibility for, or control over these stocking activities. Consequently, SRP did not participate in the 2021 consultation and had no influence over its outcome. The measures proposed by this addendum to address incidental take of gartersnakes associated with SRP's storage of water in Roosevelt Lake are not dependent upon, and will be undertaken by SRP without regard to, any measures imposed by FWS's 2021 Biological Opinion.

[9] SRP submitted comments during the public comment period on the draft Environmental Assessment. See SRP (June 2021) comments.

Chapter 2. Species and Critical Habitats

This chapter provides background and baseline information about the listed species and designated critical habitats relevant to the proposed amendments to the RHCP (i.e., addition of the gartersnake as a covered species, expansion of the covered activities to include flood control operations, and expansion of the permit area to include the FCS and lower Tonto Creek corridor). The scope of the updated background and baseline information provided in this chapter is tailored to the specific changes to the RHCP proposed by SRP.

For example, this addendum summarizes the gartersnake biology, life history, and habitats, since it is a new covered species for the RHCP, but also provides a thorough description of available information about the gartersnake pertaining to the population that occurs at Roosevelt Lake and lower Tonto Creek. Additionally, the original RHCP contains background information about the covered bird species and baseline information related to these species in the CS. This addendum does not repeat that information here. However, because flood control operations are proposed to be added as covered activities, this addendum provides supplemental information about the abundance and distribution of the covered bird species in the FCS.

To aid the FWS in its evaluation of effects on other listed species (including other covered species and species, like the spikedace not covered by the original RHCP) and critical habitats related to its review of the proposed ITP amendment under Section 7 of the ESA, this addendum also provides information about other listed species and critical habitats found in the expanded permit area.

A. Northern Mexican Gartersnake

i. Biology, Life History, and Habitats

The FWS summarized the biology, life history, and habitat use of the gartersnake in its proposed and final listing rules (FWS 2013a, 2014a) and proposed and final critical habitat designation rules (FWS 2013a, 2020a, 2021c). The FWS also maintains an informal status assessment of the gartersnake with additional information about the species (FWS 2021d). SRP has reviewed each of these documents. The discussion below summarizes and incorporates key aspects of gartersnake biology, life history, and habitats, particularly information pertaining to the population at Roosevelt Lake and on lower Tonto Creek, to help understand the effects of SRP's covered activities.

At Roosevelt Lake, there have been several studies conducted on the natural history, ecology, and occurrences of the gartersnake:

Breeding, feeding, and sheltering activities—Myrand (2019); Nowak et al. (2019)

Predators, competitors, and prey—Nowak et al. (2019); ERO Resources Corporation and GEI Consultants, Inc. (ERO-GEI) (2022a [Appendix E], 2022b [Appendix F]); Jones (2019)

Habitats and spatial ecology—Myrand (2019); Nowak et al. (2019); ERO (2020); SWCA (2020, 2022a [Appendix G], 2022b [Appendix H])

Occurrence information—Altemus (2020); Baker et al. (2019); Burger (2010); ERO (2020); Grimsley-Padron et al. (2020); Holycross et al. (2006); Madara (2012); Nowak et al. (2015); Nowak et al. (2019)

Studies on the gartersnake in other areas of Arizona also provide regionally relevant information to help understand the effects of the covered activities at Roosevelt Lake and on lower Tonto Creek. These studies include bodies of work from Ian Emmons (Emmons 2017; Emmons and Nowak 2016; Emmons, Nowak, and Lauger 2016), Valerie Boyarski (Boyarski et al. 2015; Boyarski et al. 2019), and Tiffany Sprague (Sprague 2017; Sprague and Bateman 2018).

1. Species Description and General Behavior

The gartersnake is a cryptic, large-bodied snake, reaching a maximum length of 44 inches (112 centimeters [cm]). The gartersnake is typically olive colored with paired black spots along the back and sides and three pale yellow to light tan lateral stripes that run the length of the body (FWS 2014a). The northern Mexican gartersnake is distinguished from other gartersnakes by the location of the lateral stripes, which overlap the fourth scale row rather than being confined to lower scale rows (FWS 2014a).

The gartersnake is generally diurnal and typically active at air temperatures ranging from 22 to 33 degrees Celsius (°C) (71–91 degrees Fahrenheit [°F]) (FWS 2014a). When active, gartersnakes engage in a variety of breeding, feeding, thermoregulation, and dispersal activities. When weather conditions are not conducive to surface activities, gartersnakes shelter under cover and may enter a state of brumation with a much-reduced level of activity.

Since activity level is related to temperature, there is a degree of seasonality to gartersnake active and inactive states. At Roosevelt Lake and on lower Tonto Creek, gartersnakes are most likely to be active, and potentially moving greater distances, in the early spring through late fall. During the winter gartersnakes are most likely to be inactive but may have periods of abbreviated movements. For example, Nowak et al. (2019) tracked 14 gartersnakes via radio telemetry, locating each gartersnake one to two times per week during the winter season from 2015 to 2018, documenting when they were in or out of their brumation sites. There was individual variation in the timing of brumation, but, in general, the gartersnakes were inactive between late November and late February or early March (Nowak et al. 2019). For the purpose of the RHCP, SRP defines the gartersnake "active season" as March 1 through November 30, and the "inactive season" as December 1 through February 28/29.

Although gartersnakes exhibit reduced activity during the inactive season, Nowak et al. (2019) documented surface activity at Roosevelt Lake for nine of 14 snakes tracked during the inactive season, including seven basking events and nine changes in brumation sites. Five of these within-season site changes were associated with flooding at the brumation site.

2. Breeding and Reproduction

Gartersnakes typically mate in the spring (April and May) or fall (September or October), gestation typically occurs between April and May, and females give birth to live young typically between June and July (Emmons and Nowak 2016; Myrand et al. 2021; Nowak and Boyarski 2012; Nowak et al. 2019; Rosen and Schwalbe 1997; Sprague 2017). Reproduction may not occur every year (Boyarski et al. 2019; Rosen and Schwalbe 1988). Annual reproduction and multiple birthing events within a single year (including a fall birthing) are theoretically possible based on observations of reproduction in a female held in captivity (Kandiyeli et al. 2019). This has not been observed in the wild.

Gartersnake litter size ranges between 2 and 38 young (Jones et al. 2020). Boyarski et al. (2019) provide some of the only data available on gartersnake growth rates for different demographic stages in Arizona. At the Bubbling Ponds Fish Hatchery, Boyarski et al. (2019) monitored the gartersnake population for 4 years (2007–2011). Table 7 summarizes the reported sizes and growth rates for different gartersnake demographic stages. At birth, gartersnake neonates are typically ≤ 8.66 inches (220 millimeters [mm]) snout-vent length and are able to forage and shelter independently almost immediately afterward (Boyarski et al. 2019). Jones et al. (2020) state that it may take approximately three growth seasons for gartersnakes to reach maturity at 21.65 inches (550 mm) snout-vent length, based on growth rates reported by Boyarski et al. (2019) (see Table 7). Gartersnake survivorship rates are unknown. Boyarski et al. (2019) note that methodological challenges in capturing neonates and juveniles make estimating neonate and juvenile survivorship difficult. But given their smaller size, these size classes likely experience relatively higher predation rates and thus lower survivorship.

Table 7. Summary of northern Mexican gartersnake size and growth rates, derived from Boyarski et al. (2019).

Demographic Stage	Size in inches (mm)	Growth Rates: inches/year (mm/year)†
Neonate	≤ 8.66 (220)	Male: 6.81 ± 0.44 (173.1 ± 11.3) Female: 6.03 ± 0.53 (153.1 ± 13.5)
Juvenile	11.81–19.69 (300–500)*	Male: 4.02 ± 0.57 (102.1 ± 14.6) Female: 3.37 ± 0.13 (85.6 ± 10.2)
Adults	Male = > 19.69 (500) Female = > 21.65 (550)	

Source: Boyarski et al. (2019).

* No size dimorphism detected in juveniles.

† Year is based on 245 growth days.

3. *Feeding and Diet*

The gartersnake is an active predator that feeds opportunistically on amphibians, fish, and occasionally invertebrates, small mammals, and lizards (d'Orgeix 2011; FWS 2020a; Jones et al. 2020; Harrow et al. 2022; Manjarrez et al. 2013; Rosen and Schwalbe 1988). Foraging behavior of gartersnakes includes two different strategies: 1) moving along vegetated shorelines searching for prey in water, on land, and at the air-water interface (Drummond and Macías García 1989:24–26); and 2) implementing an underwater ambush strategy (stick mimicry) that appears to involve disguising themselves as inanimate objects while waiting for prey to move within striking range (Harrow et al. 2022). Important prey include adult and tadpole native leopard frogs (*Lithobates* sp.), Gila topminnow (*Poeciliopsis occidentalis occidentalis*), desert pupfish (*Cyprinodon macularius*), Gila chub (*Gila intermedia*), and roundtail chub (*Gila robusta*) (Rosen and Schwalbe 1988). Drummond and Macías García (1989) observed that gartersnakes fed primarily on frogs, and when frogs became unavailable, studied individuals ceased foraging rather than seek alternative prey. Manjarrez et al. (2017) show that gartersnake diet can vary spatially and temporally with fish being the dominant prey of the gartersnake in the Mexican plateau. Leeches, earthworms, and amphibians were secondary prey items consumed by gartersnakes at their study sites (Manjarrez et al. 2017).

Emmons, Nowak, and Lauger (2016) documented gartersnakes consuming nonnative frogs including American bullfrogs (*Lithobates catesbeianus*) and spiny-rayed fish including largemouth bass and bullhead catfish (*Ameiurus* spp.), confirming that the subspecies is a dietary generalist. The FWS notes that viable gartersnake populations can occur in areas where native aquatic prey species are uncommon and where gartersnakes feed on available nonnative species such as American bullfrogs and various species of soft-rayed and spiny-rayed fish (FWS 2020a).

The Tonto Arm and lower Tonto Creek contain potential prey for the gartersnake, including American bullfrog, lowland leopard frog (*Lithobates yavapaiensis*), Woodhouse's toad (*Anaxyrus woodhousii*), desert spiny lizard (*Sceloporus magister*), tiger whiptails (*Aspidoscelis tigris*), zebra-tailed lizards (*Callisaurus draconoides*), ornate tree lizards (*Urosaurus ornatus*), common side-blotched lizards

(*Uta stansburiana*), western mosquitofish (*Gambusia affinis*), red shiner, threadfin shad, longfin dace (*Agosia chrysogaster*), and largemouth bass (ERO-GEI 2022b [see Appendix F]; Nowak et al. 2019).

4. Predators and Competitors

American bullfrogs, northern (virile) and red swamp crayfish (*Orconectes virilis* and *Procambarus clarkii*), and several species of nonnative fish in the families of Centrarchidae and Ictaluridae, are known or suspected predators and competitors of the gartersnake (FWS 2014a, 2020a, 2021c). Nonnative fish species known to prey on the gartersnake include largemouth bass (Young and Boyarski 2013). The FWS (2021c) lists additional species considered to be harmful predators and competitors of the gartersnake, including other species of bass (*Micropterus* spp.), flathead catfish, channel catfish, bullhead catfish (*Ameiurus* spp.), crappie (*Pomoxis* spp.), and bluegill (*Lepomis* spp.). These species have been included in the list of harmful predators and competitors of the gartersnake due to their aggressive behaviors, generalized diets, and large gape size. As noted in Subchapter 2.A.i.3 above, gartersnakes also consume small individuals of these nonnative species. Avian species including wading birds and raptors are also known or suspected predators of the gartersnake (Boyarski et al. 2019; Gawlik 2002; Jones et al. 2020; Nowak et al. 2019).

Nowak et al. (2019) detected American bullfrogs and crayfish at all sites where gartersnakes have been documented in the Tonto Arm of Roosevelt Lake. The presence of these nonnative species suggests the potential for predation of and competition with the gartersnake (Nowak et al. 2019). However, the net effect of the ecological relationship between the gartersnake and these species is likely more complicated, as gartersnakes also consume American bullfrogs (Emmons, Nowak, and Lauger 2016; Nowak et al. 2019). American bullfrogs are generalist and cannibalistic foragers, overlapping in diet with the gartersnake (FWS 2014a; Rosen et al. 2001). According to Rosen et al. (2001), approximately 45% of the American bullfrogs' diet is of conspecifics.

Northern crayfish are aggressive, territorial, and generalist omnivores and scavengers that prey on and compete with fauna in their vicinity and may be predators or competitors of the gartersnake (Collicut 1998; Durland 2021; Fernandez and Rosen 1996; FWS 2015; Witte et al. 2008). Northern crayfish also degrade and denude aquatic habitats via consumption of macrophytes and increase water turbidity and siltation of substrates by their burrowing behaviors (Durland 2021; Fernandez and Rosen 1996; FWS 2015).

SRP consultants sampled 13 pools along Tonto Creek located within the CS or FCS (specifically, between the lake edge and A-Cross Road) in October 2019, April 2020, and July 2020 (ERO-GEI 2022b [see Appendix F]). This study detected the presence of eight nonnative and one native fish species in the pools and collected 1,473 fishes. The most abundant detections were of largemouth bass, bluegill, and common carp. These three species collectively represented 77% of the total number of fish caught in the study (ERO-GEI 2022b [see Appendix F]).

ERO-GEI (2022b [see Appendix F]) analyzed stomach samples from 231 fish caught during the study, representing five nonnative predatory species: largemouth bass, green sunfish, yellow bullhead, smallmouth bass, and channel catfish. These stomach samples were collected during the gartersnake active season, with the July and October sample periods occurring when small neonate or juvenile gartersnakes could have been present on the landscape. The stomach samples of these fish included visually identifiable invertebrates, other fish, and organic matter (ERO-GEI 2022b [see Appendix F]). While it had been previously documented that nonnative predatory fish prey on gartersnakes—see Young and Boyarski (2013)—none of the stomach samples in the ERO-GEI (2022b [see Appendix F]) study contained visually identifiable snakes or fragments of snakes.

In a separate study, Owens et al. (2023) and Electric Power Research Institute, Inc. (2023), used a genetic sequencing approach (polymerase chain reaction [PCR]) to analyze gut contents (fecal matter) of nonnative predatory fish species in this same study area. They confirmed gartersnake DNA was present in the gut content of three of the 98 largemouth bass samples. Two samples that tested positive for gartersnake DNA were collected from largemouth bass in the lake, and one was collected from a largemouth bass in a pool in lower Tonto Creek. Following verification using Sanger sequencing, only one sample was confirmed to have gartersnake DNA. This study confirmed that gartersnakes may be killed by predatory nonnative fish within the permit area.

5. *Habitat and Habitat Use*

The gartersnake is a semi-aquatic, riparian-obligate species that uses a variety of aquatic and riparian habitats and adjacent terrestrial habitats from 140 to nearly 8,500 feet elevation. The presence of water is a primary determinant of suitable gartersnake habitat and can be associated with perennial, intermittent, or ephemeral waterways; in-channel and off-channel pools and backwater areas subject to periodic flooding; and wetlands, ciénegas, stock tanks, fish hatchery ponds, riparian woodlands, and gallery forests (Emmons 2017; Emmons and Nowak 2016; FWS 2014a, 2020a, 2021c; Myrand 2019; Nowak et al. 2019; Sprague 2017). The presence of cover (e.g., vegetation, rocks, debris piles) and available prey are also important components of suitable habitat (Burger 2007; Burger et al. 2010). The gartersnake also uses terrestrial habitats that are adjacent to or near aquatic and riparian habitats, such as meadows and woodlands, or areas influenced by human development (FWS 2021d).

In published studies of gartersnake habitat associations, gartersnakes are most frequently detected in riparian edge, pond edge, or wetland edge habitat, followed by terrestrial habitats and occasionally open-water habitat (Emmons and Nowak 2016; Nowak et al. 2019; Sprague and Bateman 2018). Emmons and Nowak (2016) located gartersnakes mostly on land (i.e., 88% of the time gartersnakes were located on plots on land, and 8% of the time gartersnakes were located on plots in water, among the 350 paired sets of plots for their microhabitat study). Sprague and Bateman (2018) also found that, at the Bubbling Ponds Fish Hatchery (a highly modified, pseudo-natural property), approximately 80% of locations of telemetered females and 60% of locations of telemetered males were on pond banks and marshy areas. During their active season, gartersnake home ranges extend beyond aquatic boundaries and into riparian and upland areas; and the gartersnake diet consists of large proportions of anuran prey, including species found in terrestrial areas, such as Woodhouse’s toad (Emmons and Nowak 2016; Nowak et al. 2019).

Myrand (2019) suggested that gartersnake detections of telemetered individuals were on land and concluded that gartersnakes may avoid areas of open water, defined by Myrand (2019) as water surfaces devoid of emergent vegetation regardless of inundation of the surrounding area. During inundation, nine telemetered females were located at 116 plots and specifically used plots located in terrestrial edge and aquatic edge significantly more than other habitats. Areas of open water were ranked last among the six categories of habitats (Myrand 2019). This is consistent with the understanding that gartersnakes can and will cross open water habitat typical of within-channel pools but are less likely to remain in the center of these open water habitats. Myrand (2019) and Nowak et al. (2019) conclude that gartersnakes generally avoid open water and remain on the edge.

The presence of cover, specifically dense vegetative cover, is an important component of gartersnake habitat (Sprague and Bateman 2018). Gartersnakes may use other forms of cover such as rocks, woody debris piles, or other objects, particularly in areas devoid of dense vegetation (Burger et al. 2010). Cover provides structure for gartersnake thermoregulation, predator avoidance, and foraging opportunities while consuming prey (Emmons and Nowak 2016; FWS 2020a; Harrow et al. 2022; Nowak et al. 2019; Sprague and Bateman 2018). At Roosevelt Lake, Nowak et al. (2019) found that gartersnakes selected areas that were closer to water and had greater ground cover relative to control areas, regardless of sites and years. Nowak et al. (2019) also found that adult female gartersnakes selected sites with canopy over sites without canopy (where canopy is defined to mean vegetation greater than 1 meter [m; 3.3 feet] tall) and with willow and forb canopy cover significantly more than other types of available canopy cover (Nowak et al. 2019). For vegetation cover less than 1 m tall, female gartersnakes selected sites with forbs and willows, secondarily selected sites with grasses, and avoided sites lacking vegetation cover (Nowak et al. 2019). Female gartersnakes at Roosevelt Lake selected sites with debris or litter piles formed during flood events or with beaver lodges and dams significantly more often compared to reference locations (Nowak et al. 2019).

Gartersnakes use riparian and upland habitats for brumation. Generally, gartersnake brumation sites include cavities and animal burrows beneath inorganic and organic structures (e.g., boulders, wood debris, trash piles) within riparian, meadow, shrubland, and woodland habitats (Emmons 2017; Emmons and Nowak 2016; FWS 2014a, 2020a; Nowak et al. 2019; Sprague 2017). At study areas along the Verde River, brumation sites were 20 to 140 m from the nearest identified water source and were located in rock fill and rock piles near artificial ponds and in burrows in upland mesquite bosque habitat (Emmons and Nowak 2016). At Roosevelt Lake, brumation sites used by the gartersnake were located an average of 83.2 ± 21.33 m (range=0.7 to 383 m) from the water's edge and included rodent and crayfish burrows, cavities formed by partially buried woody debris and cracked clay soils, and the spaces under piles of flood debris (Nowak et al. 2019). The macrohabitats associated with these sites were riparian woodland, meadow, dry edge, dead woodland floodplain, shrub-forb upland, and mesquite uplands, with dense vegetation surrounding or adjacent to the brumation sites (Nowak et al. 2019).

The gartersnake may use multiple brumation sites within and between years (Emmons 2017; Emmons and Nowak 2016; Nowak et al. 2019; Sprague 2017). Nowak et al. (2019) documented gartersnakes changing brumation sites nine times, of which five changes were attributed to flooding at the previous brumation site. The nine new brumation sites were located a mean distance of 45.22 ± 24.95 m (range = 5 to 235 m) from previous brumation sites. Some gartersnakes appear to use the same area for brumation across multiple years, with specific brumation sites located within 12 to 15 m of each other between years (Boyarski et al. 2015; Emmons 2017; Emmons and Nowak 2016). Observations of brumation area fidelity have been limited to one or two individuals out of samples sizes of eight to nine individuals (Boyarski et al. 2015; Emmons 2017; Emmons and Nowak 2016). Specific brumation sites may also occasionally be occupied by two or three female gartersnakes (Emmons and Nowak 2016).

ii. Baseline Status

1. Listing Status and Threats

The FWS listed the gartersnake as a threatened species under the ESA in 2014. The FWS identified predation from and competition with nonnative species as the most significant threat to gartersnake populations (FWS 2014a). The FWS (2014a) also identified disease implicated in wide-ranging amphibian declines as a significant factor in gartersnake declines. Other threats to the conservation of the gartersnake (FWS 2014a) are land uses that reduce, alter, or pollute aquatic habitats; drought and anthropogenic modifications to aquatic habitats such as dams, water diversions, flood-control projects, and groundwater pumping; and altered flow regimes (e.g., by the impoundment of water).

2. Range-wide and Regional Distribution and Abundance

Approximately 85% of the gartersnake's historical range is located in Mexico and includes Sonora, Chihuahua, and areas south along the Sierra Madre Occidental and the Mexican Plateau (Jones et al. 2020) (Figure 10). There are scattered populations in Nuevo Léon and Oaxaca, Mexico. The Mexican

Government lists the gartersnake as threatened throughout its range in Mexico, but there are many regions where little is known about the current status of the subspecies (FWS 2014a; Jones et al. 2020).

In the United States, the gartersnake occurs primarily in Arizona, with a smaller number of records reported from the upper Gila and San Francisco River Basins in New Mexico (FWS 2021d; Jones et al. 2020) (see Figure 10). The FWS (2014a) noted at the time of listing that the gartersnake likely occurs at low to very low densities or may be extirpated across 90% of the subspecies' historical range within the United States. In 2021, the FWS (2021d) provided specific updated statuses by river subbasins of the United States. Some river subbasins, such as the Gila River Subbasin, contain large gaps, as much as 120 years, between the dates of records and the status change from presumed extirpated to presumed extant at very low population densities (FWS 2021d; Holycross et al. 2006; Jones et al. 2020). Because of the gartersnake's cryptic and secretive nature, and low detection probability associated with current survey methodologies that require surface activity, it is difficult to document its current distribution and abundance throughout its range, especially where populations occur in low densities with habitats containing dense cover or where survey effort has been scant (Emmons and Nowak 2016; FWS 2013a, 2021d; Jones et al. 2020; Nowak and Emmons 2014).

In New Mexico, the gartersnake was found in scattered locations within the Upper Gila River watershed. The FWS (2021d) considers the gartersnake to be extant in the Gila River watershed, but with populations occurring at very low densities.

In Arizona, the gartersnake has been documented in every county and nearly every river subbasin of the state (see Figure 10). Twenty-six of the 29 localities listed by the FWS (2014a) are in Arizona, mostly in the southern two-thirds of the state. But gartersnakes have been documented recently in the Bill Williams River Subbasin, specifically in the Big Sandy, Santa Maria, and Bill Williams Rivers in western Arizona (Cotten et al. 2019; FWS 2020a, 2021d; O'Donnell et al. 2016) (see Figure 10). In 2014, the FWS (2014a) considered five of the 26 localities in Arizona to be viable populations where gartersnakes are consistently detected: 1) Page Springs and Bubbling Ponds Fish Hatchery along Oak Creek, 2) lower Tonto Creek, 3) Upper Santa Cruz River in San Rafael Valley, 4) Bill Williams River, and 5) Upper and Middle Verde River. There are statewide (FWS 2021d) and regional assessments of gartersnake distribution (Holycross et al. 2006; Jones et al. 2020), but detailed population statuses are limited to Bubbling Ponds Fish Hatchery along Oak Creek, lower Tonto Creek, Upper and Middle Verde River, and the upper Santa Cruz River in the San Rafael Valley. The gartersnake populations with detailed data continue to be regularly detected in these localities (Emmons, Nowak, and Lauger 2016; Lashway 2015; Myrand 2019; Nowak et al. 2019; Sprague 2017). Currently, the FWS (Servoss 2022) considers three of the 26 localities in Arizona to be viable populations where gartersnakes are consistently detected: 1) Page Springs and Bubbling Ponds Fish Hatchery along Oak Creek, 2) Upper Santa Cruz River in San Rafael Valley, and 3) Upper and Middle Verde River. The FWS notes (Servoss 2022) that the low detection rates of the gartersnake in lower Tonto Creek indicate that this population may be of lower to moderate density.

3. Permit Area Distribution and Abundance

The FWS considers Tonto Creek to be a location where the gartersnake population is irregularly, but repeatedly among years, detected, with recent records confirming that the gartersnake is extant in Tonto Creek (Altemus 2020; FWS 2014a, 2021d; Nowak et al. 2015; Nowak et al. 2019). The gartersnake was first documented in Tonto Creek in 1995 (FWS 2014a), and subsequent surveys for the gartersnake within the permit area (Figure 11) and upstream of the permit area in Tonto Creek have documented presence of the subspecies through aquatic trapping, visual encounters, or cover board arrays (Altemus 2020; Burger 2010; Holycross et al. 2006; Madara 2012; Nowak et al. 2015; Nowak et al. 2019).

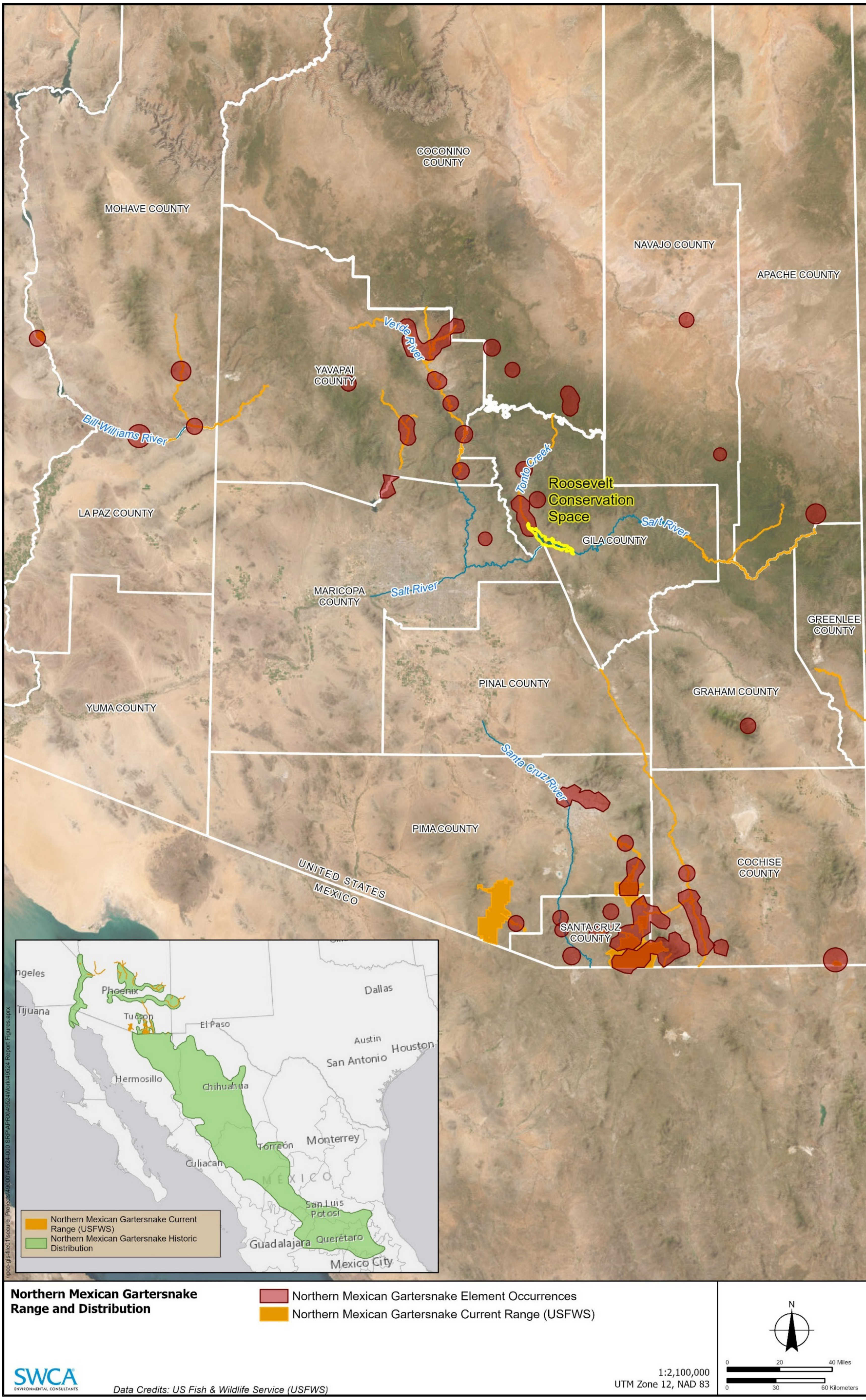

Figure 10. Northern Mexican gartersnake range and distribution.

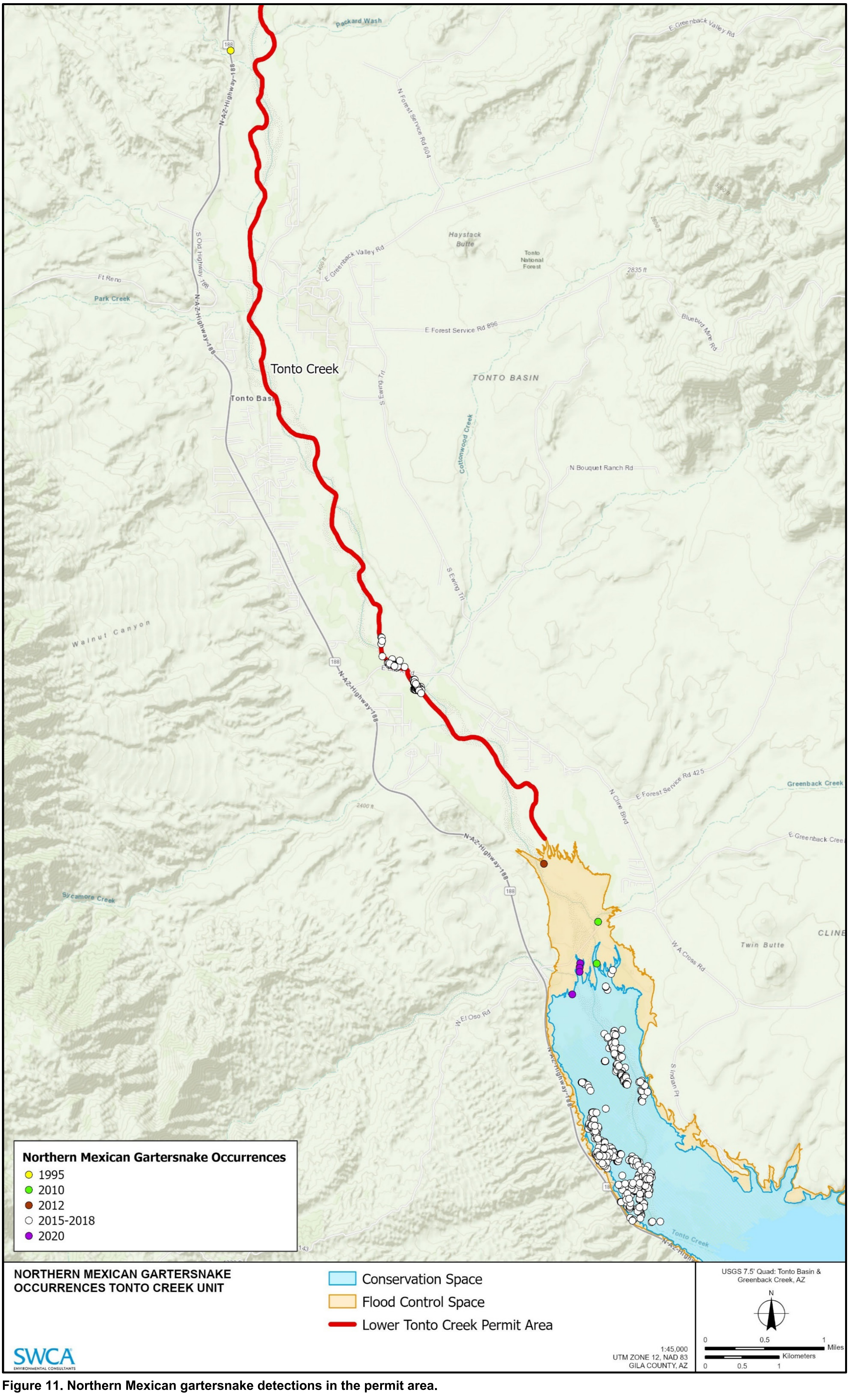

Figure 11. Northern Mexican gartersnake detections in the permit area.

Nowak et al. (2019) provide numbers of gartersnakes detected at each of their three study sites in the permit area. One study site, located in the Tonto Arm of the CS, was named "Orange Peel" in their study (Nowak et al. 2019). A second site, overlapping the upper limit of the CS and continuing into the FCS, was named "A-Cross Road Crossing" (Nowak et al. 2019). The third site, located in lower Tonto Creek adjacent to Bar-X Road, was named "Bar-X Road Crossing" (Nowak et al. 2019). They detected 81 unique gartersnakes across the three sites between 2015 and 2017. Of the 81 individuals, 39 were male and 38 were female (four were undetermined). Nowak et al. (2019) do not provide counts of juveniles or neonates, but of the 81, some individuals were juveniles or neonates based on their snout-vent length (see Figure 3 in Nowak et al. 2019). The specific number of unique gartersnakes detected per site is: Orange Peel—54 individuals, A-Cross Road Crossing—13 individuals, and Bar-X Road Crossing—14 individuals. At the A-Cross Road Crossing study site, all the gartersnake detections were in the CS below A-Cross Road.

A few additional detections of gartersnakes in the FCS were made by Burger (2010) and Madara (2012). Burger (2010) detected three gartersnakes in July 2010, and Madara (2012) detected three gartersnakes in July 2012. All of the gartersnakes were detected along the braided channels of Tonto Creek, which contained water (Burger 2010; Madara 2012). Madara (2012) described the gartersnakes as "young" gartersnakes but did not report their sizes.

Holycross et al. (2006) surveyed for gartersnakes along Tonto Creek (i.e., survey sites 44–47), including the upper end of the FCS and upstream of the permit area between Gun Creek and Houston Creek, in 2004 and 2005. During this survey, Holycross et al. (2006) detected 17 gartersnakes over 191 person-hours of survey (i.e., 1 gartersnake per 11 person-hours of survey) and 20,543 trap-hours.

Gartersnake detection rates have been used to compare the status of the gartersnake over time and between areas (Emmons and Nowak 2016; Nowak et al. 2019). Nowak et al. (2019) note that detection rates were very low at all sites. Between the three sites studied in Nowak et al. (2019), detection rates were highest at Orange Peel with 1 gartersnake per 5,994 trap hours or 1 gartersnake per 11 person-hours of visual encounter survey [VES]). Detection rates were lowest at Bar-X Road Crossing (1 gartersnake per 15 trap hours, 1 gartersnake per 20 person-hours of VES). These detection rates are within the range of detection rates for the gartersnake in the Verde Valley, which spanned from 1 gartersnake per 586 trap hours to 1 gartersnake per 9,827 trap hours; and 0 gartersnakes per 45 person-hours of VES to 1 gartersnake per 25 person-hours of VES (Emmons and Nowak 2016). For comparative purposes, the Verde River population is considered to be robust (FWS 2014a).

All gartersnakes observed at Roosevelt were located in the Tonto Arm of Roosevelt Lake (see Figure 11), indicating that this area contains attributes of suitable habitat for the gartersnake. The Tonto Arm consists of an intermittent braided stream, side channels, and beaver ponds (ERO 2020). The riparian zone is a diverse mosaic of woody vegetation and herbaceous marsh interspersed with cobble or open sandy areas (ERO 2020). The riparian woody vegetation includes velvet mesquite (*Prosopis velutina*), desertbroom (*Baccharis sarothroides*), Goodding's willow (*Salix gooddingii*), Fremont cottonwood (*Populus fremontii*), and patches of dense stands of nonnative saltcedar or tamarisk (*Tamarix ramosissima*) between 2,136 and 2,151 feet amsl (SWCA 2022a [see Appendix G]). The marshes are dominated by cattail (*Typha* sp.), rushes (*Juncus* sp.), and sedges (*Carex* sp. and *Scirpus* sp.). The woody vegetation and marsh habitat offer canopy and ground cover commonly associated with sites selected by gartersnakes (Nowak et al. 2019).

The landscape of the Tonto Arm contains a combination of dense vegetation, bare ground, water, and prey that makes it suitable for gartersnake occupancy (SWCA 2022a [see Appendix G]). The vegetation contains low-lying canopy cover and a variety of plant species, interspersed with small patches of bare ground and shallow waters that provide the physical elements of suitable habitat for gartersnakes

(Nowak et al. 2019; SWCA 2022b). These characteristics provide opportunities for the gartersnake to perform its various essential behaviors, and the dense vegetative cover provides shelter for thermoregulation and predator avoidance (Nowak et al. 2019; Sprague and Bateman 2018; SWCA 2022a [see Appendix G]). In studies of gartersnake habitat associations in Arizona, several authors found gartersnakes in locations with dense vegetative cover significantly more often than in locations lacking cover (Emmons and Nowak 2016; Nowak et al. 2019; Sprague and Bateman 2018). The dense vegetative cover conditions present in studies of gartersnake habitat associations (Emmons and Nowak 2016; Nowak et al. 2019; Sprague and Bateman 2018) also contain predatory nonnative species, and are typical throughout much of the gartersnake's range in Arizona. In Mexico, the riparian vegetation is severely denuded or missing altogether due to land uses, but many locations contain robust gartersnake populations attributed to the presence of an aquatic community that is nearly or wholly native (Burger 2007). These contrasting scenarios underscore that the aquatic community is an important habitat variable.

Sprague and Bateman (2018) observed gartersnakes relocating from areas where vegetative cover was removed to areas where vegetative cover was present and concluded that this habitat component was important for gartersnake sheltering behaviors, including protection from predators such as bullfrogs, and thermoregulation. The small patches of bare ground provide areas for basking for thermoregulation (SWCA 2022a [see Appendix G]). The aquatic edge areas contain emergent vegetation and shallow water and are areas where potential prey aggregate, thus providing foraging opportunities for the gartersnake (Nowak et al. 2019).

As stated above (see Subchapter 2.A.i.3), a variety of potential aquatic, riparian, and terrestrial prey are present in the Tonto Arm, including native and nonnative fishes, anurans, and lizards (Nowak et al. 2019). The combination of a shallow water source, the vegetative cover characteristics, and the available prey creates suitable habitat conditions for the gartersnake in the Tonto Arm (Myrand 2019; Nowak et al. 2015; Nowak et al. 2019; SWCA 2022a [see Appendix G]).

The available scientific and commercial data on gartersnake occurrence in the Salt Arm suggest it is likely unoccupied by the gartersnake (SWCA 2022a [see Appendix G]). No gartersnakes were detected during recent surveys (Baker et al. 2019; Grimsley-Padron et al. 2020; Nowak et al. 2015). The survey efforts to detect gartersnakes collectively totaled 96,312 trap hours and 24.2 hours of VES. No gartersnakes were detected incidentally during recent assessments for suitable gartersnake habitat in the Salt Arm (ERO 2020; SWCA 2022a [see Appendix G]). The gartersnake is considered to be extirpated from the lower Salt River below the Roosevelt Dam (Baker et al. 2019; FWS 2014a, 2021d; Holycross et al. 2006; Jones et al. 2020). The Tonto Creek population is located approximately 20 linear miles northwest of the Salt Arm. The intervening landscape consists of Roosevelt Lake and its lake margins that contain steep, rugged slopes that differ from the gradual slopes present in the Tonto Arm and Salt Arm.

The lack of gartersnake detections, low abundances of native prey, presence of nonnative and invasive aquatic predator and competitors, and physical characteristics of the hydrology within the Salt Arm and elsewhere along the lower Salt River suggest that these areas are less suitable for the gartersnake than the Tonto Arm (Baker et al. 2019; FWS 2014a; Holycross et al. 2006; Jones et al. 2020; SWCA 2022a [see Appendix G]). For instance:

- The Salt Arm differs from the Tonto Arm in canopy structure, plant diversity, availability of bare ground, water characteristics, and the ecological community (ERO 2020; SWCA 2022a [see Appendix G]). The Salt Arm consists of a single, wide perennial stream channel dominated by a dense monoculture of tamarisk with intermittent patches of giant reed (*Arundo donax*), cattail, Goodding's willow, and Fremont cottonwood (ERO 2020). The dense monoculture of nonnative tamarisk creates a taller canopy structure and reduces structural complexity and plant diversity (Baker et al. 2019; SWCA 2022a [see Appendix G]). Data on gartersnake habitat associations on the Tonto Arm indicate gartersnakes are more commonly associated with shorter canopy structure (Myrand 2019; Nowak et al. 2019; SWCA 2022a [see Appendix G]), and gartersnake basking sites are generally lacking under the dense tamarisk stands (SWCA 2022a [see Appendix G]). Although the vegetation composition and complexity in both the Tonto Arm and Salt Arm can change with flooding, the previous studies suggest that cover and complexity are important attributes of suitable habitat for the gartersnake in Arizona (Emmons and Nowak 2016; Nowak et al. 2019; Sprague and Bateman 2018).

- The Salt River exhibits higher flows and greater turbidity (ERO 2020), which may affect gartersnake prey or foraging success as these characteristics are associated with lower water quality and reduced ability to detect prey (SWCA 2022a [see Appendix G]). In addition, the abundances of potential amphibian prey differ by one or two orders of magnitude between the Tonto Arm and the Salt Arm, indicating that the Salt Arm is also likely less suitable to amphibians (Baker et al. 2019; Grimsley-Padron et al. 2020; Nowak et al. 2019). If the Salt Arm is not conducive to supporting the diversity and abundance of important prey for the gartersnake (SWCA 2022a [see Appendix G]), then it may not be suitable, or may be less suitable, for the gartersnake.
- Nonnative predatory fish are present in the Salt Arm (SWCA 2022a [see Appendix G]).

The gartersnake habitats in the FCS and lower Tonto Creek portion of the permit area are characterized by a braided stream channel, the riparian vegetation community within the active channel, and adjacent uplands. Tonto Creek flows intermittently through the FCS and the lower Tonto Creek portion of the permit area and is characterized by shallow, wide, braided stream channels and pools interspersed between the channels (ERO-GEI 2020). The riparian vegetative community contains narrow (< 15-m-wide) strips of cattails, mixed stands of Fremont cottonwood, Goodding's willow, and tamarisk, and the adjacent uplands are characterized by Sonoran desertscrub vegetation (ERO-GEI 2022a [see Appendix E]). Both the FCS and the lower Tonto Creek portion of the permit area contain native and nonnative animal species that may serve as either potential predators, competitors, and/or prey for the gartersnake, including the fishes, amphibians, lizards, small mammals, and invertebrates previously mentioned (see Subchapters 2.A.i.3 [Feeding and Diet] and 2.A.i.4 [Predators and Competitors]).

iii. Critical Habitat

The FWS (2013c) proposed to designate critical habitat for the gartersnake on July 10, 2013, with two revisions to the proposed rule published on April 28, 2020 (FWS 2020a) and April 28, 2021 (FWS 2021c), resulting in a reduction in the acreage of the proposed designation (FWS 2020a). The FWS published a final rule, effective May 28, 2021, designating 20,236 acres as critical habitat for the gartersnake (FWS 2021c).

The FWS designated eight critical habitat units; all but one of the critical habitat units (the Upper Gila River Subbasin) are in Arizona (FWS 2021c). The seven gartersnake critical habitat units in Arizona total 19,193 acres (FWS 2021c) and represent 94% of the subspecies' critical habitat within the United States. The FWS (2021c) asserts that gartersnakes occupied all critical habitat areas at the time of listing in 2014, based on records of gartersnake occurrence from 1998 to 2019.

The Roosevelt Lake CS does not contain critical habitat for the gartersnake (FWS 2021c) (Figure 12). The FCS contains 232.1 acres along 1 river mile of the Tonto Creek Unit. The lower Tonto Creek portion of the permit area contains 2,143.1 acres along 14.1 river miles of the Tonto Creek Unit (see Figure 12; FWS 2021a). The FWS (2021c) describes the Tonto Creek Unit as containing physical or biological features (PBFs) 1–3, 4 in degraded condition, and 5 (FWS 2021c). PBFs 1–3 are the habitat features, hydrologic processes, and prey resources present in the aquatic and terrestrial habitats that support gartersnake essential life history activities and persistence of gartersnake populations (FWS 2021a). PBF 4 is a biological factor of the status of nonnative invasive species in the critical habitat unit. The nonnative species must either be absent or at low enough levels to neither inhibit recruitment of gartersnakes nor inhibit the viability of populations of prey species consumed by gartersnakes. PBF 5 is the elevational range at which gartersnakes may occur, listed as 130 to 8,497 feet amsl.

The FWS (2021a) definitions of PBFs 1 through 5 are listed below.

1. Perennial or spatially intermittent streams that provide both aquatic and terrestrial habitat that allows for immigration, emigration, and maintenance of population connectivity of northern Mexican gartersnakes and contain:
   (A) Slow-moving water (walking speed) with in-stream pools, off-channel pools, and backwater habitat;
   (B) Organic and natural inorganic structural features (e.g., boulders, dense aquatic and wetland vegetation, leaf litter, logs, and debris jams) within the stream channel for thermoregulation, shelter, foraging opportunities, and protection from predators;
   (C) Terrestrial habitat adjacent to the stream channel that includes riparian vegetation, small mammal burrows, boulder fields, rock crevices, and downed woody debris for thermoregulation, shelter, foraging opportunities, brumation, and protection from predators; and
   (D) Water quality that meets or exceeds applicable State surface water quality standards.
2. Hydrologic processes that maintain aquatic and terrestrial habitat through:
   (A) A natural flow regime that allows for periodic flooding, or if flows are modified or regulated, a flow regime that allows for the movement of water, sediment, nutrients, and debris through the stream network; and
   (B) Physical hydrologic and geomorphic connection between a stream channel and its adjacent riparian areas.
3. A combination of amphibians, fishes, small mammals, lizards, and invertebrate prey species such that prey availability occurs across seasons and years.
4. An absence of nonnative fish species of the families Centrarchidae and Ictaluridae, American bullfrogs (*Lithobates catesbeianus*), and/or crayfish (*Orconectes virilis*, *Procambarus clarkii*, etc.), or occurrence of these nonnative species at low enough levels such that recruitment of northern Mexican gartersnakes is not inhibited and maintenance of viable prey populations is still occurring.
5. Elevations from 130 to 8,497 feet amsl (40–2,590 m amsl).

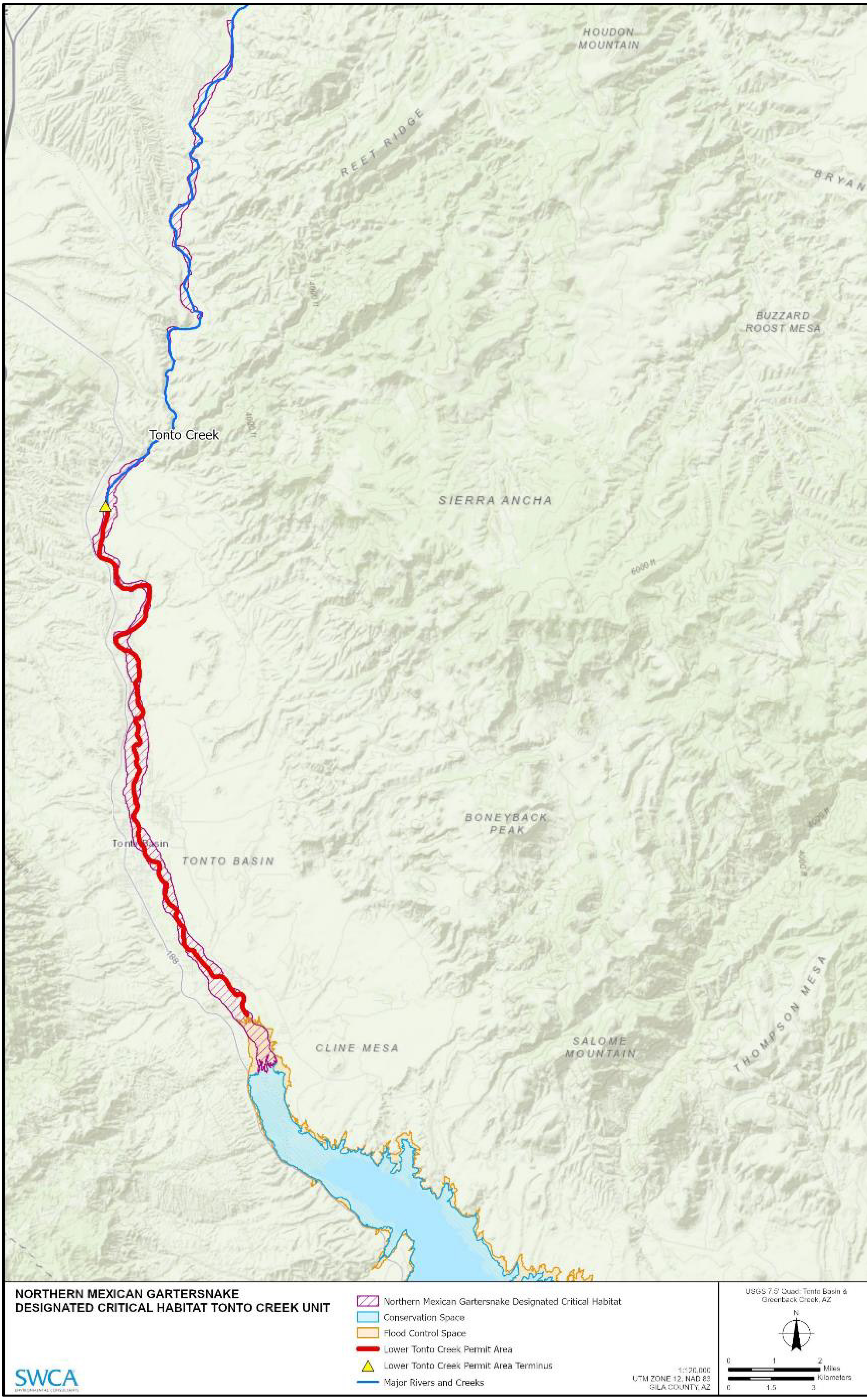

Figure 12. Northern Mexican gartersnake critical habitat (Tonto Creek Unit) in the vicinity of the permit area.

The Tonto Creek critical habitat unit was occupied by the gartersnake at the time of listing. The FWS (2021a) lists several factors that may affect aquatic and terrestrial habitats within the Tonto Creek Unit, including declines in water availability associated with water diversions and groundwater pumping, development in terrestrial habitats, and increased risk of mortality from predation by nonnative predatory fish present in Roosevelt Lake and Tonto Creek (FWS 2021c). The FCS and lower Tonto Creek have features consistent with PBFs 1–3 for gartersnake critical habitat. Tonto Creek flows intermittently through the FCS and the lower Tonto Creek portion of the permit area. Tonto Creek is characterized by shallow, wide, braided stream channels and pools interspersed between the channels (ERO-GEI 2022a [see Appendix E]). The riparian vegetative community contains mixed stands of Fremont cottonwood, Goodding's willow, and tamarisk, and the adjacent uplands are characterized by Sonoran desertscrub vegetation (ERO-GEI 2022a [see Appendix E]). PBF 4 is listed as degraded because of the presence of nonnative species, including largemouth bass and American bullfrogs (FWS 2021c). Both the FCS and the lower Tonto Creek portion of the permit area contain native and nonnative species that may serve as predators, competitors, and/or prey for the gartersnake, including the fishes, amphibians, lizards, small mammals, and invertebrates previously mentioned (see Subchapters 2.A.i.3 [Feeding and Diet] and 2.A.i.4 [Predators and Competitors]). The FCS and lower Tonto Creek are located at an elevational range of 2,151 to 2,500 feet amsl, which is within the specified elevational range of 130 to 8,497 feet amsl for PBF 5.

B. Southwestern Willow Flycatcher

The southwestern willow flycatcher is a covered species in the original RHCP (SRP 2002). The original RHCP contains a review of the biology, life history, and habitats of and threats to this species (see Subchapter II.B.1 of the RHCP). The original RHCP also describes the status of the flycatcher in the CS. This addendum provides updated information on the status of the flycatcher in the CS, new information on the status of the flycatcher in the FCS, and other new or updated information relevant to understanding the effects of flood control operations (including current operations and the planned deviation) on the species.

i. Baseline Status

1. Threats

After approval of the original RHCP in 2002, the FWS published 5-year status reviews in 2014 and 2017 (FWS 2014b, 2017). In these documents, the FWS identified two new threats to the species: the introduction and spread of the introduced tamarisk leaf beetle (*Diorhabda* spp.), and impacts from climate change. Both the northern (*D. carinulata*) and subtropical (*D. sublineata*) species of the tamarisk leaf beetle are spreading in the southwestern United States and are present in occupied flycatcher nesting habitats (FWS 2017). As of the 2017 5-year review, the tamarisk beetle was believed to be capable of spreading throughout the full breeding range of flycatcher (FWS 2017). Because many flycatcher territories have tamarisk (*Tamarix* spp.) as an important vegetative component (and FWS 2017 asserts that the presence of tamarisk is not itself a threat to the species), defoliation by tamarisk leaf beetles can reduce quality and quantity of habitat for this species. Climate change and prolonged drought in the Southwest are expected to be a significant threat to flycatcher recovery as its riparian habitat and prey (emergent aquatic insects) are adversely affected by reduced water availability (FWS 2017).

2. Range-wide and Regional Distribution and Abundance

The FWS compiled the most recent range-wide review of the flycatcher population using data collected through 2012, at which time there were an estimated 1,629 southwestern willow flycatcher territories

(Durst 2017). Of the estimated 1,629 range-wide territories in 2012, 679 were in Arizona (approximately 42%), and 99 were in the Roosevelt Management Unit (approximately 6%).

3. Permit Area Distribution and Abundance

The amount of suitable flycatcher habitat within the CS varies widely, depending on fluctuations in lake elevation, and the number of flycatcher territories varies accordingly. Low lake elevations allow riparian vegetation to develop on exposed sediments, and high lake elevations submerge or alter the vegetation (Paxton et al. 2007). The flycatcher habitat probability model estimated 563.2 acres of potentially suitable habitat in the CS at Roosevelt Lake in 2019, and 164.8 acres in 2020, when the lake was approximately 30 feet higher than it was in 2019 (SRP 2020).

In 2020, EcoPlan Associates, Inc. (EcoPlan), completed flycatcher surveys on behalf of SRP in suitable habitats at the Tonto Arm and Salt Arm of the Roosevelt Lake basin, up to an elevation of 2,175 feet amsl (i.e., the top of the FCS). Field personnel recorded territory locations as the approximate center of activity of a male flycatcher or a pair unless a nest was found, in which case the nest represented the territory location. EcoPlan identified 236 territories (Liknes and Ashbeck 2021). SWCA further analyzed the territory locations and determined there were 220 territories centered in the CS, 11 territories above 2,151 but below 2,156 feet amsl, and five territories above 2,156 feet amsl. Of all the territories, 58% were in the Tonto Arm and 42% were in the Salt Arm. Nine of the 220 territories in the CS, all 11 territories in the 2,151- to 2,156-foot amsl elevation band, and one territory above 2,156 feet amsl were centered within 10 horizontal meters of an elevation of 2,151 feet amsl; the areas used by these flycatchers likely overlapped more than one of these elevation bands.

In 2021, EcoPlan completed flycatcher surveys on behalf of SRP in the FCS (Liknes and Ashbeck 2022). Although the surveys targeted areas above 2,151 feet amsl, many of the territories detected were in the CS but near 2,151 feet amsl. Field personnel detected 45 territories (three in the Tonto Arm and 42 in the Salt Arm) centered in the CS; three of the 42 territories in the Salt Arm were centered within 10 horizontal meters of an elevation of 2,151 feet amsl. Eight territories (five in the Tonto Arm and three in the Salt Arm) were centered between 2,156 and 2,175 feet amsl; two of these, both in the Salt Arm, were within 10 horizontal meters of an elevation of 2,156 feet amsl. The area used by flycatchers with territories centered near the edge of an elevation band likely overlapped both elevation bands. No territories were centered between 2,151 and 2,156 feet amsl.

Personnel from EcoPlateau Research sampled for tamarisk leaf beetles in 2020 and 2021 in both the Salt and Tonto Arms, but no beetles were found (Johnson 2021; Johnson et al. 2021). Beetles were detected in July 2022 on both the Salt and Tonto Arms (Valencia 2022a).

ii. Critical Habitat

In 2013, the FWS designated revised critical habitat for flycatcher, totaling approximately 1,975 stream miles (FWS 2013b).

In consideration of SRP's conservation measures implemented under the original RHCP and accompanying management support from the Tonto National Forest, the CS was excluded from flycatcher critical habitat (FWS 2013b). However, approximately 382.9 acres of the FCS in the Tonto Arm and 506.5 acres of the FCS in the Salt Arm overlap flycatcher critical habitat (Figure 13 and Figure 14). Of this acreage, 208.2 acres is between 2,151 and 2,156 feet amsl elevation. These areas of critical habitat are part of the Roosevelt Management Unit, and the FWS determined that they have substantial recovery value, were known to be occupied at time of listing, and contain the primary constituent elements (PCEs)[10] essential for the conservation of the species (FWS 2013b).

In its critical habitat designation (FWS 2013b), the FWS identified the following PCEs essential to the long-term conservation of the flycatcher:

PCE 1—Riparian vegetation. Riparian habitat along a dynamic river or lakeside, in a natural or human-made successional environment (for nesting, foraging, migration, dispersal, and shelter) that comprises trees and shrubs and some combination of:

(a) Dense riparian vegetation with thickets of trees and shrubs that can range in height from about 2 to 30 m (about 6–98 feet). Lower-stature thickets (2–4 m, or 6–13 feet tall) are found at higher-elevation riparian forests, and tall-stature thickets are found at middle- and lower-elevation riparian forests;

(b) Areas of dense riparian foliage at least from the ground level up to approximately 4 m (13 feet) above ground or dense foliage only at the shrub or tree level as a low, dense canopy;

(c) Sites for nesting that contain a dense (about 50%–100%) tree or shrub (or both) canopy (the amount of cover provided by tree and shrub branches measured from the ground); and

(d) Dense patches of riparian forests that are interspersed with small openings of open water or marsh, or areas with shorter and sparser vegetation that create a variety of habitat that is not uniformly dense. Patch size may be as small as 0.1 hectare (0.25 acre) or as large as 70 hectares (175 acres).

PCE 2—Insect prey populations. A variety of insect prey populations found within or adjacent to riparian floodplains or moist environments, which can include flying ants, wasps, and bees (Hymenoptera); dragonflies (Odonata); flies (Diptera); true bugs (Hemiptera); beetles (Coleoptera); butterflies, moths, and caterpillars (Lepidoptera); and spittlebugs (Homoptera).

[10] At the time the flycatcher critical habitat rule was published, the FWS used the term "primary constituent elements" to describe the specific attributes of critical habitat that are essential to the conservation of a species. The FWS has replaced this term with "physical or biological features" (FWS 2016b).

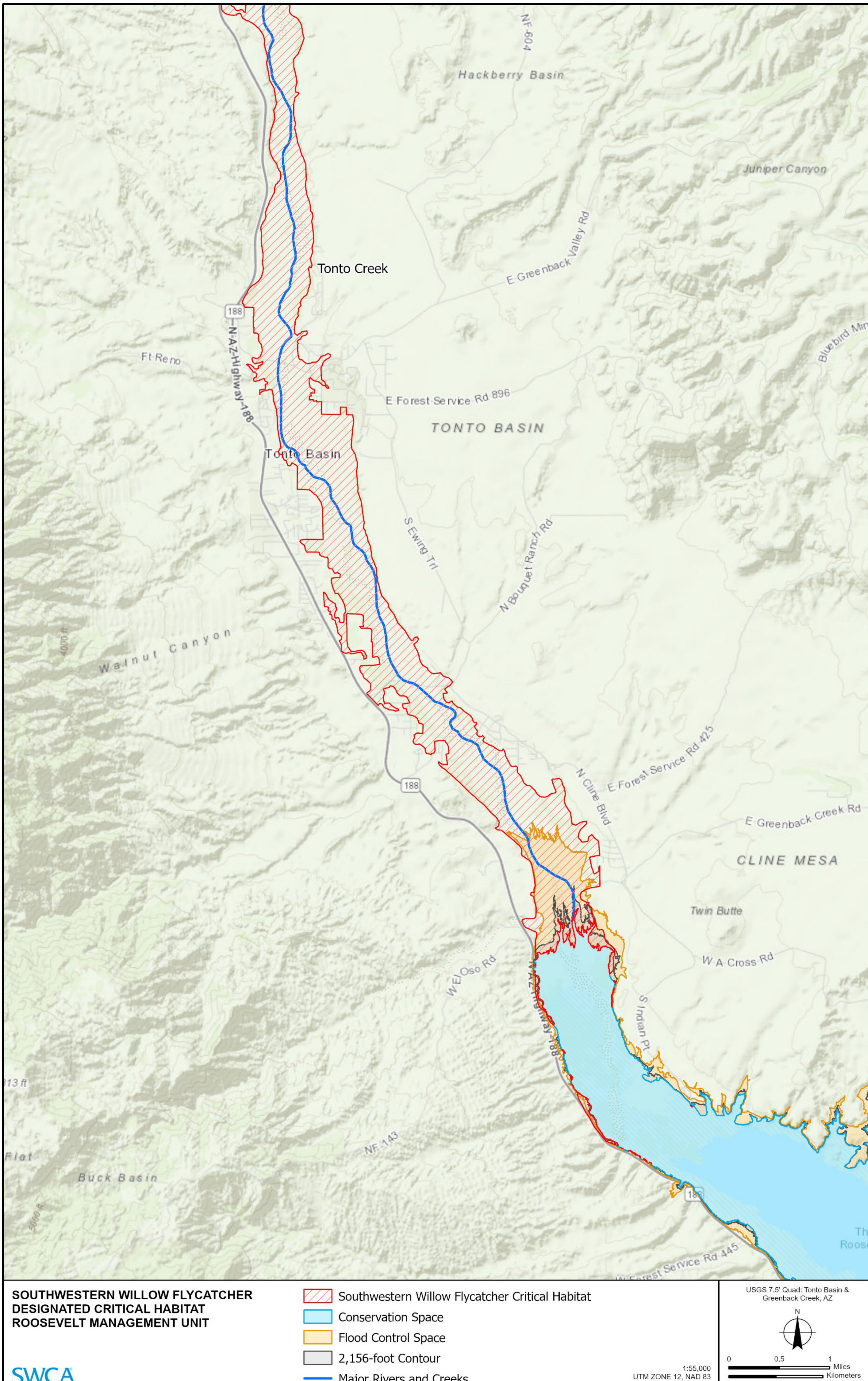

Figure 13. Flycatcher designated critical habitat in the Tonto Arm of the Roosevelt Management Unit.

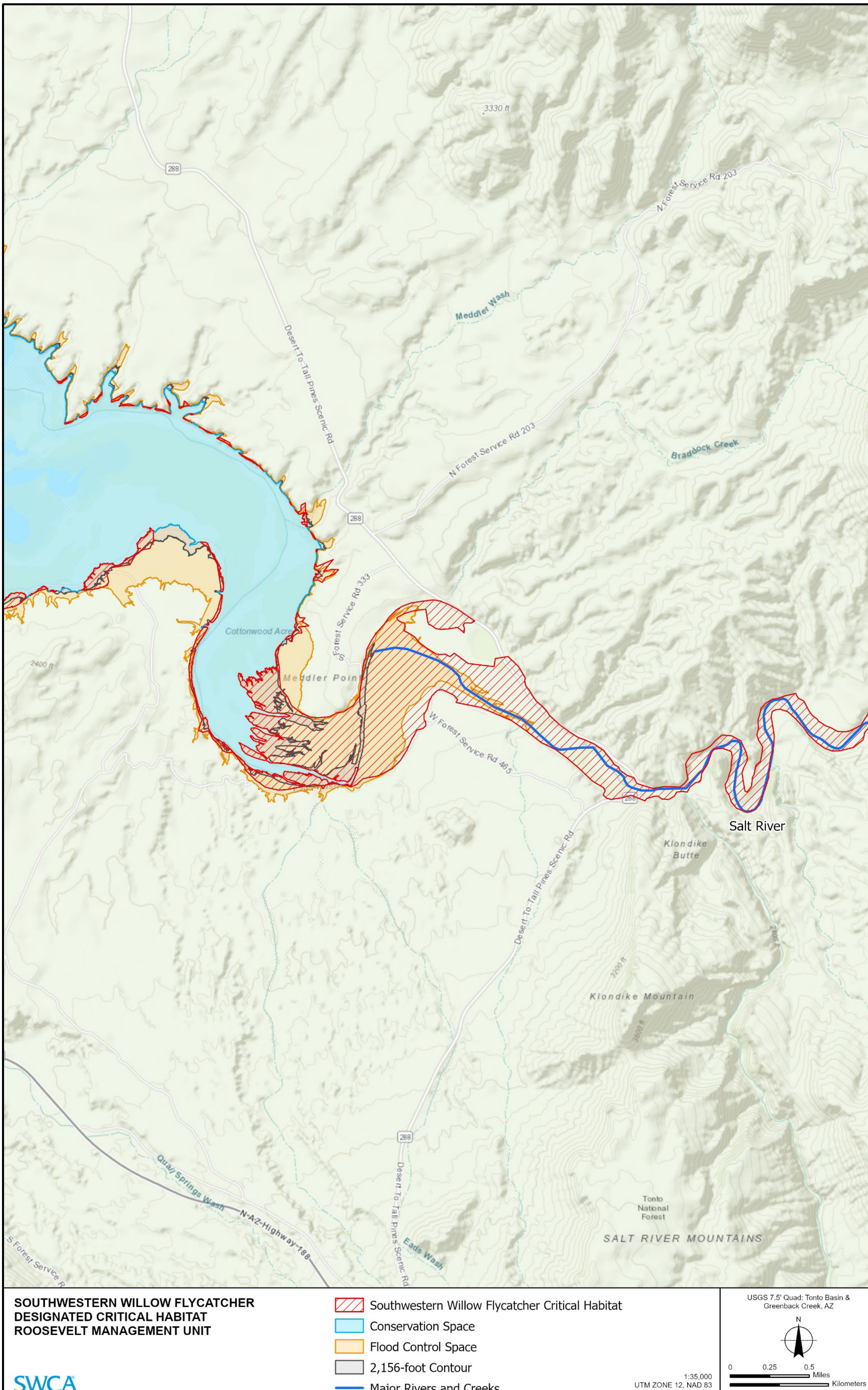

Figure 14. Flycatcher designated critical habitat in the Salt Arm of the Roosevelt Management Unit.

C. Yellow-Billed Cuckoo

The cuckoo is a covered species in the original RHCP (SRP 2002). The original RHCP contains a review of the biology, life history, and habitats of and threats to this species (see Subchapter II.B.4 of the RHCP). The original RHCP also describes the status of the cuckoo in the CS. This addendum provides additional information on the status of the cuckoo in the CS, new information on the status of the cuckoo in the FCS, and other new or updated information relevant to understanding the effects of flood control operations (including current operations and the planned deviation) on the species.

i. Baseline Status

1. Listing Status

After publication of the original RHCP, the FWS proposed the cuckoo for listing on October 3, 2013, and published a final rule listing cuckoo as threatened on November 3, 2014 (FWS 2013c, 2014c).

2. Range-wide and Regional Distribution and Abundance

In 2019, the FWS estimated the cuckoo breeding population at 500 breeding pairs in Mexico and 800 breeding pairs north of the U.S.–Mexico border, with the core of the population centered in Arizona, New Mexico, and northwestern Mexico (FWS 2019). The FWS estimated the population in Arizona in 2019 at 450 breeding pairs; of these, approximately 100 territories were along the lower Colorado River (FWS 2019).

3. Permit Area Distribution and Abundance

In 2020, EcoPlan completed cuckoo surveys on behalf of SRP in suitable habitats at the Tonto Arm and Salt Arm of the Roosevelt Lake basin, up to an elevation of 2,175 feet amsl (i.e., the top of the FCS). Field personnel identified an estimated two cuckoo territories within the CS (one in the Tonto Arm and one in the Salt Arm), an estimated four territories within the FCS (three in the Tonto Arm and one in the Salt Arm), and an estimated additional three territories in the Salt Arm that were partially within the CS and partially within the FCS (Liknes and Ashbeck 2021). All but one of the territories in the FCS included areas between 2,151 and 2,156 feet amsl. Surveys in 2020 were incomplete because a nearby wildfire restricted access during the second survey period.

In 2021, EcoPlan completed cuckoo surveys on behalf of SRP in suitable habitats in the FCS (Liknes and Ashbeck 2022). Field personnel identified an estimated one cuckoo territory in the Salt Arm and two territories in the Tonto Arm; all detections in these estimated territories were near the 2,175-foot amsl elevation contour.

ii. Critical Habitat

The FWS (2014d) proposed to designate critical habitat for the cuckoo on August 15, 2014, with a revision to the proposed rule published on February 27, 2020, that reduced the acreage of the proposed designation (FWS 2020b). The FWS published a final rule, effective May 21, 2021, designating 298,845 acres as critical habitat for the cuckoo (FWS 2021e).

The FWS excluded the CS from the cuckoo critical habitat designation (FWS 2021b) because of the conservation benefits to the cuckoo resulting from implementation of the RHCP. However, approximately 429.9 acres of the FCS along Tonto Creek (Unit 12: AZ-10, Tonto Creek) and 423.2 acres of the

FCS along the Salt River (Unit 23: AZ-21 Salt River) are designated cuckoo critical habitat, which extends upstream from an elevation of 2,151 feet amsl for approximately 10 miles along Tonto Creek and 2.5 miles along the Salt River (Figure 15 and Figure 16). Of this acreage, 181.0 acres is between 2,151 and 2,156 feet amsl elevation. Cuckoos nest in both units, and both units provide movement corridor and migratory stopover habitat (FWS 2021e).

The FWS (2021e) identified the following PBFs which are essential to the long-term conservation of the cuckoo:

> PBF 1—Range-wide breeding habitat. Range-wide breeding habitat is composed of riparian woodlands within floodplains or in upland areas or terraces often greater than 325 feet (100 m) in width and 200 acres (81 hectares) or more in extent with an overstory and understory vegetation component in contiguous or nearly contiguous patches adjacent to intermittent or perennial watercourses. The slope of the watercourses is generally less than 3 percent but may be greater in some instances. Nesting sites within the habitat have an above-average canopy closure (greater than 70%) and have a cooler, more humid environment than the surrounding riparian and upland habitats. Range-wide breeding habitat is composed of varying combinations of riparian species, including the following nest trees: cottonwood, willow, ash, sycamore, boxelder, alder, and walnut.
>
> PBF 2—Adequate prey base. Presence of prey base consisting of large insect fauna (for example, cicadas, caterpillars, katydids, grasshoppers, large beetles, dragonflies, moth larvae, and spiders), lizards, and frogs for adults and young in breeding areas during the nesting season and in postbreeding dispersal areas.
>
> PBF 3—Hydrologic processes. The movement of water and sediment in natural or altered systems that maintains and regenerates breeding habitat. Hydrologic processes (either natural or managed) in river and reservoir systems that encourage sediment movement and deposits and promote riparian tree seedling germination and plant growth, maintenance, health, and vigor (e.g., lower-gradient streams and broad floodplains, elevated subsurface groundwater table, and perennial rivers and streams). In some areas where habitat is being restored, such as on terraced slopes above the floodplain, this may include managed irrigated systems that may not naturally flood due to their elevation above the floodplain.

Both units provide the PBFs essential to the long-term conservation of the species, including habitat components (PBF 1), prey components (PBF 2), and hydrologic process components (PBF 3), though the hydrologic processes depend on river flows and flood timing (FWS 2021e).

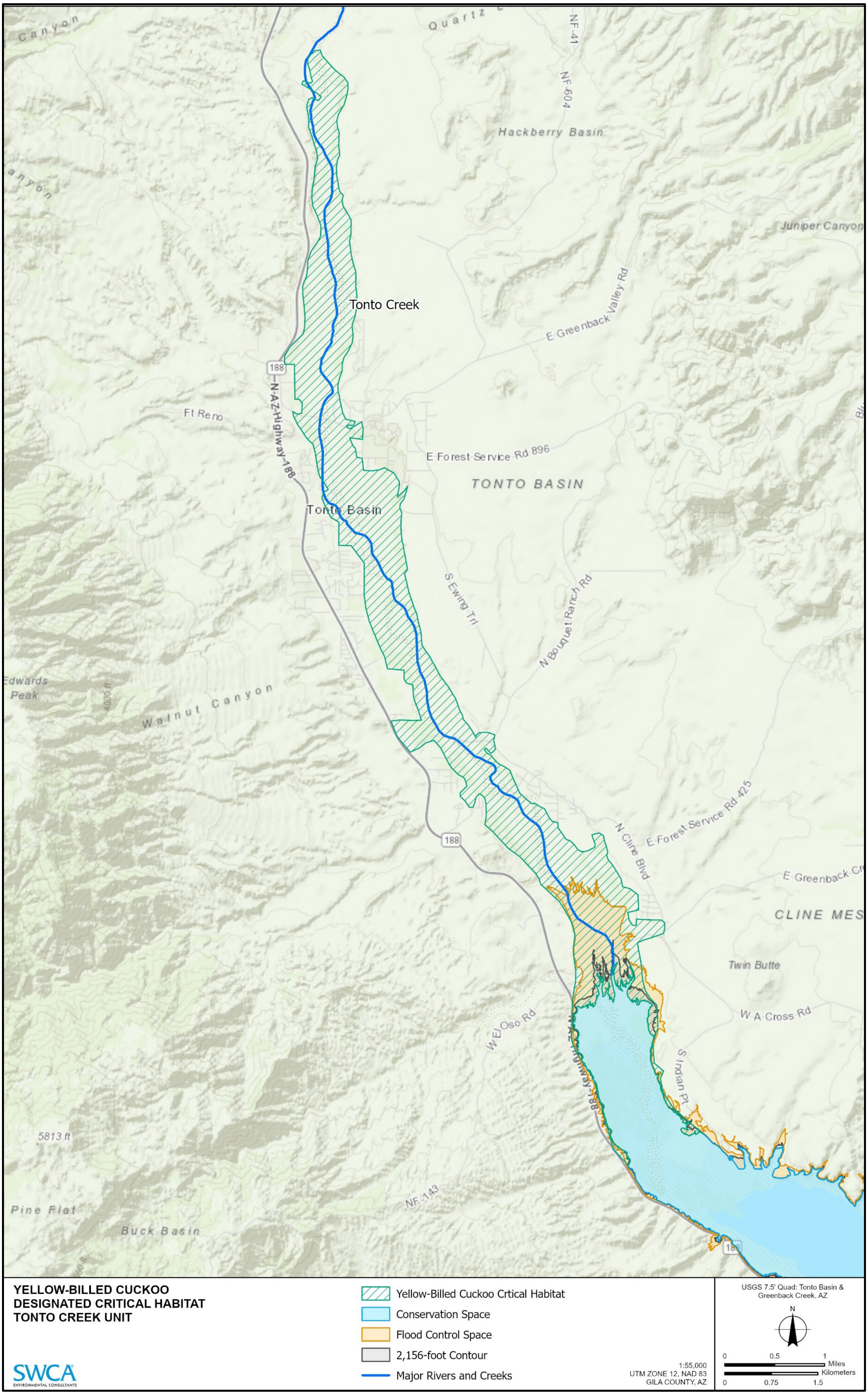

Figure 15. Cuckoo designated critical habitat in the Tonto Creek Unit.

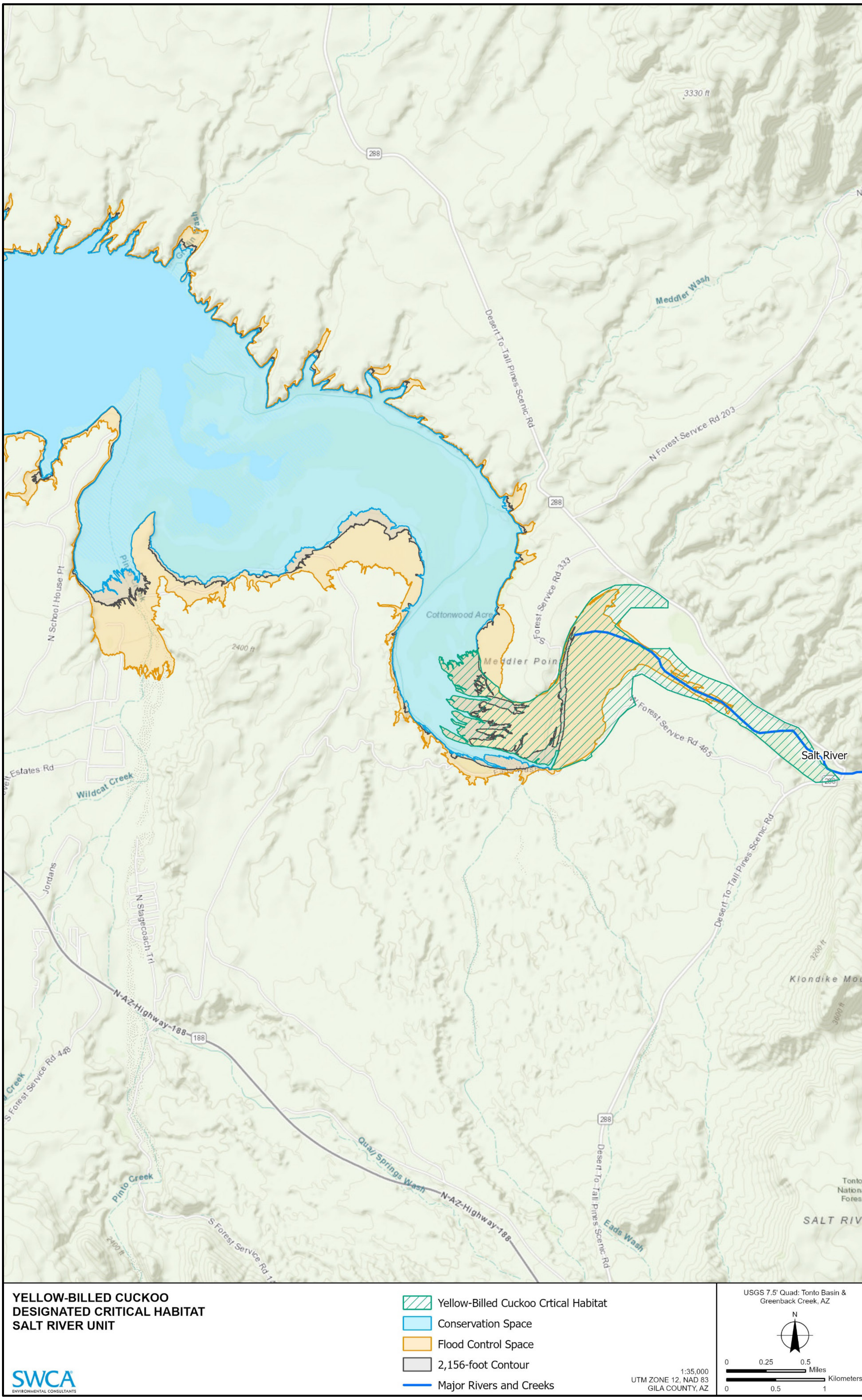

Figure 16. Cuckoo designated critical habitat in the Salt River Unit.

D. Yuma Ridgway's Rail

The Yuma Ridgway's rail (rail, *Rallus obsoletus yumanensis*) is a covered species in the original RHCP (SRP 2002). The original RHCP contains a review of the biology, life history, and habitats of and threats to this species (see Subchapter II.B.2 of the original RHCP). The original RHCP also describes the status of the rail in the CS. This addendum provides additional information on the status of the rail in the CS, new information on the status of the rail in the FCS, and other new or updated information relevant to understanding the effects of flood control operations (including current operations and the planned deviation) on the species.

i. Baseline Status

1. Listing Status

After publication of the original RHCP, the rail species name changed from Yuma clapper rail (*Rallus longirostris yumanensis*) to Yuma Ridgway's rail (*Rallus obsoletus yumanensis*) (FWS 2021f).

2. Range-wide and Regional Distribution and Abundance

In 2006, the FWS estimated 5,974 rails in Mexico, with 707 individuals detected in the United States in the same year (FWS 2010a). From 2000 through 2008, the number of rails in the United States fluctuated between 503 and 890 individuals (FWS 2010a). The recovery strategy for the rail focuses on the three core areas of rail populations: the lower Colorado River, the Salton Sea, and the Cienega de Santa Clara (FWS 2010a).

Rails occur along the Gila River near Phoenix. The number of rails detected in this area from 2000 through 2008 varied between 11 and 57 individuals (FWS 2010a).

3. Permit Area Distribution and Abundance

The original RHCP describes a single detection of a rail along Tonto Creek in 2002 (see Subchapter II.B.2.g of the RHCP). No rails were detected during a subsequent survey in 2002 or during surveys in 2003, 2004, 2015, or 2016 (SRP 2017). No surveys were conducted in other years because of a lack of marsh habitats. There are no marsh habitats in the FCS; thus, there is no habitat for rails in the FCS.

E. Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) is a covered species in the original RHCP and ITP (SRP 2002). The original RHCP contains a review of the biology, life history, and habitats of and threats to this species (see Subchapter II.B.3 of the original RHCP).

This addendum provides updated information on the status of the bald eagle in the vicinity of Modified Roosevelt and other new or updated information relevant to understanding the effects of conservation storage and flood control operations (including current operations and the planned deviation) on the species.

i. Baseline Status

1. Listing Status

The bald eagle was removed from the endangered species list in 2007 (FWS 2007a). Bald eagles nesting in the Sonoran Desert areas of central Arizona were returned to the list of threatened species in 2008 (FWS 2008a), pending a status review and 12-month finding on a petition that sought to designate a distinct population segment, list the distinct population segment as endangered, and designate critical habitat. The FWS determined that bald eagles nesting in the Sonoran Desert areas of central Arizona did not qualify as a distinct population segment, and the delisting rule was reinstated (FWS 2011b).

Bald eagles are protected under the Bald and Golden Eagle Protection Act (BGEPA; 16 USC 668–668c), which prohibits disturbance that would cause nest abandonment or a decrease in productivity by interfering with normal breeding, feeding, or sheltering behavior. Human-induced alterations to a previously used nest site are also prohibited if the alterations result in nest abandonment.

2. Permit Area Distribution and Abundance

Six breeding areas in the Modified Roosevelt vicinity (Pinal, Pinto, Sheep, Tonto, Dupont, and Rock Creek) were covered in the original RHCP. At the time of the original RHCP, the Tonto and Pinto nests were in the CS; all other nests were above the elevation of the FCS. Since then, four additional breeding areas (Armer Gulch, Bachelor Cove, Campaign Bay, and Two Bar) have been discovered in the Modified Roosevelt vicinity. Campaign Bay was in the CS but was active only in 2013; the other three breeding areas are outside both the CS and the FCS (SRP 2013, 2014, 2019). New nests associated with the Tonto breeding area have been discovered in the CS (AGFD 2020b). As of October 2022, the Tonto breeding area had one nest structure in a live cottonwood that has been used for nesting.

The original Pinto nest tree, on the Salt Arm, fell in 2016 (SRP 2016), and the Pinto eagles built a new nest in 2017 in a mature cottonwood (McCarty et al. 2017). The new Pinto nest is in the FCS at an elevation between 2,151 and 2,156 feet amsl (AGFD 2020b). The Pinto nest tree is approximately 37 feet tall, but the height of the nest above the ground is not known. Since its discovery, the Pinto nest has been used annually (English 2021; SRP 2020). The new Pinto nest had two eggs and two fledges in each of the 2017–2018 and 2018–2019 breeding seasons, and one egg and zero fledges in each of the 2019–2020 and 2020–2021 breeding seasons. The nest is currently (2021–2022 breeding season) active with one egg. As of 2021, this was the only known nest in the Pinto breeding area. No other bald eagles are known to nest in the FCS.

3. Productivity

SRP has monitored bald eagle nest success and productivity for eight different breeding areas in the vicinity of Modified Roosevelt since 2003 (Table 8). SRP received and tracked bald eagle productivity data from AGFD for five to eight of these monitored breeding areas, depending on the year (see Table 8). SRP participates in the Southwest Bald Eagle Management Committee, accompanies AGFD staff on bald eagle productivity helicopter flights, and—along with Reclamation, the U.S. Forest Service, the Bureau of Land Management, AGFD, and several tribes—provides annual financial support for Nestwatchers through the Bald Eagle Management Program.

Table 8. Eagle productivity. Nest success and productivity of monitored bald eagle breeding areas in the vicinity of Modified Roosevelt as of March 2022.

Year	Productivity Rate*	Breeding Area							
		Armer Gulch	Bachelor Cove	Campaign Bay	Dupont	Pinal	Pinto	Rock Creek	Tonto
		Nest/Eggs/ Fledge	Nest/Eggs/ Fledge	Nest/Eggs/ Fledge	Nest/Eggs/ Fledge	Nest/Eggs/ Fledge	Nest/Eggs/ Fledge	Nest/Eggs/ Fledge	Nest/Eggs/ Fledge
2003	0				F/1/0	F/1/0	O/0/0	F/1/0	F/2/0
2004	1.25				U	S/1/1	S/2/2	F/1/0	S/2/2
2005	1.50				U	S/2/2	S/2/2	S/1/1	S/1/1
2006	1.33				U	F/2/0	S/2/2	U	S/2/2
2007	0.67				U	O/0/0	F/2/0	U	S/2/2
2008	1.00				U	S/2/2	S/2/2	F/1/0	F/2/0
2009	1.67				U	F/1/0	S/2/2	U	S/3/3
2010	1.00				U	S/1/1	F/1/0	U	S/2/2
2011	1.33				U	S/2/2	F/1/0	U	S/2/2
2012	1.33				U	S/2/2	F/1/0	U	S/2/2
2013	1.00		S/1/1	F/1/0	U	S/2/2	S/2/2	U	O
2014	0.40	S/1/1	O/0/0	U	U	F/2/0	F/1/0	U	S/1/1
2015	1.50	S/2/2	S/2/2	U	X – No longer active	U	S/2/1	U	S/1/1
2016	1.50	S/2/2	S/2/2	U		U	F/1/0	U	S/2/2
2017	1.80	S/3/3	S/2/2	U		F/1/0	S/2/2	U	S/2/2
2018	1.80	S/3/3	S/2/2	U		S/2/2	S/2/2	U	F/1/0
2019	1.00	F/1/0	S/2/2	U		S/1/1	S/2/2	X – no longer active	O
2020	0.25	U	S/2/1	U		F/1/0	F/1/0		F/1/0
2021	0.50	U	S/2/2	U		F/1/0	F/1/0		F/2/0
2022	1.0†	U	A/2/2†	U		A/1/1†	A/1/1†		O
Avg	1.1								

Note: S = Successful; F = Failed; O = Occupied, no eggs; U = Unoccupied; A = Active, no conclusion as to success.
* Productivity Rate = the number of fledglings produced divided by the number of occupied breeding areas.
† Provisional data.

The combined annual productivity rate of monitored breeding areas (i.e., the number of fledglings produced divided by the number of occupied breeding areas) ranged from 0 to 1.8 and averaged 1.1 over 20 years of monitoring. The combined annual productivity rate for monitored breeding areas was less than 1.0 in five of the 20 years.

Successful breeding areas individually produced between one and three fledglings per year. Since 2003, 86 total fledglings were produced by all monitored breeding areas, or an average of 4.3 fledglings per year. Active breeding areas (i.e., breeding areas where adults occupied a nest or laid eggs in a nest) failed to produce at least one fledgling on 31 occasions, representing 39% of 80 documented or presumed nesting attempts.

4. Completed and Ongoing Bald Eagle Conservation Measures

SRP committed to implementing bald eagle conservation measures at Modified Roosevelt to address the impacts of authorized incidental take associated with operation of the CS (see Subchapter IV.C.1.c of the original RHCP). SRP also incorporated into the original RHCP Reclamation's conservation measures for the bald eagle that were required terms and conditions of various Biological Opinions addressing the effects of Modified Roosevelt and its operation (Table 9). These required conservation measures have either been completed, are ongoing, or are not yet relevant (i.e., they address effects that have not yet occurred). Reclamation has completed all of its bald eagle–related obligations as required in the Biological Opinions.

These bald eagle conservation measures, all of which were incorporated into the original RHCP, fully offset the impacts of incidental take by SRP in the CS and FCS. Even though the FCS was not part of the original RHCP's permit area, SRP committed to ensure implementation of the pertinent reasonable and prudent alternatives and minimization measures required of Reclamation associated with the construction and operation of Modified Roosevelt, including current flood control operations. Since implementation of these bald eagle conservation measures by SRP and Reclamation, the number of bald eagle breeding areas relying on Roosevelt Lake has increased (SRP monitored five breeding areas between 2003 and 2012, and six to eight breeding areas between 2013 and 2022). The number of eagles produced annually from these breeding areas has also increased, from 37 fledglings produced between 2003 and 2012, to 49 fledglings produced between 2013 and 2022.

Table 9. Pertinent bald eagle conservation measures required of Reclamation or SRP for Roosevelt Dam and Lake.

Reclamation's Section 7 Obligations for Modified Roosevelt						2003 RHCP Section 10 Obligations for Operations of Modified Roosevelt Conservation Storage	
Biological Opinion Year	**Breeding Area**	**Proposed Action Location**	**Impact Addressed**	**Pertinent Reclamation Conservation Measure**	**Reclamation Implementation**	**Reclamation's Conservation Measures Incorporated into Original 2003 RHCP**	**Original 2003 RHCP Implementation**
1983	Pinal	CS	Borrow excavation from dam construction.	Reasonable and Prudent Alternative: modify extent and timing of borrow excavation at Meddler Point near nest and restrict recreation access	Completed	None	None
1990	Sheep, Pinto, Tonto	CS, FCS, and Safety of Dams surcharge space	Higher lake elevations would result in eventual loss of all or a portion of the cottonwoods, including nest trees, below 2,151 feet amsl. Noted offsetting benefits of shallow fringe water and wetlands.	1) Tonto: Improved riparian habitat in Tonto Creek Riparian Unit 2) Purchase of Rockhouse, restore riparian habitat	1) Implemented patrol activities via Forest Protection Officer 2) Implemented planting and management 3) Not completed as inundation was not imminent	Forest Protection Officer Rockhouse planting	Forest Protection Officer establishes and patrols closure areas, patrols and protects habitat within Tonto Creek Riparian Unit; SRP planted and maintains Rockhouse riparian habitat. SRP constructed a nest platform on November 21, 2022 that is outside of the inundation area, but it has not been used for nesting (only observed perching) yet as they are still using a tree.
1993	New Tonto Nest	CS	Eventual loss of existing nest tree and nests as a result of inundation and subsequent loss of future trees, nests, productivity, eggs, and fledglings from inundation and recreation impacts for 50 years. Offsetting effects of Tonto Creek Riparian Unit.	1) Seasonal closure around breeding area 2) Annual monitoring of breeding area 3) Notify FWS and assist in rescue efforts if inundation may occur	Implemented conservation measures 1 and 2, but conservation measure 3 was not necessary	Forest Protection Officer Nestwatchers Emergency rescue plan	Forest Protection Officer works for Tonto National Forest to establish and patrol closures; SRP pays for Nestwatchers, Forest Protection Officer, and helicopter to monitor nests; SRP developed emergency rescue plan, established budget, and makes helicopter available for rescues.

Note: See Appendix C for a full list of Reclamation's history of ESA compliance at Roosevelt Dam and Lake.

F. Spikedace

The spikedace is not a covered species of the original RHCP (SRP 2002), nor is SRP seeking to add coverage for this species. Information about the spikedace and its critical habitat is provided herein to support FWS with evaluating effects as part of its intra-agency consultation on the proposed action of amending the ITP.

i. Biology, Life History, and Habitats

The spikedace is an endangered small-bodied cyprinid fish that is endemic to the Gila River watershed (FWS 2012b). The spikedace occupies flowing perennial rivers, and adult spikedace are commonly found in shallow riffle and run habitats (FWS 1990b). Habitat for the spikedace includes moderate to large perennial streams; shear zones (fast water meets slower water, riffle-pool transitions); and substrates that include sand, gravel, and rubble (FWS 2012b).

ii. Baseline Status

1. Listing Status and Threats

The FWS listed the spikedace as threatened under the ESA on July 1, 1986; this species was later reclassified as endangered on March 26, 2012 (FWS 2012c).

The FWS described the threats to the spikedace as: "Habitat destruction due to damming, channel alteration, riparian zone modification and destruction, channel downcutting, water diversion and groundwater pumping; and the introduction and spread of exotic predatory and competitive fish species" (FWS 2012c:1).

2. Range-wide and Regional Distribution and Abundance

This species was once widely distributed throughout the watershed. However, the current distribution of spikedace has been reduced to ≤ 10% of its historical range. Spikedace were historically widespread throughout the Upper Gila basin; presently, however, the species occupies only limited portions of the upper Gila River in New Mexico and Aravaipa Creek in Arizona. The current distribution includes approximately 277 miles of river/creek habitat, including the upper Gila River, the middle Gila River, the lower San Pedro River, Aravaipa Creek, Eagle Creek, and the Verde River. Currently, the species is only common in Aravaipa Creek and portions of the upper Gila River in New Mexico (FWS 2012b).

3. Permit Area Distribution and Abundance

Historical records indicate that spikedace were observed and/or captured: 1) at the confluence of Cibecue Creek and the Salt River; 2) downstream of the Roosevelt Dam on the Salt River; and 3) in the Salt River prior to the creation of Saguaro Lake, but where Saguaro Lake currently exists (FWS 2010b). There are no documented historical or current occurrences of spikedace in the CS (FWS 2010b); nor does the CS contain the elements of suitable habitat for the spikedace, since this area lacks perennial stream habitat with shallow riffle and run complexes and the FWS (2012b) observed that the species does not occupy lakes or reservoirs.

Because the species is not presently occupying the CS, the FCS, or lower Tonto Creek, SRP's covered activities will not cause incidental take of the spikedace. No identifiable individuals of the species would be killed, wounded, harmed, or otherwise taken by continued operation of Modified Roosevelt. Therefore, SRP is not proposing to add the spikedace as a covered species. However, this addendum does provide an analysis of effects in the FCS and lower Tonto Creek for the covered activities on unoccupied designated critical habitat, for the FWS to consider in preparation of its Biological Opinion under ESA Section 7.

iii. Critical Habitat[11]

In April 2000, the FWS designated approximately 807 miles of critical habitat for spikedace (FWS 2000) and later revised designated critical habitat to encompass approximately 691 miles (FWS 2007c). The FWS established approximately 44 miles of "2b" designated critical habitat under the Tonto Creek Complex Unit 2 of the Salt River Subbasin, which also includes Tonto Creek, Rye Creek, and Greenback Creek. This "2b" classification indicates there currently is no extant population of spikedace in the Unit, but spikedace were historically present there. The FWS indicated that this Unit was designated for the reestablishment of spikedace (FWS 2012b). However, neither the FWS nor any other agency has taken any action known to-date to improve the quality of habitat in Unit 2; consequently, no reintroductions have occurred or are planned at this time due to the current abundance of exotic predatory species. In addition, the FWS acknowledges that for Unit 2, "Large areas of the subbasin are unsuitable, either because of topography or because of reservoirs and other stream-channel alterations" (FWS 2012b:10845).

Designated critical habitat for the spikedace occurs from the confluence of Tonto Creek and Greenback Creek, upstream along Tonto Creek and also into Greenback Creek (Figure 17) (FWS 2012b). Designated critical habitat in the Tonto Creek Complex Unit 2 of the Salt River Subbasin includes approximately 29.7 miles of Tonto Creek and 9.4 miles of Greenback Creek (FWS 2012b). Although critical habitat for spikedace is not present within the CS, the designation does overlap portions of lower Tonto Creek and the FCS (FWS 2000). The lower Tonto Creek portion of the permit area, i.e., from the top of the FCS to East del Chi Drive, contains approximately 14.4 miles (1,337.8 acres) of critical habitat in Tonto Creek. The Greenback Creek critical habitat area is not within the lower Tonto Creek permit area but overlaps with the FCS. The FCS contains a total of 1.06 miles (78.47 acres) of critical habitat, which includes 0.84 mile (73.46 acres) in Tonto Creek and 0.22 mile (5.01 acre) in Greenback Creek (Figure 18). The permit area includes portions of lower Tonto Creek that contain suitable, but unoccupied, spikedace habitat.

[11] The spikedace critical habitat area used for this analysis was based on the FWS geographic information system (GIS) file (ECOS 2021); however, that file was incorrect because it extended into the CS, while the designation text clearly stated that it did not include Roosevelt Lake. Therefore, the line was clipped to match the text, i.e., clipped at the confluence of Tonto and Greenback Creeks.

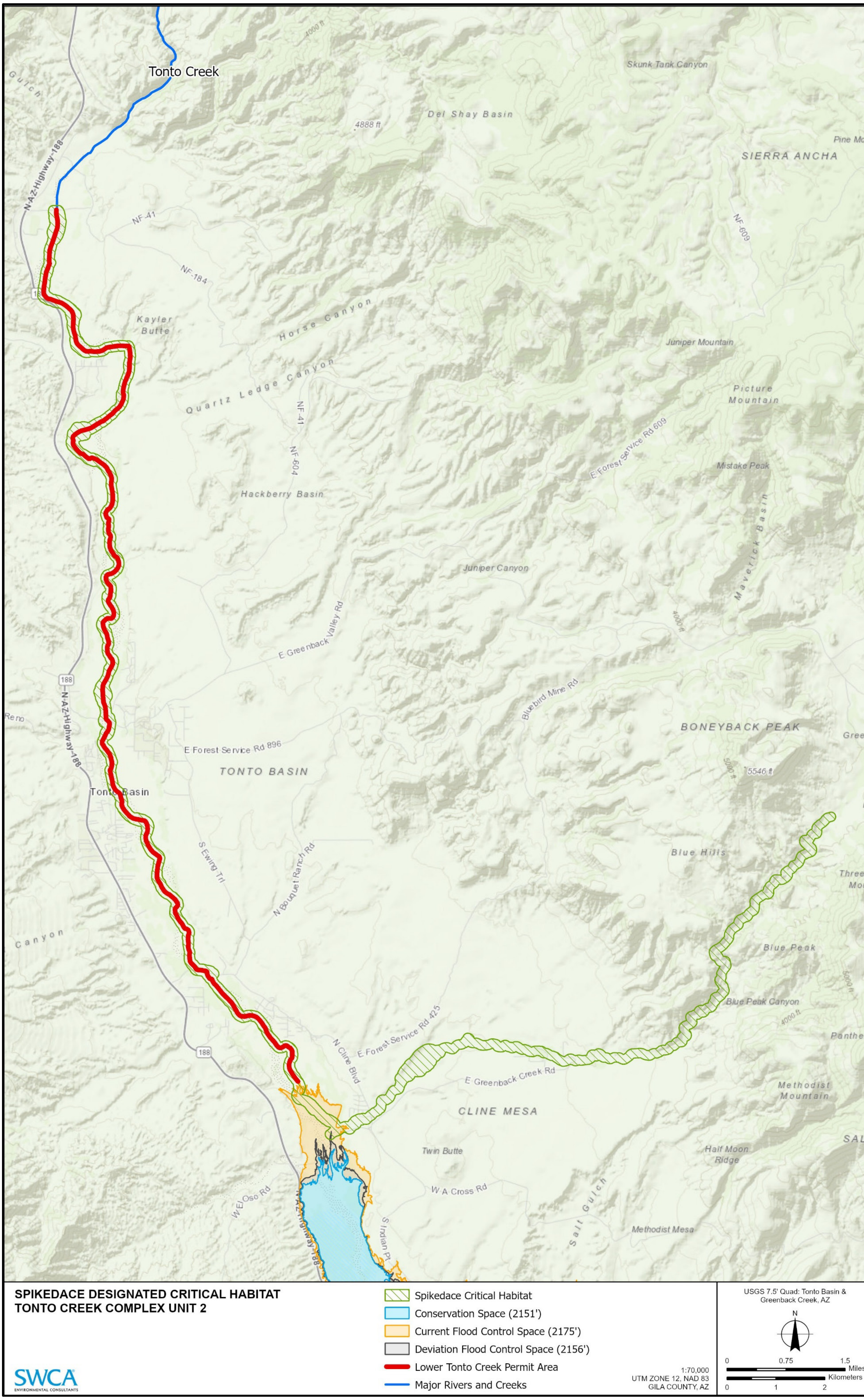

Figure 17. Spikedace designated critical habitat in the FCS and lower Tonto Creek permit areas.

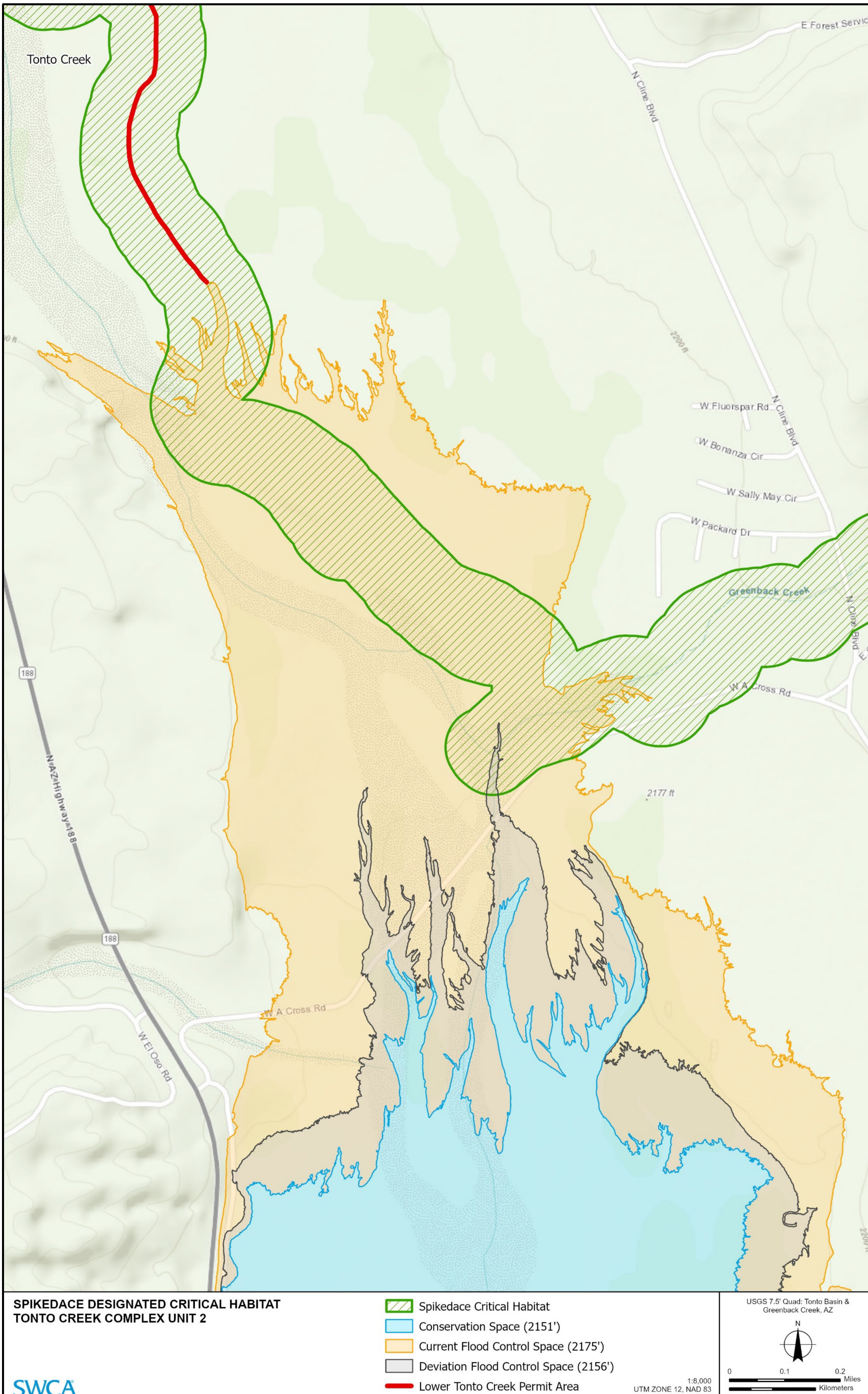

Figure 18. Detailed view of spikedace designated critical habitat in the FCS.

PBFs defined for spikedace critical habitat include the following (FWS 2010b, 2012b):

1. Space for individual and population growth and for normal behavior:
    a. Perennial stream moderate to large in size;
    b. Low elevations and low-gradient streams with sand, gravel, cobble substrate;
    c. Low to moderate fine sediment;
    d. Water temperatures in excess of 34°C (93.2°F) for 30-day exposure were lethal and wild spikedace likely have lower thermal tolerances;
    e. Adults: occur in various flow velocities, occupy shear zones, primarily found over gravel substrate, habitat measurements where adults occur are 23.3–70.0 cm/second (9.2–27.6 inches/second) flow velocity, 6.1–45.7 cm (2.4–16.8 inches) depth, 0.3 to <1.0 percent gradient;
    f. Juveniles: occur in faster flows than larvae but remain in shallow areas, commonly found over fine sediment gravel and sand, habitat measurements where juveniles occur are 16.8 cm/second (6.6 inches/second) flow velocity, 3.0–45.7 cm (1.2–18.0 inches) depth; and
    g. Larvae: occupy slowest water velocities, tend to be found near wetted margins, habitats where larvae occur are 8.4 cm/second (3.3 inches/second) flow velocity, 3.0–48.8 cm (1.2–19.2 inches) depth.
2. Food, water, air, light, minerals, or other nutritional or physiological requirements:
    a. Seasonal variation in diet;
    b. Prey size is usually small ranging from 2–5 mm in length;
    c. Primarily feed on aquatic macroinvertebrates;
    d. Riffle habitat important as association with aquatic macroinvertebrates and cobble/gravel substrates;
    e. Perennial flows are essential; areas within perennial, interrupted stream courses that are periodically dewatered but that serve as connective corridors between occupied or seasonally occupied habitat and through which the species may move when the habitat is wetted;
    f. Waters should have low levels of pollutants such as metals; and
    g. Dissolved oxygen concentration should be > 3.5 cm^3/liter.
3. Cover or shelter:
    a. No data available except what are listed above under PBF 1. The FWS does not provide any details or guidance.
4. Sites for breeding, reproduction, or rearing (or development) of offspring:
    a. Males and females occupy different habitats until eggs released with males holding in riffles and females in slower waters;
    b. Spawning occurs in riffles with depths of 7.9–15.0 cm (3.1–5.9 inches);
    c. Eggs are adhesive, bind to the cobble substrate, and require good oxygenation; spawning in riffles reduces chances of egg mortality due to sedimentation; and
    d. Eggs hatch, and larvae rear in slower water velocities; as spikedace grow larger, they occupy a wider range of flows but usually remain in shallow depths.
5. Habitats that are protected from disturbance or are representative of the historic, geographic, and ecological distributions of a species.

The designation states that the primary constituent elements (PCEs) are those specific elements of the PBFs that are essential to the conservation of the species. The following were identified as the six PCEs for spikedace (FWS 2012b):

1. Habitat to support all egg, larval, juvenile, and adult spikedace, which includes:
    a. Perennial flows with a stream depth generally less than 1 m (3.3 feet), and with slow to swift flow velocities between 5 and 80 cm/second (1.9–31.5 inches/second);
    b. Appropriate stream microhabitat types including glides, runs, riffles, the margins of pools and eddies, and backwater components over sand, gravel, and cobble substrates with low or moderate amounts of fine sediment and substrate embeddedness;
    c. Appropriate stream habitat with a low gradient of less than approximately 1.0 percent, at elevations below 6,890 feet (2,100 m) amsl; and
    d. Water temperatures in the general range of 8.0°C to 28.0°C (46.4°F–82.4°F).
6. An abundant aquatic insect food base consisting of mayflies, true flies, black flies, caddisflies, stoneflies, and dragonflies.
7. Streams with no, or no more than low levels, of pollutants.
8. Perennial flows, or interrupted stream courses that are periodically dewatered but that serve as connective corridors between occupied or seasonally occupied habitat and through which the species may move when the habitat is wetted.
9. No nonnative aquatic species, or levels of nonnative aquatic species that are sufficiently low as to allow persistence of spikedace.
10. Streams with a natural, unregulated flow regime that allows for periodic flooding or, if flows are modified or regulated, a flow regime that allows for adequate river functions, such as flows capable of transporting sediments.

Only PCEs 2, 3, and 6 are present in the Tonto Creek Unit. Food abundance consisting of aquatic macroinvertebrates does not appear to be a limiting factor in Tonto Creek, as evidenced by the abundance observed in stomach contents of fish captured in Tonto Creek (ERO-GEI 2022a [see Appendix E]). While Tonto Creek often dries upstream of the FCS, increases in precipitation (runoff and rain events) can result in periodic flooding and transportation of sediment. Although there is a known presence of methylmercury concentration in fish tissue ≥ 0.3 milligrams per kilogram in several species in Tonto Creek that were captured near Bar-X Road Crossing, this level is considered low; thus, PCE 3 is present (Arizona Department of Environmental Quality [ADEQ] 2011). PCEs identified as absent (i.e., PCEs 1, 4, and 5) were classified based on the following: PCE 1 is absent due to Tonto Creek's intermittent flow; PCE 4 is absent due to lack of spikedace present in Tonto Creek (FWS 2012b); and PCE 5 is absent due to the presence of nonnative predatory fish, which often consume small fishes (GEI 2021). Tonto Creek, downstream of East del Chi Drive, frequently dries, resulting in isolated pools. This information on PCEs also applies to Greenback Creek (ADEQ 2021).

This Unit has the presence of nonnative piscivorous species, including largemouth bass and channel catfish; thus, PCE 5 is absent. Further, the AGFD continues to stock largemouth bass and other nonnative fish in Roosevelt Lake.

Chapter 3. Effects of the Covered Activities[12]

A. Northern Mexican Gartersnake

i. Effects Pathway Model

This addendum evaluates the effects of all SRP's covered activities on the gartersnake, including operations in the CS and operations in the FCS under current WCM prescriptions and under the proposed planned deviation from the WCM. SRP approaches this analysis using the framework of an "effects pathway model" suggested in the *Habitat Conservation Planning and Incidental Take Permit Processing Handbook* (HCP Handbook) (FWS and National Marine Fisheries Service [NMFS] 2016:5-3, 8-1). This framework emphasizes the chain of causation between an activity, its consequences, the resulting responses by individuals of a listed species, and the biological effects of those responses on populations. This chain of causation can help isolate the effects of an action from other baseline conditions in the environment, identify effects that may result in take of individuals of a listed species, and understand the impacts of take on populations.

Briefly, the effects pathway model applied to SRP's covered activities and the gartersnake includes the "steps" described below which provide context for understanding effects. Technical support for the assertions and assumptions within this effects pathway model is provided in the following subchapters and elsewhere in the addendum, as indicated (SWCA 2022c [Appendix I]).

1. **Action:** SRP's covered activities are the continued operations of Modified Roosevelt for conservation storage, current flood control operations following the WCM, and a planned deviation from current flood control operations. These covered activities occur within a baseline context of an existing dam, an existing lake, more than 100 years of previous operations, and the introduction of stressors (such as the stocking of nonnative predatory fish) that affect the gartersnake. The baseline context is important to understanding the effects of the covered activities, particularly the conservation storage operations, since present conditions are representative of the effects of past operations.
2. **Major Activities or Tasks:** The covered activities involve decisions to either store or release water from Modified Roosevelt and to evacuate water from the FCS over a prescribed period. SRP makes these decisions in accordance with the operational priorities established in the 1993 Modified Roosevelt Dam Operating Agreement and the 1997 WCM or under the planned deviation of the WCM.
3. **Impacts to Gartersnake Habitat:**

   The covered activities cause two important types of physical effects relevant to gartersnakes: 1) the long-term presence (storage) of water in the CS due to conservation storage operations; and 2) consistently changing lake elevations in the CS and, occasionally, the FCS, influenced in

[12] The analysis in this addendum used lake elevations that were rounded from the actual lake elevation, i.e., CS actual lake elevation is 2,150.78 feet vs. 2,150 feet in the analysis; FCS actual lake elevation is 2,174.87 feet vs. 2,175 feet in the analysis; and FCS planned deviation actual lake elevation is 2,155.78 feet vs. 2,156 feet in the analysis. (The actual difference in the calculations is minor. The FCS was originally from 2,151 to 2,175 from modification [1996] to 2013. When the sedimentation survey was completed in 2013 (Reclamation 2014), the FCS elevations were adjusted to 2,150.78 feet to 2,174.87 feet to maintain the original storage volume within FCS and Safety of Dams space [and will likely be adjusted again whenever the next sedimentation survey occurs]). This was necessary because spatial data analysis did not have elevational contours in decimal degrees, whereas the WCM has lake elevation in decimal degrees.

part by SRP storage and release of water from Modified Roosevelt. These physical effects impact the gartersnake by changing its habitat in one or more of the following ways:

- altering the availability or amount of habitat in the CS and FCS (a direct consequence of long-term storage in the CS and changing lake elevations arising from conservation storage and flood control operations),
- altering the size, distribution, suitability, and use of gartersnake home ranges in the CS and FCS (a direct consequence of long-term storage in the CS and changing lake elevations arising from conservation storage and flood control operations),
- altering the location of lake-edge habitat in the CS (a direct consequence of changing lake elevations arising primarily from conservation storage operations), or
- altering habitat quality or suitability in the CS, FCS, and in lower Tonto Creek (a direct consequence of changing lake elevations arising from conservation storage and flood control operations and an indirect consequence of long-term conservation storage).

These types of impacts to gartersnake habitat are further explained in the following paragraphs.

Altering the availability or amount of habitat in the CS or FCS. The relatively persistent pools within the Tonto Arm that are mostly along the braided Tonto Creek channel are the basis for much of the gartersnake habitat at Modified Roosevelt. When the lake rises, it inundates this habitat. When inundated by the lake, these areas are largely unsuitable for use by gartersnakes—the gartersnake does not regularly use open water as gartersnakes are not fully aquatic and depend on terrestrial/aquatic edge habitat to support essential life history functions such as foraging. When lake elevations decline, previously inundated portions of the Tonto Creek channel and floodplain are exposed, leaving behind pools of water replenished by the receding lake or by Tonto Creek flows. The exposed and replenished pools expand available gartersnake habitat within the Tonto Arm.

The lake edge itself, created by the long-term storage of water in the CS, also provides gartersnake habitat. Changes in lake elevations caused by conservation storage and flood control operations alter in minor ways the configuration and amount of lake edge habitat. The topography of the basin at different elevations influences the amount of lake edge that is present. While not profound, when the lake elevation changes, so does the amount of lake-edge habitat that is available for use by gartersnakes.

Thus, the availability of habitat is a direct consequence, at least in part, of long-term storage and changing lake elevations associated with conservation storage and flood control operations. In the CS, this kind of change in habitat availability can persist for months or years. In the FCS, this kind of change in habitat availability can persist for days to months. These activities do not change habitat availability in lower Tonto Creek above the FCS.

Altering the location of lake-edge habitat in the CS. In the Tonto Arm of the Roosevelt Lake basin, the topography creates a relatively long and narrow corridor. The lake edge creates a band of habitat that shifts location with changes in lake elevation without substantial changes in the amount of habitat created by this edge due to the general shape of topographic contours. When the lake elevation rises, the band of habitat created by the lake edge shifts upward in the basin. When the lake elevation falls, the habitat along the edge shifts lower in the basin. This shifting fringe of habitat is most relevant to the gartersnakes that use the CS, since the lake is the only consistent source of aquatic habitat within the CS. It is unlikely that the lake edge habitat contributes substantially to the support of gartersnakes in the FCS, since the lake has rarely entered the FCS in the past and is estimated to do so only occasionally in the future, and then for relatively brief periods. Therefore, the shifting location of lake-edge habitat is most closely associated with conservation storage operations. SRP's activities do not alter the location of gartersnake habitat in lower Tonto Creek above the FCS.

<u>Altering habitat quality in the CS, FCS, and lower Tonto Creek</u>. Lake elevation changes caused by SRP's covered activities may alter the quality or suitability (here, these terms may be considered synonymous) of the habitat associated with the relatively persistent pools in the CS and FCS. Direct changes to habitat quality may occur after inundation by the lake. When the lake recedes, it:

a. creates or refills pools of water within the lake bottom in the absence of Tonto Creek flows, or
b. provides an opportunity for nonnative predatory fish, which occur in the lake and are bolstered by ongoing stocking activities, to become trapped in these pools.

When the lake creates or refills these pools, SRP's covered activities contribute positively to habitat quality by enhancing the persistence of these important aquatic features in an otherwise relatively dry landscape. This beneficial impact is most relevant to habitat in the CS, where most changes in lake elevations occur. This beneficial impact may also occasionally enhance habitat in the FCS. However, the presence and persistence of pools is not solely the result of the lake elevation changes associated with SRP's covered activities. Tonto Creek flows also contribute to the formation and persistence of pools, particularly in the FCS and when lake elevations are low.

Since nonnative predatory fish reside in Roosevelt Lake, where these species have been and continue to be stocked repeatedly by the AGFD, with funding from FWS and other parties, lake elevation changes create the opportunity for these fish to inhabit newly inundated areas of the CS and FCS (i.e., the fish may readily use any inundated area of an appropriate depth). When the lake recedes, nonnative predatory fish from the lake may become trapped in pools where they may interact with gartersnakes in the CS and FCS. These interactions may include predatory and competitive interactions, and bodily injury to the gartersnake from spine punctures when consuming certain species of fish.

The long-term storage of water in the CS provides an environment that allows nonnative predatory fish to persist and proliferate. The persistence and proliferation of nonnative predatory fish, which is an indirect consequence of SRP's conservation storage operations, degrades the quality of the habitat for the gartersnake in the CS, FCS, and in lower Tonto Creek, as described above.

Separate from inundation by the lake, when there is hydrologic connectivity between Roosevelt Lake and Tonto Creek, there is also an opportunity under certain conditions for nonnative fish to swim upstream of the lake and interact with gartersnakes (ERO-GEI 2022a; see Appendix E). The effects of these fish alter the habitat quality along lower Tonto Creek. This impact may occur in the CS or FCS when Tonto Creek is not inundated by the lake. It may also occur above the FCS within lower Tonto Creek upstream to East del Chi Drive.

Tonto Creek flows are independent of the lake elevation or changes in lake elevations, but SRP's storage of water in the CS allows for the persistence of nonnative predatory fish in the lake and contributes in a small way to the presence of nonnative fish in lower Tonto Creek.

In contrast, SRP's FCS operations (both current and under the planned deviation) do not provide the lentic environment necessary to sustain or allow for nonnative predatory fish reproduction, as water is present in the FCS only intermittently and for extremely short durations; further, FCS operations (both current and planned deviation) entail the evacuation (rather than storage) of water over the prescribed period. As a result, nonnative predatory fish attempts to reproduce would be interrupted by falling lake elevations and any nonnative predatory fish in the FCS would be expected to move back into the lentic environment of the CS versus the drying creek bed of Tonto Creek. Therefore, SRP's FCS operations do not create an environment in the FCS that supports reproduction and persistence of nonnative predatory fish populations. The effect pathways associated with habitat quality or suitability of the FCS and lower Tonto Creek differ due to SRP's activities in the FCS vs. the CS, and Tonto Creek flows.

Whether in the CS, FCS, or along lower Tonto Creek, the interactions between nonnative predatory fish and gartersnakes are complex, having both positive and negative impacts to the gartersnake that arise from a variety of predator, prey, and competitor relationships. For example, small fish are likely an important source of food for the gartersnake, even if they are nonnative species. However, larger fish may prey on gartersnakes and their native prey species, and thus degrade the quality of channel pool habitat by increasing the risk of predation or physical wounding and reducing the native prey base.

As an important aside, there is insufficient technical information at this time to precisely quantify the relative contribution of SRP's covered activities to the impacts that nonnative predatory fish have on gartersnakes in the CS, FCS, or on lower Tonto Creek. The covered activities allow nonnative predatory fish to persist and reproduce in the CS. Lake elevation changes caused in part by conservation storage and flood control operations may cause nonnative predatory fish to be deposited in pools within the Tonto Arm when the lake recedes. Tonto Creek creates the hydrologic connection, distinct from the covered activities, allowing nonnative predatory fish to migrate up and into lower Tonto Creek. But the overall baseline context in which SRP's covered activities occur suggests that SRP's contribution to the impacts caused by these fish is small. For instance: the lake was created more than 100 years ago; other parties have repeatedly stocked nonnative predatory fish in the lake beginning in the 1930s (occasionally over the stated objections of SRP); fish habitat is actively enhanced by other parties; and Tonto Creek flows periodically create a continuous stretch of aquatic habitat reaching several miles upstream, independent of the lake elevation or changes in lake elevations. SRP's covered activities do not alter the availability of aquatic habitat for nonnative predatory fish in lower Tonto Creek.

4. **Exposure to Impacts:** Gartersnakes have been documented within the CS, FCS, and lower Tonto Creek, but population size is not known beyond an approximate count of detected snakes (Burger 2010; Holycross et al. 2006; Madara 2012; Nowak et al. 2019). The detected snakes are only a part of the total population, since it is improbable that any of the studies on gartersnakes at Roosevelt Lake and lower Tonto Creek detected all individuals, and none of the studies were designed for the purpose of either measuring or estimating the total population size. Therefore, a surrogate metric is necessary and appropriate to approximate the size of the gartersnake population at Roosevelt Lake and lower Tonto Creek and the number of individuals that may be exposed to the impacts of SRP's covered activities. Since SRP's covered activities influence the gartersnake through changes to habitat, impacts to habitat are a rational surrogate for understanding which snakes may be exposed to the impacts of SRP's covered activities, assuming that habitat is occupied to some degree. The basis for this surrogate metric and its application to estimating incidental take is described in more detail in Chapter 4.
5. **Response by Individuals:** Individual gartersnakes exposed to the impacts of the covered activities could be killed or wounded or may respond by altering essential behaviors such as breeding, feeding, sheltering, and dispersal or movement. Individual snakes are likely to respond in different ways to different impacts at different times, with any particular response ranging from merely possible to relatively certain to occur. Responses may also have positive, negative, or neutral consequences on the fitness of an individual, depending on the type of impact and the circumstances in which it occurs. When a response by an individual snake results, directly or indirectly, in death, physical wounding, or injury (where injury in this context is best approximated by reduced reproduction), then take of that individual occurs.

It is important to keep in mind that the impacts of SRP's covered activities occur in a context of independent factors with the same types of outcomes. For example, lake elevation changes caused by SRP's covered activities and Tonto Creek flows that are independent of SRP's covered activities both provide opportunities for nonnative predatory fish to become trapped in channel pools and to prey on or compete with gartersnakes. Furthermore, the introduction of nonnative predatory fish to Roosevelt Lake was (and continues to be) an independent action undertaken by other parties. Therefore, not all responses to a particular type of stressor (in this example, the effects of nonnative predatory fish on the gartersnake) are a consequence of SRP's covered activities. SRP's responsibility for such responses and any resulting incidental take extends only as far as its contribution to the stressor.

6. **Biological Effect on Populations:** Over time, the impacts of SRP's covered activities may manifest in changes to the gartersnake population through the accumulation of impacts on individual gartersnakes. Population-level changes can appear as changes in the abundance, distribution, sex or age structure, or genetic makeup of a population. In this case, there is insufficient information to predict with specificity the changes, if any, that may occur to the gartersnake population structure or genetic makeup as a consequence of the covered activities. Changes to abundance and distribution of the gartersnake population may be approximated using the habitat surrogate metric. For example, changes in habitat availability or quality may approximate changes in abundance of gartersnakes in the population. Changes in habitat location may approximate changes in the distribution of the population. Understanding the long-term consequences of SRP's operations on the gartersnake population at Roosevelt Lake and lower Tonto Creek is also reflected to some extent in the current status of this population. SRP accounts for the biological effects of its covered activities on the gartersnake population in the permit area through the application of "multipliers" to the estimates of incidental take. These multipliers scale the relative impact of the estimated take and are described in Chapter 4.

ii. Gartersnake Responses to Changing Habitat Availability

Gartersnakes are terrestrial animals and do not rest for long periods or undergo brumation underwater. When Roosevelt Lake rises, the lake inundates the shallow pools within and along the braided channel of Tonto Creek and the adjacent terraces that are gartersnake habitat. When this habitat is inundated, it is temporarily converted to deeper open water. Inundation by the lake reduces the availability of resources supporting gartersnake essential behaviors. Shallow pools used for foraging become part of the deeper and larger lake environment. Gartersnakes occasionally use open water for foraging (Harrow et al. 2022), but most of the observations of telemetered gartersnakes in the permit area were in other habitat types (Myrand 2019; Nowak et al. 2019). Resting and brumation sites closest to these shallow pools are flooded.

Gartersnakes most likely respond to the reduction in habitat by moving to other areas. For example, Myrand (2019) documents gartersnakes in the permit area making more movements and longer movements when their home ranges were inundated by Roosevelt Lake compared to when their home ranges were not inundated. Any gartersnakes not able to move sufficiently away from the rising lake elevation would drown.

If Roosevelt Lake remains high for a long period of time, the number of gartersnakes that occupy the CS would likely decrease as a result of reduced habitat availability. When gartersnakes are compelled to move away from a site, the movement would expose them to a variety of risks including, for example:

- increased risk of predation when leaving behind known cover,
- increased risk of metabolic stress due to the energy expended on movement, and

- decreased foraging success in unfamiliar or less familiar or more crowded (i.e., competitive) sites.

While death, wounding, or injury will not be the outcome for all gartersnakes that move in response to habitat inundation, these outcomes are possible for some individuals. Over time, reduced habitat availability could ultimately reduce the size of the gartersnake population at Roosevelt Lake when increased densities of gartersnakes compete for fewer habitat resources or when gartersnakes succumb to increased risks of predation or stress.

The gartersnakes that use the CS would have greater exposure to these types of impacts since the CS is where conservation storage operations occur. Some or all of the CS is inundated by the lake at any given time and for periods that may last months, years, or decades.

In the FCS, reduced habitat availability due to inundation is a relatively infrequent and short duration circumstance compared to the CS. When flood control operations occur, gartersnakes in the FCS would likely move out of inundated habitat and would be exposed to the risks listed above. But with the evacuation of the lake from the FCS within either 20 or 120 days, the duration over which risks to individual gartersnakes accumulate and cause population level consequences (i.e., reduced population size) is less.

In the FCS under the planned deviation, SRP would extend the duration in which it must evacuate the FCS from 20 days to 120 days for a single flood control event in a year. When implemented, the planned deviation would have the effect of extending the period that gartersnake habitat in the FCS would be unavailable, and would increase the cumulative amount of reduced habitat availability associated with flood control operations. Extending the time frame of the inundation under the planned deviation would result in habitat being unavailable to the gartersnake during later portions of the gartersnake active season, which in turn could increase the likelihood of disrupting essential behaviors and increase gartersnakes' exposure to certain types of risks.

When Roosevelt Lake falls, the receding lake exposes gartersnake habitat within and along Tonto Creek. Once exposed, this habitat is again available for use by gartersnakes. Tonto Creek channel pools would reform. Resting and brumation sites that had been inundated would be again available. The aquatic and riparian elements of this habitat would also be at least temporarily augmented by the inundation. Soils would be saturated, promoting the growth of riparian vegetation and refilling and supporting the persistence of Tonto Creek channel pools. The increased moisture would benefit amphibian populations that provide prey for gartersnakes. Over time, the increased availability of habitat resources would be expected to support more gartersnakes and increase the population.

iii. Gartersnake Responses to Changing Habitat Location

The edge of Roosevelt Lake creates a persistent band of gartersnake habitat in the Tonto Arm that is usually located within the CS. SRP's storage and release of water changes the lake elevation and shifts the location of gartersnake habitat associated with the lake edge. As described above, gartersnakes most likely respond to the shifts in the location of lake-edge habitat via movements (Myrand 2019; Nowak et al. 2019). This is based on Nowak et al.'s (2019) observations that gartersnake estimated home ranges in the CS appear to track natural features associated with the Tonto Creek channel in the CS. Thus, the shifting location of lake-edge habitat may cause individual gartersnakes to move with this band of habitat to avoid drowning or becoming too far away from sources of aquatic prey. The risks to gartersnakes moving to avoid inundation (described above) would also apply to gartersnakes moving to maintain proximity to lake edge habitat.

The time of year, frequency, and rate of lake elevation changes likely influences the behavior of gartersnakes that use lake edge habitat. In the CS, lake elevation changes occur daily, accumulate over time, and may persist for months or years. The Reservoir Planning Model estimates typical changes in lake elevation are small on a daily time step (i.e., 0.2 vertical foot per day; 25 feet horizontal per day, or about 1 horizontal foot per hour). These daily changes have slow water velocities (i.e., slower than walking speed), and are within the gartersnake's ability to move (Emmons and Nowak 2016).

Over several months, the daily changes accumulate to create seasonal patterns in lake elevation of approximately 20 to 30 vertical feet (see Figure 3 and Table 1). These changes equate to approximately 3,000 to 4,500 feet of horizontal movement of the lake edge. These larger changes in lake elevations cause gartersnake habitats in the CS to shift, become temporarily unavailable (when the lake is rising), or temporarily expand (when the lake is falling). Resource availability that would influence carrying capacity is most likely affected by changes over this kind of time frame (i.e., seasonal patterns of lake elevation change).

iv. Gartersnake Responses to Changing Habitat Quality

SRP's covered activities include the long-term storage of water in the CS. This long-term storage of water creates a persistent band of lake-edge habitat for the gartersnake, as described above. It also creates a persistent lentic environment that, in part, allows nonnative predatory fish to persist and proliferate. This in turn creates the opportunity for nonnative predatory fish to interact with gartersnakes in the permit area. These interactions are complex and have beneficial and adverse consequences for the gartersnake. For example, largemouth bass and bluegill are harmful predators and competitors of the gartersnake (FWS 2021c; Owens et al. 2023) but may also be gartersnake prey when the fish are small. Also, Emmons, Nowak, and Lauger (2016) document a non-lethal wounding of a gartersnake from consuming a catfish (*Ameiurus* sp.), demonstrating the risk associated with attempting to consume certain nonnative species. The balance of these ecological communities influences the quality of gartersnake habitat.

Compared to an unmodified environment, the presence of nonnative species reduces the quality of gartersnake habitat by increasing risk of predation or bodily injury and by reducing native prey availability. Predation or injury of gartersnakes in any demographic stage can affect recruitment within populations. Competition for native prey or a reduction in native prey availability can impact gartersnake foraging success.

Roosevelt Lake is a source of nonnative predatory fish that reduces the quality of lake edge habitat, since nonnative fish (particularly those of larger size classes more likely to prey on gartersnakes) have consistent access to lake-edge gartersnake habitat. Gartersnakes in the CS are most exposed to the risks of nonnative predatory fish and other nonnative species, since lake edge habitat is almost always available within the CS.

Nonnative predatory fish may also move from the body of the lake into the channels and pools of Tonto Creek, which are the natural source of habitat for gartersnakes in this vicinity. These movements are made possible when Tonto Creek is flowing with sufficient volume to support fish movement upstream or when the lake rises and inundates parts of Tonto Creek. During periods of flow on Tonto Creek (between 200 and 1,100 cfs), there is sufficient hydraulic connectivity to permit the nonnative predatory fish to swim upstream and inhabit Tonto Creek, including residual channel pools upstream of the FCS to East del Chi Drive (ERO-GEI 2022a [see Appendix E]). The number of individual fish that make these upstream migrations is anticipated to be low because the opportunities for migration are limited to flow conditions in which sufficient hydraulic connectivity exists (ERO-GEI 2022a [see Appendix E]).

Nonnative predatory fish enter lower Tonto Creek independent of Roosevelt Lake elevations when Tonto Creek is flowing. Nonnative fish also can originate from areas upstream of lower Tonto Creek. Tonto Creek flows are independent of the lake elevations or changes in lake elevations, but SRP's storage of water in the CS allows for the persistence of nonnative predatory fish in the lake and contributes in a small way to the presence of nonnative fish in lower Tonto Creek.

When creek flow ceases or when the lake recedes, fish from the lake that do not retreat back to the CS may become trapped in Tonto Creek channel pools and continue to pose risks (and in some cases benefits) to gartersnakes that forage within and along these pools. Gartersnakes in the CS, FCS, and along lower Tonto Creek may be exposed to nonnative predatory fish and other species originating from the lake, even when the lake does not directly inundate the channel. The duration of this exposure is likely limited, since most pools in Tonto Creek become dry, limiting the persistence or proliferation of nonnative fish (see Chapter 1.A and 1.F).

In the FCS, the opportunities for habitat quality to be affected are associated with entry and entrapment of aquatic nonnative predators and competitors in pools that remain when water is evacuated from the FCS. These are relatively brief and infrequent periods, and neither the lake edge nor the Tonto Creek pools persist in the FCS. This makes the frequency and magnitude of effects of reduced habitat quality in the FCS less than in the CS where nonnative predatory fish, crayfish, and American bullfrogs persist in and around Roosevelt Lake year-round.

It is important to note that Tonto Creek channel pools in the FCS are most frequently formed by creek flows, independent of lake inundation. Nonnative predatory fish can enter the FCS and occupy these channel pools in multiple ways, some of which are the result of actions independent of FCS operations. For example, Tonto Creek flows can allow nonnative predatory fish to enter the FCS in years when no flood control operations occur or the fish could enter the FCS from upstream (ERO-GEI 2022a). Thus, current FCS operations are likely to contribute only incrementally to changes in habitat quality for the gartersnake relative to the baseline conditions and other independent factors.

The planned deviation would extend the duration of inundation, and, by extension, the duration that nonnative predatory fish and other aquatic competitors and predators could move into and broadly occupy portions of the FCS. The complexity of the interactions between gartersnake and nonnative predatory fish include negative and positive effects (ERO-GEI 2022a).

SRP's responsibility for the effects of nonnative predatory fish on the gartersnake is proportional to its incremental contribution to the presence of these fish in the CS, the FCS, and lower Tonto Creek, as described above and in light of the historical and ongoing stocking of nonnative predatory fish in Roosevelt Lake by others (AGFD 2014; AGFD and FWS 2021a; FWS 2021c, 2021d; ERO-GEI 2022b [see Appendix F]; Gill 2019). The presence of nonnative predatory fish in these different parts of the permit area are not solely the consequence of the covered activities. Therefore, not all of the effects from gartersnake interactions with nonnative predatory fish in the permit area are the result of SRP's operations. The effects from the covered activities are incremental relative to other independent factors that contribute to the presence of nonnative predatory fish in the permit area.

Changing lake elevations could affect habitat quality through changes in available vegetation cover. Several authors state that cover provides structure for thermoregulation, predator avoidance, and foraging opportunities (Emmons and Nowak 2016; FWS 2020a; Nowak et al. 2019; Sprague and Bateman 2018). In the CS, the gartersnake is frequently found in dense vegetative cover at greater frequencies compared to control sites in the Nowak et al. (2019) study. Changing lake elevation could temporarily reduce the availability and density of herbaceous cover associated with inundation (SWCA 2020). Inundation also introduces moisture to the soil that supports the reestablishment, density, and diversity of vegetation (Bagstad et al. 2005). Herbaceous cover is anticipated to reestablish within 2 months of lake elevations receding, and vegetation modeling indicates that both live and dead herbaceous cover is present in gartersnake habitats after periods of inundation (SWCA 2020). Thus, changing lake elevations may not substantially affect the quality of gartersnake habitat in the CS or the FCS via changes in vegetation cover.

v. Effects on Gartersnake Essential Behaviors

1. Reproduction and Recruitment

Lake elevation changes that occur between April and August could affect gartersnake reproductive success. Pregnant females are more sedentary toward the end of gestation (e.g., May) (Rosen and Schwalbe 1988; Sprague and Bateman 2018), and lake elevation changes during this time may cause pregnant females to move when they would otherwise be sedentary. Increased movements by pregnant females may elevate their predation risk in that they may be more easily detected by predators such as raptors, wading birds, and other predators (Emmons 2017; Emmons and Nowak 2016; FWS 2014a; Myrand 2019; Rosen et al. 2001; Sprague 2017; Sprague and Bateman 2018). Increased movements by pregnant females may also divert metabolic energy away from embryo development, which may in turn adversely affect the physiology and the survivorship of the pregnant females and their offspring (Boyarski et al. 2019; Sprague and Bateman 2018). However, not all female gartersnakes reproduce every year (Boyarski et al. 2019; Rosen and Schwalbe 1988).

Recruitment of gartersnakes may also be affected by changes in lake elevations. Neonates, juveniles, or small adult gartersnakes that would move in response to inundation (Nowak and Boyarski 2012; Nowak et al. 2019; Rosen and Schwalbe 1997; Sprague 2017). These smaller size classes may be more vulnerable to predation and the physiological effects of increased movements, relative to adult gartersnakes. Nowak et al. (2019) suggest that neonates have specific physiological requirements (e.g., thermoregulation, water loss, prey size limits) that create an increased reliance on aquatic features. But there is limited information on neonate behavior and predation, which makes it difficult to determine the relative frequency with which these potential effects may occur.

Current flood control operations are predicted to occur primarily between December and May, when gartersnakes are typically engaged in brumation or mating and gestation (Emmons 2017; Emmons and Nowak 2016; Jones et al. 2020; Myrand et al. 2021; Nowak et al. 2019; Rosen and Schwalbe 1988; SWCA 2022d [Appendix J]). Therefore, mating and gestation activities are those essential breeding behaviors most likely to be affected by current flood control operations. Gartersnakes typically give birth to live young in June and July (Emmons and Nowak 2016; Myrand et al. 2021; Nowak and Boyarski 2012; Nowak et al. 2019; Rosen and Schwalbe 1997; Sprague 2017) and thus birthing behaviors are not expected to be substantially disrupted by the current flood control operations. The current operations are anticipated to occur prior to the gartersnake birthing period.

The planned deviation would extend the time frame that inundation of the FCS could occur into later portions of the breeding season when gartersnakes would be birthing (Emmons and Nowak 2016; Nowak and Boyarski 2012; Nowak et al. 2019; Rosen and Schwalbe 1988; Sprague 2017). Reproductive success could be affected if gartersnakes birth near inundated areas of the FCS and neonates are eaten by nonnative predatory fish as they forage in shallow aquatic habitats. Sprague and Bateman (2018) found pregnant females close to water and hypothesize that females may select these sites to be close to suitable foraging habitats. Here, inundation in the FCS could incrementally increase the abundance of nonnative predatory fish in the shallow waters of the FCS, which may be used by female gartersnakes and their offspring. Thus, the planned deviation could have an effect on the breeding success of the gartersnake through the incremental increase in risk of predation by nonnative predatory fish on neonate gartersnakes. The effects on breeding success differ from current operations in the FCS due to the timing of the planned deviation. The planned deviation could overlap with gartersnake birthing activities that would create the opportunities for neonates to be present and susceptible to predation by nonnative predatory fish.

2. Foraging and Feeding

Gartersnake foraging behaviors, whether in the CS, FCS, or lower Tonto Creek, could be affected by changing the availability, location, and quality of habitat resources. Foraging would be disrupted when gartersnakes move to track shifting resources. In the CS, Myrand (2019) documented increased gartersnake movements during inundation. The disruption of foraging and feeding activities in response to the need to move could reduce energy intake. Reduced energy intake could lead to reduced fitness or body condition and may increase the likelihood of death (by predation or lack of fitness) or decrease the likelihood of successful reproduction.

Gartersnakes could be physically wounded or killed by spine punctures when consuming spiny-rayed fishes or catfishes. Gartersnake foraging success could also be reduced if inundation reduces the amount of foraging habitat available, such as when Tonto Creek channel pools in the CS or FCS are inundated by the lake. These effects can lead to injury of individuals through increased risk of death, reduced individual growth, or reduced reproductive output (FWS 2014a; Myrand 2019; Rosen et al. 2001).

The likelihood that any particular gartersnake would be harmed as a consequence of modified foraging behaviors is low under most circumstances. The gartersnake has a diet that consists of terrestrial and aquatic species and exhibits plasticity in its foraging behaviors, shifting its behavior to consume the types of prey that are most readily available (Emmons, Nowak, and Lauger 2016; Manjarrez et al. 2013; Nowak et al. 2019). Although diet studies of the gartersnake in the permit area are unavailable, d’Orgeix et al. 2013 documented changes in gartersnake diet over time that reflected what was seasonally available.

3. Sheltering

Inundation may disrupt gartersnake sheltering behaviors in the CS or FCS by flooding sheltering sites and brumation sites. Gartersnakes move from brumation sites that become flooded (Nowak et al. 2019). On five occasions, Nowak et al. (2019) documented gartersnakes changing brumation sites and attributed the change to flooding of the brumation site. Gartersnakes will voluntarily shift between brumation sites even in the absence of inundation. Such movements are often of short distance, within specific small patches of habitat, and should be considered natural behavior. However, if inundation of brumation sites forces gartersnakes to involuntarily move moderate to longer distances while brumating, these movement responses are not natural behavior and may result in increased exposure to predation risk or mortality. These movements may also result in effects on physiology or survivorship from expending energy to relocate during a period when they would otherwise be conserving energy while brumating (Nowak et al. 2019).

Gartersnakes that are moving in response to inundation likely experience a temporary increase in exposure to predation or bodily injury (Lind et al. 2005; Myrand 2019; Nowak et al. 2019). But documentation of such predation events is limited (Emmons, Nowak, and Theimer 2016), which makes it difficult to determine the relative frequency with which these potential effects might occur. Myrand (2019) did not find evidence that predation of gartersnakes was elevated during inundation, based on the consistent number of telemetered snakes (n=18) that were tracked during times of inundation and non-inundation of the CS. Although predation events are difficult to detect, Myrand (2019) and Nowak et al. (2019) provided best available information on gartersnakes’ response to movements and effects from inundation within the permit area.

Inundation may flood an occupied brumation site, possibly resulting in drowning of a gartersnake, but data documenting this outcome are lacking. Emmons and Nowak (2016) document an instance where a gartersnake remained in a flooded brumation site without apparent injury. Based on this and other observations of gartersnakes moving from brumation sites during flooding, the likelihood of drowning from inundation of brumation sites is low for most individuals.

Inundation would reduce the availability of sheltering sites potentially used by the gartersnake for predator avoidance and thermoregulation. But the likelihood of harm is low for most individuals under most circumstances, given that gartersnakes use a variety of cover types (e.g., woody debris piles, rock piles, animal burrows, cavities in cracked soil) for sheltering in a variety of riparian and upland habitats that do not appear to be limited within the permit area (Emmons and Nowak 2016; FWS 2014a, 2020a; Myrand 2019; Nowak et al. 2019; Sprague 2017). In Nowak et al.'s (2019) observations of changing brumation sites attributed to flooding, gartersnakes were able to find alternative brumation sites and continue brumating.

The frequency of these effects on sheltering behaviors would be less and the duration shorter for gartersnakes in the FCS as compared to the CS. Effects on sheltering behaviors would last for a longer duration under the planned deviation than under current flood control operations due to the longer period of inundation.

vi. Effects on Critical Habitat

The Tonto Creek Unit of gartersnake critical habitat overlaps with the FCS and the lower Tonto Creek portions of the permit area (see Subchapter 2.A.iii). There is no gartersnake critical habitat in the CS (FWS 2021a). This unit of critical habitat contains PBFs 1–3, 4 in degraded condition, and 5 (FWS 2021a). PBF 1 pertains to physical factors (perennial or spatially intermittent streams, riparian habitats, and sheltering sites) associated with aquatic and terrestrial gartersnake habitat. PBF 2 pertains to the hydrologic processes that maintain the aquatic and terrestrial habitats. PBF 3 pertains to the availability of prey across seasons and years. PBF 4 pertains to the absence of nonnative aquatic and terrestrial predators and competitors of the gartersnake. PBF 5 pertains to the elevational range where the gartersnake can be found.

SRP's covered activities may affect this critical habitat, specifically PBFs 1–4. SRP's activities will have no effect on PBF 5 and this PBF is not discussed further. Some effect pathways differ in the FCS and lower Tonto Creek. FCS operations (both current and planned deviation) entail the evacuation of water over the prescribed periods (i.e., 20 days or 120 days). The controlled release of water could affect aquatic and terrestrial habitats, hydrologic processes, and the ecological community (i.e., PBFs 1–4). Specific effects are described below. Inundation of the FCS associated with the current operations of the FCS and the planned deviation would be limited to the FCS and would not extend beyond the FCS and into lower Tonto Creek. Unlike conservation storage operations, SRP's flood control operations involve actions that release water from Modified Roosevelt and not actions that store water. Therefore, SRP's flood control operations in the FCS, whether under current operations or the planned deviation, are not anticipated to affect PBFs 1 and 2 in critical habitat in lower Tonto Creek. SRP's covered activities in the CS could affect the ecological community in critical habitat in lower Tonto Creek (i.e., PBFs 3 and 4), specifically through SRP's storage of water in the CS that provides consistent aquatic habitat for nonnative fish to persist in Roosevelt Lake. When Tonto Creek flows, nonnative fish can move into lower Tonto Creek and affect the ecological community in critical habitat in lower Tonto Creek, described further below. All effects on PBFs 1–4 are discussed below, arranged by PBF.

Modified Roosevelt operations resulting in the inundation of the FCS will vary in timing, duration, extent, and frequency according to the type of operation (i.e., current flood control operations or the planned deviation). This, in turn, affects the timing, duration, extent, and frequency of effects. Roosevelt Lake is not expected to enter the FCS annually (i.e., 37 out of 106 years), according to the Reservoir Planning Model. Therefore, in many years there may be no effects on the critical habitats in the FCS. The planned deviation would extend the duration and timing of inundation that could incrementally increase the positive and negative effects on the PBFs within the FCS. Figure 19 depicts the inundation of gartersnake critical habitat on the Tonto Arm during planned deviation operations.

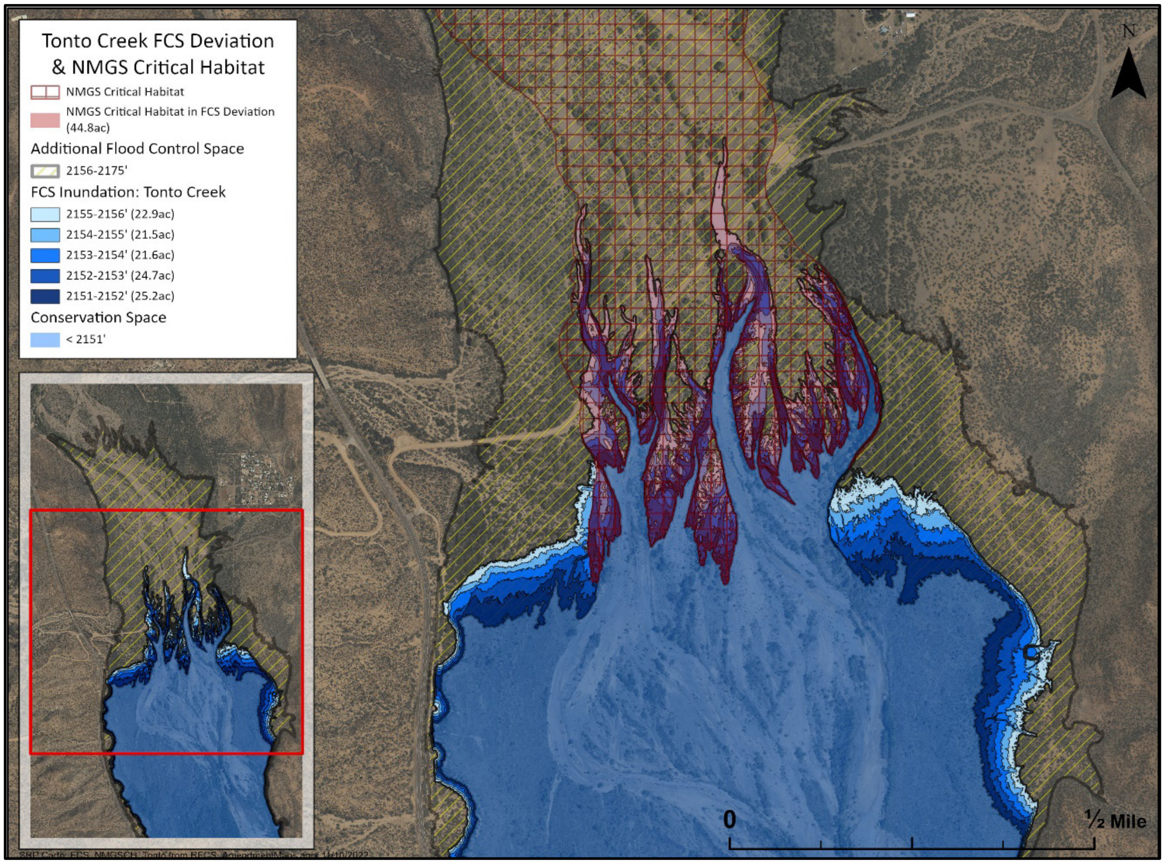

Figure 19. Inundation of gartersnake critical habitat on the Tonto Arm during planned deviation operations.

The persistence of nonnative predatory fish in the CS is associated with SRP's activities, and it is this persistence that allows them to be present and available to move upstream into lower Tonto Creek and indirectly affect critical habitat in lower Tonto Creek. The upstream migrations of nonnative fishes are associated with hydrologic connections from Tonto Creek that occur independently of SRP's covered activities. The upstream migration of nonnative fishes into lower Tonto Creek does not occur year-round (ERO-GEI 2022a [see Appendix E]). Due to flow intermittency of Tonto Creek, upstream migration of nonnative predatory fishes into lower Tonto Creek is likely limited to a time frame of March through June (ERO-GEI 2022a [see Appendix E]). Following spawning in shallow waters within the Tonto Creek channel, these nonnative predatory fishes likely move out of the critical habitat in lower Tonto Creek and back to the consistent aquatic habitat at Roosevelt Lake in the CS. Alternatively, these nonnative predatory fishes may die if they remain in isolated pools in lower Tonto Creek that dry up. Both the availability and migration of nonnative predatory fishes into critical habitat of lower Tonto Creek will affect PBFs 3 and 4.

Given the variability in timing, frequency, and duration of effects on critical habitat in the FCS and lower Tonto Creek, the effects are described below generally for simplicity; these effects are expected to occur at some time during SRP's activities.

PBF 1: The rise and fall of lake elevations in the FCS may have temporary positive effects on PBF 1 by supporting or providing slow-moving water and pools (listed as an element of PBF 1), when water inundates the FCS and is released via Modified Roosevelt operations. The areas that become inundated in the FCS have rates of fill that reach about 0.5 vertical foot per day (about 3 feet per hour horizontal movement). As water is evacuated from the FCS, aquatic habitats, including temporary pools, can be created (listed as elements of PBF 1A) (FWS 2021a). Temporary inundation can also support the riparian vegetation via increases in soil moisture availability. Increases in soil moisture promote the development of vegetation and support the germination and development of new vegetation (Bagstad et al. 2005).

The rise and fall of lake elevations in the FCS may have temporary negative effects on PBF 1 during brief periods when habitats become unavailable for gartersnakes to use for their essential behaviors. During inundation, pools and backwater habitats can be converted to open water, and sheltering sites such as animal burrows or woody debris piles can be covered up by water. Riparian herbaceous vegetation can be killed by inundation but returns within 2 months of receding water (SWCA 2020).

SRP's covered activities would not affect PBF 1 in lower Tonto Creek because lake elevation changes are limited to 2,175 feet amsl or below.

PBF 2: The rise and fall of lake elevations in the FCS may have temporary positive and temporary negative effects on PBF 2. The evacuation of water in the FCS can affect the hydrologic connections between the stream channel and adjacent riparian areas. These hydrologic connections can be created or lost via conversion to open water. SRP's covered activities would not affect PBF 2 in lower Tonto Creek because lake elevation changes are limited to 2,175 feet amsl or below.

PBF 3: The rise and fall of lake elevations in the FCS may have positive and negative effects on the availability of prey across the seasons and years (PBF 3) in critical habitat within the FCS. Nowak et al. (2019) documented amphibians, fishes, small mammals, and lizards in the FCS that could serve as prey for the gartersnake. Positive effects from the rise and fall of lake elevations in the FCS include the creation or support of temporary pools and backwater habitats in the FCS that could support aquatic and amphibious prey. The increased moisture availability can benefit the vegetative cover used by prey once the water recedes (Bagstad et al. 2005).

Negative effects on PBF 3 in critical habitat of the FCS include reductions in the availability of prey for the gartersnake during inundation associated with controlled release of water from the FCS. The long-term storage of water in the CS also contributes, in part, to the persistence and proliferation of nonnative predatory fish, that may then enter the FCS from Roosevelt Lake. Aquatic or amphibian prey occurring in shallow aquatic habitats can be reduced as their shallow aquatic habitats are temporarily deepened by inundation and become open water. Aquatic or amphibian prey can also be reduced through predation by nonnative invasive species that can enter the FCS from Roosevelt Lake. Nonnative predatory fish and crayfish consume aquatic prey (ERO-GEI 2022b [see Appendix F]; Fernandez and Rosen 1996; FWS 2014a) and frogs (Fernandez and Rosen 1996; FWS 2014a) and reduce their availability in the critical habitat unit in the FCS or in lower Tonto Creek. However, according to data on stomach samples from 231 nonnative predatory fish (ERO-GEI 2022a [see Appendix E]), the stomach contents included invertebrates, fish, and organic matter; frogs were not observed in stomach contents. Subsequent DNA analysis has confirmed that gartersnake predation by nonnative fish (Electric Power Research Institute, Inc. 2023; Owens et al. 2023). The availability of terrestrial prey can be reduced through loss of terrestrial habitat during inundation of the FCS.

There may be both positive and negative effects on PBF 3 in critical habitat in lower Tonto Creek, but the effect pathways associated with SRP's covered activities differ from the pathways of effects on PBF 3 in critical habitat of the FCS. Effects on PBF 3 in critical habitat of the FCS and lower Tonto Creek are associated with the presence of nonnative predatory fish that originated from Roosevelt Lake. These nonnative predatory fish, through spawning, can increase the availability of fry and small fishes that can serve as prey for the gartersnake. Gartersnakes are known to consume small nonnative predatory fish (FWS 2014a; Emmons, Nowak, and Lauger 2016). But these nonnative predatory fish also consume aquatic prey and amphibians, resulting in reductions in the availability of prey for the gartersnake (FWS 2014a). The long-term storage of water in the CS creates an opportunity for nonnative predatory fish to persist and proliferate, and then under the right conditions, nonnative predatory fish may migrate upstream into critical habitat in the FCS and lower Tonto Creek. These effects are only partially attributed to SRP's covered activities, specifically the presence of spawning nonnative predatory fish in the CS associated with the consistent aquatic habitat of Roosevelt Lake.

PBF 4: The current status of PBF 4 (absence of nonnative and invasive predators and competitors) is listed as "degraded." Nonnative predatory fish, American bullfrogs, and crayfish have been documented in the FCS and in lower Tonto Creek (ERO-GEI 2022a [see Appendix E]; Nowak et al. 2019). SRP's activities in the FCS may contribute incrementally to the degraded status of PBF 4 in the FCS resulting in negative effects on PBF 4. As Tonto Creek inundates the FCS, SRP evacuates the water from the FCS. During periods in which water is present, nonnative and invasive species inhabiting the CS may move into the FCS. During these periods, PBF 4 in the FCS may be degraded via the incremental contributions of individuals of nonnative and invasive species that can prey on and compete with gartersnakes. At the same time, SRP's covered activities do not provide consistent aquatic habitat similar to what is present in the CS that supports populations of nonnative and invasive predators and competitors. As water in the FCS is evacuated, these individuals may migrate back into the CS, die as a consequence of desiccated pools, or remain if pools persist. It is important to note that other independent factors also contribute to the degraded status of PBF (see Subchapter 1.F, Historic and Ongoing Fish Stocking at Roosevelt Lake). Nonnative predatory fish and other nonnative invasive species can be displaced from locations north of the FCS and introduced into critical habitat in the FCS due to flows of Tonto Creek (ERO-GEI 2022a [see Appendix E]).

SRP's activities related to long-term storage of water in the CS may also affect PBF 4 and contribute incrementally to the degraded status of PBF 4 in the FCS and lower Tonto Creek. The effects on PBF 4 in critical habitat of the FCS and lower Tonto Creek are associated with the presence of nonnative predatory fish that may persist and proliferate in part due to the long-term presence of water in Roosevelt Lake. The upstream migration of nonnative predatory fish into critical habitat in the FCS and lower Tonto Creek occurs under hydrologic high-flow events, which are independent of SRP's covered activities. The persistence of nonnative predatory fish in Roosevelt Lake is also associated with fish stocking efforts which are not part of SRP's covered activities. Thus, these effects are only partially attributed to SRP's covered activities, specifically the long-term storage of water in the CS.

The FWS specifies that occurrence of these nonnative species should be at low enough levels such that recruitment of the gartersnake is not inhibited and maintenance of viable prey populations is still occurring. Data on population trends and population dynamics are lacking for the gartersnake in the permit area, but neonates, juveniles, and adult males and females recently have been detected in the permit area (Madara 2012; Nowak et al. 2015; Nowak et al. 2019). The presence of all demographic stages could indicate that some level of recruitment is occurring in the permit area despite the presence of nonnative and invasive species. Nowak et al. (2015) and Nowak et al. (2019) give no indication that gartersnakes are emaciated or in poor body condition, as is associated with limited prey availability. Although the status of the gartersnake populations is uncertain, based on the available data, the rise and fall of lake elevations is not anticipated to inhibit the recruitment of the gartersnake.

To summarize, while SRP's covered activities would have some positive effects on gartersnake critical habitat, adverse effects are also likely. The adverse effects differ for critical habitat in the FCS and lower Tonto Creek. But overall, the effects include the temporary loss of shallow aquatic habitats, terrestrial habitats, reduced availability of prey, and incremental contributions of nonnative invasive predators and competitors into the Tonto Creek critical habitat unit.

Although these effects adversely affect critical habitat, they are not anticipated to appreciably diminish the value of critical habitat for the survival and recovery of the gartersnake. There may be many years when there are no effects on critical habitat in the FCS based on the anticipated low frequency of inundation. SRP's covered activities only incrementally contribute to impacts from nonnative predatory fish in the FCS and lower Tonto Creek. Further, the effects from SRP's covered activities are limited to the permit area. The permit area contains 2,375.5 acres and 15.1 river miles of critical habitat. This comprises approximately 75% of the acreage and 54% of the river miles of the Tonto Creek Unit and 11.7% of the acreage total critical habitat for the subspecies.

B. Southwestern Willow Flycatcher

i. Current Flood Control Operations

The effects of current flood control operations on flycatchers in the FCS were considered in the 1995 Biological Assessment (Reclamation and SWCA 1995) and subsequent 1996 Biological Opinion (FWS 1996a), which found that no effects were anticipated on flycatchers in the FCS because lake elevations would be declining throughout the flycatcher breeding season. Although the most recent hydrologic modeling—which incorporates anticipated changes in temperature and precipitation as the result of climate change on expected lake elevations over the next 106 years—anticipates a more frequent and extended presence of water in the FCS, the model continues to support the finding that no effects on flycatchers in the FCS from direct inundation are expected. The hydrologic model estimates that water would be present in the FCS in May in 28 (26%) of 106 years and could remain in or re-enter the FCS in June in seven of those 28 years. Water depth in the FCS would exceed 2 feet in 13 (12%) of the 106 years and would never exceed 6.3 feet. The maximum water depth was estimated to occur before May 15 in all but one year, and the maximum increase in water depth was 4.1 feet after May 1 and 0.8 foot after May 15. The model estimates that water would enter the FCS in July and August as the result of summer rain events in only one of 106 years and would not exceed 2.1 feet in depth.

Although the earliest flycatchers may arrive on their breeding grounds in late April, surveys at the Rockhouse Demonstration Site adjacent to Roosevelt Lake have not documented flycatchers arriving before early May (Valencia 2021). Female flycatchers typically arrive after the males, and nest building rarely starts before mid-May and continues through June (Sogge et al. 2010). Although climate change may influence arrival dates in the future, nest initiation is unlikely to start before early May; thus, lake elevations in May–July are analyzed here. The minimum nest height recorded across the flycatcher's range was 2 feet (Sogge et al. 2010), and the average nest height at Roosevelt Lake was around 12 feet (Ellis et al. 2008).

Because lake elevations would typically peak before early May, loss of flycatcher eggs or nestlings from direct inundation is unlikely since lake elevations would not increase substantially after nests are initiated. Although water could enter the FCS on rare occasions in July and August, the expected water depth would not exceed 2.1 feet, and no loss of flycatcher eggs or nestlings through direct inundation would be expected. Because water would so rarely be in the FCS after mid-June, when flycatcher young would be fledging, loss of young birds from drowning if they fledge into the water would also not be expected.

Therefore, incidental take of flycatchers from current flood control operations approximated by the Reservoir Planning Model is not reasonably certain to occur.

The analysis in the 1995 Biological Assessment (Reclamation and SWCA 1995) and subsequent 1996 Biological Opinion (FWS 1996a) found that no effects on tall, dense vegetation were anticipated in the FCS because inundation in the FCS would be brief. The most recent hydrologic model estimates that multiple consecutive fill events could result in water being in the bottom 2 feet of the FCS nearly continuously for 3 to 6 months in 19 (18%) of 106 years. However, the model overestimates the duration of inundation because it does not account for operator discretion, which would result in the FCS being fully evacuated down to 2,151 feet amsl after each fill event (see Figure 9). At 2,152 feet amsl, back-to-back fill events would be expected to result in alternating inundated and dry periods at the vegetative root crown of approximately equal duration (i.e., cycles of approximately 10 days of inundation followed by 10 days dry). The ratio of dry periods to wet periods within each 20-day cycle would be smaller for areas closer to 2,151 feet amsl and larger for areas above 2,152 feet amsl. At 2,151 feet amsl, the period between inundation events would be approximately 1 day.

Seedlings and young saplings in the bottom 1 foot of the FCS could be killed as a result of inundation, but recruitment would be expected as lake elevations recede if the water table remains high (Levine and Stromberg 2001; Stromberg et al. 1993). This would be especially true for tamarisk die-off and regeneration. Ellis et al. (2008) documented rapid regeneration of riparian habitat at Roosevelt Lake, with tamarisk recruitment occurring within months of receding lake elevations, and tamarisk growing approximately 4.9 feet (1.5 m) within a year. Recruitment of Goodding's willows and Fremont cottonwoods were favored when substrates were moistened by receding floodwaters and high water tables during spring months. As a result of the infrequency of anticipated back-to-back fill events, the short-term (maximum 20-day) period of inundation, and the interim dry periods between fill events, there would be infrequent and short-term impacts to seedlings and saplings.

The effects of intermittent inundation on riparian vegetation are not addressed in the literature; however, mature willows are tolerant of prolonged inundation (see Appendix 4 of the original RHCP) and would not be expected to suffer detrimental effects from the intermittent inundation anticipated under standard operations of the FCS. Similarly, mature cottonwoods would tolerate partial submersion for 4 months (Markovchick 2021) and would not be expected to suffer detrimental effects from intermittent inundation. Mature tamarisk would be more susceptible to stress from consecutive fill events compared to native vegetation (Ellis et al. 2008; Gladwin and Roelle 1998; Stromberg 1997; Stromberg et al. 1993). Any effects, which could include branch dieback or sparse foliage, would be limited to tamarisk rooted in the bottom few inches of the FCS (i.e., close to 2,151 feet amsl). Temporary flooding of the FCS could also result in increased soil moisture availability, promote the development of dense foliage in existing vegetation, and support the germination and development of new vegetation in the FCS. Although adverse effects on individual tamarisk plants rooted in the bottom few inches of the FCS could occur, this would not be expected to alter essential breeding, feeding, or sheltering behaviors to an extent that death or injury of a flycatcher occurs.

ii. Planned Deviation of Flood Control Operations

The planned deviation would not alter the timing of peak lake elevations at Modified Roosevelt, which typically occur in late April or early May. As described in the RHCP and in the previous subchapter, loss of flycatcher eggs or nestlings from direct inundation is unlikely because lake elevations would not be increasing substantially during the breeding season.

The original RHCP determined that death of flycatcher eggs or nestlings in the CS was unlikely but could occasionally occur if a nest tree fell over as the result of inundation or subsequent drying or if young birds drowned when they fledged over water (see Subchapter III.C of the original RHCP). These forms of direct take would be even less likely in the FCS than in the CS because there are far fewer flycatcher territories in the FCS than in the CS. The presence of water under nest trees has been associated with increased nest success (Moore and Ahlers 2018), and surface water and/or saturated soils beneath the nest could benefit nesting flycatchers by deterring predators, increasing the availability of insect prey, and moderating microclimate.

Flycatchers could also be affected by changes in riparian vegetation caused by extending the evacuation period from the planned deviation space for up to an additional 100 days. Increased water availability for vegetation that is rooted either within or near the planned deviation space could result in increased vegetation vigor, which could benefit flycatchers by providing nest concealment and moderating microclimate. Conversely, prolonged submersion of the root crown can reduce vegetation vigor and eventually cause mortality, and mortality increases as depth and duration of inundation increase (see Appendix 4 of the original RHCP). The literature reviewed for the RHCP showed that the effects vary among species. Goodding's willows showed little mortality after 12 months of inundation and had higher growth rates when their root crowns were inundated. Mature cottonwoods showed no mortality after 73 days of inundation but had complete mortality after 2 years. No studies evaluating intermediate time periods were found in the literature; however, cottonwood researchers indicated that trees would tolerate partial submersion for 4 months (Markovchick 2021). Tamarisk appeared to be more sensitive to inundation than either cottonwoods or willows, with some mortality possible after 80 or more days of inundation, although mortality rates varied widely between studies. Tamarisk survival was higher for plants that were tall enough to extend above the water surface. Sublethal effects (e.g., reduced growth rates or branch dieback) were not evaluated. The expected maximum duration of inundation in the planned deviation space ranges from 87 days between 2,155 and 2,156 feet amsl, to 120 days between 2,151 and 2,152 feet amsl (see Table 5). No mortality would be expected for mature cottonwoods or Goodding's willows for these inundation periods, and growth rates could be increased. Some mortality or dieback could occur for tamarisk; these effects would occur on a gradient, increasing in intensity from 2,156 to 2,151 feet amsl. The tamarisk that provide nesting habitat for flycatchers are tall enough that most of the plant would be above the water for the duration of the planned deviation; therefore, widespread tamarisk mortality would not be expected. Mortality and dieback of vegetation could be more pronounced in the Salt Arm, which is primarily tamarisk, than in the Tonto Arm, where the overstory is primarily Goodding's willows.

The maximum acreage of flycatcher habitat that could be affected was estimated by 1) using the flycatcher model (Hatten and Paradzick 2003) combined with lidar to determine how much predicted habitat (classes 3–5 in the model with some part of each model grid cell being at least 6 m [20 feet] in height) is present in the planned deviation space, and 2) buffering the most recently identified flycatcher territory locations, as identified during surveys in 2020 and 2021, with a 11-acre (394-foot-radius) circle (the neighborhood size used in models predicting flycatcher occupancy [Hatten and Paradzick 2003]) to determine whether the amount of occupied flycatcher habitat in the planned deviation space that might be affected differed substantially from the model results. In total, 43.0 acres of the planned deviation space were predicted to be flycatcher habitat, whereas 75.9 acres were within 394 feet of a flycatcher territory center. Thus, 75.9 acres is the maximum acreage of current habitat that would be adversely affected by changes in riparian vegetation.

The planned deviation could result in water receding from the planned deviation space as late as August, rather than in May or earlier. Exposing sediments in the FCS in summer rather than spring may favor the establishment of tamarisk trees—which release seeds from late April through September—over native riparian plants that release seeds earlier in the spring. Monsoon stream flows and summer flood events also provide opportunities for tamarisk germination. However, tamarisk leaf beetles, introduced by the federal Animal and Plant Health Inspection Service, colonized tamarisk at Roosevelt Lake in 2022

(Valencia 2022a). The defoliation caused by tamarisk leaf beetles results in reduced tamarisk flowering, and repeated defoliation can cause tamarisk terminal dieback or death. For this reason, the presence of tamarisk leaf beetles may minimize any effect of the planned deviation that would otherwise favor the establishment and growth of tamarisk in the planned deviation space. Therefore, the effects of the delayed evacuation of water from the FCS on tamarisk establishment and, by extension, on flycatcher productivity and habitat, are indeterminable. In contrast to tamarisk, existing Goodding's willows and cottonwoods would likely benefit from short-term inundation and higher water tables.

The presence of water in the planned deviation space during the flycatcher breeding season could affect the availability of habitat for flycatchers in both the FCS and the CS by reducing the height of the vegetation above the water. Flycatchers at Roosevelt Lake typically use habitat that is at least 6 m (20 feet) in height, and this is the height SRP uses, in combination with a multi-scaled flycatcher breeding habitat model, to calculate the amount of potentially suitable flycatcher habitat at Roosevelt Lake. SRP used lidar data acquired in 2018 to calculate the amount of vegetation that would be ≥ 6 m in height above the water at a lake elevation of 2,151 feet amsl but that would be < 6 m in height above the water at a lake elevation of 2,156 feet amsl.

Lidar data were available from multiple years (2012, 2015, 2018, and 2021). The data from 2018 showed the greatest amount of vegetation ≥ 6 m in height above the water at a lake elevation of 2,151 feet amsl; thus, the 2018 data provided the most conservative estimate of the amount of habitat that could be affected. The amount of affected habitat that was recently occupied by flycatchers was estimated by buffering each territory center identified during surveys in 2020 and 2021 by an 11-acre (394-foot-radius) circle.

- In the CS, 20.7 acres of vegetation ≥ 6 m in height were available at a lake elevation of 2,151 feet amsl; 12.3 of those acres had < 6 m of the vegetation exposed above the water at a lake elevation of 2,156 feet amsl. Of those 12.3 acres, 10.8 acres (7.8 acres in the Salt Arm and 3.0 acres in the Tonto Arm) were within 394 feet of a flycatcher territory center.
- In the FCS, 39.1 acres of vegetation ≥ 6 m in height were available at a lake elevation of 2,151 feet amsl; 4.8 of those acres had < 6 m of the vegetation exposed above the water at a lake elevation of 2,156 feet amsl. Of those 4.8 acres, 2.6 acres (2.3 acres in the Salt Arm and 0.3 acre in the Tonto Arm) were within 394 feet of a flycatcher territory center.

In summary, the planned deviation could result in up to 12.3 acres of tall, dense vegetation in the CS being less suitable for flycatchers because < 6 m of the vegetation would be exposed above the water. In the FCS, up to 75.9 acres of flycatcher habitat could be affected by changes in riparian vegetation, and an additional 2.2 acres (4.8 acres minus 2.6 acres accounted for as part of the 75.9 acres) could become less suitable because < 6 m of the plant would be exposed above the water at a lake elevation of 2,156 feet amsl. These effects reduce the amount of habitat available to nesting flycatchers by up to 90.4 acres (up to 12.3 acres in the CS and up to 78.1 acres within the FCS) in each of the 3 years of the planned deviation. The effects on the 75.9 acres where riparian vegetation could be affected by dieback or death would last up to 5 years (the assumed period to full recovery under the vegetation model used in the original RHCP) after the final year of the planned deviation. Using the surrogate metrics established in the original RHCP, this seasonal reduction in nesting habitat would result in incidental take of flycatchers via harm in an amount equivalent to the acres of habitat modification (i.e., up to 78.1 acres). While the planned deviation is a new covered activity that would result in a small amount of incidental take not contemplated in the original RHCP, the amount of the additional take and the impacts of these takings on the flycatcher are fully offset by the amount of currently authorized incidental take and the conservation measures implemented to address the impacts of the authorized take. See Subchapter 4.C for additional discussion.

iii. Critical Habitat

1. Current Flood Control Operations

Under the current operations, water within the FCS would be evacuated within 20 days of a fill event. The most recent hydrologic model estimates that multiple consecutive fill events could result in water being in the bottom 2 feet of the FCS nearly continuously for 3 to 6 months in 19 (18%) of 106 years. However, the model overestimates the duration of inundation because it does not account for operator discretion, which would result in the FCS being fully evacuated down to 2,151 feet amsl after each fill event (see Figure 9). At 2,152 feet amsl, back-to-back fill events would be expected to result in alternating inundated and dry periods at the vegetative root crown of approximately equal duration (i.e., cycles of approximately 10 days of inundation followed by 10 days dry). The ratio of dry periods to wet periods within each 20-day cycle would be smaller for areas closer to 2,151 feet amsl and larger for areas above 2,152 feet amsl. At 2,151 feet amsl, the period between inundation events would be approximately 1 day. As detailed in Subchapter 3.B.i, current flood control operations would not have any detrimental effects on mature cottonwoods and willows but could affect individual tamarisk trees (PCE 1; riparian vegetation) rooted in the bottom few inches of the FCS. In total, 44.9 acres of flycatcher critical habitat are present between 2,151 and 2,152 feet amsl. Any effects, which could include branch dieback or sparse foliage, would be limited to tamarisk in a fraction of this acreage. Although individual plants could be affected, no significant changes to the vegetation are anticipated. Temporary flooding of the FCS could result in increased soil moisture availability, promote the development of dense foliage in existing vegetation, and support the germination and development of new vegetation in the FCS; thus, current operations could enhance PCE 1 (riparian vegetation). Surface water and moist soils are important for emergent aquatic insects; thus, current operations could also enhance PCE 2 (insect prey populations) in years when surface water and moist soils remain in the FCS at the beginning of the flycatcher breeding season.

2. Planned Deviation of Flood Control Operations

The planned deviation could have detrimental effects on PCE 1 (riparian vegetation) through the mortality or degradation of tamarisk. However, the tamarisk that provide nesting habitat for flycatchers are tall enough that most of the plant would be above the water for the duration of the planned deviation, and widespread tamarisk mortality would not be expected. Any detrimental effects would occur on a gradient, increasing in intensity from 2,156 to 2,151 feet amsl. The 208.2 acres of flycatcher critical habitat in the planned deviation space are approximately equally distributed among the five 1-foot contour intervals; thus, the acreage affected increases linearly with declining elevation (Figure 20 and Figure 21).

The timing of the drawdown of water during the planned deviation could favor the establishment of tamarisk over native woody vegetation in the planned deviation space; however, tamarisk leaf beetles colonized Roosevelt Lake in 2022, and may minimize the establishment and growth of tamarisk. Inundation longer than 30 days would result in the death of developing vegetation in the planned deviation space, which could decrease the ability of this portion of the FCS to develop additional tall, dense vegetation (PCE 1; riparian vegetation) during and in the years immediately following the planned deviation. Mature vegetation rooted in the bottom foot of the FCS could experience stress from consecutive fill events, and tamarisk would be more susceptible to total or partial die-off compared to native riparian vegetation (Ellis et al. 2008; Gladwin and Roelle 1998; Stromberg 1997; Stromberg et al. 1993). The degree of stress exhibited by mature riparian vegetation within this zone would be influenced by factors such as tree size and location on the floodplain. Overall, habitat within areas exposed to the longest inundation times would be expected to exhibit lower density, less canopy cover, and more canopy gaps (Ellis et al. 2008). These changes could make existing habitat less suitable for flycatcher nesting. Conversely, the planned deviation could result in increased soil moisture availability throughout the flycatcher breeding season for vegetation rooted within or near the planned deviation space, thus promoting the development of dense foliage and enhancing PCE 1 (riparian vegetation). Increased soil moisture and surface water could promote the production of emergent aquatic insects, thus enhancing PCE 2 (insect prey populations). Although these effects adversely affect critical habitat, they are not anticipated to appreciably diminish the value of critical habitat for the survival and recovery of the flycatcher.

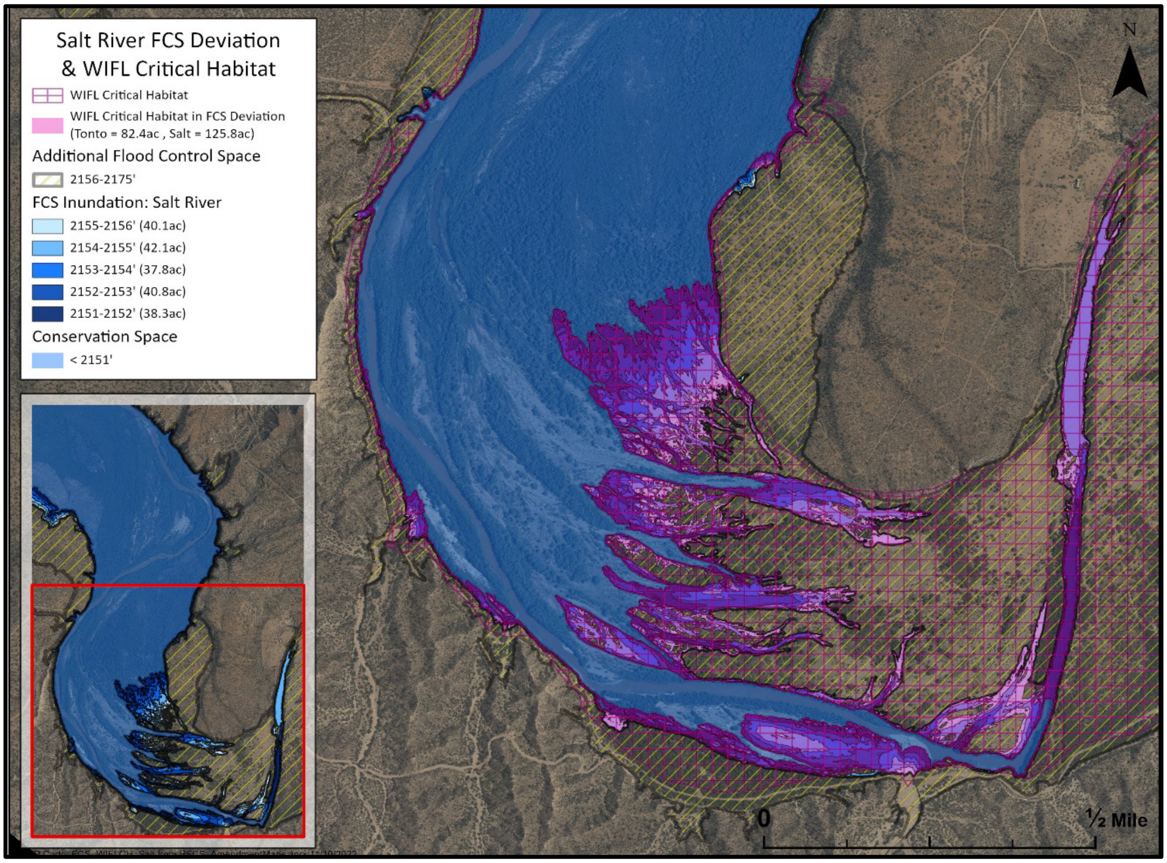

Figure 20. Inundation of flycatcher critical habitat on the Salt Arm during planned deviation operations.

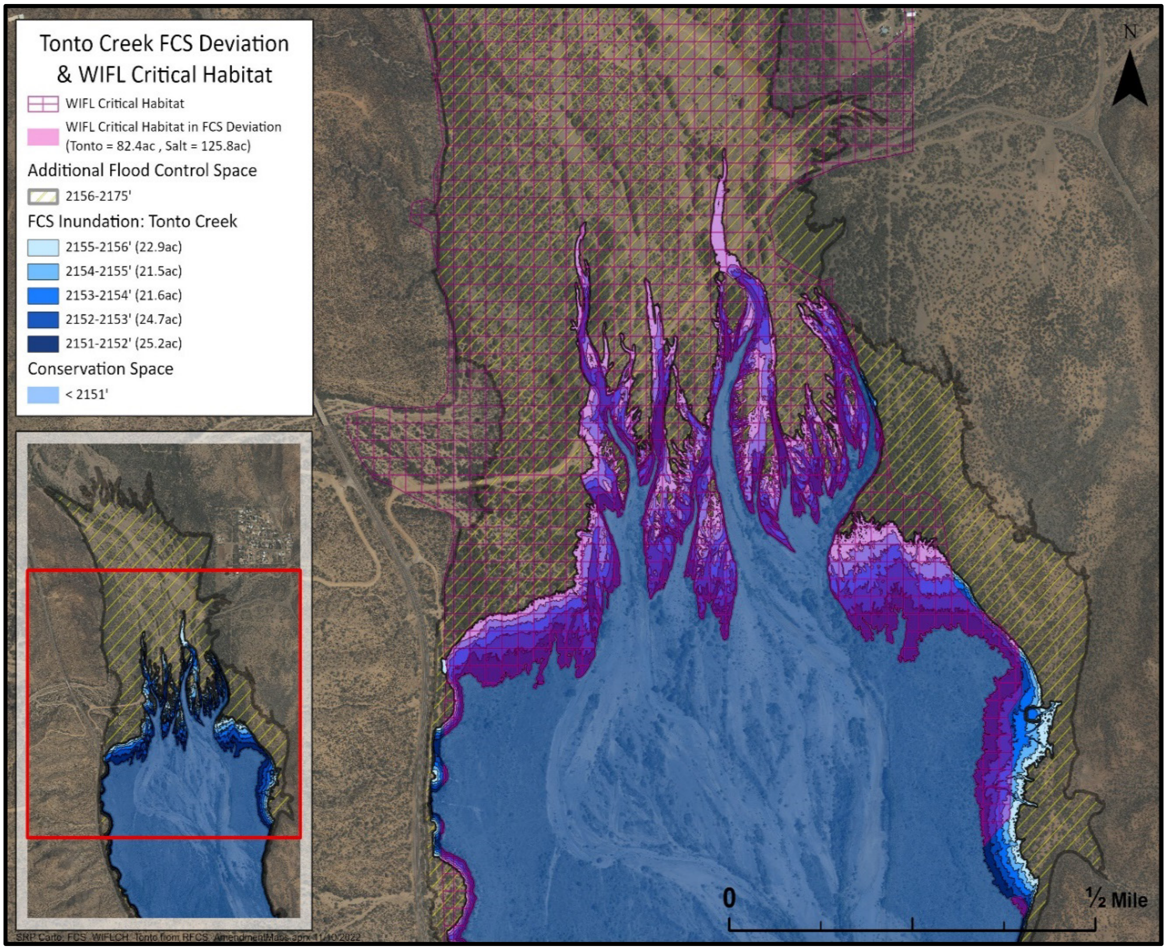

Figure 21. Inundation of flycatcher critical habitat on the Tonto Arm during planned deviation operations.

C. Yellow-Billed Cuckoo

i. Current Flood Control Operations

Lake elevations at Roosevelt Lake usually peak in late April or early May. Cuckoos rarely arrive on their breeding grounds before the last week of May and more typically arrive in mid-June. The most recent hydrologic model predicts that water could be present in the FCS in June in seven of 106 years; however, the maximum rise in the lake elevations in June is not expected to exceed 0.8 foot. Although water could enter the FCS on rare occasions in July or August, the expected water depth would not exceed 2.1 feet. Thus, there would be no loss of cuckoo eggs or nestlings from inundation of nests. Because water would so rarely be in the FCS between mid-June and September, when cuckoo young would be fledging, loss of young birds from drowning when they fledge into the water also would not be expected. The original RHCP determined that loss of cuckoo eggs or nestlings in the CS was unlikely but could occasionally occur as the result of inundation or subsequent drying if a nest tree fell over during the short period (< 30 days) in which a nest contains eggs or young (see Subchapter III.B.F of the original RHCP). This form of direct take would be even less likely in the FCS under current operations than in the CS because the period of inundation in the FCS would be limited to 20 days.

The analysis in the 1995 Biological Assessment (Reclamation and SWCA 1995) and subsequent 1996 Biological Opinion (FWS 1996a) found that no effects on tall, dense vegetation were anticipated in the FCS because inundation in the FCS would be brief. The most recent hydrologic model estimates that multiple consecutive fill events could result in water being in the bottom 2 feet of the FCS nearly continuously for 3 to 6 months in 19 (18%) of 106 years. However, the model overestimates the occurrence of consecutive fill events because it does not account for operator discretion, which would result in the FCS being fully evacuated down to 2,151 feet amsl after each fill event (see Figure 9). At 2,152 feet amsl, back-to-back fill events would be expected to result in alternating inundated and dry periods of approximately equal duration (i.e., cycles of approximately 10 days of inundation followed by 10 days dry). The ratio of dry periods to wet periods within each 20-day cycle would be smaller for areas closer to 2,151 feet amsl and larger for areas above 2,152 feet amsl. At 2,151 feet amsl, the period between inundation events would be approximately 1 day.

Seedlings and young saplings in the bottom 1 foot of the FCS could be killed as a result of inundation, but recruitment would be expected as lake elevations recede if the water table remains high (Levine and Stromberg 2001; Stromberg et al. 1993). This would be especially true for tamarisk die-off and regeneration. Ellis et al. (2008) documented rapid regeneration of riparian habitat at Roosevelt Lake, with tamarisk recruitment occurring within months of receding lake elevations, and tamarisk growing approximately 4.9 feet (1.5 m) within a year. Recruitment of Goodding's willows and Fremont cottonwoods were favored when substrates were moistened by receding floodwaters and high water tables during spring months. As a result of the infrequency of anticipated back-to-back fill events, the short-term (maximum 20-day) period of inundation, and the interim dry periods between fill events, there would be infrequent and short-term impacts to seedlings and saplings.

The effects of intermittent inundation on riparian vegetation are not addressed in the literature; however, mature willows are tolerant of prolonged inundation (see Appendix 4 of the original RHCP) and would not be expected to suffer detrimental effects from the intermittent inundation anticipated under standard operations of the FCS. Similarly, mature cottonwoods would tolerate partial submersion for 4 months (Markovchick 2021) and would not be expected to suffer detrimental effects from intermittent inundation. Mature tamarisk would be more susceptible to stress from consecutive fill events compared to native vegetation (Ellis et al. 2008; Gladwin and Roelle 1998; Stromberg 1997; Stromberg et al. 1993). Any effects, which could include branch dieback or sparse foliage, would be limited to tamarisk rooted in the bottom few inches of the FCS. Temporary flooding of the FCS could also result in increased soil moisture availability, promote the development of dense foliage in existing vegetation, and support the germination and development of new vegetation in the FCS. Although adverse effects on individual tamarisk plants rooted in the bottom few inches of the FCS could occur, this would not be expected to alter essential breeding, feeding, or sheltering behaviors to an extent that death or injury of a cuckoo occurs.

ii. Planned Deviation of Flood Control Operations

The planned deviation would not alter the typical yearly pattern of lake elevations at Roosevelt Lake, in which lake elevations peak in late April or early May and then decrease. Cuckoos do not arrive on their breeding grounds before May; thus, lake elevations are not rising during the breeding season. As described in the RHCP, loss of cuckoo eggs or nestlings from direct inundation is unlikely because lake elevations would not be increasing during the breeding season.

The original RHCP determined that loss of cuckoo eggs or nestlings in the CS was unlikely but could occasionally occur if a nest tree fell over as the result of inundation or subsequent drying or if young birds drowned when they fledged over water (see Subchapter III.B.F of the original RHCP). These forms of direct take would be less likely in the FCS than in the CS; the period of inundation in the FCS would be limited to 120 days per event and, depending on the timing of the fill event, water could be evacuated from the FCS before late-season cuckoo nests fledge. Surface water and/or saturated soils beneath the nest could benefit nesting cuckoos by deterring predators and moderating microclimate.

Cuckoos could also be affected by changes in riparian vegetation caused by releasing water from the planned deviation space over a period of 120 days. Increased water availability for vegetation that is rooted either within or near the planned deviation space could result in increased vegetation vigor, which could benefit cuckoos by providing nest concealment and moderating microclimate. Conversely, prolonged submersion of the root crown can reduce vegetation vigor and eventually cause mortality, and mortality increases as depth and duration of inundation increase (see Appendix 4 of the original RHCP and the summary in Subchapter 3.B.ii above). The expected maximum duration of inundation in the planned deviation space ranges from 87 days between 2,155 and 2,156 feet amsl to 120 days between 2,151 and 2,152 feet amsl (see Table 5). No mortality would be expected for mature cottonwoods or Goodding's willows for these inundation periods, and growth rates could be increased. Some mortality or dieback could occur for tamarisk; these effects would occur on a gradient, increasing in intensity from 2,156 to 2,151 feet amsl. Any tamarisk that would contribute to nesting habitat for cuckoos are tall enough that most of the plant would be above the water for the duration of the planned deviation; therefore, widespread tamarisk mortality would not be expected. Mortality and dieback of vegetation could be more pronounced in the Salt Arm, which is primarily tamarisk, than in the Tonto Arm, where the overstory is primarily Goodding's willows. The maximum acreage of cuckoo habitat that could be affected was estimated by using the flycatcher model (Hatten and Paradzick 2003) combined with lidar to determine that 43.0 acres of predicted habitat (classes 3–5 in the model and at least 6 m in height) are present in the planned deviation space. This is the maximum acreage of current habitat in which the vegetation would be adversely affected by the planned deviation to a degree reasonably certain to cause take.

The planned deviation could result in water receding from the planned deviation space as late as August, rather than in May or earlier. Exposing sediments in the FCS in summer rather than spring may favor the establishment of tamarisk—which releases seeds from late April through September—over native riparian plants that release seeds earlier in the spring. Monsoon stream flows and summer flood events within inflows to Roosevelt Lake also provide opportunities for tamarisk germination. Tamarisk, particularly where it is mixed with native vegetation, can be a component of cuckoo breeding habitat, although there is no record of cuckoos nesting in tamarisk at Roosevelt Lake (Valencia 2022b). However, tamarisk leaf beetles, introduced by the federal Animal and Plant Health Inspection Service, colonized tamarisk at Roosevelt Lake in 2022 (Valencia 2022a). The defoliation caused by tamarisk leaf beetles results in reduced tamarisk flowering, and repeated defoliation can cause terminal dieback or mortality of tamarisk; thus, the presence of tamarisk leaf beetles may minimize any effect of the planned deviation that would otherwise favor the establishment and growth of tamarisk in the planned deviation space.

These factors make the effects of the delayed release of water from the FCS on tamarisk establishment indeterminable. However, existing Goodding's willows and cottonwoods would likely benefit from short-term inundation and higher water tables.

The presence of water in the planned deviation space during the cuckoo breeding season could affect the seasonal availability of habitat for cuckoos in both the FCS and the CS by reducing the height of the vegetation above the water. EcoPlan collected cuckoo detection locational data at Roosevelt Lake as a part of cuckoo surveys in 2020 and 2021. Cuckoos are a wide-ranging species, however, and locations are difficult to determine accurately from aural detections; therefore, vegetation data collected near cuckoo nest sites provide a more robust evaluation of the vegetation characteristics of suitable cuckoo habitat. The average tree height in a 0.1-acre plot around cuckoo nests was 8.8 m (28.9 feet) for nests located in 1998–2001 in the Bill Williams River National Wildlife Refuge (Halterman 2001), and 9.7 m (31.8 feet) for nests located in 2001 along the San Pedro River (Halterman 2002). The 8.8-m height provides a more conservative method for estimating the amount of habitat that could be affected; therefore, SRP used lidar data acquired in 2018 to calculate the amount of vegetation that would be ≥ 8.8 m in height above the water at a lake elevation of 2,151 feet amsl but would be < 8.8 m in height above the water at a lake elevation of 2,156 feet amsl.

Lidar data were available from multiple years (2012, 2015, 2018, and 2021). The data from 2018 showed the greatest amount of vegetation ≥ 8.8 m in height above the water at a lake elevation of 2,151 feet amsl; thus, the 2018 data provided the most conservative estimate of the amount of habitat that could be affected.

- In the CS, 2.8 acres of vegetation ≥ 8.8 m in height were available at a lake elevation of 2,151 feet amsl; 2.6 of those acres had < 8.8 m of the vegetation exposed above the water at a lake elevation of 2,156 feet amsl.
- In the FCS, 10.2 acres of vegetation ≥ 8.8 m in height were available at a lake elevation of 2,151 feet amsl; 2.6 of those acres had < 8.8 m of the vegetation exposed above the water at a lake elevation of 2,156 feet amsl.

In summary, the planned deviation could result in up to 2.6 acres of tall, dense vegetation in the CS being less suitable for cuckoos. In the FCS, up to 43.0 acres of cuckoo habitat could be affected by changes in riparian vegetation, and an additional 2.3 acres (2.6 acres minus 0.3 acre accounted for as part of the 43.0 acres) of tall, dense vegetation could become less suitable because < 8.8 m of the tree would be exposed above the water at a lake elevation of 2,156 feet amsl. These effects reduce the amount of habitat available to nesting cuckoos by up to 47.9 acres (up to 2.6 acres in the CS and up to 45.3 acres within the FCS) in each of the 3 years of the planned deviation. The effects on the 43.0 acres where riparian vegetation could be affected by dieback or death would last up to 5 years (the assumed period to full recovery under the vegetation model used in the original RHCP) after the final year of the planned deviation. Using the surrogate metrics established in the original RHCP, this seasonal reduction in nesting habitat would result in incidental take of cuckoos via harm in an amount equivalent to the acres of habitat modification (i.e., up to 45.3 acres). While the planned deviation is a new covered activity and would result in a small amount of incidental take not contemplated in the original RHCP, the amount of take and the impacts of these takings on the cuckoo are fully offset by the amount of currently authorized incidental take and the conservation measures implemented to address the impacts of the authorized take. See Subchapter 4.C for additional discussion.

iii. Critical Habitat

1. Current Flood Control Operations

Under the current operations of Modified Roosevelt, water within the FCS would be evacuated within 20 days of a fill event. The most recent hydrologic model estimates that multiple consecutive fill events could result in water being in the bottom 2 feet of the FCS nearly continuously for 3 to 6 months in 19 (18%) of 106 years. However, the model does not account for operator discretion, which would result in the FCS being fully evacuated down to 2,151 feet amsl after each fill event (see Figure 9). At 2,152 feet amsl, back-to-back fill events would be expected to result in alternating inundated and dry periods of approximately equal duration (i.e., cycles of approximately 10 days of inundation followed by 10 days dry). The ratio of dry periods to wet periods within each 20-day cycle would be smaller for areas closer to 2,151 feet amsl and larger for areas above 2,152 feet amsl. At 2,151 feet amsl, the period between inundation events would be approximately 1 day.

As detailed in Subchapter 3.B.i, current flood control operations would not have any detrimental effects on mature cottonwoods and willows but could affect individual tamarisk trees rooted in the bottom few inches of the FCS. Seedlings of both tamarisk and native vegetation could be killed. These vegetation changes would affect PBF 1 (range-wide breeding habitat) on a fraction of the 36.7 acres of cuckoo critical habitat between 2,151 and 2,152 feet amsl. Although individual plants could be affected, no significant changes to the vegetation are anticipated. Temporary flooding of the FCS could result in increased soil moisture availability, promote the development of dense foliage in existing vegetation, and support the germination and development of new vegetation in the FCS; thus, current FCS operations could enhance PBF 1 (range-wide breeding habitat) and PBF 3 (hydrologic processes). Under current FCS operations, water would not be present in the FCS during the cuckoo breeding season; thus, current operations would not be expected to affect PBF 2 (adequate prey base).

2. Planned Deviation of Flood Control Operations

The planned deviation could have detrimental effects on existing mature vegetation (PBF 1; range-wide breeding habitat) through the mortality or degradation of tamarisk. However, the tamarisk that contribute to nesting habitat for cuckoos are tall enough that most of the plant would be above the water for the duration of the planned deviation, and widespread tamarisk mortality would not be expected. Any detrimental effects would occur on a gradient, increasing in intensity from 2,156 to 2,151 feet amsl. The 181.0 acres of cuckoo critical habitat in the planned deviation space are approximately equally distributed among the five 1-foot contour intervals; thus, the acreage affected increases linearly with declining elevation (Figure 22 and Figure 23). The timing of the drawdown of water during the planned deviation could favor the establishment of tamarisk over native woody vegetation in the planned deviation space; however, tamarisk leaf beetles colonized Roosevelt Lake in 2022, and may minimize the establishment and growth of tamarisk. Inundation longer than 30 days would result in the death of developing vegetation in the planned deviation space, which could decrease the ability of this portion of the FCS to develop additional tall, dense vegetation (PBF 1; range-wide breeding habitat) during and in the years immediately following the planned deviation. Conversely, the planned deviation could result in increased soil moisture availability throughout the cuckoo breeding season for vegetation rooted within or near the planned deviation space, thus promoting the development of dense foliage and creating a cooler, more humid microclimate. The planned deviation would thus enhance PBF 1 (range-wide breeding habitat) in the FCS.

D. Yuma Ridgway's Rail

There is no habitat for rails in the FCS. Therefore, no rails would be affected by the current operation of the FCS or by the planned deviation in FCS operations.

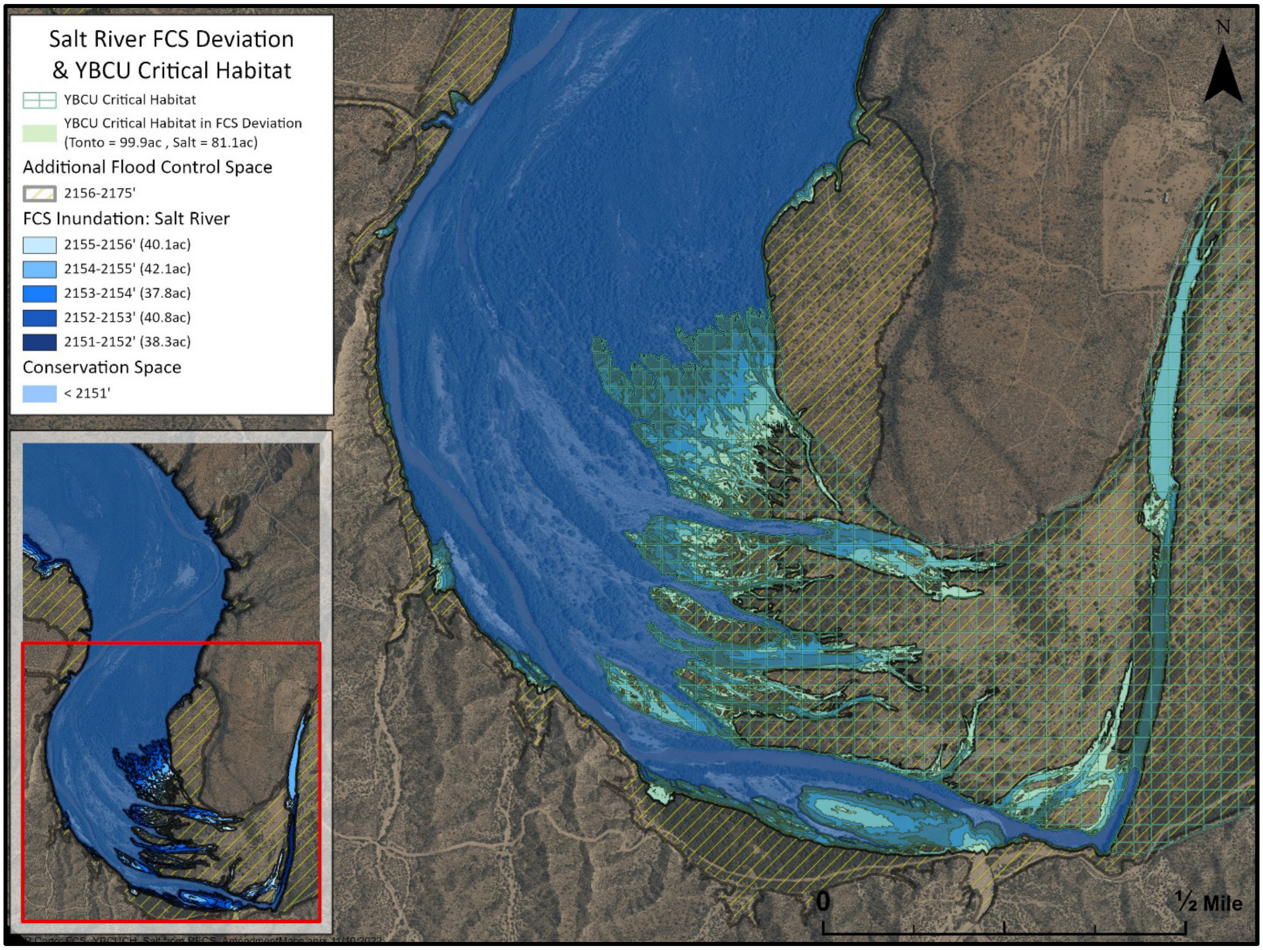

Figure 22. Inundation of cuckoo critical habitat on the Salt Arm during planned deviation operations.

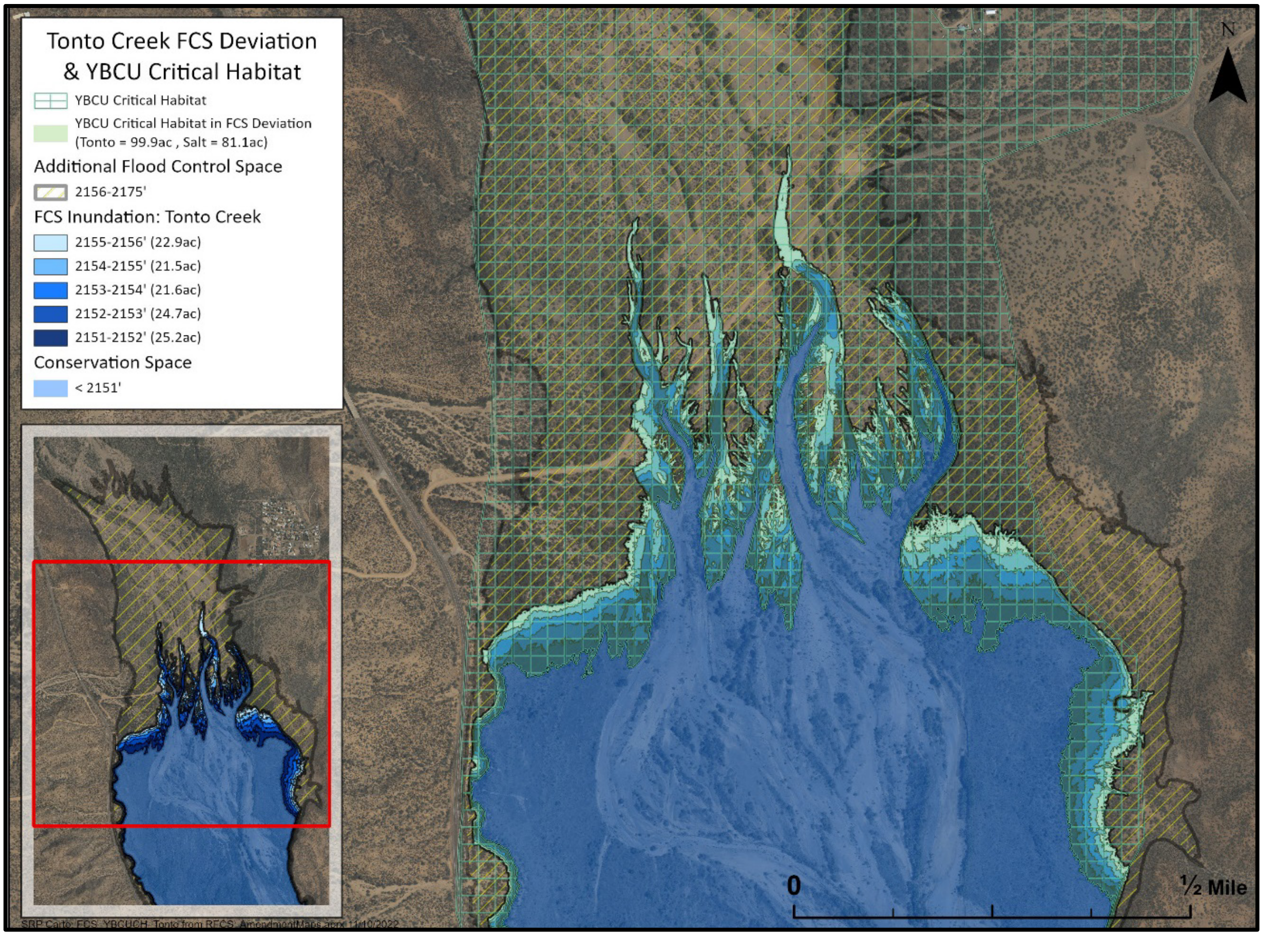

Figure 23. Inundation of cuckoo critical habitat on the Tonto Arm during planned deviation operations.

E. Bald Eagle

i. Effects on Individuals

The original RHCP took into account previous bald eagle effect analyses from FWS Biological Opinions issued to Reclamation from the construction and operation of Modified Roosevelt, as well as additional adverse effects resulting from the loss of future nest or perch trees that may grow on the Roosevelt Lake bed during an extended drought, be used by bald eagles, and subsequently be inundated when lake elevations rise (see Subchapter III.E.3 of the original RHCP). Effects on bald eagles from the construction and operation of Modified Roosevelt were previously described in three Biological Opinions and subsequent amendments issued to Reclamation. The 1983 Biological Opinion (FWS 1983; consultation number 2-21-83-F-10) described effects on bald eagles related to borrow excavation necessary for dam construction. The 1990 Biological Opinion (FWS 1990a; consultation number 2-21-83-F-10) described adverse effects related to inundation of nest and perch trees used by bald eagles and beneficial effects on the growth of such trees from an expanded zone of shallow water and wetlands associated with a rising lake. The 1993 Biological Opinion (FWS 1993; consultation numbers 2-21-83-F-10 and 2-21-92-F-285) further described adverse effects on eagles from inundation and added a description of adverse effects from recreational use of Modified Roosevelt. The original RHCP incorporated these previous effect analyses and considered additional adverse effects on bald eagles associated with desiccation of lands supporting nest or perch trees during periods of extended drought, including the potential loss of future nest and perch trees (see Subchapter III.E.3 of the original RHCP).

Mature cottonwood trees, which provide nesting and perching habitat for bald eagles, typically grow along the maximum lake elevation at or near elevation 2,151 feet amsl. Mature willow trees, which are more tolerant of inundation, may also be used by nesting bald eagles. When the lake is low for extended periods, new trees could grow in the previously inundated lake bed of the CS. When the lake rises again, these trees may become inundated for longer periods or at more frequent intervals. Excessive inundation may cause the death of the tree. Trees in the FCS may also be subject to excessive inundation and could die, although trees rooted at higher elevations in the FCS would be less likely to be exposed to excessive inundation. When the lake is low for extended periods, some trees previously close to the maximum lake elevation will become more distant from water and could become desiccated and die. Trees closer to the lower Tonto Creek channel would have less potential for desiccation.

When nest or perch trees die due to environmental stresses from inundation or desiccation, bald eagles may be affected. Although eagles would likely continue to nest in and perch on dead trees (i.e., snags) for a time, environmental stresses to eagles nesting and perching in snags could be higher than the stresses to those nesting in live trees and could result in reduced productivity for breeding adults (FWS 1993).

The collapse of dead trees would reduce the availability of nesting and perching habitat (see Subchapter III.E.3 of the original RHCP). If the collapse occurred during the nesting season, it could result in the loss of eggs or nestlings and reduced productivity of breeding adults (FWS 1993), if the nest is destroyed when the supporting tree or limb collapses or when the nest is modified to the extent that it is rendered unusable by nesting eagles for (e.g., the nest is intact but on the ground or the nest is intact but not upright).

Loss of eggs or nestlings, and as a consequence reduced productivity of breeding adults, could also occur during an extreme flood event that inundates nest structures (FWS 1990a, 1993). It is also possible that adult eagles would abandon nests that are at risk of inundation, leading to the death of eggs or nestlings, even if the nest is not ultimately destroyed by rising water. If water is present under or close to an active nest at the time when nestlings are fledging, inexperienced fledglings could be at increased risk of death if they fall or land in the water and are unable to get airborne again.

Bald eagles could also be affected by changes in the availability of prey associated with lake elevation changes. High water could create shallow, near-shore areas that support fish, whereas lower lake elevations could concentrate both fish and waterfowl. Bald eagles are territorial, opportunistic foragers and change prey species according to availability. Bald eagles at Roosevelt Lake rely heavily on fish carrion (Hunt et al. 1992, see Subchapter III.E.2.e of the original RHCP), and the availability of floating carrion is not expected to be affected strongly by changes in lake elevations (see Subchapter III.E.2.e of the original RHCP). Low productivity of bald eagle breeding areas at reservoirs in Arizona between 1993 and 2001 was associated with extended periods of very low lake elevations, although at Modified Roosevelt this association appeared to be true only for breeding areas at some distance from the lake (Dupont and Pinal) and not for those (Tonto and Pinto) along the lake margin (see Subchapter III.E.2.f of the original RHCP).

The effects described above are summarized from prior analyses in the original RHCP and the prior Biological Opinions issued to Reclamation and consider the effects of conservation storage operations and flood control operations at Modified Roosevelt under the current WCM. The planned deviation of flood control operations has not been previously reviewed for effects on bald eagles. The planned deviation could allow water to be present between elevations 2,151 feet amsl and 2,156 feet amsl for longer periods of time (120 days vs. 20 days) as compared to flood control operations under the current WCM. Extended inundation of nest and perch trees is a type of effect previously analyzed (i.e., extended inundation could cause the death of nest and perch trees, eventually reducing the availability of these habitat resources and influencing eagle use and the reproductive output of breeding areas at Modified Roosevelt). The planned deviation would increase the likelihood that 1) water would be present under or near an active nest at the time when nestlings are fledging, and 2) that extended inundation would affect trees rooted between 2,151 feet amsl and 2,156 feet amsl for the period of the planned deviation—although the degree to which the planned deviation would cause such effects is also dependent on actual stream flow during the deviation period. At present, the Pinto breeding area maintains a nest at or near elevation 2,156 feet amsl, and is likely the only breeding area that could be additionally affected by the planned deviation.

F. Spikedace

i. Effects on Individuals

Spikedace does not occupy the CS, FCS, or the lower Tonto Creek permit areas; thus, the covered activities would have no effects on this species.

ii. Effects on Critical Habitat

As described in Chapter 2, designated critical habitat for spikedace occurs from the confluence of Tonto Creek and Greenback Creek and extends upstream along Tonto Creek and into Greenback Creek within the lower Tonto Creek and FCS portions of the permit area. The lower Tonto Creek portion of the permit area intersects approximately 14.4 miles or 1,337.8 acres of critical habitat along Tonto Creek. The Greenback Creek critical habitat area is not within the lower Tonto Creek portion of the permit area but is partially within the FCS. The FCS contains a total of 1.06 miles (78.47 acres) of critical habitat, which includes 0.84 mile (73.46 acres) along Tonto Creek and 0.22 mile (5.01 acre) along Greenback Creek (see Figure 17 and Figure 18). Although the creeks are dissimilar, both creeks are intermittent, with non-contiguous flow and with spatially and temporally inconsistent channel pools. The covered activities would have no effect on spikedace PCEs, except PCE 5, which states that there are "[n]o nonnative aquatic species, or levels of nonnative aquatic species that are sufficiently low as to allow persistence of spikedace" (FWS 2012a:10837). Although the FWS acknowledges that the Tonto Creek Unit does not meet the requirements of PCE 5, no restoration activities have been conducted to improve this Unit.

SRP's storage of water in the CS provides consistent aquatic habitat for nonnative fish to persist in Roosevelt Lake. Unlike conservation storage operations, SRP's flood control operations involve actions that release water from Modified Roosevelt and not actions that store water. Therefore, SRP's flood control operations in the FCS, whether under current operations or the planned deviation, do not create or contribute to the presence of consistent aquatic habitat for nonnative fish in the FCS, as Roosevelt Lake is only temporarily in the FCS. Furthermore, the short duration (i.e., 120 days) and small acreage (i.e., 0.54 acre) of the planned deviation operations within critical habitat is not likely to have a temporal effect on the spikedace stream habitat or cause a change in populations of nonnative fish (i.e., PCE 5). Therefore, the effects of nonnative fish in lower Tonto Creek are linked to only SRP's CS operations and not FCS operations.

Figure 24 shows inundation of spikedace critical habitat during FCS planned deviation operations. Nonnative fish may move into the FCS, including the planned deviation space, during FCS operations. As water in the FCS is evacuated these individuals may move/migrate back to the consistent aquatic habitat at Roosevelt Lake in the CS, die as consequence of desiccated pools, or remain if pools persist. Nonetheless, the presence or persistence of nonnative predatory fish in the Tonto Creek Unit portions of the FCS will adversely affect PCE 5; however, the covered activities would not destroy or adversely modify spikedace critical habitat.

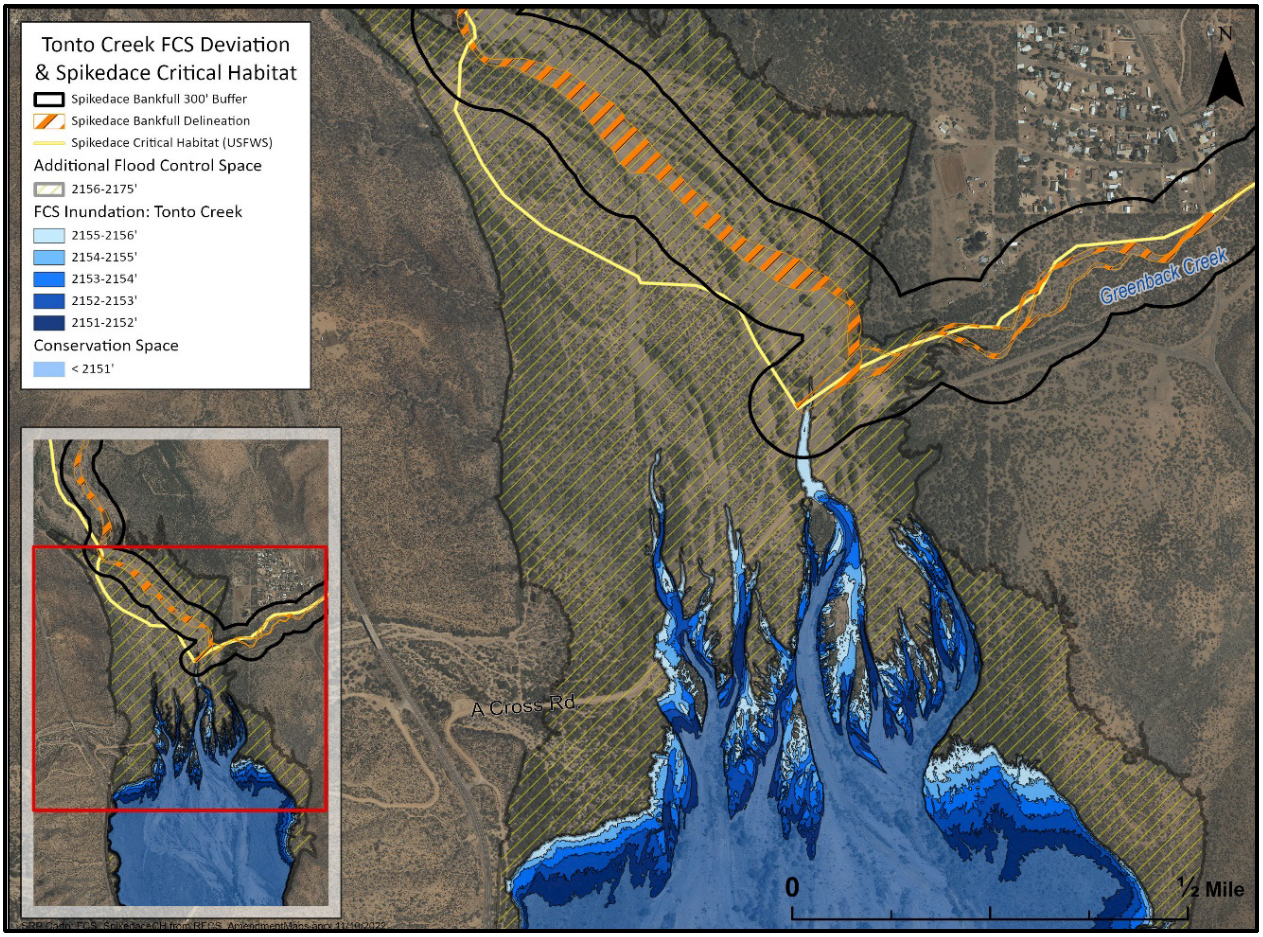

Figure 24. Inundation of spikedace critical habitat on the Tonto Arm during planned deviation operations.

Chapter 4. Incidental Take and Impacts of Take

A. Regulatory Context

With this addendum, SRP clarifies that forms of incidental take originally characterized by the FWS as "harass" in the 2003 ITP are, per subsequently issued guidance, more properly categorized as "harm" via significant habitat modification. The change in characterization does not change the amount, extent, or impacts of take authorized by the ITP when it was issued in 2003. Instead, the recharacterization is simply intended to align the language of the ITP with the recently articulated understandings of the definitions of "harm" and "harass," issued by the FWS in 2018.

In April 2018, the FWS issued guidance affirming and elaborating upon the regulatory definitions of "harass" and "harm" (FWS 2018). "Harass" means "an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering" (50 Code of Federal Regulations [CFR] 17.3). "Harm" means "an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering" (50 CFR 17.3). The 2018 guidance reaffirms the FWS's intent, expressed in the preamble to the rules addressing the regulatory definitions of harm and harass (FWS 1975), that the "concept of environmental damage being considered a 'taking' has been retained, but is now found in a new definition, of the word 'harm.'" (FWS 1975:44413). The FWS further emphasized that habitat modification is a form of harm when it revised the regulatory definition of this term in 1981 (FWS 1981). Therefore, significant habitat modification that incidentally leads to actual death or injury of a listed species is "harm," rather than "harass." The term "harass" is reserved for acts that intentionally or negligently lead to likely death or injury. The ESA's implementing regulations define "incidental taking" as "any taking otherwise prohibited, if such taking is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity" (50 CFR 17.3). Consistent with the definitions of "incidental taking" and "harm," as construed in the 2018 guidance, take arising from SRP's otherwise lawful covered activities is not intentional and manifests, directly or indirectly, through the alteration of habitat that is known or likely to be occupied by one or more of the covered species. SRP's covered activities neither intentionally nor negligently annoy individuals of the covered species in ways that meet the definition of "harass."

B. Northern Mexican Gartersnake

i. Habitat Surrogate Metric

The effects of conservation storage and flood control operations, under current and planned deviation operations, are reasonably certain to result in the incidental taking of some gartersnakes via the killing, wounding, or harming of individual snakes. The precise number of individual snakes that would be taken by these activities cannot be determined. In such circumstances, surrogate metrics may be used to approximate and track the amount or extent of take. For example, the original RHCP (SRP 2002) estimates and tracks incidental take of the covered birds using habitat as a surrogate metric. Here, SRP uses two kinds of habitat-based surrogate metric for the gartersnake: "acre-years" of reduced habitat availability for incidental take occurring in the CS or FCS, and "migration days" of potential movement of nonnative fish from the lake into lower Tonto Creek. The two metrics are needed to address the effect pathways leading to incidental take that are particular to the CS and FCS or the lower Tonto Creek parts of the permit area.

Use of a surrogate metric to track incidental take must meet the three conditions established in the FWS Surrogate Rule (50 CFR 402.14). There is ample FWS precedent for the use of surrogate metrics in HCPs, and the FWS commonly uses surrogate metrics in both the ESA Section 7 and Section 10 contexts. Federal courts have upheld the FWS's use of habitat as a proxy for take under Section 7 of the ESA, subject to requirements set out in the FWS's Section 7 implementing regulations (see 50 CFR 402.14(i)(1)(i)). The HCP Handbook (FWS and NMFS 2016) likewise sanctions the use of habitat as a surrogate for take where the criteria set forth in the HCP Handbook are met (see FWS and NMFS 2016, Section 8-3). These criteria mirror the language in the FWS Surrogate Rule.

1. Condition 1: Impractical to Track Individuals

Cryptic Species and Imperfect Detection. Studies have detected gartersnakes in the permit area, but the precise number of gartersnake individuals that reside in the permit area at any given time is unknown and such information is not practical to obtain. Because of the cryptic nature of the species, and because visual encounter and trapping survey methods require surface activity of an otherwise semi-fossorial target species, available survey methods are less than 100% effective at detecting all individuals (Durso et al. 2011). In this instance, FWS estimates that detectability may be less than 10% (Servoss 2021). It is not practical to know with confidence how many gartersnake individuals are present in the permit area or how many could be exposed to the effects of the covered activities. As a consequence, it is not practical to know how many individuals could be taken. Nowak et al. (2019) demonstrate that detection rates for the gartersnake in the CS are very low (i.e., equivalent to a survey effort of more than 5,000 trap-hours to detect one individual or between approximately 11 and 25 visual encounter-hours to detect one individual). Further, detection rates vary among years or even among weeks, making it difficult and impractical to robustly estimate the number of gartersnakes that use the permit area.

Populations within the Permit Area Change Over Time. Not only is the precise number of individuals occupying the permit area at any given time unknown (although, presence of the species is expected based on prior study) and impractical to ascertain, but gartersnake abundance also can be expected to change over time. The gartersnake population that uses the permit area is open, such that individuals may come and go without restriction. Although no data are available regarding gartersnake dispersal, the available data on the spatial ecology and habitat use of gartersnakes show gartersnakes are capable of making movements along the riparian and upland habitats adjacent to Tonto Creek (Myrand 2019; Nowak et al. 2019) and can even move across or maintain home ranges that include human-made structures and developed properties (Holycross et al. 2006; FWS 2021f). Rosen and Schwalbe (1997) and d'Orgeix (2011) provide empirical data on how gartersnakes move in, out, and back into areas in response to changes in aquatic conditions and changing availability or abundances of prey. There are no physical barriers that might prevent an individual gartersnake from traveling into, out of, or among the various components of the permit area.

Gartersnakes are subject to factors that likely influence abundance in the permit area and that are independent of the covered activities and outside of SRP's control. For example, wildfires on adjacent properties (such as the Bush Fire of 2020) may reduce or destroy riparian habitat used or potentially used by this open population of gartersnakes. Populations may also fluctuate with climate, other extrinsic factors, or intrinsic factors such as demography and fecundity (Boyarski et al. 2019). Changing populations, particularly in a dynamic system, make reliable, real-time counts of individuals impractical to obtain; therefore, the precise number of individuals that may be taken over the remaining duration of the ITP is impractical to determine.

Not All Individuals Exposed to the Effects of Covered Activities Will Be Taken. Just as the number of individuals exposed to the covered activities is impractical to ascertain, it is also impractical to know how many of these individuals would, with reasonable certainty, be taken as a consequence of the covered activities. Chapter 3 describes various ways that the covered activities may influence gartersnake habitats and behaviors and could, at least conceptually, lead to take via killing, wounding, or harm.

Instances of death or physical wounding can be directly demonstrated by the detection of a dead or wounded individual (reliable and accurate detections of dead or wounded individuals would also be difficult for the same reasons as described above, and even further complicated by scavenging or rapid decay of their carcasses) or may be inferred on the basis of the scientific literature or, in some cases, common sense. While detections of dead or wounded individuals or inferences of likely death or wounding can provide reasonable certainty that take has occurred or is possible in response to a certain action over a period of time, this is not to say that death or injury is always or even frequently the consequence for a given individual. For example, it may be reasonable to assume that inundation of an occupied brumation site could cause death or injury by drowning, given that the gartersnake is expected to be inactive and may not emerge prior to the site becoming flooded. But the literature (e.g., Emmons and Nowak 2016; Nowak et al. 2019) demonstrates that gartersnakes sometimes relocate to other sites or remain and survive in inundated brumation sites without apparent injury. Therefore, death or injury is not always a consequence of actions that would seemingly result in deleterious effects.

Similarly, the detection of a dead or wounded gartersnake in the permit area does not necessarily mean that SRP's covered activities caused the death or wounding of that individual. Gartersnakes could incur sublethal or lethal injuries from vehicular strikes while crossing roads adjacent to the permit area or from raptor predation attempts (Emmons, Nowak, and Lauger 2016; Jones et al. 2020). Though a desiccated gartersnake may be encountered in the permit area, the process of desiccation may have occurred postmortem and the cause of death may not be definitively determined.

It is even more difficult to quantify with precision the number of snakes that would be taken via non-lethal means (i.e., injury through reduced fitness, a component of harm and harass). Detecting reduced reproductive capacity or survivability would require tracking individual snakes over time to quantify normal reproductive and survival rates and to quantify the range of normal variation in those rates. Furthermore, deviations from those normal rates would require a demonstration of reasonable certainty that the covered activities were responsible for the change. Such detailed monitoring is not practical from a logistical, technological, or financial perspective.

2. Condition 2: Rational Link to Taken Individuals

Given the practical difficulties in determining with reasonable certainty the precise number of gartersnake individuals that would be taken by the covered activities, a surrogate metric is appropriate. SRP proposes to use two habitat-based surrogate metrics for the gartersnake: "acre-years" of reduced habitat availability for incidental take occurring in the CS or FCS, and "migration days" of potential movement of nonnative fish from the lake into lower Tonto Creek. The two metrics are needed to address the effect pathways leading to incidental take that are particular to the CS and FCS or the lower Tonto Creek parts of the permit area.

In both cases, gartersnake habitat is a surrogate metric for the number of individual gartersnakes that occupy the permit area. In the CS and FCS, gartersnake habitat is approximated by a 94-m area around aquatic edges created by channel water and/or the lake edge. In the CS and FCS, temporary reductions in the amount of gartersnake habitat resulting from SRP's covered activities are used as an estimate of the number of individual snakes incidentally taken.

In lower Tonto Creek, gartersnake habitat is approximated by the length (in river miles) of the affected channel. The conversion of channel length to acres is not necessary to estimate incidental take in this portion of the permit area since the relevant effects relate to presence of nonnative fish in the channel itself. This simplification is warranted because it is unclear if the 94-m distance to water finding that SRP uses to approximate gartersnake habitat in the CS and FCS is also applicable to lower Tonto Creek. In lower Tonto Creek, gartersnake habitat is associated with relatively persistent pools of water that remain in the channel after flow has ceased. While gartersnakes in the CS and FCS also rely on these channel pools, the lake itself has a greater influence on the availability and quality of habitat and may have influenced the locations of gartersnakes reported in Nowak et al. (2019). It is also unclear if an acre of gartersnake habitat along lower Tonto Creek is equivalent to an acre of gartersnake habitat in the CS and FCS, in terms of the relative number of gartersnakes represented by each acre of habitat. The use of a different habitat surrogate metric for lower Tonto Creek avoids unsubstantiated comparisons between the population of gartersnakes in the CS and FCS and the population along lower Tonto Creek.

Notably, the original RHCP similarly uses habitat acres as a surrogate for incidental take for other covered species, and SRP's Horseshoe-Bartlett Habitat Conservation Plan (which covers the gartersnake; ERO and SRP 2008) also uses habitat (expressed in terms of "river miles" rather than habitat acres) as a surrogate metric for take of the gartersnake.

I. SURROGATE METRIC FOR THE CONSERVATION SPACE AND FLOOD CONTROL SPACE

SWCA (2022b [see Appendix H]) describes a model for determining the amount and location of gartersnake habitat within the CS and FCS. This model identifies the areas most likely to be used for breeding, feeding, and sheltering activities based on the locations of telemetered snakes tracked during the active season in comparison to the location of visible surface water (i.e., water identifiable in aerial imagery). The area within 94 m of visible surface water captured 95% of the active season telemetered snake locations, and studies suggest that most brumation sites are also located near aquatic edges. While snakes may use areas beyond 94 m of visible surface water, some of this "upland use" may be due to the inability to detect and map all aquatic edges used by snakes and the movement of aquatic edges over time, as well as some actual use of uplands by snakes. However, taken together, the 94-m distance from visible surface water is a reasonable approximation of the extent of gartersnake habitat in the CS and FCS.

SRP proposes to use the acreage of gartersnake habitat as a surrogate metric for the number of individual gartersnakes that occupy the CS and FCS. While it is unlikely that the relationship between habitat acres and individual snakes is a simple linear relationship, it is reasonable to expect that the amount of gartersnake habitat positively correlates with the number of snakes that are or may be present, such that the availability of more habitat supports (at least conceptually) a larger population of snakes. This relationship is likely influenced by many factors, including habitat quality, biological factors (such as demographic rates or territorial or dispersal patterns), and current status (such as distribution and abundance patterns at a species level) (see for example findings in Myrand [2019] or Nowak et al. [2019] regarding territory overlap and other density-dependent characteristics of gartersnake spatial ecology). The body of best available science on the gartersnake is not yet sufficient to fully understand or quantify these relationships. While there have been studies in the permit area that confirmed the presence of numerous individual snakes at discrete points in time (see, for example, Nowak et al. [2019]), the total number of gartersnakes that occupy the permit area is not known and has not been estimated by the FWS or the scientific community. The proposed habitat surrogate metric is a practical and reasonable approach for approximating the size of the gartersnake population in the CS and FCS.

Since habitat acres are a reasonable surrogate for the number of individual snakes occupying the CS and FCS, it follows that changes in the amount of such habitat may approximate changes in the size of the snake population. When the amount of habitat is reduced as a consequence of SRP's covered activities, the application of this surrogate metric implies that the number of snakes has also been reduced through effects that lead to incidental take of individuals.

As discussed in Chapter 3, SRP's conservation storage activities also contribute to conditions that allow for nonnative predatory fish to reside in Roosevelt Lake, and these fish degrade the quality of gartersnake habitat in the CS, FCS, and in lower Tonto Creek. Since the lake is a consistent presence in the CS and an occasional presence in the FCS, incidental take of gartersnakes in the CS or FCS associated with the effects of nonnative predatory fish is also approximated by the presence and elevation of the lake itself. Therefore, changes in gartersnake habitat availability tracked, in part, by lake elevation over time, is also a relative measure of the degree to which gartersnakes are exposed to the effects of nonnative predatory fish. Higher lake elevations equate to less habitat and more exposure to nonnative predatory fish (lower habitat quality); lower lake elevations equate to more habitat and less exposure to nonnative predatory fish (higher habitat quality). A separate measure or metric of take arising from the effects of nonnative predatory fish in the CS and FCS is not warranted. Changes in habitat availability, based in part on lake elevations, is a reasonable surrogate for the related habitat quality changes in the CS and FCS associated with nonnative predatory fish.

SRP estimates the amount of take from its covered activities in the CS and FCS in terms of the cumulative reductions of or adverse impacts to acres of available habitat over the remaining duration of the ITP. The incidental take estimates are derived from analysis of yearly or monthly data and summarized as "acre-years" of reduced habitat availability. This time-specific metric addresses the naturally dynamic nature of the habitat resources in the CS and FCS (and, by extension, the population of gartersnakes in the CS and FCS) arising from ever-changing Tonto Creek flows and Roosevelt Lake elevations. SRP's covered activities in this dynamic system create both adverse and beneficial effects on the gartersnake that vary in both location and time. The acre-year approach is appropriate for the gartersnake and the covered activities because ecological conditions in the CS and FCS are not static from year to year. In any given year, the same physical acre of land (or water) may or may not be gartersnake habitat, depending largely on the amount and location of visible surface water.

II. SURROGATE METRIC FOR LOWER TONTO CREEK

The effects of SRP's conservation storage activities that lead to incidental take of gartersnakes in lower Tonto Creek are limited to the effects of nonnative fish that leave Roosevelt Lake and move into the creek (see Chapter 3). In this context, nonnative fish are an element of gartersnake habitat that likely have a net adverse effect on gartersnakes. The presence of nonnative fish degrades the quality of gartersnake habitat by increasing the risk of predation or physical wounding and increasing the level of competition for native prey. The abundance of nonnative fish is related to the degree of habitat degradation (i.e., more nonnative fish equates to more severe habitat degradation). Habitat degradation that leads to actual death or injury of an individual gartersnake is a form of take via harm. Therefore, more nonnative fish in lower Tonto Creek rationally equates to more harm to gartersnakes along lower Tonto Creek.

SRP's conservation storage operations in the CS create habitat for nonnative fish because conservation storage operations allow for water to reside in the CS long enough for aquatic habitat to persist to support nonnative fish. Other parties—including in recent years the AGFD, with funding support from FWS and other parties—have repeatedly introduced nonnative fish to Roosevelt Lake. These introductions are ongoing. SRP's conservation storage operations allow introduced nonnative fish to persist following their release into the lake. SRP's flood control operations involve only the release of water from Modified Roosevelt, not the storage of water or the persistence of nonnative fish habitat. Therefore, flood control operations are not the cause of effects on gartersnakes from nonnative fish upstream of the FCS along lower Tonto Creek.

When Tonto Creek flows within a certain range of cubic feet per second during a certain time of year (i.e., creek flows between 200 and 1,100 cfs that occur between February 1 and May 31), nonnative fish that typically reside in the lake may move upstream into Tonto Creek. Once in the creek, these nonnative fish may interact with gartersnakes in ways that can result in incidental take (i.e., predation, competition, and wounding). These effects are intensified once Tonto Creek stops flowing and nonnative fish become trapped in residual channel pools. These pools are important elements of gartersnake habitat in lower Tonto Creek since they extend the availability of aquatic habitat and the aquatic edge/riparian resources gartersnakes rely on. The effects of nonnative fish on gartersnakes become intensified when and where the availability of aquatic habitat is more restricted.

Nonnative fish can be present in lower Tonto Creek at times when aquatic habitat is available. Tonto Creek is not perennial and, in most years, flow ceases by July. Residual channel pools remain for some time following the cessation of flow. The number or extent of such pools is unknown and likely varies within and among years. The length of time that residual channel pools remain present is also unknown and likely varies between years and among pools. Therefore, the persistence of aquatic habitat in lower Tonto Creek, and, by extension, the potential for nonnative fish to be present, is highly variable within and among years.

It is known that Tonto Creek becomes completely dry in many years. It may be reasonably assumed that nonnative fish do not persist in lower Tonto Creek following the complete loss of aquatic habitat. Connecting flows are needed to reestablish the presence of nonnative fish in lower Tonto Creek after the creek channel becomes dry.

As described above, the presence and abundance of nonnative fish in lower Tonto Creek is highly variable and related to the persistence of aquatic habitat. Quantitative estimates of these parameters are not available, either for the lower Tonto Creek reach as a whole or for segments of this reach. However, presence and abundance of nonnative fish in lower Tonto Creek are related to the amount of time that the lake and the creek are connected. It is reasonable to conclude that the longer this connectivity occurs, the more nonnative fish will make the move from the lake into the creek.

Nonnative fish are able to move upstream when Tonto Creek flows are strong enough to create sufficient depth for swimming, but not so strong as to overwhelm the ability of a fish to move against the current. ERO-GEI (2022a [see Appendix E]) estimated that the range of flows that provides conditions suitable for nonnative fish migration upstream is between 200 cfs and 1,100 cfs, as measured at the stream gage in Tonto Creek above Gun Creek (U.S. Geological Survey [USGS] station number 09499000). The spawning behaviors of nonnative fish make it more likely that these fish will seek habitat outside of the lake and move into stream habitats between February 1 and May 31 (ERO-GEI 2022a [see Appendix E]).

The amount of harm to gartersnakes caused by nonnative fish along lower Tonto Creek is related to the presence and abundance of nonnative fish in lower Tonto Creek, which is itself related to the amount of connectivity between the lake and the creek. Therefore, SRP proposes to use the number of days in a given year that meet the conditions for likely nonnative fish migration (referred to herein as nonnative fish "migration days") as a surrogate metric for the amount of incidental take arising from the covered activities. The more migration days there are in a given year, the more harm to gartersnakes (i.e., habitat degradation from the effects of nonnative fish) can be assumed to occur. Migration days is the surrogate metric for estimating incidental take along the 14.4 miles of lower Tonto Creek within the permit area. The estimated cumulative number of migration days over the remainder of the ITP term is the estimate of incidental take of gartersnakes in lower Tonto Creek arising from the storage of water in the Roosevelt Lake CS.

3. Condition 3: Surrogate Metric is Measurable

I. MEASURING ACRE-YEARS OF HABITAT AVAILABILITY OR MODIFICATION

The proposed incidental take metric for the CS and FCS is based on the amount, location, and temporal change to gartersnake habitat in these parts of the permit area. Gartersnake habitat is associated with the presence of visible surface water. SRP routinely monitors water conditions associated with Modified Roosevelt, including the elevation of the lake elevations and inflows from Tonto Creek, which contribute to the distribution and abundance of visible surface water in the CS and FCS. SRP performs this monitoring through gage readings, analysis of aerial imagery and other remote sensing data, and field measurements. SRP has the resources and expertise to regularly map or otherwise determine the location and extent of gartersnake habitat in the CS and FCS, compare new information to prior information, and quantify changes over time. Each year, SRP will compare reductions in gartersnake habitat in the CS and FCS to the cumulative estimate of habitat reduction that is the incidental take authorization for these parts of the permit area. In this way, the proposed surrogate metric is measurable on a yearly basis using readily available data, the cumulative take estimate expressed in acre-years of reduced habitat availability sets a clear limit on the amount of authorized take, and annual accounting of realized vs. authorized take can be tracked over time to ensure that authorized take is not exceeded.

II. MEASURING THE NUMBER OF MIGRATION DAYS

The proposed incidental take metric for the lower Tonto Creek portion of the permit area is based on the cumulative number of migration days (i.e., days with connectivity between Roosevelt Lake and the creek) for the duration of the ITP term. Migration days are defined in terms of stream flows between a certain range of cubic feet per second during a certain time of year. Migration days represent the conditions most suitable for nonnative fish migration upstream.

The stream gage operated by the USGS on Tonto Creek above Gun Creek (gage station number 09499000) provides publicly available historical data beginning in 1941 that are suitable for estimating the number of migration days (i.e., amount of take) likely to occur over the remaining duration of the ITP. This stream gage is expected to remain in operation for the foreseeable future. SRP may rely on data from this stream gage to account for the actual migration days experienced during the ITP term. By annually comparing the running total of actual migration days to the cumulative estimate for the remainder of the ITP term, SRP and FWS can determine if authorized take is at risk of being exceeded.

ii. Incidental Take and Impacts in the Conservation Space and Flood Control Space

SRP estimates separately the amount of incidental take of gartersnakes arising from conservation storage operations in the CS, current flood control operations in the FCS, and the planned deviation of flood control operations in the FCS.

1. Delineating Northern Mexican Gartersnake Habitat

SRP created a model to quantify the amount of gartersnake habitat in the CS and FCS (SWCA 2022e [see Appendix H]). Proximity to water is an important factor in gartersnake habitat selection, and the species is closely associated with aquatic edge habitats (Emmons and Nowak 2016; Nowak et al. 2019; Sprague and Bateman 2018). Visible surface water (i.e., water identifiable in aerial imagery) is an environmental parameter that is readily mappable for past, present, and future conditions and is a suitable parameter for predicting and monitoring gartersnake habitat. As more fully described in SWCA (2022b [see Appendix H]), SRP determined that the proximity to visible surface water was the variable associated most strongly with telemetered, active-season gartersnake locations within the CS and FCS.

SRP used high-resolution National Agriculture Imagery Program (NAIP) imagery from 2007, 2010, 2013, 2015, and 2017, as well as a set of images from Reclamation dating to 2000 and 2002, to map the location and extent of visible surface water in the CS and FCS over a 17-year period. Some of these images corresponded with the time of the gartersnake telemetry data reported in Nowak et al. (2019). SRP found that the area within 94 m (308 feet) of visible surface water captured the location of 95% of the telemetered, active-season gartersnake detections. See SWCA (2022b [Appendix H]) for additional discussion.

SRP used the 94-m distance-to-water finding to delineate the extent of gartersnake habitat within the CS and the FCS. The specific application of this 94-m distance-to-water finding to the CS and FCS was slightly different to address the specific context of the analysis for that area. Additional detail on how SRP applied the 94-m distance-to-water finding is provided in the following subchapters.

2. Conservation Storage Operations

I. ESTIMATED HABITAT AVAILABILITY IN THE CONSERVATION SPACE

Within the CS, SRP applied the 94-m distance-to-water finding to: 1) the presumptive lake edge at elevations between approximately 2,036 feet amsl (the lowest lake elevation observed in the CS since 2002) and the top of the CS at 2,151 feet amsl; and 2) the non-inundated portions of the cumulative extent of visible surface water in the Tonto Arm, mapped from available aerial imagery dating to six time periods between 2002 and 2017 (i.e., the channel water).

SRP estimated the amount of gartersnake habitat in the CS associated with the lake edge and the channel water at each 2-foot change in lake elevation. This analysis created a relationship between lake elevation (which is a consequence of the covered activities) and the estimated amount of gartersnake habitat in the CS (Figure 25; Table 10). The amount of gartersnake habitat associated with the lake edge remains relatively consistent across the range of possible lake elevations due to the relatively narrow shape of the Roosevelt Lake basin. Consequently, as the lake elevation rises, it inundates and makes unavailable habitat associated with channel water in Tonto Creek and creates a generally negative relationship between total habitat availability and lake elevation.

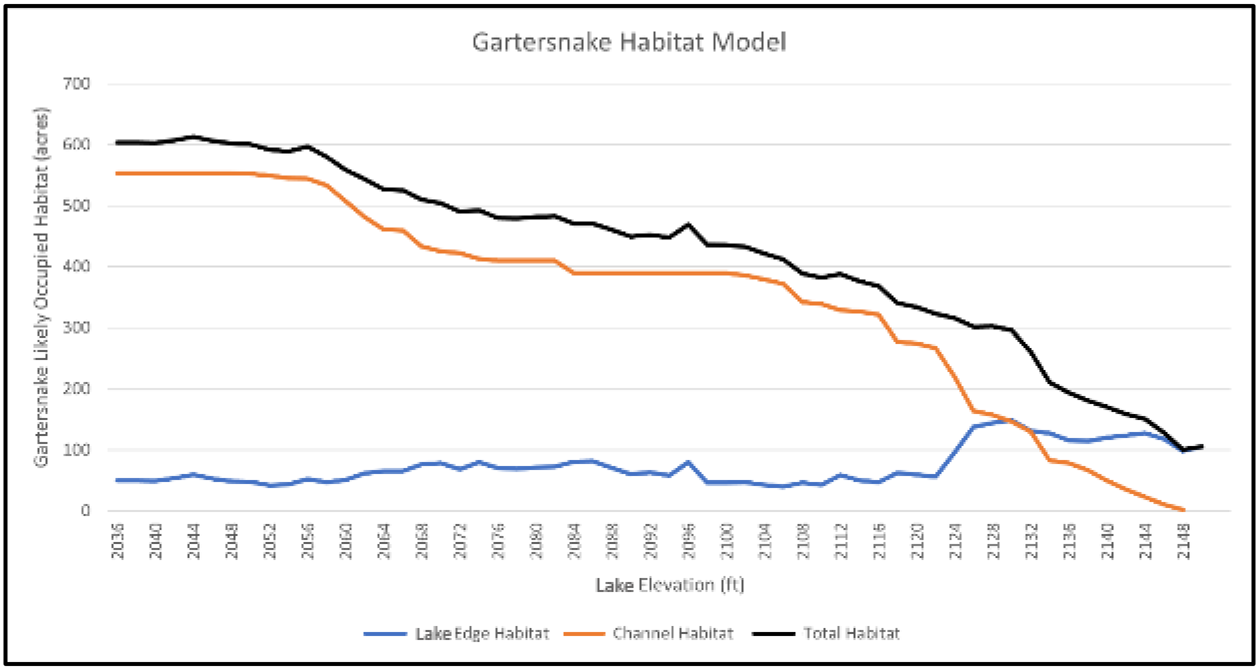

Figure 25. Estimated acres of gartersnake habitat available in the conservation space at each 2-foot increment in lake elevation, in feet amsl.

Table 10. Gartersnake habitat availability in the conservation space by lake elevation.

Elevation (feet amsl)	Lake Fringe Habitat (acres)	Tonto Creek Channel Habitat (acres)	Total Habitat (acres)
2,036	49.8	553.5	603.3
2,038	50.2	553.5	603.7
2,040	49.1	553.5	602.6
2,042	53.5	553.5	607.0
2,044	59.8	553.5	613.3
2,046	53.4	553.5	606.9
2,048	48.8	553.5	602.3
2,050	48.1	552.6	600.7
2,052	42.4	549.4	591.8
2,054	43.6	545.4	589.0
2,056	52.3	544.7	597.0
2,058	47.3	533.2	580.5
2,060	50.7	508.1	558.8
2,062	62.1	481.6	543.7
2,064	65.4	461.1	526.5
2,066	65.8	459.5	525.3
2,068	76.8	433.2	510.0
2,070	78.4	425.5	503.9
2,072	68.1	422.1	490.2

Elevation (feet amsl)	Lake Fringe Habitat (acres)	Tonto Creek Channel Habitat (acres)	Total Habitat (acres)
2,074	80.1	412.6	492.7
2,076	70.4	409.8	480.2
2,078	69.2	409.8	479.0
2,080	71.5	409.8	481.3
2,082	72.9	409.8	482.7
2,084	80.9	389.4	470.3
2,086	81.3	389.4	470.7
2,088	70.6	389.4	460.0
2,090	60.2	389.4	449.6
2,092	63.1	389.4	452.5
2,094	58.4	389.4	447.8
2,096	80.0	389.4	469.4
2,098	46.8	389.4	436.2
2,100	46.3	389.4	435.7
2,102	47.0	385.9	432.9
2,104	42.9	378.9	421.8
2,106	40.1	371.6	411.7
2,108	46.2	342.1	388.3
2,110	43.1	338.9	382.0
2,112	59.2	328.7	387.9
2,114	50.1	326.3	376.4
2,116	47.0	321.3	368.3
2,118	62.9	277.5	340.4
2,120	59.6	274.5	334.1
2,122	55.9	267.0	322.9
2,124	95.9	219.8	315.7
2,126	137.5	164.2	301.7
2,128	144.7	157.8	302.5
2,130	149.1	146.8	295.9
2,132	131.0	129.9	260.9
2,134	127.9	83.2	211.1
2,136	116.2	78.3	194.5
2,138	114.6	66.7	181.3
2,140	120.1	50.3	170.4
2,142	124.1	35.3	159.4
2,144	127.8	23.0	150.8
2,146	118.3	10.3	128.6
2,148	98.5	2.0	100.5
2,150	105.5	N/A	105.5

SRP added a special consideration to the habitat-lake elevation relationship for the uppermost elevation increment in the CS. When the lake reaches elevation 2,151 feet amsl (the maximum CS elevation), SRP assumes that lands inundated by no more than 1 m (3 feet) of water could retain some habitat value for gartersnakes, since gartersnakes forage at the aquatic edge and in areas of shallow water (Emmons and Nowak 2016; Nowak et al. 2019). Therefore, even at the maximum lake elevation for conservation storage operations, some small amount of habitat (and by extension, individual snakes) may remain present in the CS. This exception to the habitat-lake elevation relationship is intended to address the potentially erroneous assumption that the CS is completely unsuitable for gartersnake use when the lake elevation reaches its maximum height in the CS (a scenario that is both uncommon and very temporary). It is also improbable to assume that no gartersnakes occur in or use the CS when the lake elevation reaches the maximum in the CS. This narrow modification to the habitat-lake elevation relationship compensates for these concerns.

SRP applied the habitat-lake elevation relationship to the estimated lake elevations in the Reservoir Planning Model to estimate habitat availability for the remaining duration of the ITP (Figure 26; see Appendix B). The Reservoir Planning Model provides the estimated lake elevation in June for each of the 106 years in the model's time series (see Appendix B). SRP chose June for the annual lake elevation estimates since it is the month most closely aligned with the time period of the aerial imagery used to generate the 94-m distance-to-water finding (i.e., the visible surface water used to create the metric was most often based on imagery from early summer). Water conditions in June are most consistent with the assumptions used to delineate gartersnake habitat.

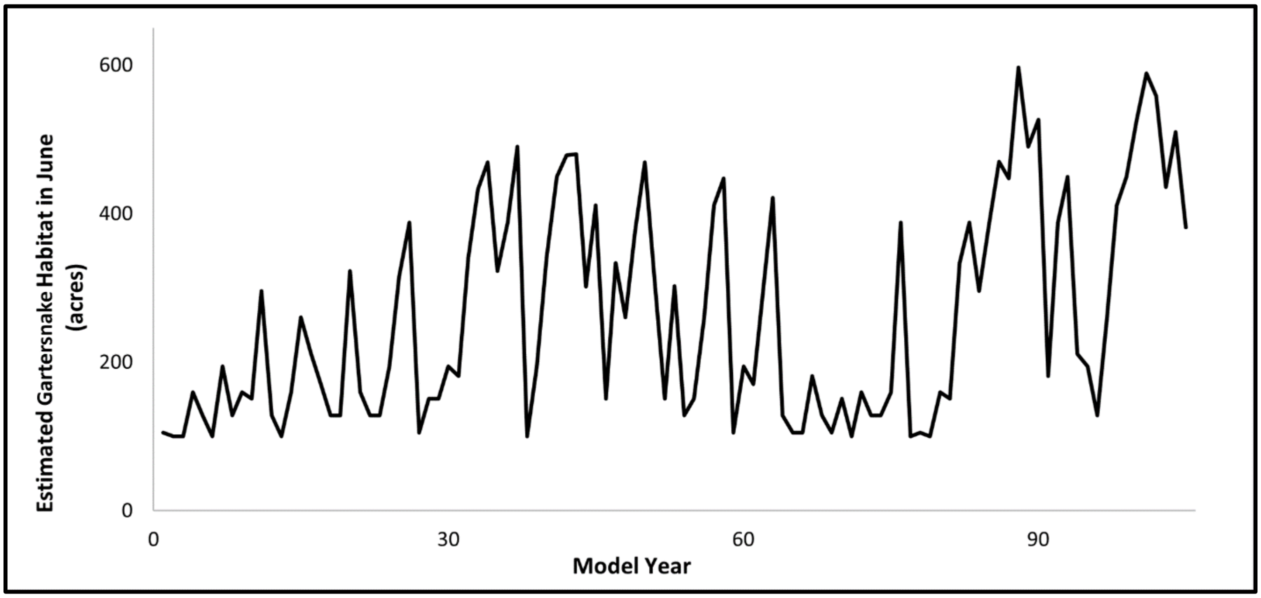

Figure 26. Estimated acres of gartersnake habitat in the conservation space under the Reservoir Planning Model.

Across this long-term estimate of habitat availability in the CS, 53.4% of the years provide between 100 and 250 acres of habitat, 41.0% of the years provide between 250 and 500 acres of habitat, and 5.8% of years provide between 500 and 600 acres of habitat (Figure 27). The long-term annual average amount of gartersnake habitat in the CS is 264 acres.

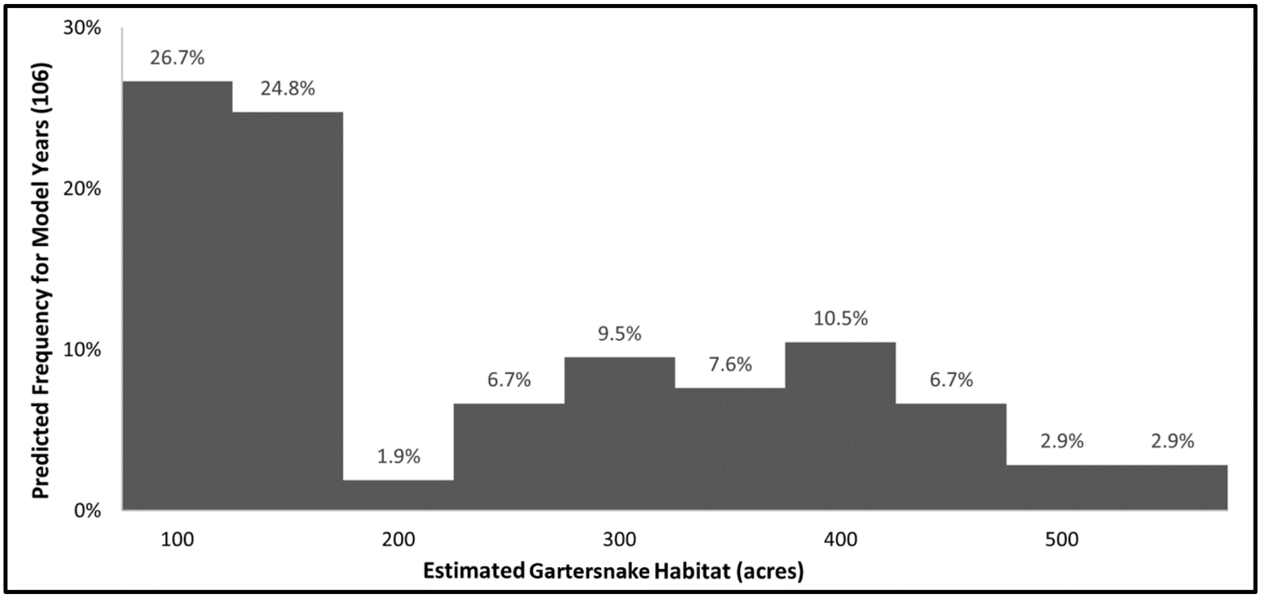

Figure 27. Frequency distribution of estimated habitat availability in the conservation space under the Reservoir Planning Model.

II. ESTIMATED AMOUNT OF TAKE

Year-to-year changes in habitat availability may either be positive, negative, or neutral (no change). Cumulative reductions over a time period (i.e., expressed as "acre-years") are the sum of each year-to-year negative change in the number of available habitat acres. SRP proposes to estimate the amount or extent of take associated with its covered activities over the remaining ITP term by the cumulative acre-years of reduced habitat availability, which also captures the forms of take associated with habitat degradation, i.e., habitat quantity and quality. Inundation by the lake reduces habitat availability and increases the degree to which gartersnakes are exposed to nonnative predatory fishes. These fish degrade the quality of gartersnake habitat associated with the lake edge and with Tonto Creek channel pools (i.e., fish may become entrapped in these pools when the lake elevation recedes or when independent Tonto Creek flows allow for upstream fish movement from the lake into the creek). Cumulative gains are the sum of each year-to-year positive change in the number of available habitat acres (which occurs as lake elevation falls).

The Reservoir Planning Model contains seventy-six 30-year sample periods that are consistent with the duration of the remaining ITP term. Cumulative year-to-year reductions in habitat availability over the population of these 30-year samples varies from 951.4 to 2,200.9 acre-years, with a mean 30-year cumulative reduction of 1,470.7 acre-years and a standard deviation on the mean of 306.1 acre-years.

SRP estimates the amount of take associated with conservation storage operations using the "worst case" 30-year period in the Reservoir Planning Model (i.e., the period with the greatest cumulative reduction in habitat availability) (Figure 28). The worst case 30-year period occurs during model years 35 to 64. The cumulative year-to-year reductions in available habitat during this worst-case period is 2,200.9 acre-years, which is 730.2 acre-years greater than the average cumulative reductions for all 30-year periods. To further address uncertainty regarding fluctuations in future lake elevations, and, thus, the changes in the amount of available habitat, SRP added another 306.1 acre-years (i.e., the standard deviation around the mean for all 30-year periods) to its base estimate of take, for a total take estimate of 2,507.0 acre-years of cumulative habitat reductions over 30 years. Conceptually, this take estimate is equivalent to an average 84 acres of reduced habitat availability each year for the remaining 30 years of the ITP term.

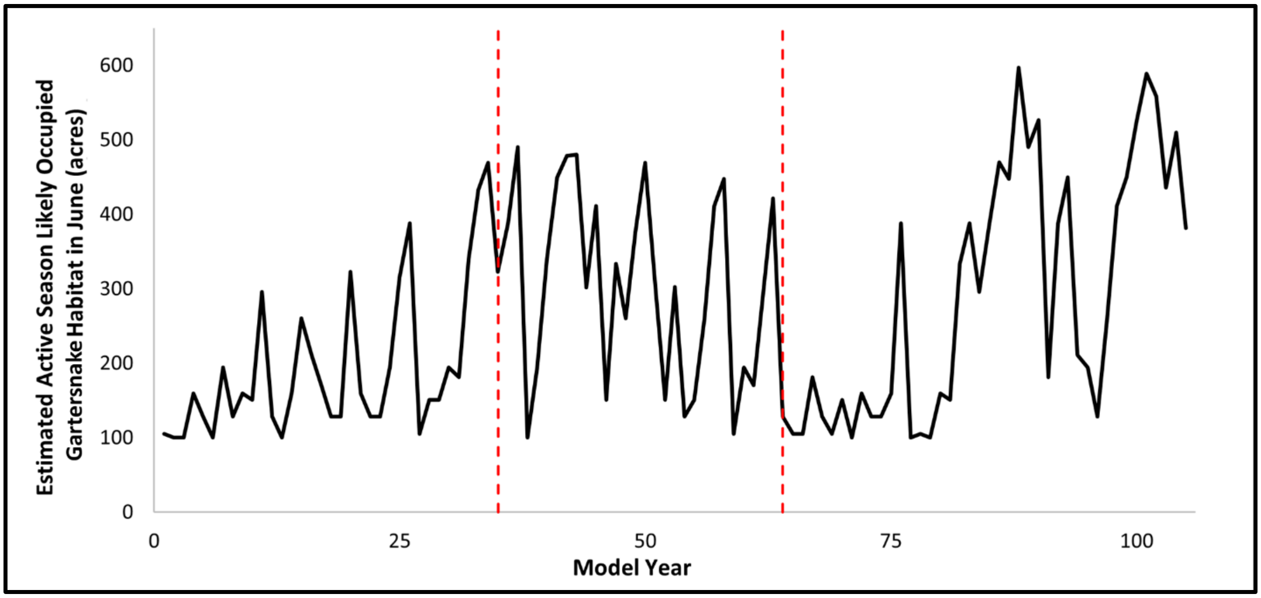

Figure 28. Estimated gartersnake habitat availability in the conservation space. Dashed red lines indicate the 30-year window with the greatest cumulative reduction (2,200.9 acre-years) of gartersnake habitat.

The "worst case" 30-year period for estimated take associated with conservation storage operations coincides with a long-term drought period within the Reservoir Planning Model. The Salt and Verde watersheds experience 25- to 30-year cycles between drought (dry) and pluvial (wet) periods, evident from historical inflows and tree-ring records. During drought periods, conservation storage operations typically result in declines in the lake elevation for several consecutive years due to below-normal inflows. Consequently, the lake would more frequently be at lower elevations that are associated with greater amounts of available gartersnake habitat. Within the drought cycles, individual wet years may "refill" the lake, increasing lake elevations and reducing the available habitat. At lower lake elevations, less water storage volume in the lake is available per foot, and vertical elevation for each acre-foot of inflow increases at a greater rate. This repeated pattern in lake elevation change throughout the 30-year drought pattern corresponds with the "worst-case" 30-year period.

SRP proposes that the amount of take authorized for conservation storage operations in the CS over the remaining ITP term be capped at a maximum of 2,507.0 acre-years of reduced habitat availability. As described in more detail in Chapter 6, SRP will track actual takings against this 2,507.0 acre-year cap by calculating changes in habitat availability each year. This annual accounting of actual take, in terms of the surrogate metric, will be accomplished with annual delineations of visible surface water in Tonto Creek in June, observed lake elevations in June, and the application of the 94-m distance-to-water finding to these waters.

III. IMPACT OF THE TAKE

The HCP Handbook (FWS and NMFS 2016) directs applicants and the FWS to also consider the impacts of take on populations of listed species. The HCP Handbook recommends that impacts be considered in light of context, duration, and intensity (FWS and NMFS 2016:8-6). SRP proposes to adjust the quantity of take using multipliers that reflect the anticipated short-term population-level impacts associated with different annual change scenarios. These scenarios consider the context and intensity of annual changes in habitat availability (and their potentially greater short-term impacts on the population) as compared to the long-term average. The size of the multipliers relates to the anticipated duration of the population-level impacts.

Context

At a population level, the past consequences of SRP's covered activities in the CS are also part of the current status of the gartersnake, since conservation storage operations have been ongoing since the early 1900s. FWS (2014a) characterized the lower Tonto Creek gartersnake population as relatively viable and consistently detected. However, the FWS views this characterization as provisional, since detailed population estimates and trends are unavailable for this species (Servoss 2021).

Nonetheless, given current information, it is reasonable to conclude that the incidental take caused by conservation storage operations is likely to have a relatively minor, long-term impact on the population of gartersnakes in the CS (although, as described in more detail below, short-term impacts may be more severe). From a biological perspective, the gartersnake is adapted to life in a dynamic environment including "spatially and temporally dynamic stream and river systems where water is typically shallow and braided and whose flows, disturbance regime, and habitat structure are regulated by seasonal rainfall pulse events (Klawon 2000)" (Jones et al. 2020:426). These changes present both challenges and opportunities for the individuals that reside in the CS.

Intensity

Annual reductions in available habitat that are of relatively larger magnitude may have more intense short-term impacts to the gartersnake population at Roosevelt Lake, resulting from more intense effects on the individual gartersnakes. For example:

- After a "large fill" event, previously available gartersnake habitat may be inundated for multiple years, leaving snakes within the CS with less available habitat and fewer habitat resources.
- As gartersnakes move upstream to find new "edge" habitat, increased intra- or inter-specific competition for a finite amount of resources may adversely affect the population.
- In a large fill event, increased interaction between the gartersnake and nonnative species may result in increased impacts due to predation and competition between these species.

The impacts of larger-magnitude lake elevation changes are more likely to extend beyond effects on individual gartersnakes in a way that influences the population. SRP addresses these population-level impacts by assigning greater weight to "acre-year" losses occurring during years with larger magnitude events, described below.

The Reservoir Planning Model demonstrates that there has been and is likely to be a large amount of year-to-year variation in habitat availability within the CS, both positive and negative. However, the gains and losses are, on balance, highly consistent over long periods such as 30 years (i.e., change is constant). Figure 29 shows the rolling 30-year average of change in habitat availability across the time period of the Reservoir Planning Model as compared to the annual year-to-year change. The long-term trend for changing habitat availability over 30-year periods demonstrates that reductions in habitat are consistently balanced by gains within a narrow range of variation. Over all 30-year periods, the net change in habitat availability varies between −11.7 and 16.3 acres.

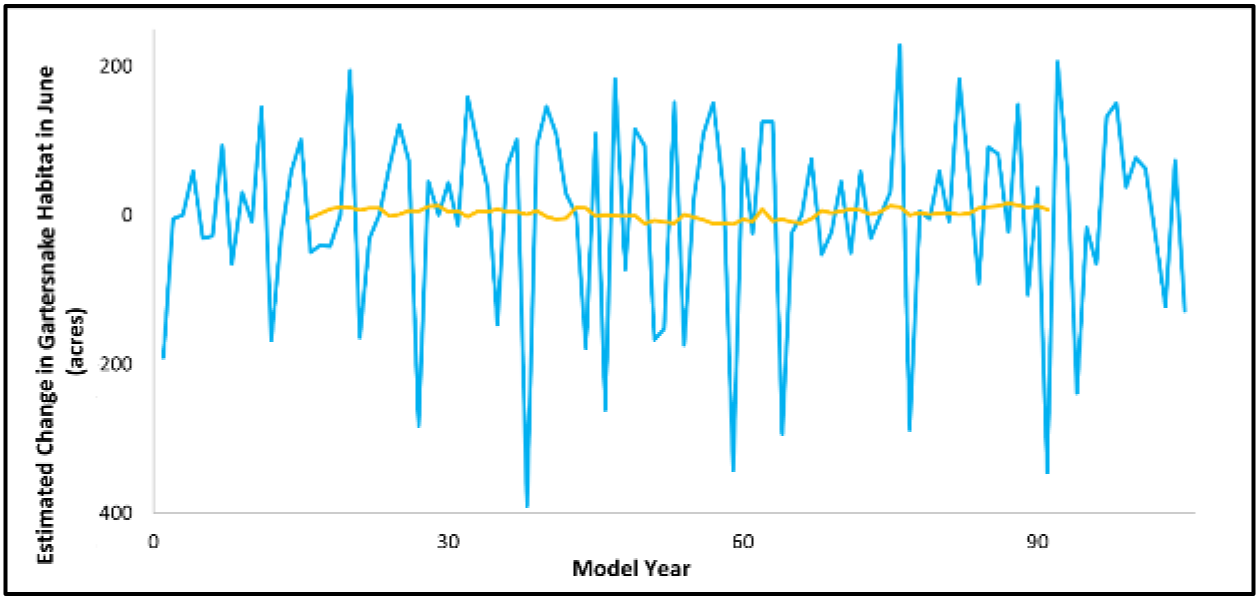

Figure 29. Change in gartersnake habitat availability. Blue line indicates annual change. Orange line indicates 30-year rolling average of annual change.

The long-term average annual estimated amount of gartersnake habitat in the CS is 264 acres. This benchmark value (264 acres) represents the amount of habitat likely to be available to the gartersnake over the long term. Therefore, the impact of take associated with episodic reductions in available habitat may be measured in comparison to this long-term and relatively consistent metric of average available habitat.

Duration

Population trends for gartersnakes in the CS are not available and it is not possible at this time to predict with any precision how quickly the population adjusts to changes in habitat availability under different scenarios. Using habitat as a proxy for the gartersnake, SRP identified the following short-term trends in habitat availability:

- Most reduction years happen in isolation as single-year events, such that a reduction year is followed by a gaining year. This indicates that the duration of impacts to the population over the 30-year period are likely to be relatively short term. Typically, the pressure of reduced habitat availability on the population is relieved, at least in part, within a year. This pattern is representative of a dynamic system where change is a constant feature of the landscape.
- Some reduction years occur for two consecutive years—a scenario that occurs six times over the 106-year time period of the Reservoir Planning Model. In these instances, short-term impacts to the population may be somewhat longer than when a reduction year is immediately followed by a gaining year.
- Rarely have reduction years occurred for three consecutive years or more—a scenario that occurred five times over the 106-year time period of the Reservoir Planning Model. Four years is the maximum run of consecutive reduction years estimated by the Reservoir Planning Model.
- The median duration of periods with lower-than-average available habitat (i.e., periods when the amount of available habitat is less than 264 acres) is 3.5 years.

Quantification

The short-term, population-level impact of any particular year-to-year reduction in habitat availability may increase with the magnitude of the change and the amount of available habitat remaining after the change. SRP applied multipliers of 1, 2, or 3 to specific habitat reduction events based on the magnitude of the change and the amount of available habitat remaining after the change (Figure 30). SRP used the long-term average available habitat in the CS (i.e., 264 acres) as the benchmark for categorizing large vs. small reductions and abundant vs. limited remaining habitat (see Figure 30). In this way, application of the multipliers characterizes the impacts of take, considering intensity (application of different multipliers based on small vs. large reduction events) and context (application of different multipliers based on remaining available habitat) and using the long-term average amount of available habitat as the benchmark for applying the multipliers to different scenarios. The size of the multipliers relates to the range of durations for short-term trends in habitat availability, although the application of a specific multiplier value is made based on the combination of intensity and context as shown in Figure 30.

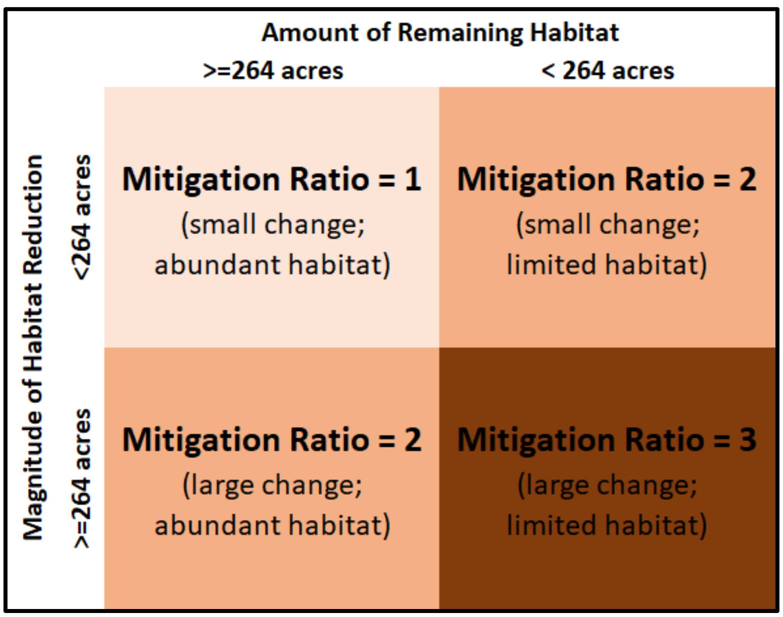

Figure 30. Application of mitigation ratios (or multipliers) to different annual take events.

As illustrated in Figure 30, SRP quantified the impact of take for conservation storage operations in the CS as follows:

- Each annual instance of incidental take (i.e., a reduction in available habitat from the prior year) was compared to the long-term average annual amount of available habitat (264 acres) to determine if the reduction was a "**small change**" (less than 264 acres) or a "**large change**" (more than or equal to 264 acres).
- In each year with incidental take, the absolute amount of habitat available that year was also compared to the long-term average annual amount of available habitat (i.e., 264 acres) to determine if the habitat reduction occurred in the context of "**limited available habitat**" (less than 264 acres) or "**abundant available habitat**" (more than or equal to 264 acres).
- The amount of incidental take in a given year was assigned a multiplier of 1 if the reduction in available habitat was a **small change** in the context of **abundant available habitat**.

- The amount of incidental take in a given year was assigned a multiplier of 2 if the reduction in available habitat was a **small change** in the context of **limited available habitat** or was a **large change** in the context of **abundant habitat**.
- The amount of incidental take in a given year was assigned a multiplier of 3 if the reduction in available habitat was a **large change** in the context of **limited habitat.**

Applying this framework, the impact of the taking associated with conservation storage operations on gartersnakes in the CS, is the equivalent of 4,935.1 acre-years of reduced habitat availability. Over the remaining 30 years of the permit term, the ratio of impact to take is 2.0 to 1. The impact of the take quantifies the amount of conservation value needed to fully offset the population-level impacts. Therefore, the multipliers applied to the amount of take may also be thought of as mitigation ratios.

3. Current Flood Control Space Operations

I. HABITAT IN THE FLOOD CONTROL SPACE

Gartersnake habitat in the FCS is associated with water in the Tonto Creek channel. Unlike conditions in the CS, Roosevelt Lake is not a frequent or persistent aquatic feature in the FCS, because inundation events in the FCS occur only during large inflow events and the WCM requires releases of water entering the FCS within 20 days. The gartersnake is not known to occur in the Salt Arm of the FCS.

SRP applied the methods used to identify and delineate areas of relatively consistent water in the portion of Tonto Creek within the CS to the portion of Tonto Creek within the FCS. SRP delineated areas of visible surface water from available historical aerial imagery (i.e., imagery dating to six time periods between 2000 and 2018) to create a combined extent of visible surface water for this segment of Tonto Creek (Figure 31), representing the aquatic habitat most consistently available to support use by the gartersnake. SRP applied the 94-m distance-to-water finding to this combined delineation of aquatic habitat, including Tonto Creek channel water in the FCS and in adjacent parts of the CS, to approximate the extent of gartersnake habitat in the FCS. Inclusion of adjacent channel water in the CS was necessary to ensure that all lands within the FCS that are within 94 m of Tonto Creek channel water were identified, even if the channel water itself is outside of the FCS.

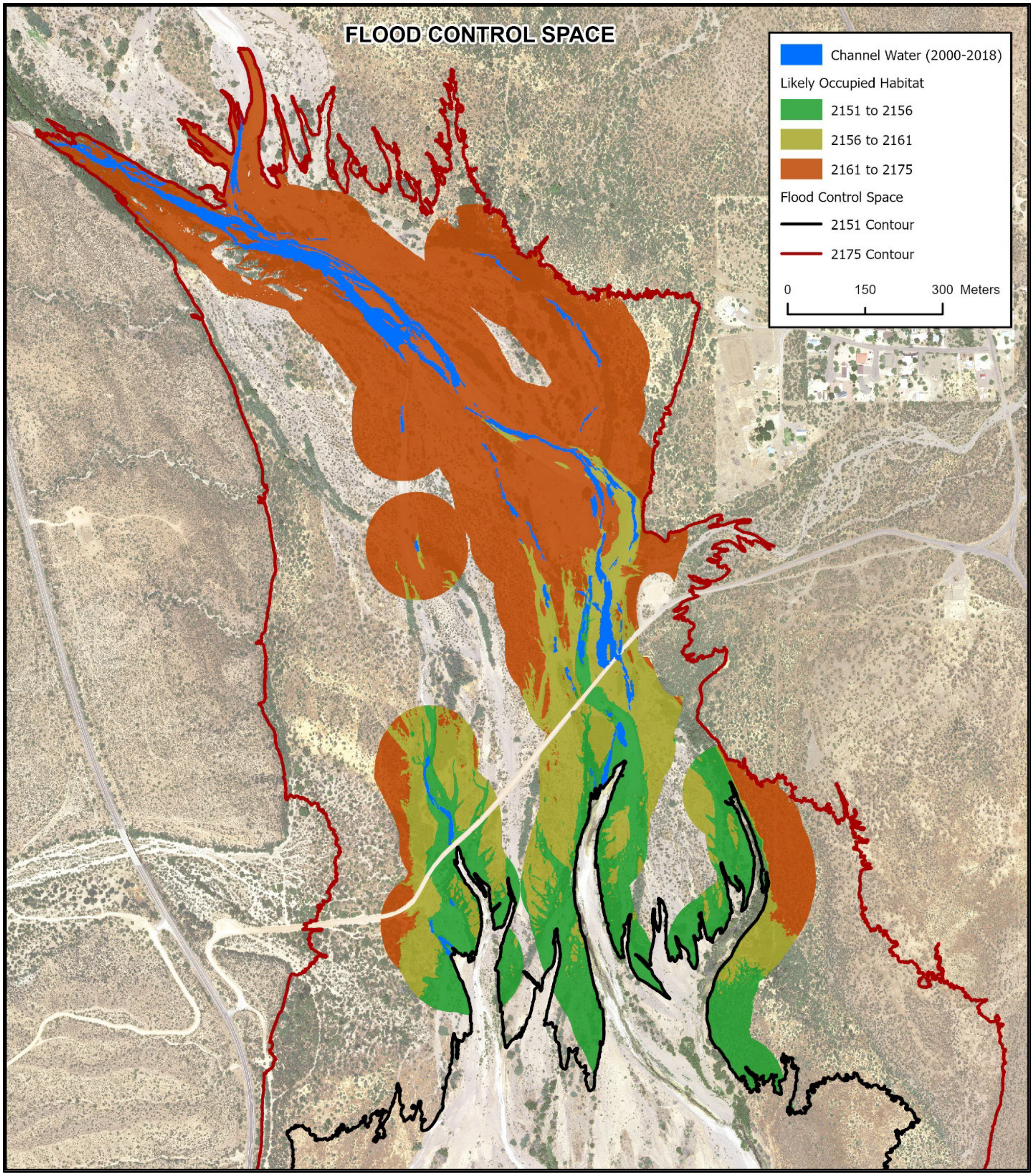

Figure 31. Gartersnake habitat in the FCS. Tonto Creek channel water in the conservation space (not shown) contributes to habitat availability in portions of the FCS.

Using this methodology, the FCS contains a maximum of approximately 192.2 acres of gartersnake habitat (Figure 32). SRP calculated how much gartersnake habitat occurs within each foot of vertical elevation in the FCS. This relationship predicts how much habitat would be inundated or available when the lake reaches a certain elevation (see Figure 32). The first 5 vertical feet of the FCS (between the elevations of 2,151 feet amsl and 2,156 feet amsl) contains 37.7 acres of this gartersnake habitat (20%), the next 5 vertical feet of the FCS (between the elevations of 2,156 feet amsl and 2,161 feet amsl) contains 39.1 acres of gartersnake habitat (20%), and the remainder of the FCS (between the elevations of 2,161 feet amsl and 2,175 feet amsl) contains 115.3 acres of gartersnake habitat (60%).

The gartersnake has been detected within the FCS (Burger 2010; Madara 2012; Nowak et al. 2019). However, the distribution, abundance (beyond any individual detection records), demographics, and trends for this segment of the population are unknown.

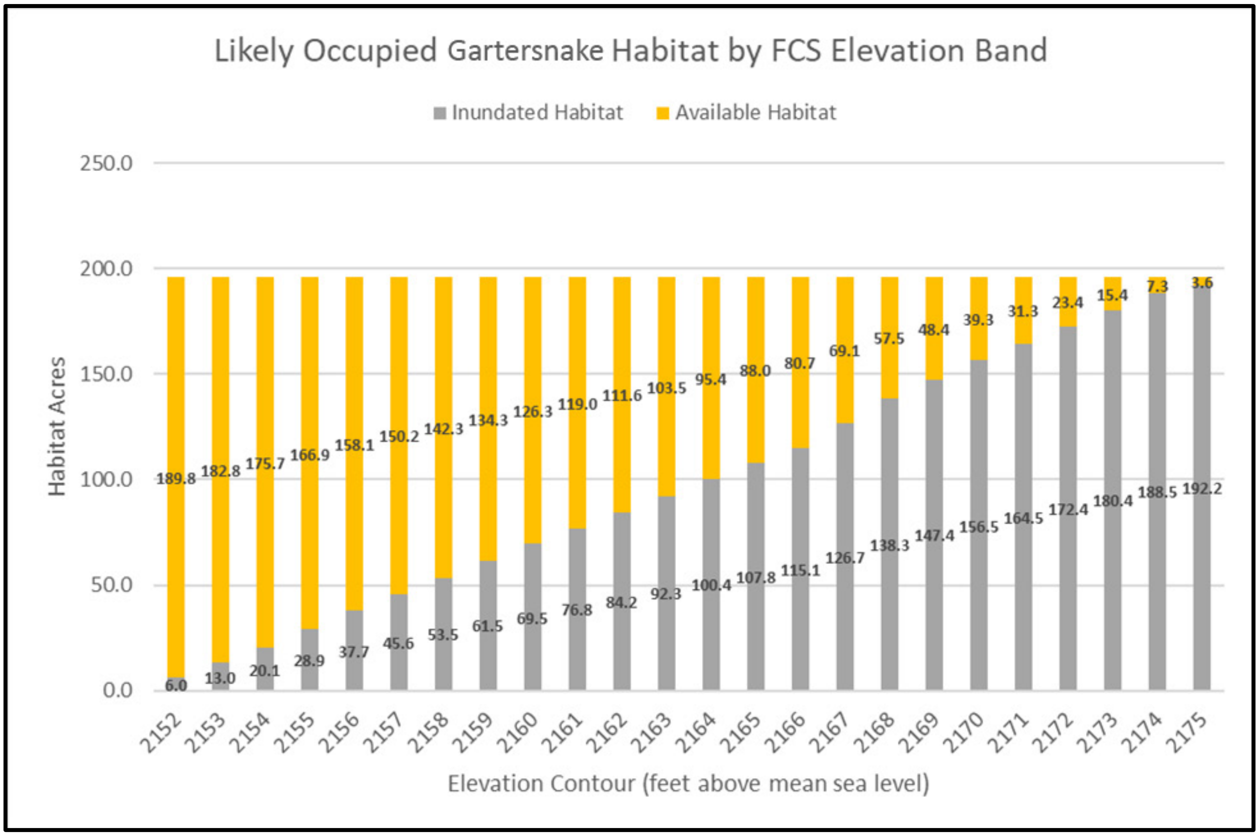

Figure 32. Inundation by the lake and remaining acres of gartersnake habitat across the range of FCS elevations.

Note: This figure provides habitat estimates for each 1-foot elevation band, such that the area of habitat inundated at an elevation represents the amount of habitat present in the FCS up to that elevation.

II. ESTIMATED AMOUNT OF TAKE

The effects of current flood control operations on the gartersnake in the FCS are discussed in Chapter 3. In summary, effects on individual gartersnakes are primarily the consequence of movement triggered by the occasional inundation of gartersnake habitat, leading to increased physiological stress, increased exposure to predation, and increased potential for death by drowning during brumation. The receding lake can trap nonnative predatory fishes in Tonto Creek within the FCS. Some of these predatory fish can remain for a time in the relatively consistent wet portions of Tonto Creek that provide most of the gartersnake habitat in the FCS (i.e., the lake is an infrequent source of habitat in the FCS and the Tonto Creek pools become dry in most years). The presence of these fish can lead to increased predation, risk of physical wounding, and increased competition with the gartersnake for prey. With respect to the effects arising from nonnative predatory fishes, Tonto Creek flows also provide opportunity for the dispersal of fish from the lake into Tonto Creek, regardless of the lake elevation. Furthermore, other parties have repeatedly stocked nonnative predatory fish in Roosevelt Lake (AGFD 2014; ERO-GEI

2022a [see Appendix E]; Gill 2019) and future stocking activities are expected to continue bolstering the population (AGFD and FWS 2021a). Therefore, not all of the effects of nonnative predatory fish on the gartersnake in the FCS are the result of operations in the FCS.

For the reasons described in Subchapter 4.B.i, SRP estimates incidental take arising from current operations in the FCS using a surrogate metric where acres of gartersnake habitat represent gartersnake individuals, and reductions in the availability of this habitat represent instances of incidental take. Available habitat in the FCS associated with Tonto Creek channel water may become temporarily inundated by the lake and thus become unavailable to the gartersnake or may be otherwise altered during or following such inundation. The affected gartersnakes, represented by the number of acres of temporarily inundated habitat, may be taken by flood control operations.

Unlike conservation storage operations, where SRP has the ability to store water in the CS and habitat may be inundated by the lake for months or years, operations in the FCS are short-term, episodic events (SWCA 2022d [see Appendix J]). Sequential events triggering flood control operations may result in multiple months with the lake somewhere in the FCS, but, per the 1997 WCM, each individual event must be evacuated from the FCS within 20 days. Current FCS operations are described in more detail in Subchapter 1.D.

Given the difference in operations, SRP estimates take from current flood control operations using a monthly, rather than yearly, time step from its Reservoir Planning Model. For elevations within the FCS, the estimated monthly peak lake elevation determines how much of the gartersnake habitat in the FCS is inundated and made unavailable or altered during that month. The acres of inundated habitat approximate the amount of incidental take of gartersnakes from current flood control operations, month by month.

As described in Subchapter 1.D, the Reservoir Planning Model estimates that the lake would be within the FCS in 143 of 1,272 months of the 106-year time series (11% of the months). However, incursions into the FCS are not evenly distributed over time, nor is the monthly peak lake elevation consistent over time. To estimate the amount of incidental take associated with current flood control operations over the remaining duration of the ITP (i.e., 30 years), SRP calculated the cumulative monthly acreage of habitat inundation for each of the seventy-six 30-year periods represented in the Reservoir Planning Model. For consistency with other metrics, SRP converted these monthly cumulative totals from acre-months to acre-years by dividing by 12 (i.e., 1,111.2 acre-months ÷ 12 = 92.6 acre-years). The mean cumulative habitat reduction across all 30-year periods is the equivalent of 92.6 acre-years of reduced habitat availability, with a standard deviation around this mean of 49.3 acre-years (Table 11).

Table 11. Predicted cumulative habitat reductions over 30-year periods from current flood control space operations.

Count of 30-Year Periods:	76
Maximum Cumulative Habitat Reduction (Model Years 53–82):	177.0 acre-years
Minimum Cumulative Habitat Reduction (Model Years 30–59):	17.1 acre-years
Mean Cumulative Habitat Reduction:	92.6 acre-years
Standard Deviation of the Mean:	49.3 acre-years
Take Estimate = Max + StDev:	226.3 acre-years

Consistent with the methods applied to estimating take in the CS, SRP identified the 30-year period with the greatest cumulative amount of habitat reduction as representing the worst-case scenario for habitat reductions. The model years 53 to 82 represent this worst-case scenario, when the lake is present in the FCS in 66 of 360 months. SRP requests authorization for incidental take from current flood control operations in the amount of the maximum (worst-case) 30-year cumulative habitat reduction plus the amount of the standard deviation to account for uncertainty, resulting in a take estimate of 226.3 acre-years.

III. IMPACT OF THE TAKE

SRP evaluated the impact of the requested take from current flood control operations, considering elements of context, intensity, and duration, on the gartersnake population in the permit area. SRP quantified the impact of take by applying multipliers to the monthly take estimates in the worst-case 30-year period and the uncertainty buffer to scale the take estimate to the context, duration, and intensity of impacts to the population. The application of these multipliers to the take estimate generates an estimate of the amount of mitigation needed to fully offset the impact of take.

Context

Incidental take associated with current flood control operations can take the form of death, physical wounding, or sub-lethal injury. The relative frequency of these outcomes for individual gartersnakes is not known. However, it is likely that gartersnakes taken by current flood control operations will more frequently experience a sub-lethal form of take than a lethal form with little adverse impact on the population. Because flood control operations are expected to be infrequent, the amount of habitat in the FCS inundated by the lake is relatively small compared to the CS, and death is expected to be a less frequent occurrence, the overall effect on the population is reduced.

This outcome (i.e., a lower impact of take as compared to impacts in the CS) is reasonable to expect, in part, because of the apparent persistence of the gartersnake along Tonto Creek and at Roosevelt Lake, which is a dynamic environment characterized by changing water flows and lake elevations (FWS 2014a, 2021c; Nowak et al. 2015; Nowak et al. 2019). Gartersnakes continue to reliably occur in close proximity to aquatic edges along Tonto Creek, even when these aquatic edges move seasonally in response to inflows (Myrand 2019; Nowak et al. 2019). The broad floodplain of Tonto Creek illustrates the spatial extent of lake elevation changes in the FCS independent of the lake. In the CS, gartersnakes remain present despite the frequent rises and falls of the lake (Myrand 2019; Nowak et al. 2019); these individuals have more frequent exposure to the effects of operations and nonetheless continue to persist in the CS. Jones et al. (2020) describe how gartersnakes are adapted to a dynamic environment. Current flood control operations cause less frequent and less persistent inundation of gartersnake habitat than CS operations, and therefore cause less movement and movement-related effects that could lead to take of individual gartersnakes.

Furthermore, take associated with inundation of the FCS under current operations would affect primarily adult gartersnakes that are capable of moving as needed to minimize the likelihood of lethal outcomes from drowning or predation. Telemetry studies that document snake movement use adult snakes as study subjects, demonstrating that adults can and do make such movements (Nowak et al. 2019). Predicted current flood control operations would not occur in months when birthing occurs or when neonates are present on the landscape (Figure 33). Therefore, most of the individual gartersnakes directly affected by inundation of the FCS are likely capable of moving to avoid lethal consequences, particularly in an environment where cover and shelter is not known to be a limiting factor.

Sub-lethal forms of take should have a less adverse impact on the population than if a similar amount of take resulted in primarily lethal outcomes. Individual gartersnakes that experience sub-lethal forms of take may continue contributing to the population, while individuals that die would not.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Predicted FCS Inundation (limited to months when events occur)	9%	14%	17%	25%	20%	5%	1%	1%	0%	1%	1%	5%
NMGS Activity Season	*brumation*		*active*	*mating and gestation*		*birthing and neonates*		*active*	*mating*		*active*	*brum-ation*

Figure 33. Timing of current flood control operations compared to gartersnake phenology.

The effects of nonnative predatory fish on gartersnakes in the FCS can result in incidental take, including lethal take via predation or physical wounding. Inundation by the lake can temporarily enhance the persistence of pools in the FCS and leave behind nonnative predatory fish after the lake recedes to the CS. Gartersnakes of any size are subject to predation by nonnative fish, but small snakes (which are more likely to be neonates or juveniles) are at greater risk of predation by a wider range of fish size classes.

However, this outcome (nonnative predatory fish occupying wet portions of the FCS and any subsequent direct or indirect interaction with the gartersnake) is not strictly a "but for" consequence of current flood control operations. As described in Subchapter 3.A.iv, there is connectivity between Roosevelt Lake (the primary habitat for nonnative predatory fish in the permit area) and Tonto Creek when flows in Tonto Creek meet certain criteria that are independent of the lake elevation. Therefore, the impact of take arising from the effects of nonnative fish in the FCS is not solely the responsibility of SRP (i.e., not all such take is a consequence of SRP's covered activities) and the amount of conservation offset needed to address the impact of take arising from the effects of nonnative predatory fish in the FCS should be proportionately reduced.

Duration

If, as explained above, most take arising from current flood control operations takes a non-lethal form, the duration of any impact to the population should not be expected to last beyond 1 year. However, SRP acknowledges that the lake does not frequently inundate the FCS, even under parameters of the Reservoir Planning Model. Consecutive years with inundation in the FCS could increase the relative severity of the impact on sub-lethally taken gartersnakes.

The Reservoir Planning Model estimates that current flood control operations occur in 37 of the 106 model years (i.e., 37 years have at least 1 month with the lake elevation reaching into the FCS, as shown in Table 3). The model estimates that 8 years have flood control operations that occur in isolation (i.e., preceded by and followed by a year without flood control operations) and nine periods when current flood control operations occur in 2, 3, 5, or 7 consecutive years (with four, three, one, and one such period for each respective duration).

SRP observes from its Reservoir Planning Model that hydrologically wet periods experience more years with flood control operations and that these events tend to be of greater magnitude (i.e., the peak elevations are higher). Therefore, the FCS peak elevation is positively correlated with the frequency of flood control operations and the likelihood of multi-year periods with such operations.

Intensity

It is reasonable to expect that the intensity of the impact relates to the magnitude of the take, such that months with greater reduction in habitat availability would have a more severe impact on the population.

Greater habitat reduction creates more displacement of individual gartersnakes and has the potential to increase physiological stress and risk of predation or other lethal outcomes.

SRP proposes to apply a multiplier to the acres of reduced habitat availability (i.e., the surrogate metric for incidental take) in each month in which current flood control operations occur, to account for the relative intensity of the impact. The multiplier to be applied in a given month will be determined by the percentage of the total acreage of gartersnake habitat in the FCS (i.e., 192.2 acres) that is inundated by the lake. The size of the multiplier will be 1, 2, or 3, and applied as follows:

- Multiplier of 1 applied to months with up to 33% of the habitat subject to inundation
- Multiplier of 2 applied to months with up to 66% of the habitat subject to inundation
- Multiplier of 3 applied to months with up to 100% of the habitat subject to inundation.

The size of these impact factors (1, 2, or 3) relates to the range of multi-year periods that most frequently occur in the Reservoir Planning Model. However, the multipliers are applied to each month when take occurs not based on the duration of periods with current flood control operations, but on the magnitude of the monthly reduction in habitat availability. The range of durations simply provides a basis for setting the size of these multipliers.

Quantification

To quantify the impact of take associated with current flood control operations, SRP applied the multipliers described above to the monthly estimates of take and remaining available habitat for the worst-case 30-year period in the Reservoir Planning Model (i.e., model years 53 to 82, the same period used to estimate take). SRP applied a multiplier of 2 to the amount of take added to the cumulative 30-year total to address future uncertainty.

This approach results in an impact of take equivalent to 241.3 acre-years of reduced habitat availability. When compared with the size of the take estimate itself (i.e., 226.3 acre-years), the overall impact of take results in a ratio of 1.1 to 1. This ratio may also be interpreted as the mitigation ratio needed to offset the impacts of the authorized take.

4. Planned Deviation of Flood Control Space Operations

I. ESTIMATED AMOUNT OF TAKE

Subchapter 4.B.ii.3.I describes how SRP estimated the amount and location of gartersnake habitat in the FCS. When not inundated by the lake, the FCS contains approximately 192.2 acres of gartersnake habitat. This habitat is associated with those portions of the Tonto Creek channel where water tends to persist once creek flow ceases.

The effects of the planned deviation on the gartersnake are described in Subchapter 3.A. In summary, these effects are the consequence of the extended period of potential inundation by the lake within a small portion of the FCS in no more than 3 years of the 5-year deviation period. The planned deviation would allow SRP to hold water in the first 5 vertical feet of the FCS for a period not exceeding 120 days. Flood control operations above this elevation (i.e., above 2,156 feet amsl) would continue to follow the prescriptions of the WCM and must be cleared within 20 days. The extended release period under the planned deviation is dependent on inflows into the lake that are large enough to enter the FCS. Because flood control space operations depend on inflow, the precise timing of these operations is uncertain.

The extended period of inundation by the lake, if it occurs, would cause a longer period of reduced habitat availability and reduced habitat quality in the FCS, as compared to current flood control operations. The extended period of reduced habitat availability temporarily reduces the resources (e.g., cover and brumation sites) otherwise available to gartersnakes occupying the FCS and may increase competition among gartersnakes for remaining resources. The extended period of inundation also reduces the quality of the remaining habitat by increasing gartersnake exposure to the effects of nonnative predatory fish that reside in the lake. This reduction in habitat quality may persist after the lake recedes if nonnative predatory fish become trapped in residual channel pools. Finally, the timing of FCS inundation under the planned deviation could extend further into the gartersnake active season, depending on the timing of the large runoff event in the spring months that creates the inundation event, and overlap with the period when females are giving birth to neonates. Neonates are particularly vulnerable to predation, likely related to their small size and inexperience, including predation by nonnative predatory fish. Compared to current flood control operations, this potential shift in the timing of inundation by the lake is the effect pathway with the most potential influence on gartersnakes. All of these effects are related to temporary inundation by the lake.

SRP estimates take associated with the planned deviation of flood control operations using similar methods and metrics as described for current flood control operations (see Subchapter 4.B.ii.3.II). Reduced habitat availability is the surrogate for estimating (and tracking) incidental take in the FCS (see Subchapter 4.B.i). To produce an estimate of take for the planned deviation, SRP modified the Reservoir Planning Model to address flood control operations under the rules for the planned deviation (see Subchapter 1.B). SRP used this alternate version of the Reservoir Planning Model and the delineation of gartersnake habitat in the FCS to predict how habitat availability may change over time. To isolate the incremental effects of the planned deviation from current flood control operations, SRP calculated the difference in habitat availability between current flood control operations and the planned deviation. As for current flood control operations, SRP evaluated these changes on a monthly basis in consideration of the relatively brief period that the lake may occupy the FCS. SRP converted cumulative monthly estimates of reduced habitat availability (i.e., acre-months) to cumulative acre-years of reduced habitat availability by dividing the monthly estimates by 12. This conversion facilitates comparison among take estimates for different components of the covered activities.

The planned deviation is limited to 3 of the 5 years of the deviation period. To quantify the estimated amount of incidental take, SRP identified the 5-year period of the alternate Reservoir Planning Model with the greatest cumulative amount of incremental habitat reduction in the FCS. This “maximum reduction” period, corresponding to model years 7 to 12, experienced an estimated 16.1 acre-years of reduced habitat availability in excess of the estimate for current flood control operations. For comparison, the average cumulative incremental habitat reduction among all 5-year periods in the alternate model was 5.5 acre-years. Therefore, the use of the maximum reduction period is a highly conservative approach. SRP prorated this maximum 5-year estimate to reach a 3-year estimate of incidental take from the planned deviation of 9.6 acre-years of reduced habitat availability (i.e., [16.1 acre-years ÷ 5] × 3 = approximately 9.6 acre-years).

II. IMPACT OF THE TAKE

For simplicity, SRP applied the overall impact ratio for current flood control operations (i.e., 1.1, as described in Subchapter 4.B.ii.3.III) to the take estimate for the planned deviation. SRP believes this approach is justified since the effect pathways and context, duration, and intensity of the impact of take described for current flood control operations are similar to that for the planned deviation. However, where the magnitude of reduced habitat availability during current flood control operations is the primary indicator of intensity of the impact, the timing of the habitat reduction (i.e., extending deeper into the gartersnake active season) is the primary indicator of intensity for the planned deviation. The application of a 1.1 impact factor to take arising from the planned deviation, despite the relatively small amount of habitat reduction, accounts for the impact of timing. Therefore, SRP estimates that the impact of take from the planned deviation is equivalent to 10.6 acre-years of reduced habitat availability (i.e., 9.6 acre-years of take × 1.1 impact factor = 10.6 acre-years).

iii. Incidental Take and Impacts along Lower Tonto Creek

SRP's contribution to the "harm" of gartersnakes along lower Tonto Creek results from the storage of water in the Modified Roosevelt CS (which provides breeding, feeding, and sheltering habitat for nonnative fish) (AGFD 2019; ERO-GEI 2022b [see Appendix F]; FWS 2021a). But this activity, by itself, does not make possible a persistent population of nonnative fish in the lake. The largest contributor to the sustained population of nonnative fish in Roosevelt Lake is the continued, prolonged stocking of those fishes (AGFD 2019). SRP is not involved in and has no responsibility for or control over these stocking activities. Modified Roosevelt Dam is part of the Salt River Federal Reclamation Project works and is operated by SRP for water supply, flood control, and dam safety purposes. Recreation and fishing are not purposes of the Reclamation Project and SRP does not operate Modified Roosevelt in furtherance of those purposes.

This addendum addresses the share of upstream take of gartersnakes attributable to SRP's conservation storage operations, specifically, the storage of water in the CS. This addendum does not address or mitigate for the actions of others, which also contribute to this upstream "take". See discussion of these other actions in Chapter 1.F. An ESA Section 7 consultation, completed in August 2021, addressed AGFD's and FWS's responsibility for the effects of their actions involving long-term stocking of nonnative fish, including "harm" or "harassment" of gartersnakes upstream of Roosevelt Lake (AGFD and FWS 2021a). SRP did not participate in the consultation and had no influence over its outcome. Consequently, the "take metric" for the Roosevelt ITP quantifies impact resulting from SRP's actions potentially resulting in take, excluding the contributions of actors outside of SRP's control.

In addition to the AGFD's actions, other factors upstream of Modified Roosevelt influence the circumstances under which "take" of gartersnakes along lower Tonto Creek may occur:

1. Sufficient flows in Tonto Creek (ranging from 200 to 1,100 cfs) must be present to create the connectivity allowing for the migration of nonnative fish upstream (ERO-GEI 2022a [see Appendix E]).
2. At 20 cfs or below (flows measured at the USGS stream gage for Tonto Creek above Gun Creek), stream flows within lower Tonto Creek become discontinuous or cease altogether. Surface water remains in mostly temporary pools. However, some pools may persist until the next stream flow occurs, such as in pools closer to the lake that are influenced by a higher groundwater table.
3. The culvert infrastructure at East del Chi Drive, 14.1 miles upstream of the FCS, functions as a barrier to the continued migration of nonnative fish past this point (ERO-GEI 2022a [see Appendix E]). The three 9-foot-diameter culverts under East del Chi Drive are perched more than 1 foot above the downstream plunge pool elevation and have a smooth interior, which increases overall water velocity through the pipe. The combination of the water velocity and the drop creates a barrier to fish passage.
4. Lower Tonto Creek within the permit area is intermittent in most years (ERO-GEI 2022a [see Appendix E]; SWCA 2021). Due to a higher groundwater table in the most downstream portion of this segment (up to Bar X Crossing), isolated pools of water remain in the channel for a period of time after continuous flows within the creek cease. Nonnative fish migrating upstream can persist in these pools while they exist and potentially compete with and prey upon gartersnakes. Upstream of Bar X Crossing, groundwater pumping for residential and agricultural

uses affects the groundwater table such that there is an observed decrease in the presence and persistence of pools in this reach. Consequently, in most years, nonnative fish that migrate upstream of Modified Roosevelt past Bar X Crossing may not persist unless they are in one of the few pools that persist through the dry season.

Upstream human activities, including but not limited to sand and gravel operations, agricultural diversions, groundwater pumping, and repositioning of stream sediments in Tonto Creek upstream of Punkin Center, affect persistence of pools and stream channel configurations. These factors collectively dictate the circumstances under which gartersnakes may be "harmed" by nonnative predators migrating upstream of Modified Roosevelt, as well as the temporal and geographical limits of any such "harm". Taking these factors into account, this conservation program sets forth a framework for mitigation and minimization of upstream "take" of gartersnakes attributable to SRP's activities and possible for adaptive management.

1. Estimated Amount of Take

SRP's conservation storage operations contribute to the adverse effects of nonnative fishes on the population of gartersnakes along lower Tonto Creek. SRP estimates the amount of incidental take arising from this covered activity in terms of the cumulative number of migration days that are expected to occur over the remaining ITP term. As described in Subchapter 4.B.2.II, migration days are those days that Tonto Creek is flowing at a rate between 200 cfs and 1,100 cfs between February 1 and May 31. These are conditions under which nonnative fish are most likely to move from the lake upstream into Tonto Creek. Once in Tonto Creek, these nonnative fish degrade habitat conditions for the gartersnake and cause incidental take via harm. After 5 consecutive migration days in a given year, SRP assumes that incidental take of gartersnakes along lower Tonto Creek due to its conservation storage activities in the CS is reasonably certain to occur. However, to produce an estimate of incidental take that is sufficiently conservative in light of the degree of day-to-day variation in stream flow and uncertainty regarding future conditions, SRP estimates the cumulative amount of incidental take along lower Tonto Creek without this 5-day qualifying condition. Actual takings tracked during implementation of this addendum will apply this 5-day qualifying condition, as described in Subchapter 6.A.i.2.

SRP reviewed historic USGS stream gage data for the Tonto Creek above Gun Creek, near Roosevelt, AZ gage (station number 09499000) (USGS 2021). The historic data cover a time period beginning in approximately 1941 and continuing through the present time (a time period of 81 years with data relevant to this analysis). SRP identified the average daily rate of discharge (i.e., average daily stream flow, in cfs) for each day in this dataset that fell between February 1 and May 31. The average daily rate of discharge and the date determined if the stream flow that day met the criteria for a migration day.

The historic dataset for this stream gage includes 1,713 days over 81 years that meet the criteria for a migration day. The mean number of migration days per year was 21.1, with a range of 0 to 75 migration days per year and a standard deviation around the mean of 22.4 migration days per year (Table 12) (SWCA 2022f [Appendix K]). Further, SRP analyzed the historic gage data to inform the potential scenarios of years when mitigation would be triggered, which was approximately 3 out of every 5 years (60%) of the historic dataset (see Table 2 in SWCA 2022f [Appendix K]).

Table 12. Summary statistics for the number of days with Tonto Creek stream flow meeting the criteria for a migration day.

Summary Statistic	All Years (1941–2021)	30-year Periods
Number of data points (years or 30-year periods)	81	52
Minimum number of migration days	0	533.0
Maximum number of migration days	75	812.0
Mean number of migration days	21.1	682.2
Standard deviation of the mean number of migration days	22.4	94.0
30th percentile of migration days	0.0	599.1
60th percentile of migration days	25.6	744.0
90th percentile of migration days	57.0	791.9

Within this historic dataset are fifty-two 30-year periods (i.e., the equivalent of the remaining duration of the ITP term). The average number of migration days in a 30-year period was 682.2, with a range of 533.0 to 812.0 migration days and a standard deviation around the mean of 94.0 migration days (see Table 12) (SWCA 2022f [see Appendix K]).

Similar to the approach taken for estimating take in the CS, SRP identified the 30-year period with the greatest cumulative number of migration days and added the number of days in the standard deviation around the cumulative 30-year mean to estimate the amount of take associated with its covered activities along lower Tonto Creek. In this case, the 30-year period with the greatest cumulative number of migration days is 1969 to 1998 with 812 migration days, and the standard deviation around the 30-year means is 94.0 migration days. Therefore, SRP estimates the amount of take along lower Tonto Creek as 906 migration days (i.e., 812 migration days + 94.0 migration days = 906 migration days).

2. *Impact of the Take*

The impact of SRP's incidental take of gartersnakes along lower Tonto Creek is complex and difficult to assess. The FWS (2014a) considers nonnative fish to be a primary threat to the conservation of the gartersnake. But many factors independent of SRP's conservation storage operations contribute to the presence and abundance of nonnative fish in lower Tonto Creek. The effects of nonnative fish on gartersnakes are complex and include effects that range from beneficial (i.e., small nonnative fish are eaten by gartersnakes and can support the presence of gartersnakes when native prey are scarce) to adverse (i.e., death by predation). Gartersnakes and nonnative fish have also coexisted at Roosevelt Lake and along lower Tonto Creek for at least 80 years, although the gartersnake population trend over this time period is unknown. These considerations relate to the context, intensity, and duration of the impact of the take.

Overall, the ongoing effects of nonnative fish on gartersnakes in lower Tonto Creek may be perpetuating a relatively consistent lower population size (compared to historic conditions) or may be creating a downward trend in the abundance of gartersnakes, or both. But available data are not sufficient to either confirm or quantify the magnitude of this presumed negative population impact.

Regardless of the actual quantity of the impact, the proportion of that impact attributable to SRP's conservation storage operations is but a small part of the total. SRP is not responsible for the repeated and ongoing stocking of nonnative fish in Roosevelt Lake. Instead, stocking of nonnative fish in Roosevelt Lake has been and continues to be the deliberate act of other parties, primarily the two agencies responsible for the management and conservation of native wildlife in Arizona: AGFD and FWS.

The FWS first identified the gartersnake as candidate for listing in 1985 (FWS 1985). The gartersnake remained a candidate for listing until 1996 (FWS 1996b) and regained candidate consideration in 2008 (FWS 2008b) after a positive 12-month findings on a petition to list. The FWS proposed the gartersnake for listing as threatened in 2013 (FWS 2013a) and issued the final listing rule for the gartersnake in 2014 (FWS 2014a). The AGFD sportfish stocking program, funded in part by the FWS's WSFR program, released nonnative fish to Roosevelt Lake on many occasions between 1985 and 2014 (see discussion in Subchapter 1.F). Referring to the AGFD 2014 stocking program, FWS acknowledged in the 2014 listing rule that "…we expect a higher risk of predation of gartersnakes in lower Tonto Creek when a suitable hydrologic connection is made between Tonto Creek and the lake body (providing the opportunity for predatory nonnative fish to move into lower Tonto Creek)" (FWS 2014a:38690). FWS, through its WSFR program, funded in part the stocking of nonnative fish at Roosevelt Lake after listing the gartersnake as threatened (FWS 2021b).

SRP's contribution to the effects of nonnative fish on gartersnakes along lower Tonto Creek is but a small part of the overall chain of actions that lead to the presence of this threat. SRP did not introduce nonnative fish to Roosevelt Lake, although the storage of water in the CS perpetuates the availability of fish habitat. SRP has not contributed to the AGFD's efforts to improve fish habitat in Roosevelt Lake, thereby improving the ability of nonnative fish to persist in the lake following a stocking event. The elevation of Roosevelt Lake, which is influenced by SRP's covered activities, does not influence the connectivity between the lake and lower Tonto Creek (i.e., there are no barriers that prevent fish from moving upstream that would be overcome by a high lake elevation). Instead, connectivity between the lake and Tonto Creek is established by stream flows that facilitate movement by fish (i.e., migration days), independent of the lake elevation.

Given all of these considerations, the impact of SRP's requested take of gartersnakes along lower Tonto Creek for the duration of the remaining ITP term is expected to be nominal.

iv. Summary of Take and Impacts of Take

Table 13 summarizes the estimated amount of take arising from SRP's covered activities and the estimated impact of this take on the gartersnake for activities affecting the CS and FCS. These estimates are provided in units of cumulative acre-years of habitat modification and total 2,742.9 acre-years for all covered activities. For incidental take of gartersnakes along lower Tonto Creek, SRP estimates the amount of take as 906 migration days over the remainder of the ITP term. SRP requests authorization for incidental take of the gartersnake in an amount equivalent to these estimates. The estimated impact of take approximates the amount of conservation benefit that would be needed to fully offset the authorized take.

SRP's covered activities and the effects on gartersnakes are described in Subchapter 3.A. All of the effects are related to forms of gartersnake habitat modification by changing habitat availability, location, and/or quality (see Subchapter 3.A.i). The likely biological responses of gartersnakes to the forms of habitat modification caused by the covered activities are also described in Subchapter 3.A (see Subchapters ii through v). Gartersnakes respond to changing habitat availability, location, and quality in similar ways.

Table 13. Summary of gartersnake take and impacts of take.

Covered Activity and Permit Area Location	Estimated Take	Estimated Impact of Take	Average Annual Impact of Take over 30 Years	Overall Ratio of Impact to Take*
Conservation storage operations in the CS	2,507.0 acre-years	4,935.1 acre-years	164.5 acres	2.0
Current flood control operations in the FCS	226.3 acre-years	241.3 acre-years	8.0 acres	1.1
Planned deviation of flood control operations in the FCS	9.6 acre-years	10.6 acre-years	0.4 acres	1.1
Long-term storage in the CS and related impacts in lower Tonto Creek	906 migration days	See qualitative discussion in Subchapter 4.B.iii.2	N/A	N/A
Total	**2,742.9 acre-years and 906 migration days**	**5,187.0 acre-years plus the nominal additional impact of take for lower Tonto Creek**	**172.9 acres**	**1.9**

* Ratio of impact to take is calculated using only the estimates for the CS and FCS. The take and impacts associated with effects along lower Tonto Creek are in a different metric and are not comparable to the acre-year estimates.

The estimated amount of take and the estimated impact of the take on the gartersnake were developed using detailed analyses tailored to the specific nature and location of each covered activity. The spatial extent, context, intensity, and duration of effects on gartersnakes varies among covered activities (see Subchapter 4.B.ii). For example, changes in habitat availability are best measured annually in the CS but monthly in the FCS. These activity-specific analyses ensure that the estimates of take and impact have a rational basis.

Nevertheless, the range of effects on gartersnakes in the CS and FCS is the same. The take and impact to gartersnakes in these areas from conservation storage operations and flood control operations under current and planned deviation conditions are described in a common metric: acre-years. One acre-year of take from conservation storage operations is equivalent to 1 acre-year of take from flood control operations. The amount of take generated by a change in habitat availability in the CS or FCS considers the specific circumstances relevant to how gartersnakes use habitat in these parts of the permit area (see Subchapter 4.B.ii). The use of a common metric allows for the estimated quantities of take and impact of take to be aggregated across activities and years to produce total estimates of the amount of take to be authorized by the amended ITP and the amount of impact that will be offset by implementation of the conservation program. This is a reasonable approach given that take is related to habitat modification and that gartersnakes respond similarly to habitat modification regardless of location.

SRP does not propose to use the activity-specific estimates of take as separate limits of authorized take. Instead, as described in Subchapter 6.A, SRP will monitor the actual amount of take that occurs in each year of RHCP implementation and implement an annual accounting process for debiting actual takings from the total authorized amount. The methods for monitoring take during implementation are based on the methods used to generate the estimates of take and thus are activity specific. This ensures that the appropriate amount of take is debited from the total authorized amount each year, depending on which activities occurred and under what circumstances. Further, SRP has articulated a Changed Circumstance that is triggered when the remaining amount of authorized take reaches a certain elevation. In response, SRP will initiate a process to amend the ITP and, if appropriate, increase the amount of authorized take to support ongoing operations before the current authorization is exceeded. Since the amount of take is both estimated and measured using a common metric (i.e., acre-years), is debited annually from the total, and there are procedures in place to ensure that additional take can be authorized if needed, SRP and FWS can be assured that the amount of authorized take will not be exceeded.

The impact of an acre-year of take from conservation storage operations is weighted differently than an acre-year of take from flood control operations (see Subchapter 4.B.ii). The different impacts of take are accounted for in the total estimate of impact summarized in Table 13. Overall, the impact of an acre-year of take from conservation storage operations has nearly twice as much impact as an acre-year of take from flood control operations. SRP is committed to implementing a conservation program that fully offsets the impacts of take at a level that achieves at least 5,187.0 acre-years of conservation benefit for the gartersnake for the remaining ITP term. This amount of conservation benefit is based in part on the estimated distribution of take and the impact of take from each of the covered activities.

If the actual amount of take from flood control operations under either current or planned deviation conditions exceeds the estimates for these particular activities, but the total amount of take debited from the authorized amount is not exceeded, then SRP has not exceeded its authorized amount of take (i.e., acre-years of take are equivalent). But the actual impact of the take will be lower than estimated since the impact of take from flood control operations is weighted less than the impact of take from conservation storage operations. However, SRP remains committed to implementing conservation measures in an amount that generates the 5,187.0 acre-years of conservation benefit. Therefore, if flood control operations generate more take than estimated, SRP's conservation program will generate more conservation value than is needed to fully offset the impact of take that has actually occurred, producing an additional benefit to the gartersnake. In no circumstance will the changes to the distribution of actual take among the covered activities produce more impact than currently estimated or lead to a circumstance where the conservation program does not fully offset the impacts of the authorized take.

C. Southwestern Willow Flycatcher and Yellow-Billed Cuckoo

The original RHCP estimates and tracks incidental take of the flycatcher and cuckoo using a surrogate metric of acres of habitat modification (i.e., temporary reductions in available nesting habitat). The planned deviation may reduce the amount of habitat available to nesting flycatchers by up to 90.4 acres (up to 12.3 in the CS and up to 78.1 acres within the FCS) in each of the 3 years of the planned deviation. Similarly, the planned deviation would reduce the amount of habitat available to nesting cuckoos by up to 47.9 acres (up to 2.6 acres in the CS and up to 45.3 acres within the FCS) in each of the 3 years of the planned deviation. This seasonal reduction in nesting habitat for the flycatcher and cuckoo would result in incidental take via harm in an amount equivalent to the acres of habitat modification.

The original RHCP describes how habitat modifications related to changing lake elevations (i.e., incidental take) impact the flycatcher and cuckoo. The amount of additional incidental take from the planned deviation of flood control activities is small and could impact approximately 21 flycatcher nesting territories (see discussion in Subchapter 2.B.i) and approximately eight cuckoo nesting territories (see discussion in Subchapter 2.C.i). The duration of these impacts would be short, since the planned deviation would only alter flood control operations in at most 3 years. The intensity of the impacts would be relatively minor since the loss of eggs or nestlings from direct inundation is unlikely, and substantial degradation of the quality of existing habitat is also unlikely. Detrimental effects would be limited to individual tamarisk plants rooted in the bottom few inches of the FCS, and cottonwoods and willows are likely to benefit from higher water tables. The planned deviation could increase the chance for tamarisk to become established; however, tamarisk leaf beetles may minimize the establishment and growth of tamarisk; thus, the impact of this vegetation change on flycatchers and cuckoos is likely neutral.

The original ITP authorized SRP to take flycatchers in an amount up to 750 acres (1,250 with adaptive management) in any given year and to take cuckoos in an amount of up to 313 acres (1,113 with adaptive management) in any given year, although this amount of take is not expected every year. Actual takings of these species have been well below these authorized limits in each year of the ITP term to-date. Therefore, while current FCS operations and the planned deviation are new covered activities and will result in a small amount of incidental take not contemplated in the original RHCP, the amount of the additional take and the impacts of these takings on the flycatcher and cuckoo are fully offset by the amount of currently authorized incidental take and the conservation measures implemented to address the impacts of the authorized take. SRP does not request an increase in the amount of take authorized for the flycatcher or the cuckoo and does not propose additional conservation measures for these species.

D. Bald Eagle

i. Incidental Take Surrogate Metrics and Estimates

In this addendum, SRP restates with updated surrogate metrics the amount of incidental take of bald eagles previously authorized through the original RHCP and ITP for its conservation storage activities in the CS. Herein, using the same updated surrogate metrics, SRP also explicitly seeks to restate the treatment of prior eagle analyses and measures in the original RHCP and ITP coverage for incidental take that had been previously considered and addressed by Reclamation in the Incidental Take Statements attached to the Biological Opinions issued in 1990 and 1993 (i.e., the federal actions that considered operation of Modified Roosevelt). The amended ITP is intended to provide restated and clarified coverage for incidental take of the bald eagle under the ESA (as an unlisted species that may be listed in the future), as well as under BGEPA, resulting from all of SRP's covered operations at Modified Roosevelt, including conservation storage operations, flood control operations under the current version of the WCM, and the planned deviation of flood control operations.

The effects of SRP's covered activities on bald eagles that are likely to result in incidental take via death or harm (with harm manifesting primarily as habitat modification leading to non-lethal injury of adult eagles through reduced reproduction) are described in Subchapter 3.E.i. In summary, effects of the covered activities leading to incidental take are:

- Water being present under or near an active nest when nestlings are fledging. Fledging eagles would die after falling into or landing in water.
- An active nest containing eggs or nestlings becomes inundated by the lake or is abandoned by the adult breeding pair when inundation threatened the integrity of the nest structure. Eggs would be destroyed or nestling eagles would die, and the adult breeding pair of eagles would be non-lethally harmed by reduced reproduction.
- A nest, whether active or alternate, is destroyed by inundation or as a consequence of a nest tree rooted in the CS or FCS dying from extended inundation or extended desiccation and the nest falling to the ground or otherwise becoming unusable when the tree or a supporting limb falls. Eggs would be destroyed or nestlings would die if present when the nest is destroyed. The adult breeding pair would be non-lethally harmed by reduced reproduction if the nest is active at the time of destruction or if the nest is the only known nest for the pair. Destruction of an eagle nest itself, whether active or alternate, is a form of take under the BGEPA. However, not all instances of nest destruction that may occur in the CS or FCS are the consequence of SRP's covered activities. Eagle nests may be destroyed independent of SRP's covered activities by events such as strong winds or when an eagle has built a nest in a tree that is already dead or dying. Jacobson (2022) indicated that it is a "very common" occurrence for eagle nests in Arizona to fall from a tree outside of the eagle nesting season and that eagles often rebuild such nests. The destruction of an alternate eagle nest may not result in harm to the adult breeding pair if the pair maintains and ultimately uses another alternate nest or is able to rebuild the nest prior to the next nesting season (i.e., harm to the breeding pair would not occur if reproductive output is not impaired).

- The foraging (i.e., feeding) activities of eagles during the nesting season are significantly impaired when the lake is at very low elevations that reduce the availability or accessibility of prey. Nestling eagles would die if the adult breeding pair is unable to adequately provision them with food. Adult breeding pairs would be non-lethally harmed through reduced reproduction if the scarcity of prey leads to no or reduced egg laying or if nestlings die in the nest from insufficient food. In addition to the eagles that nest in the CS or FCS, this pathway to incidental take could affect eagles that primarily forage at Roosevelt Lake but nest outside of the CS or FCS.

The original RHCP (see Subchapter III.E.3) and the 1990/1993 Biological Opinions (FWS 1990a, 1993) also identified another potential pathway to incidental take of eagles related to the loss of suitable nest sites and feeding perches. The feeding or breeding activities of eagles could be significantly impaired if a substantial proportion of trees in the CS or FCS die as a consequence of extended inundation or extended desiccation, fall over, and are not replaced with new growth. Such trees are or could be used by eagles for nest sites or perches that support feeding or breeding activities. The loss of a substantial portion of the available nest sites and perches could make successful foraging at Modified Roosevelt more difficult and lead to non-lethal harm through reduced reproduction by one or more of the adult breeding pairs in the vicinity (i.e., a breeding pair may become undernourished and produce no or fewer eggs or may fail to adequately provision nestlings). While incidental take via this effect pathway is, in concept, possible, the likelihood that actual death or injury (i.e., harm) would occur is not reasonably certain. For instance, most of the eagle breeding areas monitored in the vicinity of Modified Roosevelt maintain nests outside of the CS or FCS (see Subchapter 2.E.i.2), some eagles in the vicinity nest on rock cliffs or cactus instead of trees, eagles can search for food while soaring above the lake, and eagles are known to perch on structures such as cliffs and utility poles or on the ground. Bald eagles are adaptable and use the available environment opportunistically (Grubb 1995).

SRP is restating the amount of incidental take of bald eagles that is reasonably certain to occur from its expanded list of covered activities at Modified Roosevelt with new surrogate metrics that make it easier to determine if the authorized amount of take has been exceeded. SRP proposes to use three metrics for this purpose that address the different rational connections between the covered activities and incidental take: 1) the number of fledgling eagles that drown at Modified Roosevelt, 2) the number of eagle nests in the CS or FCS that are destroyed (directly or indirectly) by the rise or fall of lake elevations, and 3) the number of years in which foraging during the bald eagle nesting season is significantly impaired by low lake elevations.

The new surrogate metrics for estimating and tracking incidental take of bald eagles satisfy the conditions articulated in the FWS Surrogate Rule and the HCP Handbook (FWS and NMFS 2016). It is impractical to track take of individual eagles (Condition 1 of the Surrogate Rule) because it is not always known with certainty if SRP's covered activities are the proximate cause of nest destruction, reduced reproduction, or death of a bald eagle. The bald eagles that use Modified Roosevelt are exposed to many environmental and human factors independent of SRP's covered activities that influence their behavior, habitat, survival, and productivity (e.g., weather conditions and events, aging trees, land use activities, recreation activities). The metrics have a rational link to taken individuals (Condition 2 of the Surrogate Rule) as described in the above discussion explaining how the effects of the covered activities may lead to incidental take. Finally, the metrics make necessary and rational simplifying assumptions about when and how much incidental take is expected, and (as further discussed below) the metrics are quantifiable and objectively measurable (Condition 3 of the Surrogate Rule).

ii. Number of Drowned Fledglings

SRP believes that eagles actually dying by fledging into water and drowning is likely a rare scenario. SRP provides support for bald eagle nest monitoring in the CS or FCS and nest monitors are trained in rescue protocols for eagles that are injured or at significant risk of injury. The activities of the nest monitors reduce substantially, but may not eliminate, the possibility that a fledgling eagle would drown. To date, one bald eagle nestling from the Tonto breeding area is suspected of drowning during a period of high water at Modified Roosevelt in 2007 or 2008 (Jacobson 2022). It is not known if this eagle died as a proximate consequence of SRP's covered activities or from some independent circumstance.

Based on the suspected drowning of one Tonto breeding area nestling in the first 20 years of ITP issuance, SRP estimates that no more than three eagle fledglings could drown because of SRP's covered activities during the remainder of the ITP term (approximately 30 years). Incidental take using this metric will be measured by the detection of a drowned fledgling eagle at Modified Roosevelt that is 1) reported between March 15 and June 15 (i.e., the period corresponding to the time of year when most bald eagle nestlings fledge [AGFD 2022a]), and 2) reasonably believed to have fledged from a nest that is in the CS or FCS. SRP, AGFD, and FWS will jointly review reports of drowned fledgling eagles from Modified Roosevelt and any other relevant information (such as nest monitoring data) to reach concurrence on a potential instance of incidental take using this metric.

iii. Number of Destroyed Nests

A bald eagle nest is destroyed when the nest structure is damaged to the point where it is or would be unusable for nesting activities. SRP's covered activities may cause or substantially contribute to the destruction of a nest when a nest is inundated by the lake or when the nest tree falls or a supporting limb breaks. Destruction of an eagle nest is a surrogate for a variety of adverse effects that may lead to take of eagles.

Also included in the category of "destruction" of an eagle nest are:

- the destruction of a supporting nest tree or snag when the bald eagle nest is also destroyed;
- instances where bald eagle nests with viable eggs or nestlings are abandoned by the adult breeding pair, the nest fails due to abandonment, and the proximate and reasonably certain cause of the abandonment is high water under the nest, even if the nest itself is not ultimately destroyed; and
- instances where nest destruction resulting from SRP activities is imminent and any bald eagle eggs or nestlings are proactively salvage collected by other parties.[13]

SRP conservatively estimates that no more than 40 bald eagle nests in the CS or FCS, whether active or alternate, would be destroyed by the direct or indirect effects of rising or falling lake elevations during the remainder of the ITP term. SRP arrived at this estimate by assuming that 1) there may be as many as four bald eagle breeding areas that maintain a nest in the CS or FCS in any given year, 2) each of these breeding areas maintains one nest within the CS or FCS, and 3) flood control operations leading to higher lake elevations in the CS and FCS (a proxy for the number of events that could inundate and destroy an eagle nest) occur in 10 of the 30 remaining years of the ITP term (consistent with the estimate that flood control operations occur in 35% of the years modeled in the Reservoir Planning Model). The estimate of

[13] SRP clarifies that it is not proposing to perform salvage collection of bald eagles or cover incidental take arising from salvage collection. SRP assumes that any entities performing salvage collection of bald eagles will have the necessary authorization to do so.

40 destroyed nests is the product of: 4 breeding areas × 1 nest located in the CS or FCS × 10 instances where all nests would be inundated and destroyed = 40 destroyed nests.

This estimate of incidental take is based on a set of assumptions about the number of breeding areas nesting in the CS and FCS, the number of nests maintained by each breeding area, and a variety of effects from inundation (including instances of nest tree/snag destruction or nest abandonment) during conservation storage and flood control operations. The application of the surrogate metric will apply to any detection of a destroyed nest, as defined above, up to the authorized limit, that is directly or indirectly caused by SRP's covered activities regardless of the mode of nest destruction or the specific breeding areas and nests that may be affected. SRP, AGFD, and FWS will jointly review reports of destroyed nests from Modified Roosevelt and any other relevant information (such as nest monitoring data or weather conditions) to reach concurrence on a potential instance of incidental take using this metric.

Documented instances of destroyed nests at Modified Roosevelt are few, with only the Tonto, Pinto, and Bachelor Cove breeding areas known to have lost a nest in the CS or FCS since the 1990s. SRP believes that its estimate of incidental take is generous under current conditions and appropriate to accommodate increasing bald eagle abundance range-wide (FWS 2020c) and in Arizona (AGFD 2022a); increasing eagle use of Modified Roosevelt (see Subchapter 2.E.i.2); and increasing frequency of flood control operations (see Subchapter 1.D.ii).

The number of individual eagles taken when a nest is destroyed may vary. No adult eagles would be harmed if the breeding pair is able to use an alternate nest in its breeding area, but the adults of this breeding pair would be non-lethally and temporarily harmed through reduced reproduction if another nest were not available for one or more breeding seasons. No eagles would be killed if a nest did not contain any eggs or nestlings at the time it was destroyed. But both of the breeding adults and any eggs or nestlings would be incidentally taken when an active nest is destroyed. The adults would be non-lethally and temporarily harmed by reduced reproduction and the eggs or nestlings would be killed. The actual number of eagles that will be killed or harmed over the remaining ITP term when nests are destroyed is neither predictable with reasonable certainty nor measurable in the field, but the number of nests that are destroyed is measurable and a suitable surrogate metric for the associated take.

iv. Number of Reduced Foraging Events

The original RHCP defined "low" lake elevations that might affect bald eagle foraging success at Modified Roosevelt as elevations of less than 2,100 feet amsl (see Subchapter III.E.3 of the original RHCP). SRP assumes that when the lake elevation is at or below 2,100 feet amsl during a substantial portion of the bald eagle breeding season, there is an opportunity for incidental take of eagles due to reduced foraging opportunities or increased competition for food. For this metric, a substantial portion of the bald eagle breeding season is defined to mean either 60 consecutive days between January and March (i.e., the portion of the breeding season when eagles are producing or incubating eggs and are most limited in their ability to forage) or at least 90 total days between January and June. To estimate this metric using the monthly Reservoir Planning Model data, the lake elevation on the last day of the month is used to represent the lake elevation for all days in the month (however, take during implementation will be tracked using the daily lake elevation). If the combined productivity rate of monitored eagle breeding areas relying on Roosevelt Lake is less than 1.0 (i.e., less than the 20-year average annual productivity rate; see Table 8) in a year when the lake is at or below 2,100 feet amsl for a substantial portion of the bald eagle breeding season, then SRP assumes its operations at Modified Roosevelt contributed to incidental take of bald eagles.

The Reservoir Planning Model estimates that the lake elevation is at or below 2,100 feet amsl for a substantial portion of the bald eagle breeding season in 18 of the 106 model years, which is 17% of the model years (see Appendix B). Over a 30-year period (i.e., the remaining duration of the ITP), the elevation of Roosevelt Lake could be expected to trigger this criterion in 5 years (i.e., 17% of 30 years is 5.1 years). Over the 20 years of eagle monitoring at Modified Roosevelt, the combined productivity rate of monitored eagles relying on Roosevelt Lake was less than 1.0 in 4 of those 20 years (30% of the years in which monitoring occurred; see Table 8).

SRP estimates that no more than four reduced foraging events (i.e., years in which the lake elevation is below 2,100 feet amsl for a substantial portion of the bald eagle breeding season and the combined productivity rate of monitored eagles relying on Roosevelt Lake is less than 1.0) will occur over the duration of the remaining ITP term. For the purposes of this surrogate metric, both conditions (i.e., low lake elevation and lower than average productivity rate) must be met in a given year for incidental take to be caused, with reasonable certainty, by SRP's covered activities.

The number of individual eagles taken when a reduced foraging event occurs is not practicably knowable, making the use of a surrogate metric appropriate. However, in such instances, at least one adult breeding pair maintaining a breeding area in the vicinity of Modified Roosevelt would be non-lethally and temporarily harmed via reduced reproduction from either not laying eggs, laying or hatching fewer eggs, or at least one nestling dying (i.e., there would be at least one egg that did not hatch and mature to the fledgling stage). The actual number of taken individuals would depend on the actual number of breeding areas and nesting activities within those breeding areas during that year. Other factors independent of SRP's covered activities (such as heat exposure, nest site disturbances, or the availability of other foraging resources) would also influence eagle breeding activities and could contribute to reduced productivity, further complicating precise attribution of the proximate cause(s) of any observed reduction in productivity.

v. Summary of Restated Eagle Take

SRP restates and clarifies the amount of eagle take to be authorized under the amended ITP using three surrogate metrics. Each metric is rationally connected to effects of SRP's covered activities that are likely to lead to incidental take and is practical to measure during implementation of the amended RHCP. The updated metrics are needed to estimate and measure incidental take in a manner that is clearly understandable and to account for incidental take that was previously considered and addressed by Reclamation as part of the Biological Opinions for Modified Roosevelt or by SRP as part of the original RHCP. SRP estimated the amount of incidental take of eagles that is reasonably certain to occur over the remaining duration of the ITP term (Table 14), as described in the preceding analysis.

SRP's authorized incidental take of bald eagles at Modified Roosevelt would be exceeded if any one of the limits established in Table 14 is exceeded.

Table 14. Eagle take. Restated amount of incidental take of bald eagles from SRP covered activities for the remainder of the ITP term.

Surrogate Metric	Amount of Take	Measurement or Exceedance Criteria
Number of drowned fledglings	3 drowned fledglings	Detection of a drowned juvenile bald eagle at Roosevelt Lake that is: 1) reported between March 15 and June 15; and 2) reasonably believed to have fledged from a nest that is located in the CS or FCS.

Surrogate Metric	Amount of Take	Measurement or Exceedance Criteria
Number of destroyed nests	40 destroyed nests	Destroyed nests meet one or more of the following conditions: A. Detection of a bald eagle nest (active or alternate) in the CS or FCS: 1) that is damaged to the point where it is or would be unusable for nesting activities; and 2) where the cause of the destruction is wholly or substantially related to direct inundation by the lake or to a nest tree falling or breaking after a period of extended inundation or desiccation; B. Detection of a tree or snag supporting a bald eagle nest (active or alternate) in the CS or FCS: 1) that is damaged such that the nest is intact but unusable (e.g., the nest is intact on the ground or the nest is intact but not upright); and 2) where the cause of the destruction is wholly or substantially related to inundation by the lake; C. Detection of a bald eagle nest with viable eggs or nestlings that are abandoned by the adult breeding pair, the nest fails due to abandonment, and the proximate and reasonably certain cause of the abandonment is high water under the nest, even if the nest itself is not ultimately destroyed; and/or D. A bald eagle nest in the CS or FCS where eggs or nestlings have been salvage collected by other authorized parties based on a determination that inundation (and subsequent destruction) of the nest is imminent (see Subchapter 3.E.i).
Number of reduced foraging events	4 reduced lake elevation events	A year in which 1) the lake elevation is at or below 2,100 feet amsl for a substantial portion of the bald eagle breeding season (i.e., at least 60 consecutive days between January 1 and March 31 or at least 90 total days between January 1 and June 30), and 2) the combined productivity rate of monitored bald eagle breeding areas relying on Roosevelt Lake is less than 1.0.

vi. Impacts of the Take Fully Offset

The operation of Modified Roosevelt causes or is likely to cause incidental take of bald eagles or the destruction of eagle nests. The number of individual eagles that would be taken by SRP's covered activities at Modified Roosevelt is unknown and not practical to determine with precision (see Subchapter 4.D.i). However, SRP can estimate a range of individual eagles that may be taken by these covered activities over the remaining duration of the ITP term using best- and worst-case assumptions.

The best-case scenario assumes that no fledgling eagles drown, all nests destroyed in the CS or FCS are not actively used by eagles (i.e., are empty), that breeding areas have at least one alternate nest available, and that years with combined productivity rates below 1.0 do not occur when lake elevations are below the thresholds established as an indicator of substantially reduced foraging opportunities. In this best-case scenario, no bald eagles would be killed, wounded, or non-lethally injured (i.e., no bald eagles are incidentally taken).

The worst-case scenario assumes that:

- three bald eagle fledglings die by drowning;
- all 40 destroyed nests are active such that three eggs or nestlings are killed and two adult eagles are non-lethally injured via reduced reproduction with each destroyed nest (the same pair of adult eagles could be non-lethally taken multiple times); and
- in each of the 4 years with reduced lake elevations, the bald eagles occupying the breeding areas relying on Roosevelt Lake for food (see Table 8) would be non-lethally taken via reduced reproduction or (as it relates to viable eggs or nestlings) would die.

Based upon effects on bald eagles occurring during the first 20 years of the ITP, neither the best-case nor the worst-case scenario is likely to occur. The number of bald eagles that would be taken over the next 30 years from SRP's covered activities is likely to be closer to the best-case scenario estimate.

The beneficial effects of ongoing bald eagle conservation measures at Modified Roosevelt and the persistence of the lake itself have outweighed the occasional adverse effect. Bald eagle use at Modified Roosevelt has increased in recent decades, the combined productivity rate of monitored breeding areas has averaged more than 1.0, and the absolute number of eagles produced annually from monitored breeding areas relying on Roosevelt Lake has increased over time (see Subchapter 2.E.i.3).

Given the trend of increasing bald eagle abundance range-wide and the beneficial effects of ongoing conservation measures under the original RHCP and completed under the prior Biological Opinions, additional bald eagle conservation measures are not needed at Modified Roosevelt. The impact of authorized incidental take is fully offset by ongoing seasonal nest monitoring, the activities of a year-round Forest Protection Officer, and local and statewide eagle productivity monitoring.

Chapter 5. Northern Mexican Gartersnake Conservation Measures

Chapter 5 describes the conservation measures that SRP will implement to minimize and mitigate the impacts of gartersnake take to the maximum extent practicable. These conservation measures are in addition to the conservation program described in the original RHCP (SRP 2002), which offsets take of the other covered species.

A. Biological Goal and Objectives

To offset impacts of take in the CS and FCS, SRP will apply conservation measures that act on the primary threats to the gartersnake in the Tonto Creek Basin: the degraded condition of the PBFs concerning prey availability and presence of nonnative predators. By addressing the primary threats to the population, these measures have the potential to enhance species recovery through a cascade of ecological benefits. Gartersnake habitat will be enhanced by reducing the number of nonnative predators and increasing the availability of native prey items, with the potential to help establish a self-sustaining native prey population. The habitat enhancement is expected to produce better outcomes for individual gartersnakes with improved condition, fitness, survival, and recruitment. Better individual outcomes will contribute to improved population outcomes, which may include increased population dispersal and resiliency to stochastic events.

The conservation measures to offset gartersnake take support the following biological goal and objectives:

Biological Goal: To improve the growth or stability of the gartersnake population in the Tonto Creek Basin or other nearby population.

> *Objective 1*. Reduce the deleterious effects of nonnative predatory fish, including predation pressure and competition for prey, during the permit term. This objective seeks to improve the condition of critical habitat PBF 4, which is "An absence of nonnative fish species of the families Centrarchidae [bass and sunfish] and Ictaluridae [catfish and bullhead], American bullfrogs (*Lithobates catesbeianus*), and/or crayfish (*Orconectes virilis*, *Procambarus clarkii*, etc.), or occurrence of these nonnative species at low enough levels such that recruitment of northern Mexican gartersnakes is not inhibited and maintenance of viable prey populations is still occurring" (FWS 2021a).
>
> *Objective 2.* Increase the availability of native prey, specifically native fishes and the lowland leopard frog (*Lithobates* [*Rana*] *yavapaiensis*), during the permit term. This objective seeks to improve the condition of critical habitat PBF 3, which is "A combination of amphibians, fishes, small mammals, lizards, and invertebrate prey species such that prey availability occurs across seasons and years" (FWS 2021a).

B. Conservation Measures

i. Location of Conservation Measures

SRP will implement gartersnake conservation measures in two reaches of Tonto Creek:

1. **Gisela Reach.** The Gisela Reach is a 3-mile reach of Tonto Creek, outside of the permit area, between Gisela, Arizona, and the 76 Ranch (Figure 34). For planning purposes, SRP has divided

the Gisela Reach into three, approximately 1-mile-long segments (Segments A, B, and C; see Figure 34).

   a. Segment A (upstream coordinates: 473813.4217 Easting (E), 3770849.677 Northing (N); lower coordinates: 473537.4891 E, 3769656.574 N) is associated with 53.8 acres of gartersnake critical habitat.
   b. Segment B (upstream coordinates: 473537.4891 E, 3769656.574 N; lower coordinates: 472917.8425 E, 3768430.127 N) is associated with 91.6 acres of gartersnake critical habitat.
   c. Segment C (upstream coordinates: 472917.8425 E, 3768430.127 N; lower coordinates: 473395.5281 E, 3767061.632 N) is associated with 76.1 acres of gartersnake critical habitat.[14]

2. **Lower Tonto Creek and the Flood Control Space.** SRP will implement certain conservation measures in lower Tonto Creek and a portion of the FCS, described below (Figure 35). For planning purposes, SRP has divided this area into four segments:
   a. Reach 1: A-Cross Road to Bar X Crossing (3 river miles). Reach 1 is partially within the FCS. It is closest to the lake and, therefore, nearest in proximity to SRP's water storage operations. Due to the higher groundwater table, the likelihood of pool persistence in this reach is greatest. Likewise, because of its proximity to the lake, there is a greater likelihood that fish inhabiting the lake will migrate into this reach of Tonto Creek and persist in the pools.
   b. Reach 2: Bar X Crossing to East Greenback Valley Road (3.5 river miles). In Reach 2, distance from the lake increases, fish must move farther away from the preferred lentic habitat in the lake, and the stream channel is bounded by extensive human development and subsequent groundwater pumping. As a result of the intermittent nature of the stream in this reach, after stream flows have ceased, periodic drying of residual pools is more likely. Consequently, fewer fish that swim out of the lake into Reach 2 will survive, compared to Reach 1.
   c. Reach 3: East Greenback Valley Road to Haufer Wash (3.5 river miles). In Reach 3, habitat conditions are similar to Reach 2 but with less human development. However, agricultural groundwater pumping occurring upstream in Reach 4 (described below), coupled with greater distance from the lake, decreases both the number of lake-derived fish and the number of pools that persist through time to support those fish.
   d. Reach 4: Haufer Wash to East del Chi Drive (5 river miles). The distance from the downstream terminus of Reach 4 is nearly 10 miles from the lake (at full pool elevation), and other uses such as channel modifications, sand and gravel mining, etc., occur between Haufer Wash and East del Chi Drive. SRP has no control over these activities, which may influence the persistence of pools within the stream channel and affect the presence and persistence of nonnative fish. Nonnative fish found in this segment may originate from either the lake or from upstream sources. The reach is similarly intermittent, and fish will not survive due to regular periodic drying of residual pools after stream flows have ceased (ERO-GEI 2022a; SWCA 2021).

[14] Coordinates are reported in North American Datum (NAD) 1983, Universal Transverse Mercator (UTM) Zone 12 North.

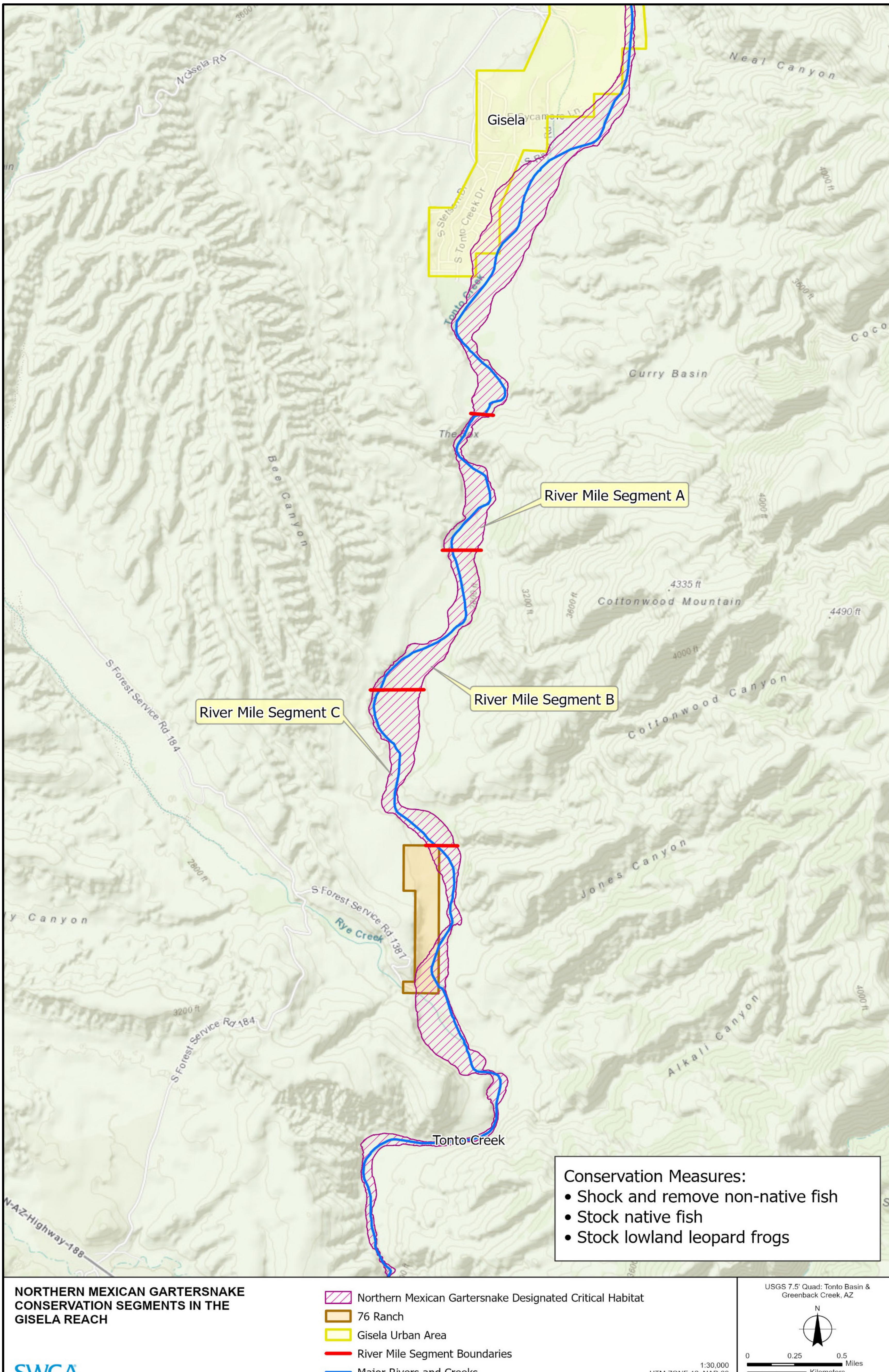

Figure 34. Gartersnake critical habitat in the Gisela Reach with river mile segments (Segments A, B, and C) selected for conservation measures.

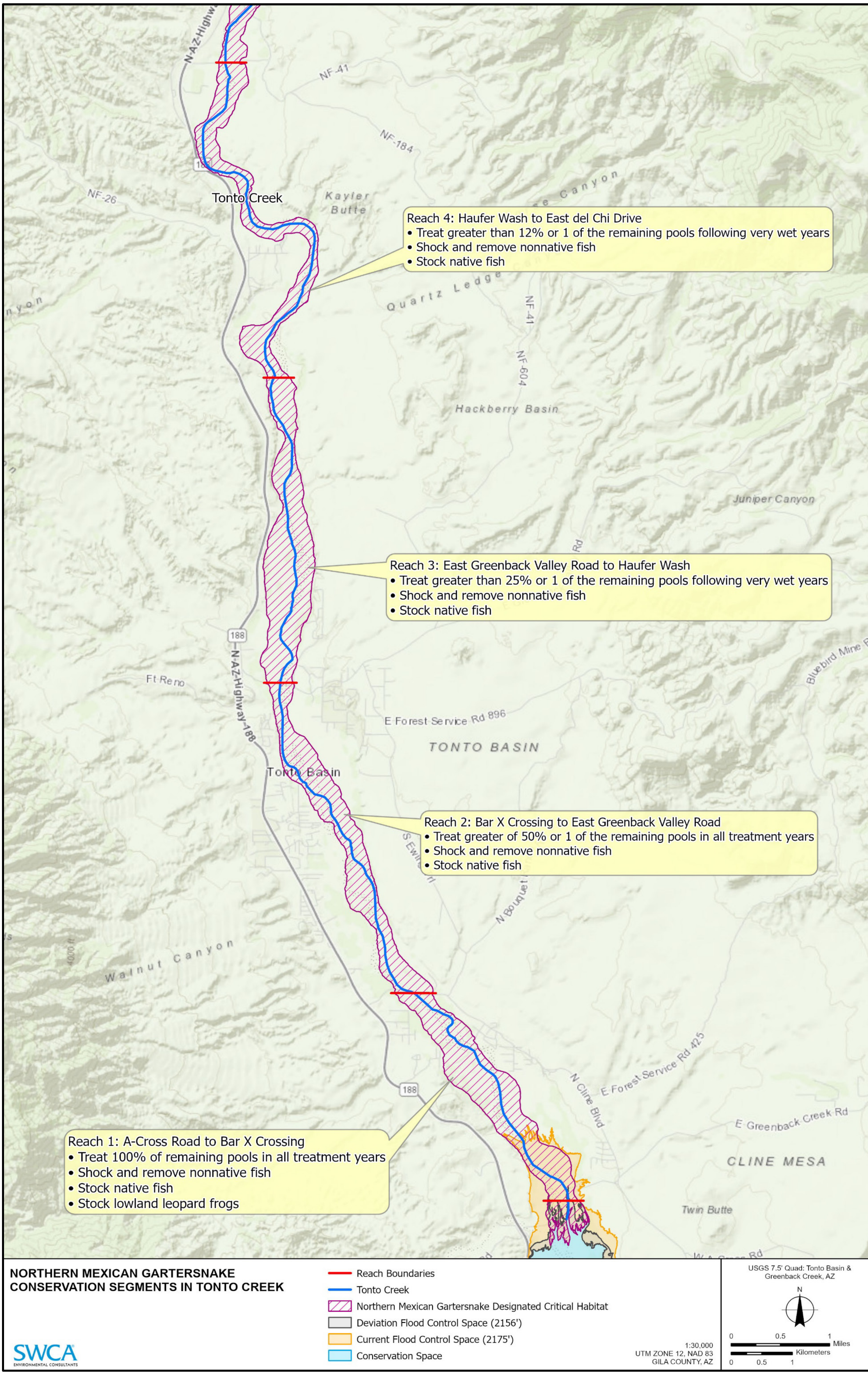

Figure 35. Locations of the lower Tonto Creek mitigation reaches.

ii. Suppression of Predatory Nonnative Fish

Persistent pools in Tonto Creek provide habitat for nonnative centrarchid and ictalurid fish species from upstream and downstream sources (ERO-GEI 2022a [see Appendix E], 2022b [see Appendix F]; SWCA 2022g). These fish pose a threat to gartersnakes through predation, competition for prey, and wounding (FWS 2014a, 2020a, 2021c). Gartersnake habitat is in a degraded condition where these nonnative fish are present (see gartersnake critical habitat PBF 4; FWS 2021c). Accordingly, the mechanical removal of centrarchid and ictalurid fishes to suppress their local populations may generate conservation credit under the HCP Handbook's threat reduction or elimination and habitat enhancement mitigation strategies (FWS and NMFS 2016). Application of this conservation measure supports SRP's Biological Objective 1.

This conservation measure will precede fish or frog stocking in selected pools to the maximum extent practicable to maximize the efficacy of those actions.

1. Gisela Reach

Selection of Treatment Pools. SRP will remove nonnative fish from discrete permanent pools within one or more selected segments of the Gisela Reach. SRP will select Gisela Reach segments for treatment in a given year based on technical feasibility, ecological effectiveness, and credit generation needs. SRP will identify pools within a selected segment based on specific criteria, also driven by technical feasibility and ecological effectiveness. SRP field crews will identify pools where nonnative fish suppression can be safely and effectively applied at the time of treatment.

Pools selected for nonnative fish suppression will:

- have discrete boundaries (i.e., no perennial flow and bounded by bedrock);
- be less than 3 feet deep to allow safe access with backpack electrofishing equipment; and
- be practicably accessible via road or helicopter, as available.

Timing and Level of Effort. To the extent practicable (e.g., subject to weather conditions), nonnative fish removals from selected segments of the Gisela Reach will be conducted in each of the first 5 years following completion of the permit amendment and in 2 out of 3 years, on average, thereafter through the remaining permit term. Fish removal will occur primarily between May 1 and June 30 but could be extended into other months depending on conditions of safety and discrete pool formation.

Due to the variability in pool size and distance between pools, SRP field crews will treat as many pools as possible within a selected segment of the Gisela Reach that meet the criteria within 2 field crew-days of effort. A field crew-day is defined as a 10-hour workday for three to four crew members, excluding preparation and travel times.

Treatment Methods. Nonnative fish removal will occur by electrofishing. The field crew will make two or more electrofishing passes through a pool, identifying and enumerating fish captured after each pass. All fish captured in the Centrarchidae and Ictaluridae families will be identified to species, measured for total length, and lethally removed. Electrofishing passes will continue in each treated pool until a noticeable depletion effect occurs (i.e., the number of fish in the Centrarchidae and Ictaluridae families >50 mm total length [2.0 inches] captured in the last pass is <50% of the fish captured in the first pass) or until the 2 field crew-days of effort are finished. Centrarchidae and Ictaluridae fish removed from pools will be humanely euthanized and left on-site to benefit local wildlife, such as bald eagles. Fish in the

Cyprinidae, Catostomidae, and Poeciliidae families will be returned to the pool after each pass or held in aerated containers outside the pool until the removal passes are complete, and then returned.

SRP will consider using different methods of fish removal from larger pools when those activities can be done successfully and safely. Alternate methods of fish removal will be subject to FWS approval.

Adaptive Management. Data collected on the number, size, and type of fish encountered during treatments will be used to describe the work completed and to support decisions about how SRP will implement this conservation measure in the future. After the first 5 years, SRP will work with FWS to assess whether to continue nonnative fish suppression in the Gisela Reach or, instead, to redirect these activities to one or more of the alternative locations described in Subchapter 6.A.iii.1.

2. Lower Tonto Creek and the Flood Control Space

SRP will remove predatory nonnative fish from select reaches and pools within lower Tonto Creek and the FCS following the steps below:

1. Trigger Conditions
    a. Time of Year: SRP will monitor daily mean flows at the Tonto Creek stream gage above Gun Creek during the spring runoff period of February 1 through May 31.
    b. 5 or More Consecutive Days: In years when daily mean flows in Tonto Creek reach greater than 200 cfs and less than 1,100 cfs anytime within the period identified in step 1 for a period of 5 or more consecutive days, connectivity allowing for the migration of nonnative fish from the lake upstream into Tonto Creek is assumed to occur (SWCA 2022f [see Appendix K]). In these years, SRP will remove nonnative fish from persisting pools, as described below.
    c. Less than 5 Consecutive Days: In years when the 200- to 1,100-cfs flow trigger occurs for a shorter period (1 to 4 days), SRP will coordinate with the FWS to discuss whether the short duration and intensity of flows provided the requisite conditions for fish migration from the lake into Reaches 1 and 2. Based on that review of conditions, the FWS may request a site assessment be conducted in Reaches 1 and 2 to determine whether fish removal efforts should be conducted in that year.
2. Treatment Timing:
    a. Once spring runoff diminishes and the maximum daily stream gage reading reaches 20 cfs daily mean flow or less on a falling hydrograph, continuous stream flow ceases (ERO-GEI 2022a [see Appendix E], 2022b [see Appendix F]) and surface water is limited to discontinuous pools distributed along the stream channel. This typically occurs in the April–May time frame.
    b. Pools continue to diminish in size as the hydrograph decreases, concentrating any fish that occur in the stream channel into these residual pools. Because there is the chance for spring storm events to occur during the period (February 1–May 31) when nonnative fish are spawning and most likely to move into Tonto Creek (ERO-GEI 2022a [see Appendix E]), SRP will use the first 20-cfs flow trigger on or after May 1 to initiate nonnative fish removal.
    c. SRP will mobilize within 30 days after the 20-cfs daily mean flow trigger occurs in May to remove as many nonnative fish that are >50 mm total length as possible from a subset of remaining pools by using electroshocking techniques or other practicable and appropriate methods as may be identified in coordination with FWS. This 30-day period provides time for mobilization to begin fish removal. Based on past stream gage data for

Tonto Creek, there is a slight probability that a late spring storm will occur after spring runoff ceases. If that occurs, it could allow for conditions where nonnative fish again have the chance to move upstream, and thus make fish removal actions less effective. Therefore, if stream flows increase within this 30-day period to above 20 cfs due to a late spring storm event, the clock will reset to when flows again decrease to 20 cfs or less. The intent is to conduct nonnative fish removal activities prior to the onset of monsoon precipitation events. If it is anticipated that fish are not available in any year to stock, then all size classes of nonnative fish would be removed.

3. Reach and Pool Selection (see Figure 35):
    a. Only pools on federal lands will be treated. No pools on private property will be accessed for fish removal and such pools are not part of the percentages described below.
    b. The number of pools remaining in any given reach in any given year is indeterminable. In addition, other factors, as described in the reach descriptions above, weigh into the degree to which SRP's actions contribute to take of gartersnakes in these reaches. Therefore, SRP will treat pools in the following manner.
        i. Reach 1 – Treat 100% of remaining pools
        ii. Reach 2 – Treat 50% of remaining pools
    c. In very wet years when flows are continuous throughout the year (flows greater than 20 cfs persist), SRP will remove nonnative fish as described above in the following year once flows become discontinuous and pools form. In these instances, SRP will perform removals as follows.
        i. Reach 1 – Treat 100% of remaining pools
        ii. Reach 2 – Treat 50% of remaining pools
        iii. Reach 3 – Treat 25% of remaining pools
        iv. Reach 4 – Treat 12% of remaining pools
    d. In the reaches where a percentage of less than 100% is proposed, SRP will treat a minimum of one pool unless there are no remaining pools.
4. A subsample of nonnative fish that are removed from pools will be enumerated, measured, classified by taxa, and sacrificed (i.e., those nonnative fish >50 mm total length). Any native species will be returned to the pool(s).

iii. Stocking Native Fishes Following Suppression

Small fish are prey for gartersnakes (Emmons, Nowak, and Lauger 2016; Manjarrez et al. 2013; Manjarrez et al. 2017; Nowak et al. 2019), as well as for other fish and wildlife of the Tonto Creek Basin (ERO-GEI 2022b [see Appendix F]). However, the ictalurid and centrarchid fish species that currently comprise the majority of the biomass in the persistent pools of Tonto Creek are suboptimal prey for gartersnakes as they may wound gartersnakes (Emmons, Nowak, and Lauger 2016), compete with gartersnakes for prey, or prey directly on gartersnakes. Native fishes (e.g., longfin dace [*Agosia chrysogaster*], native sucker species [*Catostomus* spp.], speckled dace [*Rhinichthys osculus*], and Gila topminnow [*Poeciliopsis occidentalis occidentalis*]) lack spiny rays, making them ideal prey species for the gartersnake to consume.

Following the removal of fish during nonnative fish suppression efforts, stocking native fishes will resupply and diversify prey available to gartersnakes and other wildlife in the treated pools. As described in the FWS's critical habitat designation, gartersnake habitat is in a degraded condition where the diversity and biomass of prey is low (PBF 3, FWS 2021c). Accordingly, increasing the diversity and abundance of prey for gartersnakes through the regular stocking of native fishes may generate conservation credit under the HCP Handbook's habitat enhancement mitigation strategy (FWS and NMFS 2016). Application of this conservation measure supports SRP's Biological Objective 2.

1. Gisela Reach and the Flood Control Space

Following nonnative fish suppression in the Gisela Reach or the portion of lower Tonto Creek Reach 1 in the FCS, SRP will stock native fish prey into the treated pools. To the extent practicable, SRP will implement stocking within the same year and as soon as practicable following the suppression activities. SRP anticipates stocking one or more of the following species native to the Tonto Creek Basin, as available and as appropriate to the stocking location: longfin dace, native sucker or chub species, and speckled dace. Other species may be stocked in coordination with and concurrence from FWS. Stocking will occur, in coordination with FWS, at rates commensurate with the size of the pool treated and the availability of fish for stocking. Fish will be transferred from the hatchery in coordination with the AGFD and applying best practices to maximize stocking success (e.g., following the AGFD's draft small-bodied, warm water native fish collection, transport, and stocking protocol [AGFD 2022b]).

C. *Lower Tonto Creek Above the Flood Control Space*

SRP will provide the AGFD (or another suitable partner, with FWS concurrence) sufficient funds to rear and stock native fish in lower Tonto Creek during the remaining permit term. SRP anticipates that hatchery-reared native species (e.g., longfin dace, sucker species, or chub species) will be the focus of this effort, but other species may be considered with FWS concurrence. SRP will ensure directly or through contract that these stocking activities will be performed and will report the implementation of this stocking to FWS as described in Subchapter 6.A.ii. SRP acknowledges that unexpected circumstances may arise in which fish for stocking are not available or not available in the desired numbers. SRP will make a good-faith effort to find sources to enable it to stock fish in each year when a removal effort takes place.

SRP will coordinate with the AGFD and FWS to identify which pools within Reach 1 above the FCS or within Reach 2 have the greatest likelihood of benefiting gartersnakes. These determinations will be made in consideration of data such as, but not limited to, the size and likely duration of pool persistence, proximity to gartersnake detections, biomass of nonnative fish removed from a pool, and the diversity and abundance of other native prey in proximity of the pool (such as amphibians).

SRP estimates that the funding it will provide to support stocking activities will result in the release of native fish into at least one lower Tonto Creek pool above the FCS in years when the trigger conditions for implementing nonnative fish suppression in lower Tonto Creek and the FCS are met. SRP will work with its partners to help ensure that these funds are spent in ways that maximize the amount of native prey that is released into lower Tonto Creek.

iv. Stocking Lowland Leopard Frogs

Lowland leopard frogs are a native prey species for the gartersnake (FWS 2014a; Jones et al. 2020; Rosen and Schwalbe 1988), as well as for other fish and wildlife of the Tonto Creek Basin. Coupled with the suppression of nonnative fish predators in the persistent pools of Tonto Creek, stocking of lowland leopard frog is likely to increase the availability and diversity of suitable native prey locally available to the gartersnake and other wildlife. It is reasonable to expect at least a temporary improvement of the native prey base for gartersnakes immediately following each stocking event. The duration and durability of this benefit is uncertain and dependent on how long the introduced frogs survive and whether they reproduce in the wild. As described by the FWS, gartersnake habitat is in a degraded condition where the diversity and biomass of prey is low (PBF 3, FWS 2021c). Accordingly, increasing the diversity and abundance of prey for gartersnakes through the regular stocking of lowland leopard frog is eligible for conservation credit under the HCP Handbook's habitat enhancement mitigation strategy (FWS and NMFS 2016).

There remains the potential for American bullfrogs to occur within this mitigation reach. Bullfrogs are known predators of native lowland leopard frogs and are capable of displacing native lowland leopard frog populations over time. However, it is expected that if American bullfrogs are extant in the Gisela mitigation reach, the flashy, flood-prone hydrology of Tonto Creek would serve as a control on their populations. American bullfrogs evolved in the Mississippi Basin and are not tolerant of flash flooding of their habitat, or high-gradient systems, whereas lowland leopard frogs evolved in the arid zones of Arizona and are naturally accustomed to flash floods, using flood pulses to assist in colonizing new areas within watersheds or subbasins as well as modifying behaviors to withstand flooding where they already occur. With the additive conservation effect of regular predatory fish removal and the subsequent, significant increase in survival and metamorphosis of larval lowland leopard frogs, it is expected that lowland leopard frogs will continue to exist within the permit area under the fluctuating pressure of American bullfrogs over time. Indeed, lowland leopard frogs currently persist in this environment despite the presence of American bullfrogs and other nonnative predators, albeit at likely depressed levels of abundance (Nowak et al. 2019). These elements of natural history are expected to facilitate the accomplishment of stated goal and objectives of diversifying, improving, and stabilizing the gartersnake prey base.

Stocking lowland leopard frogs in pools of Tonto Creek would entail introduction of egg masses or tadpoles, as those life stages have been found to have higher success rates in populations becoming established compared to juvenile or adult life stages (Hossack et al. 2022). Application of this conservation measure supports SRP's Biological Objective 2.

If available, SRP will stock captive-reared lowland leopard frogs in pools of the Gisela Reach following nonnative fish suppression within those pools. Rates of stocking may vary greatly and will depend on the age class (i.e., eggs, tadpoles, or adults), the size of the pool, and the availability of frogs for stocking. Frogs will be transferred from the breeding facility, applying best practices to maximize stocking success (e.g., Protocols for Transportation, Captive Care, and Release of Leopard Frogs [*Rana* spp.] in the *Chiricahua Leopard Frog Final Recovery Plan* [FWS 2007d]; Hossack et al. 2022).

SRP is not currently planning to stock lowland leopard frogs in lower Tonto Creek or the FCS, preferring to stock native fish in these areas. However, if during the annual coordination meeting (see Subchapter 6.A.iii), SRP and the FWS decide to stock lowland leopard frogs in lower Tonto Creek or the FCS, this conservation measure is eligible to generate conservation credit. Stocking would proceed as described for the Gisela Reach.

V. Lowland Leopard Frog Breeding Facility

Currently, no breeding facilities have been secured to produce lowland leopard frogs for stocking, although the methods for captive propagation have been established and are feasible (FWS 2007d:Appendix F). If SRP can find a qualified and FWS-approved organization that is interested in breeding lowland leopard frogs suitable for stocking in the Tonto Creek Basin, SRP will commit up to $625,000 toward establishing, operating, and maintaining a breeding facility as well as stocking lowland leopard frogs over the remaining permit term.

vi. Other Conservation Measures

The FWS has not yet published a recovery plan for the gartersnake. It is possible that a future recovery plan or other conservation strategy will identify other practicable conservation measures of similar or increased benefit to the gartersnake. SRP anticipates that the FWS may grant conservation credit for other types of conservation measures on a case-by-case basis. SRP expects the FWS will help meet conservation targets by actively looking for additional practicable opportunities to generate conservation credit. Case-by-case credit approvals enable the programmatic flexibility to act on a variety of opportunities that would benefit the gartersnake or the best available science on the species.

vii. Conservation Measure Crediting

Table 15 summarizes the connections between SRP's covered activities, the form and location of incidental take, and corresponding mitigation measures, metrics, and locations.

Table 15. Summary of covered activities and corresponding mitigation measures.

Covered Activity	Form of Incidental Take	Location of Incidental Take	Mitigation Measure	Mitigation Metric	Mitigation Location
Long-term Conservation Storage	Harm via habitat modification through the adverse effects of nonnative predatory fish	CS or FCS	Suppression of nonnative predatory fish; stocking native fishes; stocking lowland leopard frogs*; support for lowland leopard frog breeding facility*	Acre-years of conservation credit from a menu of options	Gisela Reach of Tonto Creek; lowland leopard frog breeding facility would be outside of the permit area
Long-term Conservation Storage	Harm via habitat modification through the adverse effects of nonnative predatory fish	Lower Tonto Creek	Suppression of nonnative predatory fish; stocking native fishes in coordination with other parties	Specified level of effort, by reach, based on Tonto Creek flow conditions	Reaches 1–4 of the Lower Tonto Creek portion of the permit area; stocking focused on Reach 1 above the FCS or Reach 2
Conservation Storage Operations	Kill, wound, or harm via habitat modification through changes in habitat availability, habitat location, and habitat quality (including the adverse effects of nonnative predatory fish)	CS	Suppression of nonnative predatory fish; stocking native fishes; stocking lowland leopard frogs*; support for lowland leopard frog breeding facility*	Acre-years of conservation credit from a menu of options	Gisela Reach of Tonto Creek; lowland leopard frog breeding facility would be outside of the permit area
Current Flood Control Operations	Kill, wound, or harm via habitat modification through changes in habitat availability, habitat location, and habitat quality (including the adverse effects of nonnative predatory fish)	FCS	Suppression of nonnative predatory fish; stocking native fishes; stocking lowland leopard frogs*; support for lowland leopard frog breeding facility*	Acre-years of conservation credit from a menu of options	Gisela Reach of Tonto Creek; lowland leopard frog breeding facility would be outside of the permit area
Flood Control Planned Deviation	Kill, wound, or harm via habitat modification through changes in habitat availability, habitat location, and habitat quality (including the adverse effects of nonnative predatory fish)	Planned deviation space	Stocking native fishes	Acre-years of conservation credit from a menu of options	FCS

* This activity is subject to the availability of stock, need for conservation credit generation, and coordination with FWS as described in Subchapter 5.B.iv.

SRP's conservation measures performed in portions of lower Tonto Creek above the FCS (i.e., suppression of nonnative fish and funding to AGFD or another suitable partner to rear and stock native fish in lower Tonto Creek) are intended to fully offset SRP's portion of the impact of nonnative fish on the gartersnake outside of the CS and FCS. These activities have a specified timing and level of effort based on observed Tonto Creek flows.

SRP's conservation measures for the gartersnake performed in the Gisela Reach or in the FCS, or as approved by FWS on a case-by-case basis, will generate credit to offset the impact of incidental take on gartersnakes in the CS and FCS. The benefit of these actions will be measured in units of acre-years, representing both the relative value and duration of the mitigation benefit. Since SRP will retain some discretion about when and which conservation measures to implement in any given year, SRP will estimate and account for the conservation benefits from the measures it implements with a conservation credit metric.

Gartersnake conservation credits will be calculated as the product of three variables:

1. Acres benefited by the conservation measure
2. Relative conservation value (factor ranging from 0.5 to 1.0)
3. Duration of the conservation measure in years

Acres benefited by the conservation measure is measured as the area of gartersnake habitat that experiences a conservation uplift. In treating the aquatic portion of the gartersnake habitat, conservation measures are anticipated to benefit the gartersnake beyond the direct footprint of the action. It is assumed that treatment of pools in the center of gartersnake habitat will benefit the species to the lateral boundaries of that habitat. Specifically:

- Conservation measures completed in the Gisela Reach are assumed to benefit the acres of critical habitat associated with a treated segment. SRP would choose which segments (defined in Figure 34 in Subchapter 5.B) and how many segments (i.e., one, multiple, or none) it wants to treat in a year. The actual credit generated by a conservation measure depends on the segment(s) to which it is applied:
    - Gisela River Mile Segment A: 53.8 acres of critical habitat.
    - Gisela River Mile Segment B: 91.6 acres of critical habitat.
    - Gisela River Mile Segment C: 76.1 acres of critical habitat.
- Conservation measures completed in the FCS benefit the gartersnake to the boundaries of the modeled habitat in the FCS (estimated 192.2 acres of habitat; see modeled habitat in SWCA 2022e [Appendix H]).

Relative conservation value is a factor that reflects the relative efficacy of the action in supporting the recovery of the gartersnake based on professional opinion. For the conservation measures proposed, the relative efficacy depends on the location in Tonto Creek:

- Gisela Reach (1.0×)
    - Stocking actions benefit a larger proportion of the Tonto Creek Unit gartersnake population because there is room for downstream dispersal of these prey species
    - The State's management objective for this reach of Tonto Creek is a native fishery (AGFD 2022c). Given this context, the conservation measures are predicted to be more durable.

- Roosevelt Lake FCS (0.5×)
    - The State's management objective for Roosevelt Lake is a sport fishery. Given this context, the conservation measures performed in the Roosevelt FCS are predicted to be less durable.

Duration of the conservation measure is measured as the expected duration of the conservation uplift resulting from the action, in years. Given that there is considerable uncertainty regarding the durability of the conservation measures, considering seasonal connectivity with habitats containing nonnative predatory fish and survival rates of stocked fish with endemic diseases and predators, conservation credit will only be granted for one year, each year the conservation measure is applied. While SRP hopes these conservation measures will produce durable landscape-level benefits for the gartersnake, these benefits are not assumed, thereby taking a conservative approach to conservation crediting.

In rare circumstances, other conservation measures may be proposed for conservation credit. These actions are subject to case-by-case approval by the FWS (see Subchapter 5.B.vi). One of these circumstances is SRP's commitment of up to $625,000 (subject to further investigation) toward establishing, operating, and maintaining a breeding facility for lowland leopard frogs over the remaining permit term, provided an interested and qualified organization can be identified. SRP proposes that this would be worth acre-years of credit equal to the area of gartersnake habitat in the FCS (192.2 acres) and in the Gisela Reach (221.4 acres) for 4 years. This equals 1,654.4 acre-years.

SRP demonstrates how it is practicable to generate enough conservation credit to fully offset the impacts of incidental take on gartersnakes in the CS and FCS within the permit term with a combination of the conservation measures proposed (Table 16), although SRP may vary the location, number of reaches, and frequency of treatment from what is shown here. The actual number and frequency will depend on current conditions, ongoing coordination with the FWS and other partners, and credit generation needs. The credit generated by the conservation measures in Table 16 over 30 years (up to 8,127 acre-years) exceeds the 5,187 acre-year estimated impact of take. SRP is responsible for generating only 5,187 acre-years of gartersnake conservation credit, in addition to implementing the actions required to fully offset the impacts of nonnative fish on gartersnakes in lower Tonto Creek above the FCS, over the remaining permit term.

Table 16. Estimated conservation credit for the conservation measures proposed by SRP to offset impacts of incidental take in the CS and FCS.

Location	Conservation Measure	Acres	Relative Conservation Value	Duration and Estimated Frequency	Estimated Conservation Credit Generated (acre-years)
Gisela Reach	Suppression of predatory nonnative fish	73.8 acres critical habitat (average)	1.0	Duration of benefit is 1 year for each application. The measure is applied in 20 of 30 years = 20 years credit	1,476
	Stocking native fishes	73.8 acres critical habitat (average)	1.0	Duration of benefit is 1 year for each application. The measure is applied in 20 of 30 years = 20 years credit	1,476
	Stocking lowland leopard frogs*	73.8 acres critical habitat (average)	1.0	Duration of benefit is 1 year for each application. The measure is applied in up to 17[†] of 30 years = up to 17 years credit	Up to 1,254.6

Location	Conservation Measure	Acres	Relative Conservation Value	Duration and Estimated Frequency	Estimated Conservation Credit Generated (acre-years)
Roosevelt Lake FCS	Stocking native fishes	192.2 acres modeled habitat	0.5	Duration of benefit is 1 year for each application. The measure is applied in an estimated 23 of 30 years = 23 years credit estimated	2,210 estimated
	Stocking lowland leopard frogs*	192.2 acres modeled habitat	1.0	Duration of benefit is 1 year for each application. Application of this measure is not currently planned for this location = minimum 0 years credit	0 minimum
Lowland leopard frog breeding facility	Funding up to $625,000 (subject to further investigation)*	192.2 + 221.4 = 413.6 total	1.0	4 years	1,654.4
Total credit generated by proposed conservation measures					**Up to 8,071.0**

* In lieu of this activity, SRP may instead perform nonnative fish suppression and native fish stocking more frequently or in additional river mile segments of the Gisela Reach.

† This is equivalent to stocking in 2 out of 3 years after an initial 4 years to establish the breeding facility and begin propagation.

viii. Considerations for Covered Birds

Nonnative fish suppression and native prey stocking activities could be performed when the covered birds are nesting. To the extent practicable, SRP and its field crews will minimize impacts to covered birds that may occur near areas where gartersnake conservation measures are implemented. Prior to mobilizing field crews, SRP will coordinate with FWS and AGFD to understand the present distribution of flycatchers, cuckoos, rails, and bald eagles in or near the Gisela Reach and lower Tonto Creek. SRP and its field crews will, to the extent practicable, avoid working in or traveling through areas known to be occupied by nesting covered birds. Where it is impractical to avoid work in or travel through areas occupied by nesting covered birds, SRP and its field crews will minimize impacts to covered birds by using roads, trails, or existing open areas and minimize instances of "bushwhacking" through riparian habitat.

C. Impacts of Take Are Fully Offset

FWS guidance states that "[t]he statutory standard of minimizing and mitigating the impacts of the take 'to the maximum extent practicable' under ESA Section 10(a)(2)(B)(ii) will always be met if the HCP applicant demonstrates that the impacts of the taking will be fully offset by the measures incorporated into the plan" (FWS and NMFS 2016:9-28). The HCP Handbook describes "fully offset" as meaning "…the biological value that will be lost from covered activities will be fully replaced through implementation of conservation measures with equivalent biological value. Fully offset also means the mitigation is commensurate (equal) with the impacts of taking" (FWS and NMFS 2016:9-28). The HCP Handbook (see page 9-30) provides examples of concepts that can help demonstrate how the minimization and mitigation measures of a conservation program fully offset the impacts of the taking, such as (paraphrased from the HCP Handbook):

- the ratio of the amount of habitat lost to the amount of habitat protected;
- the type of habitat lost compared to the type of habitat protected;
- the biological value of the habitat lost compared to the biological value of the habitat protected;

- the additional impact, if any, resulting from lag time between the impact of the habitat lost and the full ecological functioning of the protected habitat;
- the impact of uncertainty regarding the effectiveness of minimization and mitigation measures; and
- consistency of the minimization and mitigation measures with previously defined recovery objectives.

In its decision to withdraw previously published ESA compensatory mitigation guidance, the FWS noted that it "will make sure that any statutorily authorized mitigation measures will have a clear connection (i.e., have an essential nexus) and be commensurate (i.e., have rough proportionality) to the impact of the project or action under consideration" (83 *Federal Register* 36470).

A conservative assessment of the impacts of the requested incidental take is provided in Chapter 4. This occurs through two separate processes, one for impacts occurring in the CS and FCS, and one for lower Tonto Creek for covered activities in the CS. The impacts of the authorized take of gartersnakes are fully offset by the mitigation and minimization measures in the conservation program. In this conservation program, SRP set biological goals and objectives that support or enhance the PBFs from the gartersnake critical habitat designation (see Subchapter 5.A); identified mitigation and minimization measures that align with its conservation objectives and may be implemented for conservation credit (see Subchapter 5.B.vii); described specific conservation actions that apply to these measures (see Subchapters 5.B.ii through 5.B.vii); defined a metric for crediting the proposed conservation measures (see Subchapter 5.B.vii); and defined an ongoing coordination process with the FWS until take is fully offset (see Subchapter 6.A.iii.1).

The requested incidental take would not occur without the implementation of the conservation program and the minimization and mitigation measures described herein. The practicable minimization and mitigation measures described in Chapter 5, in concert with the funding assurances (Chapter 8) and measures for addressing Changed Circumstances (Chapter 7), ensure that impacts to gartersnakes are fully offset. SRP describes how the conservation program conforms to the considerations identified by the FWS for evaluating "fully offset" when using a habitat surrogate:

1. **Mitigation Ratios**—The multipliers applied in the calculation of the impact of take from the estimate of take may also be thought of as mitigation ratios. The ratios of impacts of take to take range from 1.1 to 2.0 (average 1.9) depending on the covered activity and permit area location (see Table 13). The conservation program offsets the impacts of take at an overall ratio of 1:1. Therefore, the mitigation ratios proposed in this addendum fully offset (or more) the amount of habitat directly lost or partially degraded due to covered activities.
2. **Habitat Type**—The conservation program applies conservation measures within designated critical habitat for the gartersnake (conservation measures in the Gisela Reach) or within the modeled habitat in the FCS (conservation measures in the FCS), which exhibits all the PBFs the FWS used to define critical habitat (FWS 2021c) and includes areas designated as critical habitat. Through the conservation program, SRP will apply conservation measures to enhance the same type of habitat and to benefit the same population as was impacted.
3. **Biological Value**—The FWS advised SRP to select these conservation measures because they would support the forthcoming recovery goals for the gartersnake and provide the greatest biological value to the gartersnake population in the Tonto Creek Basin. The FWS placed a much higher value on measures that addressed aquatic habitat degradation than terrestrial habitat preservation or enhancement. The conservation program also contains multiple measures to ensure that the biological value of the mitigation meets or exceeds the biological value of the habitats impacted by covered activities. The adjustment of the estimated amount of take to the

impacts of take explicitly considers the biological value of the habitats as well as the context, context, duration, and size of the habitat change, applying multipliers ranging from 1.0 to 3.0. Likewise, the graduated conservation values of the conservation measures proposed reflect the relative biological value of those actions, applying multipliers ranging from 0.5 to 1.0. These graduated ratios for impact of take and conservation value ensure that the amount of mitigation associated with a covered activity fully offsets the biological value of the affected habitats under this addendum.

4. **Lag Time in Implementing Mitigation**—To the extent practicable, SRP will generate conservation credit concurrent with or in advance of take to ensure there is no lag time in implementing mitigation. A lag time in implementing mitigation is determined by comparing the conservation credit generated to date to benchmarks that assume an even pace of credit generation over the remaining permit term (see Subchapter 6.A.ii.2). A lag in the timing of mitigation is made more unlikely by the very conservative assumptions SRP used to quantify the impacts of take and is anticipated to exceed the actual impacts of take. In the rare event a substantial lag in the timing of implementation occurs, Changed Circumstances specify provisions to offset the impact of this lag. These include a 5% increase in the mitigation still owed each year the lag persists after an initial 5-year grace period (see Subchapter 7.C).
5. **Addressing Uncertainty**—Uncertainty regarding the application of certain minimization measures and the effectiveness of the mitigation are addressed by the use of very conservative estimates of the impacts of take and SRP's commitment to offset the full estimated impacts of take to the extent practicable.

   The conservative approach to offset take in the CS and FCS is protective of the gartersnake, setting an objective for mitigation that is likely to greatly exceed the actual impacts of take. Take occurring in the CS and FCS over the remaining permit term was estimated using an approach that modeled the historical monitoring and operations data and planned for the worst-case scenario by assuming the largest 30-year net habitat loss in 81 years of record plus 1 standard deviation on the mean would occur over the permit term. Take of gartersnakes over the permit term was thus very conservatively estimated (measured in acre-years) and then adjusted by impact factors (i.e., mitigation ratios) to estimate the impact of take (5,187 acre-years [see Chapter 4]). This conservative approach addresses potential variability in future conditions and uncertainty in projections of future take. SRP's objective in this conservation program is to fully offset the estimated impact of take in the CS and FCS at a ratio of 1:1. In the likely event the conservation credit generated exceeds the actual impacts of take, this collection of conservation measures will contribute to the recovery of the species in addition to fully offsetting the impact of take.

   The conservation measures proposed in lower Tonto Creek address the primary threat to gartersnakes in real time. SRP's storage of water in the CS provides breeding, feeding, and sheltering habitat for the nonnative predatory fish that the AGFD continues to stock into Roosevelt Lake using private and federal funds. If not for the establishment and ongoing maintenance of the sport fishery in Roosevelt Lake, SRP's covered activities would not likely result in take of gartersnakes in lower Tonto Creek. SRP fully offsets the share of the take in lower Tonto Creek that may be attributable to its covered conservation storage operations through this conservation program. In the conservation program, SRP proposes an annual cycle of monitoring flow and directly addressing the threats of predation and competition posed by nonnative fish to gartersnakes throughout the life of the permit. This direct approach—monitoring and addressing take as it occurs—addresses potential variability in future conditions and uncertainty in projections of future take. Given that SRP is addressing nonnative fish threats to gartersnakes, even though it is only in a small way responsible for this problem, it is likely that

SRP is contributing to the recovery of the species in addition to fully offsetting impact of take that may be attributable to its covered activities.

Mitigation under this addendum will be implemented with the coordination and approval of the FWS, and SRP will provide financial assurances for the implementation of this addendum (see Chapter 8). These coordination, consistency, and funding measures ensure that uncertainty is addressed in the delivery of mitigation that fully offsets the impacts of the taking.

6. **Consistency with Recovery Objectives—**SRP will provide mitigation in a manner that is consistent, to the extent practicable and in consideration of relevant site-specific circumstances, with best available science and with the FWS's guidance provided in the designation of critical habitat (i.e., no recovery plan for the gartersnake is currently available) or through ongoing coordination. Therefore, SRP anticipates that the minimization and mitigation measures of the conservation program will fully offset the impacts of the take and contribute to the recovery of the gartersnake.
7. **Other Benefits—**By SRP removing nonnative fish species in the Gisela Reach as part of its conservation program, PBF 4 (i.e., an absence of nonnative aquatic predators) of designated critical habitat for the narrow-headed gartersnake (*Thamnophis rufipunctatus*) would be improved in this area.

Chapter 6. Monitoring, Reporting, and Adaptive Management

SRP is adding to the monitoring, reporting, and adaptive management measures of the original RHCP to address the addition of the gartersnake as a covered species. SRP is also expanding the application of its existing monitoring, reporting, and adaptive management activities for the covered birds to the FCS. See Subchapter IV.E of the original RHCP (SRP 2002) for a description of the measures applicable to the covered birds.

A. Northern Mexican Gartersnake

i. Monitoring and Reporting for Exceedance of Gartersnake Take

SRP estimated incidental take of the gartersnake as the cumulative amount of habitat modification (i.e., changes in habitat availability) and the cumulative number of migration days anticipated to occur over the remainder of the ITP term. The take estimates are conservative in that they are based on the "worst case" 30-year periods of the Reservoir Planning Model or the historic Tonto Creek gage data and include an additional allowance for uncertainty based on the standard deviation of the mean estimates for all 30-year periods in these datasets. SRP does not anticipate that the estimated amount of incidental take will be exceeded.

SRP will ensure that authorized take is not exceeded by:

1. monitoring the actual changes in available habitat acres and the actual number of migration days that occur each year of the ITP term;
2. debiting these amounts from the authorized cumulative totals on an annual basis in a running ledger of authorized, actual, and remaining take;
3. reporting the ledger to the FWS each year with the RHCP annual report; and
4. establishing triggers for reengaging with the FWS on an amendment to the RHCP and ITP if the remaining amount of take reaches a certain level (i.e., Changed Circumstances).

The following subchapters provide more detail for how SRP will monitor and report take in the CS and FCS, and take along lower Tonto Creek.

1. Monitoring Changes in Habitat Availability in the Conservation Space and Flood Control Space

Estimates of take in the CS and FCS rely on two key field conditions: the Roosevelt Lake elevation and the location and extent of visible surface water along the Tonto Creek channel above the lake but below the 2,175-foot amsl elevation contour. Together, these field conditions generate estimates of available gartersnake habitat for a given year. To monitor changes in habitat availability each year of the remaining ITP term, SRP will perform the following:

1. **Document the elevation of Roosevelt Lake on June 30 of each year.** The lake elevation on June 30 establishes the aquatic edge for lake fringe habitat in the CS. If the lake elevation exceeds 2,151 feet amsl on June 30, then SRP will document that flood control operations are in progress and use 2,151 feet amsl as the lake elevation for the purpose of estimating habitat availability in the CS that year.

2. **Document the maximum elevation of Roosevelt Lake in each month with flood control operations**. The maximum monthly lake elevation during flood control operations, whether under current procedures or under the planned deviation, determines how much gartersnake habitat in the FCS is made temporarily unavailable for use due to inundation.
3. **Delineate the extent of visible surface water in the Tonto Arm above Roosevelt Lake each year between June 1 and June 30**. SRP may use publicly or commercially produced aerial imagery or produce its own aerial imagery for this purpose. The quality of the imagery should be comparable to or better than the 2017 NAIP imagery standards (U.S. Department of Agriculture 2017). SRP may use either visual image interpretation or software-aided processes to delineate visible surface water. SRP will delineate visible surface water between the elevation of the lake and the top of the FCS at 2,175 feet amsl. The specific methods used to delineate visible surface water may change over time as available and practical tools and data sources change. However, SRP will ensure that the method used produces results that are comparable to or better than those described in SWCA (2022b [see Appendix H]).
4. **Estimate gartersnake habitat in the CS and FCS each year**. SRP will apply the 94-m distance-to-water finding to the June 30 lake elevation contour (limited to the Tonto Arm) and the boundary of June visible surface water along Tonto Creek to estimate the amount of gartersnake habitat in the CS and FCS. SRP will extract from this estimate any areas that are unsuitable for use by gartersnakes, consistent with the methods described in Subchapter 4.B. If the lake elevation on June 30 is at or above 2,151 feet amsl, then SRP will assume that the amount of available gartersnake habitat in the CS is 105.5 acres (see discussion in Subchapter 4.B regarding habitat availability when the lake is temporarily full). The 94-m distance-to-water finding is not applied to the lake elevation contour when it is at or above 2,151 feet amsl (i.e., gartersnake habitat in the FCS is estimated from the visible surface water only because of the rapid evacuation of water from FCS).
5. **Determine the Year-to-Year Change in Habitat Availability in the CS**. SRP will calculate the change in gartersnake habitat availability in the CS each year as compared to the prior year's calculation. A negative change (i.e., a reduction) in habitat availability represents incidental take of the gartersnake in the CS from conservation storage operations.
6. **Determine the Monthly Reductions in Habitat Availability in the FCS**. SRP will calculate how much gartersnake habitat in the FCS was inundated by the lake in each month with flood control operations. The amount of gartersnake habitat in the FCS that is below the monthly maximum lake elevation contour will determine how much of the gartersnake habitat is made temporarily unavailable in a given month (i.e., the metric for incidental take in the FCS).
   SRP will combine the monthly estimates of reduced habitat availability for a given year to produce an annual total and divide the annual total by 12 months to convert the total from acre-months to acre-years. This unit conversion is needed to facilitate consistent comparison with the accounting of take in the CS. For the purpose of this assessment, years will begin on July 1 to conform with the timeline for producing updated habitat estimates.
7. **Update the Take Ledger and Check for Changed Circumstances**. SRP will update the take ledger each year to debit the acre-years of take observed in the CS and FCS during the prior year from the remaining total acre-years of take authorization. SRP will update the ledger based on years that begin on July 1 and run through June 30. SRP will confirm that the remaining balance of take authorization after each update remains below the threshold for Changed Circumstances (see Chapter 7) or notify the FWS that there has been a Changed Circumstance triggering initiation of a new amendment process to increase the amount of take authorization.

8. **Include the Updated Take Ledger in the Roosevelt Lake HCP Annual Report**. SRP will provide the FWS a copy of the updated take ledger each year with its annual report. SRP will also provide notice of a Changed Circumstance triggering initiation of a new amendment process with the annual report, if the threshold for this Changed Circumstance has been exceeded.

2. Monitoring Migration Days for Lower Tonto Creek

The estimate of take along lower Tonto Creek is expressed in terms of the number of migration days that occur. Migration days are represented by observations of stream flow measured at the USGS stream gage in Tonto Creek above Gun Creek (gage station number 09499000). To monitor how much take occurs in each year of the remaining ITP term and to ensure that authorized take is not exceeded, SRP will perform the following:

1. **Calculate the Average Daily Flow Rate for Each Day between February 1 and May 31**. SRP will obtain the stream gage data for Tonto Creek above Gun Creek (USGS stream gage station number 09499000) for the period between February 1 and May 31 each year of the remaining ITP term. SRP will calculate the average daily flow rate for each day in this time period.
2. **Determine the Number of Migration Days Contributing to Incidental Take that Occur Each Year**. SRP will count the number of days between February 1 and May 31 when the average daily flow in Tonto Creek is between 200 cfs and 1,100 cfs (i.e., days that meet the definition of a migration day). When the number of consecutive migration days in a given year exceeds 5, then SRP will count those 5 days and each migration day that follows for the remainder of the year (through May 31) as a day of take.
3. **Update the Take Ledger and Check for Changed Circumstances**. SRP will update the take ledger each year to debit the number of migration days contributing to incidental take that occurred during the current year from the remaining total number of migration days of take authorization. SRP will update the take ledger for lower Tonto Creek after May 31 each year. SRP will confirm that the remaining balance of take authorization after each update remains below the threshold for Changed Circumstances (see Chapter 7) or notify the FWS that there has been a Changed Circumstance triggering initiation of a new amendment process to increase the amount of take authorization.
4. **Include the Updated Take Ledger in the Roosevelt Lake Habitat Conservation Plan (RHCP) Annual Report**. SRP will provide the FWS a copy of the updated take ledger each year with its annual report. SRP will also provide notice of a Changed Circumstance triggering initiation of a new amendment process with the annual report, if the threshold for this Changed Circumstance has been exceeded.

ii. Monitoring and Reporting Implementation of Conservation Measures

SRP will monitor the implementation of the conservation measures described in Chapter 5 to ensure that it is performing those activities necessary to minimize and mitigate to the maximum extent practicable the impacts of the authorized incidental take.

1. Documenting Implementation of Conservation Measures

SRP will report to the FWS annually its completed conservation measures, to include:

a. SRP will report the number and locations of pools in each mitigation reach or segment that were treated to remove fish and the level of effort applied. For treatments occurring in lower Tonto Creek, SRP will also report if the treated pools are within the FCS or within lower Tonto Creek above the FCS.

b. SRP will report the number and disposition, by species and size class, of fish removed (Ictalurids and Centrarchids) or returned (all other taxa) to each treated pool.

c. SRP will report the locations and number of pools in each mitigation reach or segment where native fish or, separately, lowland leopard frogs were stocked.

d. SRP will report the number, by species and size class, of native fish species or the amount (e.g., size of egg masses, number of tadpoles) of lowland leopard frogs released into each treated pool.

e. SRP will document financial support provided to an FWS-approved entity and dedicated to the establishment or operation of a captive-breeding facility for lowland leopard frogs. SRP will report to FWS how the funds were applied to this purpose.

SRP will additionally report to FWS data or analysis that may inform discussions and decisions about how the conservation measures are applied in future years:

a. SRP will report length frequency histograms to assess the population age structure of the nonnative fish in mitigation areas over time.

b. SRP will report the number of fish removed and effort per pass. Catch will be standardized by pass or by electrofishing seconds to assess changes in relative abundance over time.

c. SRP will report electrofishing catches of native fish species stocked into mitigation areas. The small-bodied fish stocked will not be as easily captured using electrofishing gear as the larger nonnative fish being targeted. However, the species observed and notes on their general abundance will be recorded. These may be used to generally assess whether stocked fish are surviving and retained in the pools over time.

d. SRP will report incidental detections of amphibians at mitigation areas. Observations of amphibians, especially lowland leopard frog, will be recorded whenever encountered during implementation of conservation measures. The locations and timing of these observations may be described and compared to locations and timing of lowland leopard frog stocking.

2. Tracking Conservation Credits

To fully offset the impact of the authorized take of gartersnakes in the CS or FCS, SRP commits to generating at least 5,187.0 acre-years of conservation credit during the remaining ITP term. The amount of conservation credit generated by each conservation measure will be established using the criteria described in Chapter 5. SRP will track and report the generation of conservation credit as follows:

1. SRP will calculate annually the number of gartersnake conservation credits, in acre-years, generated by implementation of conservation measures following the provisions established in Chapter 5.

2. SRP will track the cumulative generation of gartersnake conservation credits in a ledger and compare the cumulative sum to 5-year interim benchmarks that assume an even generation of conservation credit over the 30 years of the remaining ITP term. SRP will include the ledger in the RHCP annual report to FWS.
3. The interim benchmarks are to ensure that mitigation actions are completed in a timely manner and avoid a lag in realized conservation benefits. The 5-year interim benchmarks are:
    a. Year 5: 864.5 acre-years of conservation credit
    b. Year 10: 1,729.0 acre-years of conservation credit
    c. Year 15: 2,593.5 acre-years of conservation credit
    d. Year 20: 3,458.0 acre-years of conservation credit
    e. Year 25: 4,322.5 acre-years of conservation credit
    f. Year 30: 5,187.0 acre-years of conservation credit
4. If the cumulative amount of conservation credit generated by SRP does not meet or exceed the amount specified by an interim benchmark for two consecutive 5-year periods, then a Changed Circumstance will have occurred (see Subchapter 7.C). SRP will notify FWS in the RHCP annual report of the Changed Circumstance.

3. Documenting Achievement of Biological Objectives

SRP's mitigation measures are designed to achieve improvement of habitat conditions for the gartersnake by suppressing nonnative fish predators and increasing the availability of native prey (see Subchapter 5.A). To determine whether these objectives are being achieved, SRP will analyze data collected during nonnative fish suppression and native fish stocking efforts.

During nonnative fish removal efforts, data such as location, fish species, and fish total length will be recorded. Over time, it is anticipated that should nonnative fish removal and native fish stocking efforts be successful, the numbers of nonnative fish will decline and the ratio of nonnative to native fish species will shift. Changes in size classes of nonnative fish may also indicate changes in spawning success and recruitment rates. Documenting these changes over the permit term will serve as the metric for determining whether these mitigation measures are successful in achieving Objectives 1 and 2 (see Subchapter 5.A). After 5 treatment years, data will be analyzed to determine if treatments are deemed successful and will be discussed with the FWS (see Subchapter 6.A.iii).

4. Monitoring Conservation Measures Addressing Impacts of Take in the CS and FCS

SRP will implement conservation measures to generate conservation credit that offsets the impacts of authorized incidental take. The amount of conservation credit generated by each action depends on the type of action, the area benefited by the action, and the duration of that benefit. To fully offset the impact of the authorized take, SRP commits to generating at least 5,187.0 acre-years of conservation credit during the remaining ITP term. The amount of conservation credit generated by each conservation measure will be established using the criteria described in Subchapter 5.B.vii, in coordination with the FWS.

SRP will monitor the generation of conservation credit as follows:

1. Confirm that the number of anticipated conservation credits from approved conservation measures totals at least 5,187.0 acre-years by the end of the remaining ITP term.
    a. SRP will track the anticipated total number of conservation credits generated by each approved conservation measure over the remaining ITP term (e.g., see Table 16 in Subchapter 5.B.vii). The anticipated total number of conservation credits will be compared against the commitment to generate at least 5,187.0 acre-years of conservation credit by the end of the remaining ITP term.
    b. SRP will report to the FWS annually the total acre-years of anticipated conservation credit for approved conservation measures to-date as an indicator of overall progress toward meeting the biological goals and objectives.
    c. If the total anticipated acre-years of conservation credit from approved conservation measures to-date meets or exceeds 5,187.0, then SRP will continue to implement those approved actions contributing to this total but will not be expected to identify or seek approval for new conservation measures for the remainder of the ITP term unless Changed Circumstances apply.
2. Identify whether the delivery of conservation credits is occurring on schedule, or whether additional conservation measures will need to be added.
    a. Every 5 years, SRP will calculate the number of acre-years of conservation credit realized by its completed conservation measures to-date and compare it to the amount that would be generated if the target 5,187.0 acre-years were generated at an even pace over 30 years (i.e., 5,187.0 acre-years / 30 years = 172.9 acre-years per year). This will serve as an indicator of whether mitigation delivery is on schedule.
    b. In calculating realized conservation benefits, SRP will only include the acre-years of conservation credit for years in which a conservation measure has actually been implemented. For example, if in the previous 5-year period, nonnative fish removal occurred in 3 years, native fish stocking happened in 3 years, and lowland leopard frog stocking happened in 0 years (e.g., no frogs were available for stocking this period), then only credit for the years of nonnative fish removal and native fish stocking would be included in the realized conservation credit total.
    c. SRP will calculate the benchmark amount of actual conservation credit needed to keep pace with estimated take as the number of years that have elapsed as of the time of the review (i.e., 5, 10, 15, 20, 25 years) multiplied by the average annual amount of conservation benefit needed to reach 5,187.0 acre-years over 30 years (i.e., 172.9 acre-years). These benchmark values are:
        i. Year 5: 864.5 acre-years of conservation credit
        ii. Year 10: 1,729.0 acre-years of conservation credit
        iii. Year 15: 2,593.5 acre-years of conservation credit
        iv. Year 20: 3,458.0 acre-years of conservation credit
        v. Year 25: 4,322.5 acre-years of conservation credit
    d. If the realized conservation benefits fall short of the benchmarks for conservation credit earned, additional conservation measures will be added or current conservation measures will be expanded (e.g., fish suppression and stocking in additional river mile segments of the Gisela Reach) to address any deficit before the end of the next 5-year check-in. These actions will be approved through regular coordination process (see Subchapter 6.A.iv). If the deficit is not addressed by the end of the next 5-year period, then a Changed

Circumstance will have occurred (see Subchapter 7.C). SRP will implement the measures of this Changed Circumstance to maintain its regulatory assurances.

3. Ensure that conservation measures are being applied in the manner described in Subchapter 5.B to support SRP's biological goals and objectives.
    a. SRP will report to the FWS annually its completed conservation measures. Completed conservation measures are the basis for the award of conservation credit.
        i. SRP will report the number of pools that were treated to remove nonnative fish. Pools treated will be recorded by river mile segment as described in Subchapter 5.B.ii. SRP will also report the number and disposition, by species and size class, of fish removed (Ictalurids and Centrarchids) or returned (all other taxa) to each treated pool.
        ii. SRP will report the number and locations of pools where native species were stocked. Pools treated will be recorded by river mile segment as described in Subchapter 5.B.iii. SRP will also report the number, by species and size class, of native species released into each treated pool.
    b. SRP will additionally collect information during implementation of conservation measures, which may be periodically used to inform discussions and decisions about how the conservation measures are applied in future years. For example:
        i. SRP will record species and total length measurements on the nonnative fish removed in the Gisela Reach. Length frequency histograms will be used to assess the population age structure of the nonnative fish over time.
        ii. SRP will record the number of fish removed and effort per pass. Catch could be standardized by pass or by electrofishing seconds to assess changes in relative abundance over time.
        iii. The small-bodied fish stocked will not be as easily captured using electrofishing gear as the larger nonnative fish being targeted. However, the species observed and notes on their general abundance will be recorded. These may be used to generally assess whether stocked fish are surviving and retained in the pools over time.
        iv. Observations of amphibians, especially lowland leopard frog, will be recorded whenever encountered during conservation work. The locations and timing of these observations may be described and compared to locations and timing of lowland leopard frog stocking.

5. Monitoring Conservation Measures Addressing Impacts of Take along Lower Tonto Creek

SRP will report whether the conservation measures described in Subchapter 5.B were applied, and the outcome of that application (e.g., number and percentage of pools treated and number and percentage of pools stocked by reach).

1. **Calculate the number and percentage of pools treated to remove nonnative fish.** SRP will report the number and percentage of pools that were treated to remove nonnative fish. Pools treated will be recorded by reach as described in Subchapter 5.B.ii. SRP will also report the number and disposition, by species and size class, of nonnative fish encountered in each treated pool.

2. **Calculate number of pools where native species were stocked.** SRP will report the number and percentage of pools that were treated to stock native species in pools where nonnative fish were removed. Pools treated will be recorded by reach as described in Subchapter 5.b.iii. SRP will also report the number, by species and size class, of native species released into each treated pool.

iii. Effectiveness Monitoring and Adaptive Management

SRP intends that adaptive management will apply to the implementation of its approved conservation measures so that effective and efficient conservation benefit is achieved. As SRP's covered activities are expected to continue for the foreseeable future, SRP will also contribute to monitoring and research that will help address uncertainties and data gaps important to preparing an ITP renewal or amendment for a future permit term. This monitoring and research also fulfill a purpose of adaptive management.

This addendum is intended to provide flexibility in the implementation of gartersnake conservation measures through the remaining life of the ITP. An adaptive management approach is intended to support frequent review and feedback on the progress of conservation measures implemented. Adaptive management greatly increases the potential for conservation success by providing early detection of problems and the opportunity to implement remedial actions to address these problems. Effective monitoring is an essential element of adaptive management because it provides reliable feedback on the effects of conservation measures. Based on the monitoring results, and through annual reports and meetings, SRP and FWS will be able to determine how well their actions are meeting the goals and objectives of the addendum, and what steps may be taken to modify activities to increase success.

SRP identified adaptive management alternatives for the following situations, which would require revisions to the conservation measures described in Subchapter 5.B.

1. **A qualified and FWS-approved organization is not identified to propagate lowland leopard frogs for SRP to stock.**

   SRP will make a good-faith effort to implement the conservation measures for propagation and stocking of lowland leopard frogs. However, should this situation occur, the conservation measures associated with the lowland leopard frog breeding facility and lowland leopard frog stocking will be removed from the conservation program. Through the coordination process described in Subchapter 6.A.iv, additional conservation measures or an expansion of current conservation measures (e.g., fish suppression and stocking in additional river mile segments of the Gisela Reach) will be selected. The number and size of the actions will be scaled to offset the loss of planned conservation credits to be generated by breeding and stocking frogs.

2. **Sustained flooding or perennial flows make the pools dangerous or unsuitable for treatment in a planned conservation measure year.**

   Should this occur, the conservation measures will be applied in the next year with safe access and discrete pool formation. If conservation measures are not applied in 2 of 3 years, the frequency or number of conservation measures planned over the next several years may need to increase to keep the conservation credit generated on schedule with the credit benchmarks defined in Subchapter 6.A.ii.2.

3. **The electrofishing gear is not effective for fish removal for the species or habitat encountered.**

   If the species targeted for removal (i.e., fish in the Centrarchidae and Ictaluridae families) are not readily captured using electrofishing, other gear types may be considered. Alternative gear types may include, but are not limited to, seine nets or baited hoop nets.

4. **The pools to be treated are not practicably or legally accessible.**[15]

   SRP and FWS identified two alternative locations where habitat could be enhanced for conservation credit using the proposed conservation measures. See descriptions of the alternative locations below. The number, size, and timing of the actions will be scaled to meet the credit generation benchmarks set in Subchapter 6.A.ii.2.

1. Effectiveness Monitoring at Gisela Reach and Alternate Conservation Sites

In Subchapter 5.A, SRP states the biological goal and objectives of the mitigation activities, which are 1) to reduce the deleterious effects of nonnative predatory fish on gartersnakes, and 2) to increase the availability of native prey—specifically native fishes and the lowland leopard frog—thereby improving conditions that support gartersnakes in lower Tonto Creek. SRP proposes to evaluate the effectiveness of its mitigation activities in a two-step approach that will be implemented in the reach of Tonto Creek below Gisela where nonnative fish removal and restocking efforts will occur.

The two-step approach will include the following:

1. Coincident with SRP's nonnative fish removal efforts, SRP will collect detailed fish species assemblage data (species, numbers, size distribution) in all pools where nonnative fish removal activities occur (see Subchapter 6.A.ii); and
2. SRP will conduct a baseline gartersnake trapping survey in the Gisela Reach in June 2024 and will repeat the trapping surveys in 1 out of every 3 years on average for the term of the permit. Surveys will consist of deployment of 100 Gee-style minnow traps for a period of 4.5 days (approximately 108 hours of sampling per trap, or an equivalent of 108-person search hours). SRP may choose to deploy pit tags on captured gartersnakes to assist with monitoring efforts. SRP may, with FWS consideration and approval, use alternative methods for monitoring the baseline status of gartersnakes at Gisela Reach, such as eDNA, fecal DNA, or other advanced technologies (Owens et al. 2023).

It is anticipated that, over time, nonnative fish removal and native stocking efforts will create a shift in the fish assemblage data toward a greater prevalence of native prey items, which would represent improvement in an important habitat component for the gartersnake and, although the species is cryptic, periodic trapping surveys may provide additional information that would support the determination that the mitigation activities are proving to be effective in meeting the stated objectives.

SRP may elect to implement conservation measures in one or both of these alternative locations after SRP assesses the first 5 years of mitigation activities on Tonto Creek near Gisela. After working with the FWS, SRP may elect to implement conservation measures in one or both of the alternative locations described below (Figure 36). Mitigation activities conducted in these areas could be in lieu of or in tandem with activities in the Gisela Reach of Tonto Creek as needed to generate sufficient mitigation credits to offset take (see Subchapter 5.C). The alternative locations are:

1. San Pedro River and Babocomari River within the San Pedro Riparian National Conservation Area (benefitting up to 5,237.8 acres of gartersnake critical habitat)
2. Santa Cruz River within the San Rafael State Natural Area (benefitting up to 110.8 acres of gartersnake critical habitat)

[15] Includes SRP's ability to obtain the necessary state or federal permits to access sites or conduct fish removal or stocking actions.

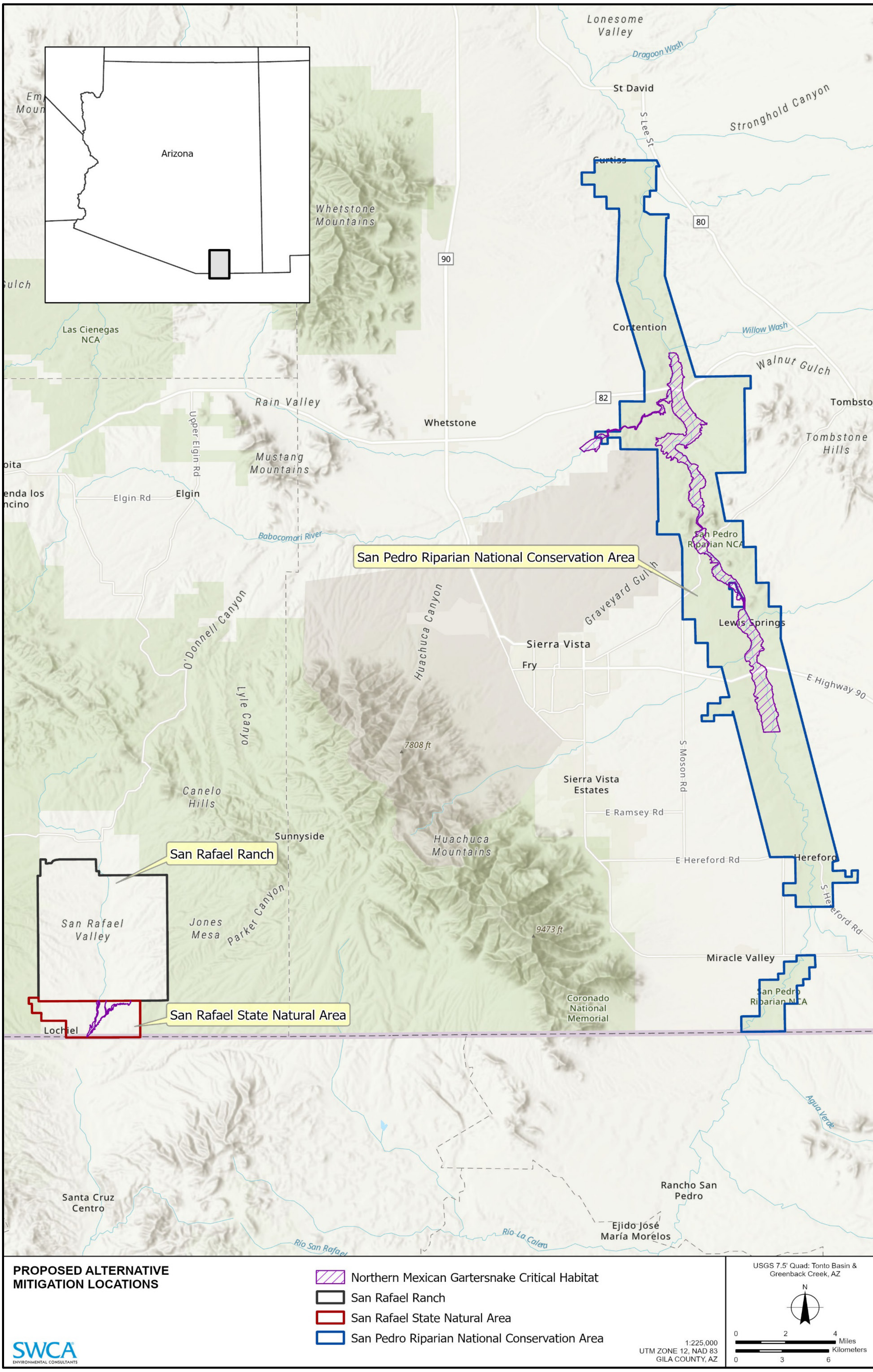

Figure 36. Alternative locations where nonnative fish removal and prey stocking conservation measures may be applied to generate conservation credit under the gartersnake conservation program.

2. Effectiveness Monitoring in Lower Tonto Creek

The same information that SRP reports to track implementation of actions to suppress nonnative fish and stock native fish and frogs will also be provide data to monitor the effectiveness of the conservation program at shifting the species composition toward a more native assemblage. For example, the number of nonnative fish removed from pools at the specified level of effort is a demonstration of the implementation of the conservation measure and an index of how many fish are present and available to be removed. The collection of species data during suppression activities will also provide information about the relative abundance of native species in treated areas.

In addition, SRP will contribute $150,000 (in 2022 dollars)[16] over the term of the permit to fund periodic gartersnake presence/absence surveys, or alternatively, other research opportunities to further the understanding of the status of the species and its habitats on lower Tonto Creek. SRP will prioritize the application of these funds toward presence/absence surveys of gartersnakes along lower Tonto Creek. The methods for such surveys will be determined in collaboration with FWS. In coordination with FWS, SRP may apply these funds to other studies, such as those shown in Table 17. SRP will also seek input from other state natural resources agencies and/or academic institutions in making decisions about funding for other research opportunities.

3. Effectiveness Monitoring for Frog Stocking

SRP will perform monitoring of the anuran (i.e., frog) populations at the Gisela Reach and the lower Tonto Creek portion of the permit area above the FCS. This monitoring will occur at a frequency of at least once every 3 years, with the intent to collect long-term data on species composition and relative abundance (using indices of abundance such as call detections per unit of survey effort or other indirect measures of abundance) of the anuran community at these mitigation locations. Specific methods for this monitoring will prioritize passive detection (e.g., passive acoustic monitoring) or environmental detection (e.g., eDNA) methods and will be determined in coordination with FWS. Any changes to monitoring methods or level of effort will consider the impact on the continuity of the long-term dataset and seek to maintain consistency and compatibility over time.

4. Other Research for Addressing Data Gaps

The activities covered by the RHCP, including this addendum, are expected to continue beyond the remaining ITP term. SRP anticipates that renewal or amendment of the current ITP will be needed in the future. SRP has identified gaps in the current body of best available information that are relevant to better understanding the effects of the covered activities on the gartersnake (see Table 17). As described in more detail below, SRP will assist the FWS and AGFD with monitoring and other studies to collect information during the remaining ITP term that will help inform a future ITP renewal or amendment. These efforts may be considered for conservation credit on a case-by-case basis when other contemplated actions are demonstrated to be impractical. New information on the gartersnake in the permit area may provide insight for more precisely estimating incidental take, the impacts of take, and the effectiveness of conservation measures. In this way, SRP will contribute to the adaptive management of the species.

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[16] SRP intends to spend these funds in increments of approximately $25,000 (in 2022 dollars) on 5-year intervals for the remainder of the ITP term. This amount is consistent with SRP's spending on similar gartersnake monitoring implemented under SRP's ESA Section 10(a)(1)(A) Recovery Permit (Permit Number ES62371D-1). Applying the average annual inflation rate over the last 30 years (about 2.34%, based on the average annual inflation rate between 1993 and 2022 reported by the U.S. Bureau of Labor Statistics), the inflation-adjusted value of $25,000 spent in Year 5 of the amendment period will be $28,065, in Year 10 will be $31,506, in Year 15 will be $35,369, in Year 20 will be $39,705, in Year 25 will be $44,573, and in Year 30 will be $50,038. The total inflation-adjusted value of the dollars spent by SRP on this type of monitoring will not exceed $229,256 (i.e., the sum of the inflation-adjusted spending increments).

Table 17. Sources of uncertainty and information needs related to the gartersnake in the permit area and the covered activities.

Information Category	Information Needs
Current distribution/status of species	Presence/absence surveys within the permit area
Predator/Competitors	Monitoring of nonnative fish in Tonto Arm pools
Prey community	Continue gartersnake diet studies (include areas where native species are stocked, do gartersnakes shift diet?)
Predator/Competitors	Study impacts of nonnative predators using quantitative approaches, such as fecal DNA analysis (see Owens et al. 2023)
Habitat	Study impacts of nonnative vegetation removal and/or supplemental planting of native vegetation on herpetofauna community
Habitat	Study of artificial brumation sites (do snakes use artificial brumation sites provided when natural brumation sites are inundated?)
Habitat	Study of artificial aquatic refugia created for snakes (assuming these are located where snakes are present, do snakes and/or aquatic prey [lowland leopard frog] start using these artificial ponds/pools/wetlands?)

SRP will ensure that all data and findings generated from these adaptive management commitments will be shared with the FWS and the AGFD.

iv. Annual Coordination with FWS

Through this conservation program, SRP will fully offset the impacts of take estimated for the gartersnake in the CS and FCS, as described in Chapter 4 of this addendum (5,187.0 acre-years [see Table 13]). This approach satisfies the requirements of an HCP and gives SRP needed predictability for mitigation planning. However, it should be noted that several conservative assumptions were made in the process of estimating the impacts of take. As a result, SRP's commitment to offset the estimated 5,187.0 acre-year impact is likely to result in over-mitigation for the actual impacts of take. Mitigation will occur before or concurrent with the taking, to the extent practicable. SRP is motivated to implement conservation measures on a timely and ongoing basis to prevent a Changed Circumstance that would trigger additional mitigation obligations.

SRP hosts an annual coordination meeting on or before November 30 of each year to support implementation of the RHCP (see Subchapter IV.E.3 of the original RHCP). Invited attendees will include representatives from SRP, FWS, U.S. Forest Service, AGFD, and Reclamation, as relevant. Implementation of this conservation program for the gartersnake will be added as a discussion topic to that standing meeting. During the annual coordination meeting, the group will do the following:

- Review the past year's information. SRP will prepare annual reports of RHCP activities, which will be provided to the meeting attendees in advance of the meeting.
- Make decisions for the upcoming year regarding implementation of ongoing conservation measures, informed by data collected during nonnative fish removal and native fish/frog stocking efforts and adaptive management measures (see Subchapter 6.A.iii).
- Discuss the general status of RHCP implementation. SRP will estimate the conservation credit generated and seek concurrence from the FWS that the actions completed warrant credit as estimated per the expectations for mitigation credit described in Subchapter 5.B.vii.

- Earned conservation credit to-date will be compared to credit generation interim benchmarks per the process defined in Subchapter 6.A.ii.2 to determine if mitigation is being delivered on schedule or if Changed Circumstances (see Subchapter 7.C) apply. SRP will provide any updates to its planned mitigation approach at this time.
- Make decisions regarding conservation and monitoring activities to be implemented in the upcoming year.

B. Bald Eagle

The original RHCP already provides for the monitoring necessary to track incidental take of the bald eagle for the remainder of the ITP term by supporting nest monitors at Modified Roosevelt, a Forest Protection Officer, and helicopter flights with AGFD's Eagle Management Program. The nest monitors, Forest Protection Officer, and AGFD will identify instances of drowned fledglings and destroyed nests in the CS or FCS, and collect information on nest productivity for eagle breeding areas relying on Roosevelt Lake. SRP maintains records of daily lake elevations. SRP will continue to report annually to FWS those events that represent instances of incidental take of bald eagles at Modified Roosevelt (i.e., see Table 14).

SRP will coordinate with the FWS following the destruction or abandonment of a bald eagle nest in the CS or FCS to determine the likely proximate cause and whether the event is a take under the original RHCP.

Chapter 7. Changed Circumstances

SRP identifies the following Changed Circumstances that may occur over the remaining ITP term and the responsive actions required of SRP to address each Changed Circumstance. These additional Changed Circumstances are specific to the gartersnake and are in addition to the Changed Circumstances already identified in the original RHCP (SRP 2002). Discussions with the FWS regarding Changed Circumstances are ongoing and others may be added.

A. Gartersnake Detections in the Salt Arm of the Permit Area

Gartersnake occupancy of the permit area has only been demonstrated in the Tonto Arm and along lower Tonto Creek. The gartersnake has not been detected in the Salt Arm of the permit area and incidental take of the gartersnake from SRP covered activities is not reasonably certain to occur in the Salt Arm. However, if a credible detection of the gartersnake in the Salt Arm of the permit area is reported to the FWS, then a Changed Circumstance will have occurred.

Upon receiving notice from the FWS that this Changed Circumstance has occurred, SRP will seek to amend the RHCP and ITP to account for any additional take of gartersnakes in that part of the permit area. To the maximum extent practicable, the estimation of take, the impacts of this take, and the crediting of conservation measures will follow the methods and assumptions described for the gartersnake in this addendum. SRP anticipates that additional field investigations will be necessary to determine the extent to which gartersnakes occupy or are likely to occupy the Salt Arm, test whether the assumptions of the Tonto Arm take metrics are relevant and reasonably applicable to the Salt Arm, and identify conservation measures appropriate to the Salt Arm. SRP will begin coordinating with FWS to design such field studies and begin implementing them as soon as practicable, with the intent that any field studies would begin in the gartersnake active season following the triggering event for this Changed Circumstance. If an amendment is warranted, SRP intends to complete an amendment application within 3 years of the triggering event. SRP acknowledges that the FWS will apply then-current regulations and policies to the evaluation of any such proposed amendment.

Once this Changed Circumstance has been triggered and while the amendment process is underway, SRP will address incidental take of gartersnakes in the Salt Arm in the following manner:

1. The area within 94 m of each credible gartersnake detection will be considered occupied habitat for the limited and temporary purposes of this Changed Circumstance only. The FWS will provide the location of each credible gartersnake detection in the Salt Arm to SRP on or before June 30 in a given year for these detections to be considered. Detections provided to SRP after June 30 will be considered in the following year's accounting. Multiple detections of the same individual will be considered independently for the purposes of this Changed Circumstance (i.e., each detection will generate a 94-m buffer of occupied habitat) and the combined extent of all such buffers will constitute the extent of occupied habitat for the purpose of estimating take.
2. The portion of this occupied habitat that is below the lake elevation as of June 30 each year will represent an instance of incidental take and the acres of occupied habitat inundated by the lake on June 30 will be the amount of the taking that year, specific to the Salt Arm.
3. The amount of take in the Salt Arm will be covered by and debited from SRP's authorization for take in the Tonto Arm of the CS and FCS until the amendment for the Salt Arm is approved or SRP exhausts its total amount of take authorization. However, SRP believes the latter circumstance is highly unlikely to occur, given the conservative nature of its take estimate for the Tonto Arm of the CS and FCS.

4. Because SRP will be relying on its existing take authorization for the expected limited duration of this Changed Circumstance, additional mitigation for that interim period is not warranted. If SRP does not complete an amendment application within 3 years of the triggering event, SRP will increase by 5% the amount of mitigation it must achieve to offset the impacts of take that occurs on the Salt Arm after year 3. For example, in year 4 after triggering this Changed Circumstance, SRP will multiply the amount of take in the Salt Arm during year 4 (using the interim metric) by 5% and will implement additional conservation measures to offset this incremental increase, in addition to the offset needed to address the actual acre-years of take. Until an amended permit is issued, SRP will continue to estimate take on the Salt Arm using the methods described in this Changed Circumstance.

If, after considering the best available information, SRP determines that its covered activities do not cause take of gartersnakes on the Salt Arm, it will notify the FWS. In such instance, this Changed Circumstance would conclude without the completion of an amendment application.

B. Actual Take Approaches the Authorized Take Limits (Gartersnake and Bald Eagle)

SRP believes that it has conservatively estimated the amount of anticipated incidental take of the gartersnake and the bald eagle for the remainder of the ITP term and that actual takings are unlikely to exceed the authorized amounts. To avoid an unexpected shortage of incidental take authorization before the expiration date of the ITP, SRP will trigger this Changed Circumstance when the remaining amount of authorized incidental take for either of these two species reaches the limits described below.

For the gartersnake, SRP will trigger this Changed Circumstance when the remaining amount of authorized incidental take reaches either 457.2 acre-years or 151 migration days. These thresholds represent the sum of 5 average years of incidental take (i.e., [2,742.9 acre-years of cumulative take / 30 years] × 5 years = 457.2 acre-years; [906 migration days of cumulative take / 30 years] × 5 years = 151 migration days).

For the bald eagle, SRP will trigger this Changed Circumstance when the remaining amount of authorized incidental take reaches two drowned fledglings, 30 destroyed nests, or three reduced foraging events.

If any of these thresholds are triggered, SRP will notify the FWS and begin the process for seeking additional incidental take authorization for the respective species. This process could include an amendment of its current permit or a new permit. The HCP Handbook contemplates that a typical time for completing an HCP process with a National Environmental Policy Act (NEPA) analysis at the level of an Environmental Assessment (i.e., the type of process applied to this addendum) is 2 years (FWS and NMFS 2016:2-11). SRP believes that triggering this Changed Circumstance with 5 average years of remaining take authorization for the gartersnake is reasonable for completing an amendment for its ongoing covered activities without exceeding actual authorizations. Likewise, SRP believes that the thresholds set for the bald eagle are sufficient for being able to complete an ITP amendment, given that drowned juveniles and reduced foraging events are likely to be rare events and five destroyed nests (equivalent to one destroyed nest per year) exceeds the historic observations of destroyed nests at Modified Roosevelt over recent decades.

C. Mitigation Lags Take in the CS and FCS

As described in Subchapter 6.A.ii.2, SRP will identify whether the amount of actual conservation benefit achieved (measured in acre-years of completed conservation measure) has substantially lagged behind the pace of anticipated takings. If SRP's implementation of mitigation has substantially lagged behind the anticipated pace of take in two consecutive 5-year periods, then this Changed Circumstance will have occurred. SRP will provide notice to FWS with its annual report if this Changed Circumstance is triggered.

In response to this Changed Circumstance, SRP will increase its total conservation obligation by 5% following each consecutive missed benchmark. For example, if SRP fails to generate 864.5 acre-years of conservation by Year 5 and fails to generate 1,729.0 acre-years by Year 10, then it will increase the total conservation obligation required by the end of the permit term to 5,446.4 acre-years (i.e., 5,187.0 acre-years × 1.05 = 5,446.4 acre-years). If it fails to generate 2,593.5 acre-years of conservation credit by Year 15, the total conservation obligation will increase by another 5% to 5,718.7 acre-years (i.e., 5,446.4 acre-years × 1.05 = 5,718.7 acre-years). The additional mitigation will offset the lag in expected conservation benefits over the term of the permit.

To generate more conservation credit, SRP may, for example, implement conservation measures in more reaches or segments of Tonto Creek than required by Chapter 5 or may stock both fish and frogs in a treated pool following suppression. When responding to this Changed Circumstance, SRP will coordinate annually with the FWS to help identify any other practicable conservation opportunities that could generate the requisite shortfall of credits and also stay on target for meeting the next 5-year benchmark and any modified total obligation. SRP and FWS will consider all reasonable means for generating these conservation credits, including actions that might generate credit on a case-by-case basis.

D. Gartersnake Extirpation from a Mitigation Reach

At the time of this addendum, FWS considered the Gisela Reach and its alternatives and the lower Tonto Creek permit area upstream of the FCS to be occupied by the gartersnake (FWS 2013a, 2020a, 2021c, 2021d; Holycross et al. 2006; Jones et al. 2020; Nowak et al. 2019; Rosen et al. 2001). SRP has proposed to implement conservation measures in these stream reaches to benefit the gartersnake and mitigate for the impacts of incidental take. It is possible, albeit unlikely, that FWS will determine that the gartersnake no longer occurs along one or more of these stream reaches.

Such a determination by FWS will constitute a Changed Circumstance that would make continued application of nonnative fish suppression and native prey stocking in an extirpated reach ineffective as a gartersnake conservation measure. This Changed Circumstance will be triggered by notification from FWS to SRP that it has determined, based on the best available information, that the gartersnake is extirpated from either the Gisela Reach and the Gisela Reach alternatives (such that there are no remaining identified alternatives) or the lower Tonto Creek permit area extension upstream of the FCS.

In response to this Changed Circumstance affecting the Gisela Reach and its alternatives, SRP and FWS will coordinate as soon as practicable to identify a mutually agreeable alternative location that is occupied by the gartersnake to implement gartersnake conservation measures. Preference will be given to alternative locations that are designated critical habitat for the gartersnake. Secondarily, preference will be given to alternative locations that are closer to the Tonto Creek population of the gartersnake, although alternative locations need not be designated critical habitat or within the Tonto Creek drainage.
The implementation and crediting of conservation measures in an alternative location will follow the applicable provisions of Chapter 5 (i.e., SRP will implement the same types of conservation measures with the same level of effort and the same expectations for conservation crediting in the new location).

In response to this Changed Circumstance affecting the lower Tonto Creek extension of the permit area, SRP may discontinue conservation measures in the lower Tonto Creek permit area extension. Identification of an alternative location for these mitigation activities will not be required. If the gartersnake becomes extirpated from this reach, then take outside of the CS and FCS by nonnative fish would no longer occur and continued mitigation would not be warranted. SRP would complete any mitigation for take that had previously occurred in lower Tonto Creek. SRP will notify FWS if it decides to take this responsive action.

Chapter 8. Budget Estimates

A. SRP Management and Coordination

SRP will fund a three-quarter-time staff position in its Environmental Services Department to manage and coordinate implementation of the mitigation and monitoring measures for the gartersnake. The person filling this position will be required to have previous experience with management of biological resource issues. The primary responsibility for this staff position will be to ensure that the obligations are fully implemented, including all adaptive management, monitoring, and reporting measures.

B. Budget

SRP fully commits to ensure that adequate funding will be provided to meet all of its obligations under the RHCP amendment. Cost estimates based on currently available information are outlined in this subchapter. SRP's funding methods and assurances are specified in the existing Implementing Agreement (see Appendix O).

SRP will ensure adequate funding of activities in support of mitigation and monitoring efforts, including providing funds to: remove nonnative fish and stock native prey species in pools on lower Tonto Creek and upper Tonto Creek (Gisela Reach); support native prey hatchery operations; investigate the feasibility of and potentially develop a lowland leopard frog propagation facility; monitor effectiveness of mitigation efforts; and hire and maintain staff to implement these measures.

All costs (Table 18) are estimated based on 2022 dollars. Total costs for a permit term of 30 years have not yet been adjusted for inflation.

Table 18. Budget summary.

Activity	% Permit Years	Annual Average Cost	Total Cost
Nonnative Fish Removal and Native Fish Stocking Efforts (Gisela Reach)*	67%	$21,666	$650,000
Nonnative Fish Removal and Native Fish Stocking Efforts (lower Tonto Creek)*	75%	$19,650	$442,125
Fish Hatchery Annual Rearing Operations and Maintenance	100%	$30,000	$900,000
Frog Propagation Facility Upfront Cost			$625,000
Frog Hatchery Annual Rearing, Stocking, Operations and Maintenance†	83%	$15,000	$373,500
Effectiveness Monitoring – Gisela Reach	30%	$8,333	$74,997
Effectiveness Monitoring – Lower Tonto Creek	75%	$5,000	$112,500
Effectiveness Monitoring – Frog Stocking	50%	$1,250	$18,750
Presence/Absence Surveys and other Research			$150,000
Permit Compliance Monitoring	100%	$8,333	$250,000
SRP Permit Implementation Staffing (3/4-time position)	100%	$147,675	$4,430,250
Subtotal		*$256,907*	*$8,027,122*
20% Contingency		$51,381	$1,605,424
Total		**$308,288**	**$9,632,546**

Note: Costs calculated in 2022 dollars, not adjusted for inflation.

* Stocking will not occur in every year but will be coordinated with fish removal efforts.

† Frog stocking will not occur every year but will be stocked in appropriate pool habitats on a periodic basis.

During the first 5 years following approval of the permit amendment, SRP will include funds in its annual budget to minimize, mitigate, and monitor impacts from the taking of covered species and to implement the permit. Funding requirements in these early years will include establishing baseline conditions of pools and species composition within Tonto Creek, assessing the feasibility of establishing a facility for the propagation of lowland leopard frogs, as well as annual management and mitigation activity expenses. No later than 5 years after the permit amendment is approved, SRP shall ensure that permanent funding is available to meet its continuing obligations. Unless other methods of assuring permanent funding are selected by SRP, principal will be placed in a non-wasting account designated solely for that purpose. The account will be in the form of a separate trust account that has already been established for the RHCP. Principal in the account will be of an amount to generate annual cash flow sufficient to satisfy SRP's continuing obligations under the RHCP, as agreed to by the FWS and SRP. While accounts are held or managed by SRP during the term of the permit: 1) SRP will supplement the principal in the accounts if income from the accounts falls below the annual cash-flow requirement; and 2) SRP may withdraw excess principal if the principal in the accounts exceeds the amount required to generate income to pay annual expenses.

The cost estimates provided in this chapter are based on the best data and information available at this time. SRP commits to fully meeting the actual costs of implementing the RHCP regardless of whether those actual costs exceed these estimates.

Chapter 9. Alternatives to the Taking

To avoid, with reasonable certainty, any incidental take of the gartersnake associated with SRP's covered activities at Modified Roosevelt (including conservation storage, current flood control operations, and the planned deviation) such that an amendment to the original RHCP and ITP would not be necessary, SRP anticipates that it would need to take the following actions (more fully described in Appendix L as the "No Action" alternative):

1. Alter how Modified Roosevelt is operated for conservation storage and flood control in that:
    a. SRP would seek to avoid incidental take of gartersnakes and work with FWS to develop and implement a long-term ESA compliance solution as quickly as possible.
    b. SRP believes that to avoid gartersnake take, it would be necessary (to the extent feasible) to maintain the lake elevations at or below the elevation as of June 2023, and avoid any increase in lake elevation thereafter until alternative authorization for gartersnake take is achieved. Roosevelt Lake could decrease in elevation, but once decreased, subsequent rises would be avoided.
    c. Based upon prior ESA compliance efforts at Roosevelt Lake and Horseshoe and Bartlett Reservoirs, SRP anticipates that it could take 1 to 3 years to secure alternative authorization for gartersnake take.
    d. SRP would endeavor to avoid rising lake elevations at Roosevelt Lake, subject to hydrological inputs, physical limitations for releases, and human health and safety considerations, for this limited period (likely less than 3 years) until alternate authorization for gartersnake take was achieved;
2. Implement extensive efforts to remove nonnative fish each year from channel pools on federal lands in lower Tonto Creek (upstream to East del Chi Drive) and stock treated pools with native fish and/or frogs;
3. Coordinate with other agencies on possible future limits on stocking nonnative predatory fish in Roosevelt Lake; and
4. Abandon plans to seek a temporary deviation to current flood control operations.

SRP's conservation storage operations contribute to the incidental taking of gartersnakes in the CS. SRP could alter how it performs conservation storage operations, consistent with the terms of its long-standing agreements with the United States and others, to alter the amount or extent of incidental take of the gartersnake attributable to conservation storage operations. SRP considered alterations to its conservation storage operations in the original RHCP (see Chapter V of the original RHCP) and described in detail why this alternative was rejected. While the specific operational adjustments needed to avoid, with reasonable certainty, the incidental take of gartersnakes from conservation storage and current flood control operations are different from those needed to avoid take of the flycatcher, cuckoo, rail, and bald eagle, the general rationale for rejecting alternate operating rules or priorities still applies. This addendum incorporates the original RHCP's detailed explanation of the reasons why a modification to existing conservation storage operations was rejected as an alternative to the taking.

The "No Permit" alternative considered in the original RHCP contemplated a somewhat different operational change than the scenario described above. Both, however, are a departure from current operations that would adversely affect water supply and hydropower generation by reducing deliveries of water and power to receiving communities and would increase the amount and frequency of downstream flood flows by restricting the amount of water storage. Appendix L describes the anticipated changes to the frequency of potential spill events at Modified Roosevelt and the possible impacts to SRP operations and reservoir spill over Granite Reef Diversion Dam into the lower Salt River under this No Action alternative.

Like the original "No Permit" alternative, the operational changes needed to operate under the No Action alternative would likely bring legal challenges by current users of water and power generated at Modified Roosevelt. The push to cease stocking of predatory nonnative fish at Roosevelt Lake, if successful, would also adversely affect recreational uses of the lake by reducing fish populations. Consistent with the rationale articulated for the "No Permit" alternative of the original RHCP, the operational changes needed to avoid incidental take of the gartersnake under the No Action alternative would not allow Modified Roosevelt to be used for the purposes for which it was built; would generate significant socioeconomic impacts with the reduction of water supply, power generation, and recreation; and expose SRP to legal challenges related to its obligations to deliver water under various water rights and contracts. For these reasons, SRP rejects the operational changes to Modified Roosevelt that would be needed to avoid incidental take of the gartersnake.

This addendum expands the covered activities to include SRP's flood control operations under both current and deviation criteria. Current flood control operations are likely to contribute to the incidental take of the gartersnake in the FCS and altering flood control operations could alter the amount or extent of this take. SRP's current flood control operations within the FCS are performed in accordance with the 1996 Water Control Agreement among the Corps, Reclamation, and SRP, and the WCM issued by the Corps in 1997. SRP's higher priority in conducting flood control operations is to minimize downstream flood damage from the Salt and Verde Rivers. For this reason, modification of the Water Control Agreement or WCM was rejected as an alternative to the taking of gartersnakes from current flood control operations.

SRP is seeking a deviation from the WCM, which is a circumstance contemplated by the WCM. The deviation would result in a small amount of additional take of the gartersnake, flycatcher, and cuckoo from activities and in locations not contemplated in the original RHCP. SRP considered not seeking this additional covered activity but rejected the alternative because growth in water use in the region, combined with likelihood of reductions in availability of Colorado River water resulting from shortage conditions, requires careful management of water supplies available to central Arizona, including spill waters provided by flood events on the Salt River. Increased operational flexibility within the FCS through extension of the evacuation period at certain elevations would allow for increased beneficial use of spill waters when available through direct use or underground recharge. Furthermore, regarding the flycatcher and cuckoo, the existing incidental take authorizations and mitigation are sufficient to address the planned deviation of flood control operations.

SRP identified and reviewed alternatives to the specific formulation of the elements composing the planned deviation (i.e., elevational range, duration of inundation, and period of applicability) (Appendix M). SRP rejected these alternatives since the proposed version of the planned deviation best balances the costs of seeking approval with the potential benefits created by implementation.

Chapter 10. Permit and Implementing Agreement Amendments

SRP proposes amendments to the ITP and the Implementing Agreement that incorporate the changes to the original RHCP described in this addendum (see Appendix N and O, respectively).

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APPENDIX A

Reservoir Planning Model

1 INTRODUCTION

The Salt River Project (SRP) Reservoir Planning Model (RPM) is used for the annual and intra-annual planning of water deliveries to SRP customers and shareholders from SRP's reservoir system depicted in Figure 1. The RPM is used to provide SRP municipal customers with supporting analysis for their state regulatory planning for Assured Water Supply and has been used to evaluate reservoir conditions in partnership studies with the U.S. Bureau of Reclamation (Reclamation), including the Salt and Verde River Reservoir System SECURE Reservoir Operations Pilot Study and the Verde Reservoir Sediment Mitigation Study.

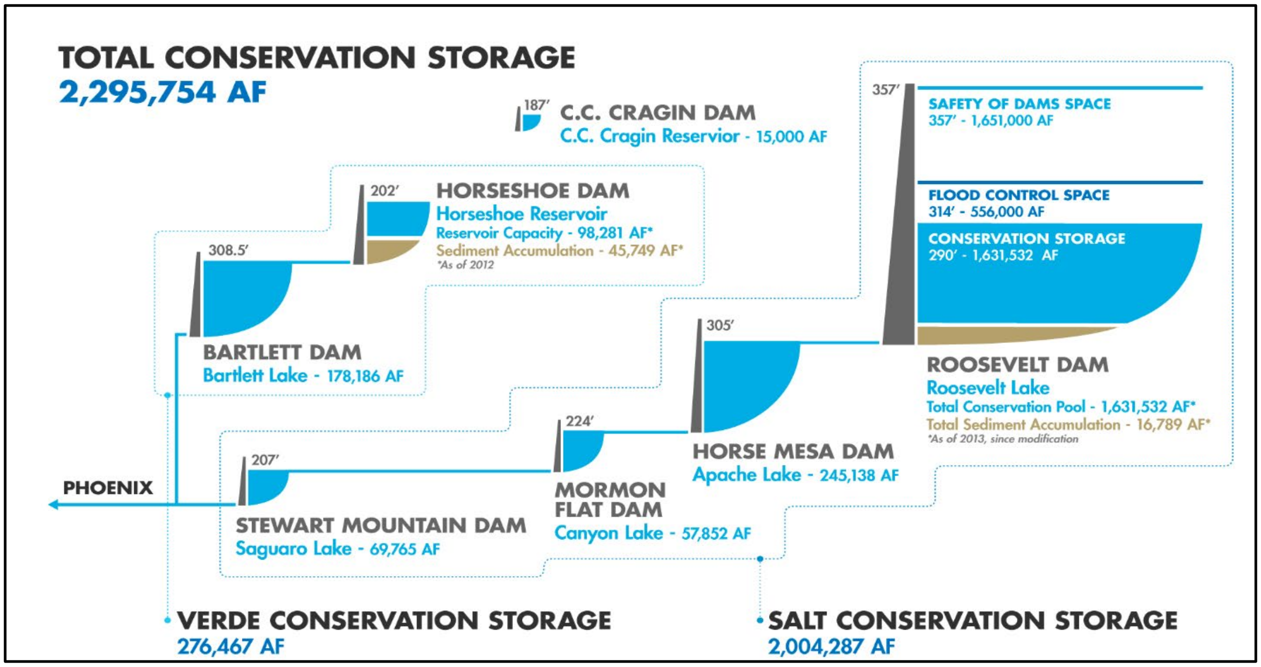

Figure 1. The SRP Reservoir System

The RPM is built on the Operational Analysis and Simulation of Integrated Systems (OASIS) software platform, which has been used for many water planning projects for several states, utilities, and other agencies. The OASIS software that runs the RPM has a proven track record of water supply analysis. The RPM was built to replace SRP's original reservoir planning tool known as SRPSIM in 2017, which was developed as part of CAPSIM for planning of the development of the Central Arizona Project (CAP) in the 1980s. SRPSIM has been used in many planning projects, including compliance activities for the existing Habitat Conservation Plans (HCPs) for the Salt and Verde River reservoir systems.

Section 2 of this document provides further detail on the development and operating logic of the SRP RPM and how it compares to its predecessor model SRPSIM. Section 3 provides detail on the model inputs and assumptions that were used to support the development of the analysis in the Roosevelt HCP Amendment. Section 4 provides a detailed description of the results from the modeling scenarios performed using the SRP RPM to support the Roosevelt HCP Amendment.

2 OVERVIEW OF RESERVOIR PLANNING MODEL

The SRP RPM is operated using the OASIS modeling platform, a water resources modeling platform that uses mass balance and rules to simulate reservoir operations. As a mass balance model, water cannot be created or removed artificially from the SRP Reservoir System (System) in RPM. As shown in Table 1, the OASIS platform is very similar to the Riverware modeling software used by Reclamation to model the Colorado River system reservoirs. OASIS is also very comparable to CalSim, used by the state of California and Reclamation to model combined operations of the State Water Project and federal Central Valley Project with multiple reservoirs and delivery points located on multiple rivers. OASIS and CalSim have the capability to simulate reservoir systems in a way that is consistent with how they are realistically operated.

Table 1. OASIS/RPM modeling software compared to Riverware.

OASIS (RPM) compared to Riverware					
Model	Reservoir system model	Mass balance	Rule based (if/then)	Optimization capability	Observed Hydrology as input
OASIS	✓	✓	✓	✓	✓
Riverware	✓	✓	✓	✓	✓

The OASIS software platform has been used for many water planning projects for several states, utilities, and other agencies. OASIS is the standard for hydrologic modeling in Georgia, Kansas, Tennessee, and North Carolina. It has also been used by New York City, the City of Santa Fe, and several river basin commissions. The United States Army Corps of Engineers approved the use of an OASIS hydrology model in the Falls Lake, North Carolina Integrated Water Supply Reallocation Feasibility Study and Draft Environmental Assessment.

The RPM was created for SRP to aid in short- and long-term operational planning of SRP's water system. The RPM is designed to evaluate SRP's system performance for a given set of demands, operating policies, and facilities given historic inflow record and/or future projections and expectations of inflow.

In 2017, RPM replaced SRP's prior operational planning tool known as SRPSIM. SRPSIM was also a reservoir systems model that used FORTRAN-based code to simulate SRP's reservoir system.
It simulated demands, groundwater pumping, surface water deliveries, and other operations. It was first developed as part of CAPSIM, the model used by the Central Arizona Water Conservation District (CAWCD) and Reclamation to simulate water supply scenarios for the Central Arizona Project in the 1980s. SRPSIM was used in many planning projects, including the modification of Roosevelt Dam, in support of development of SRP's HCPs for Roosevelt and Bartlett-Horseshoe (SRP 2002, 2008).
The RPM uses the same assumptions and methods for modeling the reservoirs as SRPSIM. However, RPM uses modern coding, has a graphical user interface (GUI), and greater ease of use than SRPSIM.
The RPM has been used as SRP's primarily reservoir planning tool since 2017. It is used for the annual and intra-annual planning of water deliveries to SRP customers and shareholders, is used to provide SRP municipal customers with supporting analysis for their state regulatory planning for Assured Water Supply, and has been used to evaluate reservoir conditions in partnership studies with Reclamation, such as the Salt and Verde River Reservoir System SECURE Reservoir Operations Pilot Study and the Verde Reservoirs Sediment Mitigation Study appraisal report (Reclamation 2020, 2021).

RPM has a proven track record of water supply analysis, giving SRP confidence in its use as a reliable and accurate tool for operational planning of SRP's water system. During development, RPM was tested and validated in two different ways. First, emulation runs of RPM and SRPSIM were performed to confirm that the RPM performed at least as well as the original SRPSIM. Discrepancies between the models were either fixed or accepted as being more consistent with actual reservoir and system operations where applicable. Second, verification runs were performed and compared to historic reservoir levels beginning in 1996, the year that current operations were implemented and existing infrastructure complete. The error of the model runs as compared to historic (1996–2018) is 3.5%.

RPM uses a map-based GUI that includes nodes for reservoirs, demands, water contracts, and other points of interest in the System, and arcs that represent means of water conveyance between nodes. The model schematic and GUI is shown in Figure 2.

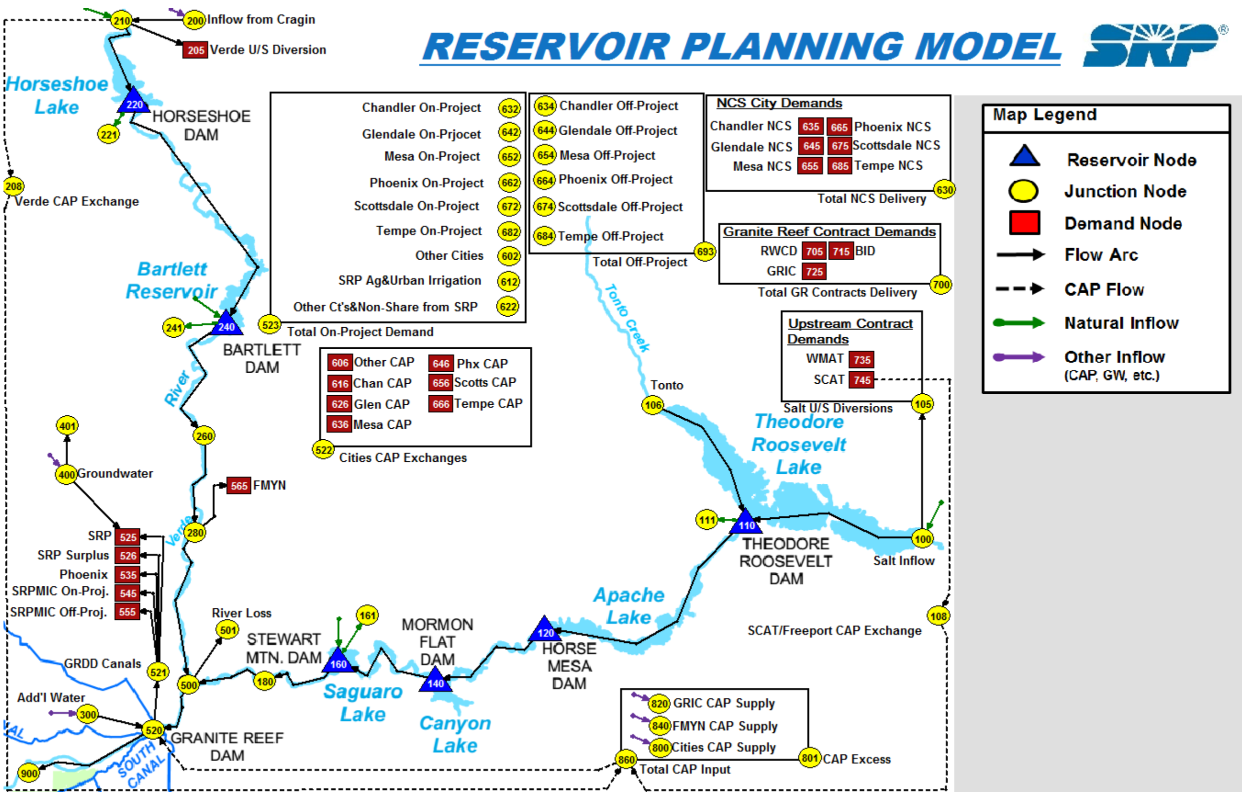

Figure 2. Diagram of the Reservoir Planning Model Graphic User Interface

In total, the model has approximately 80 nodes and 90 connecting arcs. In order to account for inflow and outflow locations for water in the reservoir system, the RPM has six reservoir nodes, 25 withdrawal nodes, 15 on- and off-project demand nodes, and other miscellaneous nodes to account for inflows, minimum flow requirements, reservoir evaporation and seepage, and other points of interest. Consistent with actual water management operations for the three lower Salt River reservoirs, the RPM treats Saguaro, Canyon, and Apache Lakes as a conduit for moving water from Roosevelt Dam to Stewart Mountain Dam for release. Therefore, the three lower Salt River reservoirs are included as a single node in the RPM. For actual operations, these reservoirs are maintained around 95% capacity year-round, because they are hydropower generating facilities; and therefore, fluctuations in reservoir elevation at these three reservoirs are primarily a function of hydropower. Any flood releases made from Roosevelt Dam are matched at the lower Salt Reservoir and are operated as pass-through systems.

Using mass balance and continuity, the RPM routes water through the System using goals and reservoir operations policies and demands on a monthly or daily timestep, as determined for the analysis. Inflow nodes are located upstream of Horseshoe Dam on the Verde River (node 210), and on Tonto Creek and the Salt River (combined at node 100) upstream of Roosevelt Dam. Major delivery nodes are located downstream of each reservoir system. Storage-elevation-area relationships are used at each reservoir to relate volume of inflow and outflow to reservoir storage and surface area. Each reservoir also has an outflow node that accounts for evaporation and seepage at the reservoir. For each timestep, delivery, evaporation, and seepage are pulled from the reservoir system, and inflow is accounted into each reservoir. Change in reservoir storage is determined using the difference between outflow and inflow, and an elevation and surface area value are determined using the storage-elevation-area tables. Operations Control Language (OCL) files use rules typically formulated as if-then statements to implement and control operations described below.

2.1 Reservoir and River Operations

The reservoir operations within the RPM are prioritized for key factors that affect the water availability within the reservoir system. Figure 3 shows the priority of deliveries and operations in the model. Higher priority (further up in Figure 3) gives that operation precedence over all below. Prioritization is performed in the model to ensure the RPM simulates the system. In a manner consistent with actual operations, storage in the reservoirs is prioritized lower than the demands at Granite Reef Diversion Dam; therefore, water will be released to meet demands before storage needs are evaluated. Demands upstream of the reservoirs have higher priority than storage. This prevents upstream delivery shortages. Evaporation, seepage, and river loss are all given higher priority than storage and downstream demands to prioritize counting those physical losses before any operational decisions are made.

The river system (i.e., Salt vs. Verde) used to meet demands is determined depending on reservoir volumes and seasonal timing. Deliveries are typically made from the Verde River in the fall and winter because the Verde River reservoirs have significantly less storage and are drawn down to make room for storage and routing of floodwaters from winter inflow, consistent with actual annual operations for the system. Deliveries are switched over to the Salt River reservoirs in the late spring and summer because demand is higher and there is significantly more storage on the Salt River reservoir system. Hydrogeneration on the lower Salt River Dams is also used more in the summer, so higher demands allow for more water to pass through the generators. Minimum releases are kept on each system while deliveries are being made from the other.

In the RPM, targets for normal seasonal operations are set for consistency with SRP's approach to actual system operations. From May through September, a target is set on the Verde River reservoir system to limit flows to the minimum release, so the model will prioritize demand releases from the Salt River reservoir system. From October through April, the model minimizes Salt River outflows, making delivery releases from the Verde River reservoir system. Once these targets are set, additional qualifiers are defined. A target is set for the Salt River reservoir system outflow not to exceed the maximum generator capacity at Stewart Mountain Dam. The priority on this target is higher than the seasonal norms, so if a demand release would cause lower Salt River outflows to exceed the generator capacity, the balance above the maximum would be attempted to be released from the Verde River reservoir system.

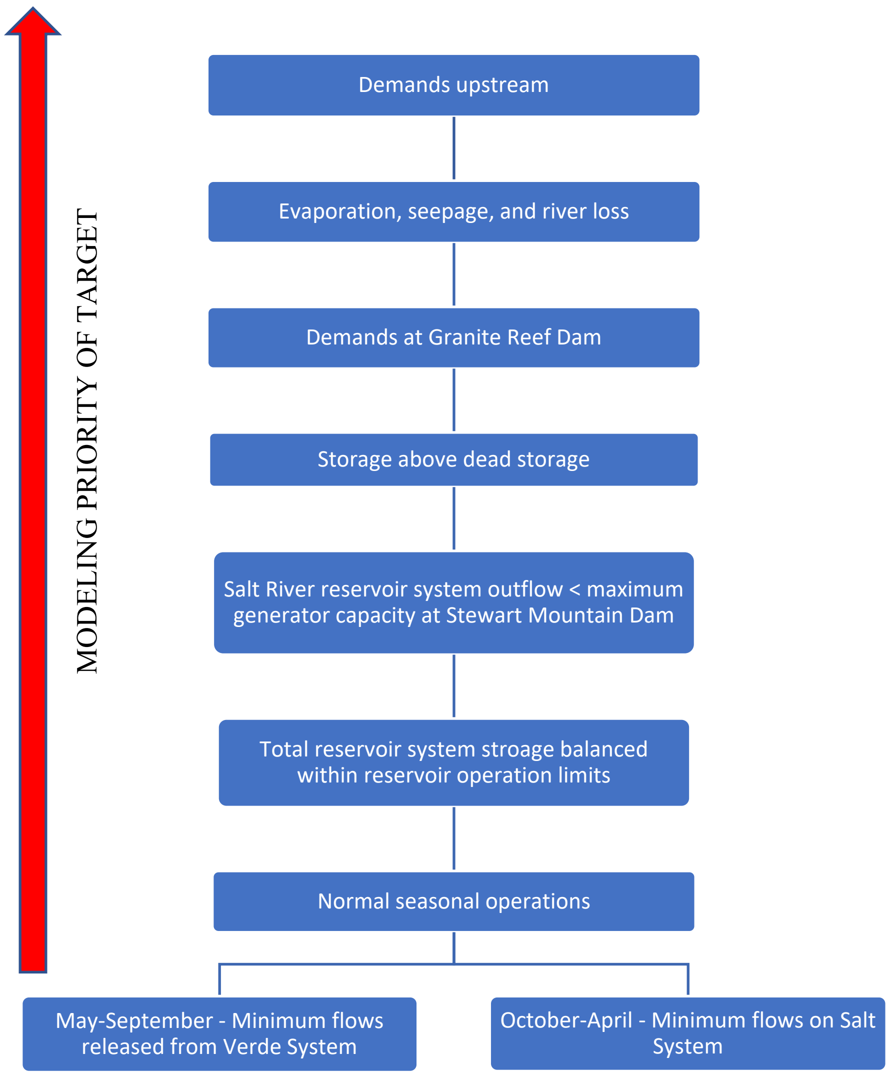

Figure 3. Operations Order of Modeling Target Priority

Additionally, targets are defined to keep a balance between the total storage in each reservoir system, defined by operating limit rule curves. Each system has a target that discourages storing water above the top of conservation pool, so if one system is above the top of conservation and one is at or below it, the demand release from the System will be adjusted appropriately to try to operate to the curves. The priority for these targets is slightly higher than the normal seasonal targets, but much lower than the weight for actual storage in the reservoirs. The effect of this is to reduce unnecessary spill from the system by swapping deliveries to the system that is full and about ready to spill.

When Modified Roosevelt Dam exceeds elevation 2,151 feet and enters Flood Control Space (FCS) in model runs, the RPM daily model has the capability to follow releases in accordance with the Modified Roosevelt Dam Water Control Manual (WCM) as determined by the United States Army Corps of Engineers. The release curve for operations within the FCS as defined by the WCM is summarized in Table 2. The release curve from the WCM is coded within the model and releases are determined based on the then-current lake elevations in each observed timestep. In the FCS, the WCM releases have highest priority of all reservoir operations on the system for consistency with actual FCS operations and to ensure the model follows the rules dictated by the WCM.

Table 2. Water Control Manual for Modified Theodore Roosevelt Dam Reservoir Release Plan (current flood control operations).

Water Surface Elevation—Rising (feet amsl)	Minimum Release Rate—Rising	Water Surface Elevation—Falling (feet amsl)	Minimum Release Rate—Falling
2,151–2,153	1,900 cfs	2,151–2,152	6,500 cfs
2,153–2,155	2,200 cfs		
2,155–2,157	6,500 cfs	2,152–2,157	12,200 cfs
2,157–2,162	12,200 cfs		
2,162–2,172	39,500 cfs	2,157–2,170	39,500 cfs
2,172–2,175	53,100 cfs	2,170–2,175	53,100 cfs

Note: amsl = above mean sea level; cfs = cubic feet per second

3 RESERVOIR PLANNING MODEL ASSUMPTIONS

The following sections describe the assumptions and data inputs that were used in the modeling scenarios in support of the Roosevelt HCP Amendment.

3.1 Introduction to RPM Assumptions

SRP's RPM was used to assess the SRP Reservoir System for current operations and the extended-release period allowed by the proposed planned deviation. Since the reservoirs on the Verde River and the Salt River are operated as one system to make shareholder and contract water deliveries, it is critical to evaluate the entire system even if operational modifications only occur at one reservoir on the system.

The RPM scenarios performed for the FCS analysis are operated on a daily timestep. The duration of analysis for the RPM is 106 water years. The analysis uses the historical gaged record at the U.S. Geological Survey (USGS) sites above Roosevelt Dam on the Salt River and Tonto Creek and above Horseshoe Reservoir on the Verde River from October 1913 through September 2019.

3.2 Climate Change Adjustment for Future Streamflow

This section describes the methods for adjusting historical records of seasonal Salt-Verde streamflow based on projected changes in temperature and precipitation. Streamflow records for the Salt River above Roosevelt Dam, Tonto Creek above Roosevelt Dam (together referred to herein as Salt+Tonto), and the Verde River above Horseshoe Dam from October 1913 to September 2019 were used to provide the baseline hydrologic record for development of a climate change–adjusted streamflow. Section 3.2.1 provides a discussion of the need and approaches for using climate change projections for planning studies. Section 3.2.2 discusses the use of temperature sensitivities and precipitation elasticities as an alternative to physical hydrologic modeling. Section 3.2.3 details the derivation of future changes in temperature and precipitation that are used to adjust the streamflow record, using the same approach employed by the Verde Reservoirs Sediment Mitigation Study (Reclamation 2021). Section 3.2.4 briefly describes the results of the climate change analysis, and the simple method for leveraging the seasonal climate change adjustments to adjust daily records is detailed in Section 3.2.5.

3.2.1 Need and Approach for Using Projections of Future Climate for Planning Studies

Phase 5 of the Coupled Model Intercomparison Project (CMIP5; Taylor et al. 2012) provides a set of projections of future climate from Global Climate Models (GCMs) from numerous institutions worldwide. The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) and other global, regional, and national assessments are largely based on output from CMIP 5 (Taylor et al. 2012). GCMs simulate climate at large spatial scales, approximately 100 × 100 kilometer (km) resolution, which is not adequate for planning studies about the impacts of climate change on water resources (Pierce et al. 2014), especially for watersheds like the Salt and Verde River watersheds that are approximately 30,000 km^2 and span a wide range in elevations. Therefore, downscaling is required to be able to consider effects of climate change for impact studies evaluating future conditions.

The two main types of downscaling are dynamical downscaling and statistical downscaling. Dynamical downscaling uses higher-resolution regional climate models nested within a portion of the coarse resolution GCM. Statistical downscaling applies statistical relationships between coarse resolution model output and observations to translate the large-scale information to a smaller scale. A significant disadvantage of statistical downscaling is that relationships between the large and small scales may change in the future. This is not a problem for dynamical downscaling, but the computational expense of dynamical downscaling is larger than statistical downscaling by orders of magnitude. This limits the climate change analysis to a small portion of CMIP5 suite. In addition, dynamically downscaled output often needs to be bias corrected before practical application (Pierce et al. 2014). Considering the need for an ensemble approach and the computational limitations of dynamical downscaling, statistical downscaling was the chosen method to produce small-scale climate change information in support of the Roosevelt HCP amendment.

3.2.2 Temperature Sensitivity and Precipitation Elasticity

Translating changes in temperature and precipitation to changes in streamflow is challenging given the complexities of streamflow generation (Reclamation 2020). Even after significant effort for bias correction and model calibration, large biases can remain, limiting the utility for planning studies (Reclamation 2020). Moreover, equifinality (Her et al. 2019) reduces confidence in hydrologic model output, making the computational expense of complex physical hydrologic models an even more unattractive feature, particularly if biases remain after calibration. Therefore, empirically derived temperature sensitivities and precipitation elasticities are indispensable tools for planning projects. Applying the sensitivities and elasticities to the historical inflow record eliminates the challenges from bias in the baseline period for climate change planning studies.

The temperature-streamflow sensitivity is,

$$S_t = \frac{\Delta Q}{Q} / \Delta T \qquad (1)$$

where ΔQ is the change in seasonal streamflow, Q is an initial seasonal streamflow, and ΔT is the change in seasonal average temperature (degrees Celsius [°C]). The temperature-streamflow sensitivity (S_t) is most easily interpreted as the percent change in streamflow per change in unit temperature but has the mathematical units of $°C^{-1}$ (Reclamation 2020). The precipitation-streamflow elasticity is,

$$\varepsilon_p = \frac{\Delta Q}{Q} / \delta \qquad (2)$$

where

$$\delta = \frac{\Delta P}{P} \quad (3)$$

and ΔP is the change in seasonal total precipitation and P is an initial seasonal total precipitation. The precipitation-streamflow elasticity ($\mathcal{E}_p$) is most easily interpreted as the ratio between the percent change in streamflow and the percent change in precipitation, but is unitless (Reclamation 2020).

3.2.3 Future Changes in Temperature and Precipitation and Adjusting the Streamflow Record

Inter-model uncertainty in CMIP5 is a significantly larger source of uncertainty than the uncertainty contained in the parameter space of hydrologic models (Her et al. 2019). The spread in the CMIP5 projections arises from a number of sources of uncertainty including natural variability of the climate system, future carbon dioxide emission scenarios, and sensitivity to increased carbon dioxide. There are also model differences in the skill in reproducing large spatial and temporal patterns in temperature and precipitation (Anagnostopoulos et al. 2010). Therefore, an ensemble approach determining a mid-point in the range of projected changes is an appropriate first step in examining the climate change signal in the CMIP5 suite.

Considering the need for an ensemble approach and the computational limitations of dynamical downscaling (Pierce et al. 2014), statistical downscaling was the chosen method to produce small-scale climate change information. Therefore, the Localized-Constructed-Analogs CMIP5 (LOCA-CMIP5) statistically downscaled dataset was used (Pierce et al. 2014). For the Salt-Verde watersheds, the LOCA-CMIP5 dataset has substantial large positive biases in monsoon season precipitation (USBR 2020). Given that most of the Salt-Verde streamflow is generated in the winter and early spring (Figure 4) and the values of the empirical temperature sensitivities (S_t) and precipitation elasticities ($\mathcal{E}_p$) for the Salt-Verde (Murphy 2016; Reclamation 2020), changes in temperature and precipitation outside of the monsoon season (e.g., October–May) are expected to have the greatest impact on future streamflow.

To quantify the projected climate change impact on temperature and precipitation, the average change in temperature and precipitation in the 64 LOCA-CMIP5 projections was calculated separately for the Salt+Tonto and Verde Rivers (Figure 5). The LOCA-CMIP5 time series span 1950–2099. The periods 1990–1999 and 2090–2099 were chosen to calculate the changes in temperature and precipitation as this was assumed to be the best representation of the full change over the next century. These 100-year changes to temperature and average precipitation were applied as a linear interpolation between the two periods (1990–1999 and 2090–2099) to produce a climate-adjusted hydrology for the full period as detailed in Appendix H of the Verde Reservoirs Sediment Mitigation Study (Reclamation 2021). In the absence of other information (e.g., projected carbon dioxide concentration in the twenty-second century and LOCA-CMIP5 projections in the twenty-second century), this is a reasonable assumption to quantify the changes in temperature and precipitation over an approximate 100-year period from the early twenty-first to the early twenty-second century. The choice of 10-year periods versus 30-year periods (e.g., 1970–1999 and 2070–2099) is justifiable because internal climate variability would be expected to be negligible when averaging 64 simulations. Given the previously mentioned issues with the monsoon season climate in the LOCA-CMIP5 data, October–May was chosen to calculate the changes in temperature and precipitation. It should be noted that results were not sensitive to calculating the changes in temperature and precipitation separately for summer and winter. This is not surprising given a relatively small portion of annual streamflow is generated from monsoon season precipitation (see Figure 4).

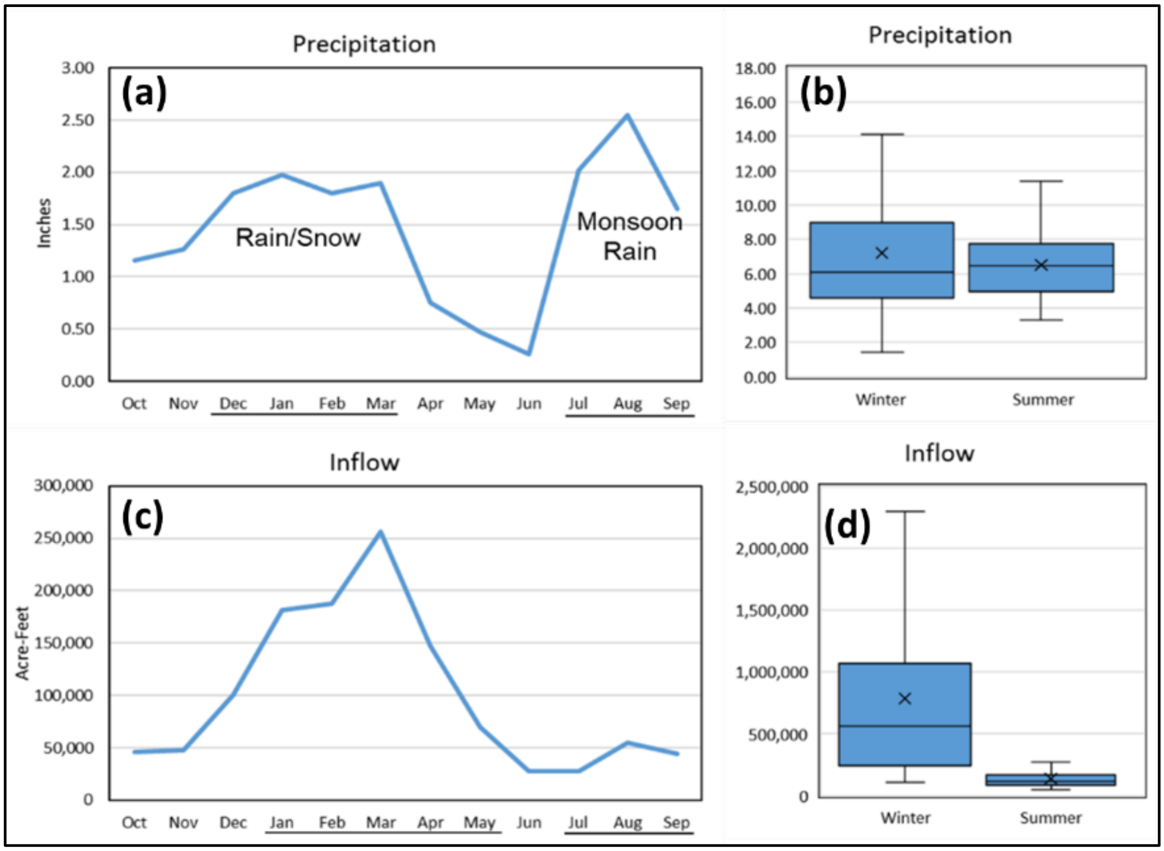

Figure 4. Monthly Salt-Verde Watershed Average Precipitation (a) and Total Reservoir Inflow (c); Seasonal Distribution of Precipitation (b) and Total Reservoir Inflow (d).

Empirical quantile mapping was used to adjust the historical precipitation record for projected changes in precipitation variability. Empirical quantile mapping is a common bias correction technique for precipitation output from numerical weather prediction models and GCMs (Cannon et al. 2015). This method can be applied in a similar fashion to represent the change in precipitation variability from a current time period to a future time period. For example, using the inverse cumulative distribution function, $F_f^{-1}\{ F_h [] \}$, Cannon et al. (2015) relate precipitation in the current time period to the future time period, where F_h and F_f are the cumulative distribution functions of precipitation in the current and future periods, respectively. Since the statistical distribution function of Salt-Verde precipitation is unknown and extremes are very impactful on the SRP Reservoir System, F_h and F_f were determined empirically and thus a lookup table represents the transfer function. For the changes in mean temperature and precipitation, a linear change over the next century was assumed. To apply a change in variability in a similar fashion, F_h and F_f would need to vary year-by-year from over the next century. For the sake of simplicity and to represent the broad late twentieth century to late twenty-first century change in precipitation variability, F_h and F_f were determined through comparison of 2050–2099 and 1950–1999. Therefore, the initial lookup table had 3,200 entries, 50 years multiplied by 64 LOCA-CMIP5 projections. To apply the lookup table to the 106-year historical record, a lookup table with 106 entries was created by smoothing the original lookup table. This was done by binning the original lookup table into 106 groups of approximately equal size (approximately 30) and averaging the bins. Complete details on the use of temperature sensitivities and precipitation elasticities to adjust seasonal streamflow based on projected changes in temperature, average precipitation, and precipitation variability are provided in Appendix H of the Verde Reservoirs Sediment Mitigation Study (Reclamation 2021).

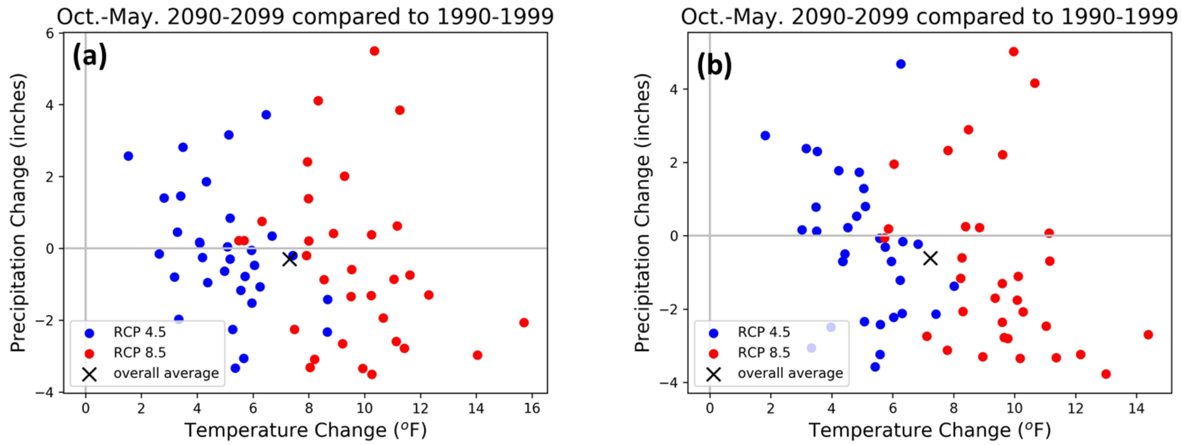

Figure 5. Late Twenty-First Century Changes in Total Winter Precipitation and Average Temperatures for the Verde (a) and Salt+Tonto (b) Basins for 64 LOCA Downscaled Simulations from the Coupled Model Intercomparison Project Phase 5 (CMIP5)

3.2.4 Future Streamflow

After applying the climate change adjustments, the difference in the average Salt-Verde October–May precipitation between 1913–2019 and the next 106 years is −0.31 inch, or about −2.5% (Figure 6). The difference in the average water year streamflow between 1913 and 2019 and the next 106 years is −25.4 thousand acre-feet (kaf) or about −2.2% (Figure 7). This suggests that the increased precipitation in the extreme wet years derived from the LOCA-CMIP5 data results in increased streamflow during those years that slightly overcomes the decrease in mean precipitation, e.g., in about 10% of the years, water year streamflow is increased by more than 100 kaf (see Figure 6).

The decrease in mean streamflow due to increased temperature is evident from comparing the percentile of the no change value (i.e., zero line) between Figure 6a and 6b. For example, water year streamflow is decreased in approximately 79% of the years while precipitation is only decreased in approximately 73% of the years (see Figure 6). Lastly, the decrease in average streamflow (−2.2%) is less than what is expected from the impact of increased temperature alone on the Upper Colorado River Basin (Vano et al. 2012; Vano and Lettenmaier 2014). This is in part because the temperature sensitivity (S_t) on the Salt-Verde average streamflow is approximately −1.2% $^{\circ}C^{-1}$ (Reclamation 2020) while S_t on Colorado River average streamflow is reported to be approximately −6.5% $^{\circ}C^{-1}$ (Vano et al. 2012; Vano and Lettenmaier 2014). The physical mechanisms responsible for this difference need further exploration but recent research suggests that the Salt-Verde is less sensitive to warming because the streamflow occurs earlier in the year (e.g., January–April) when the potential for evaporative losses resulting from increased temperatures on the landscape is limited (Robles et al. 2021).

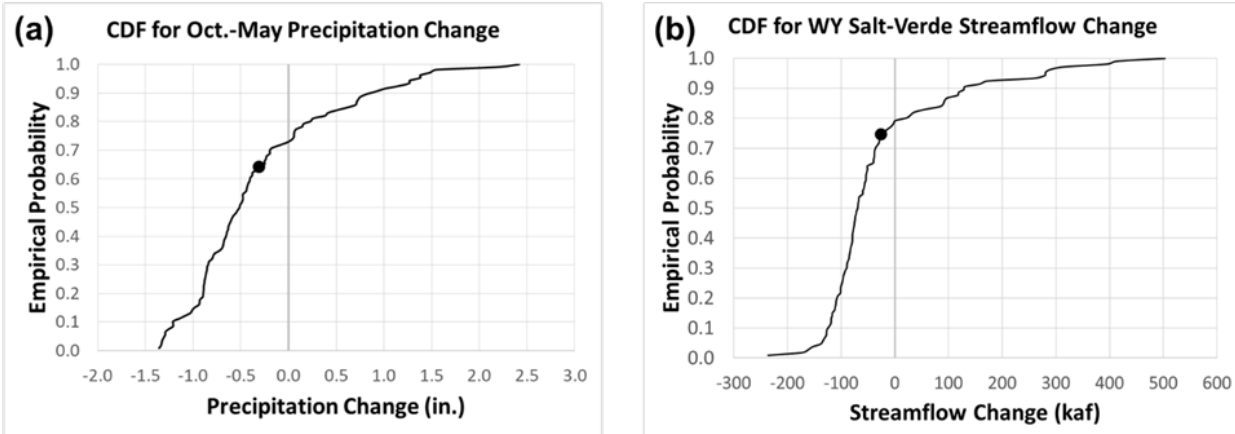

Figure 6. Cumulative Distribution Functions Displaying Differences in the Historical Precipitation (a) and Streamflow Records (b) and the Historical Records Adjusted for Climate Change (with the change in the means given by black circles)

3.2.5 Climate Change Adjustments to Daily Streamflow Records

Winter rainfall and rain-on-snow produce highly variable daily Salt+Tonto and Verde streamflow, requiring substantial adjustments to daily reservoir operations. From the methods described in Sections 3.2.2 and 3.2.3, scale factors that vary with season, watershed, and water year represent the climate change adjustments of total seasonal streamflow. These scale factors were aggregated over the entire 106-year period and for both watersheds to produce the changes displayed in Figure 6b. Applying the scale factors to each daily value within their respective season, watershed, and water year results in a daily climate change–adjusted time series with the same seasonal volumes as the climate change–adjusted seasonal streamflow that were derived in the Verde Reservoirs Sediment Mitigation Study (Reclamation 2021).

It is important to highlight the primary limitation of this method. In a warmer world with an intensified hydrologic cycle, one might expect base flow to decrease while extreme flood events increase. One would expect this to result from changes in the rates of transpiration, evaporation, sublimation, and snowmelt as well as changes in precipitation intensity and snow level (the altitude that snowfall transitions to rainfall during a precipitation event). Without complex climate model downscaling and physical hydrologic modeling, there is no basis for adjusting daily streamflow to represent these complexities. Unfortunately, climate model downscaling and physical hydrologic modeling are computationally intensive. In addition, it is challenging to produce model output from these methods that does not have substantial bias (Pierce et al. 2014; Her et al. 2019; Reclamation 2020), thus limiting the potential for confident decision making. Given the impact of daily streamflow variability to reservoir operations, it is prudent to leverage both historical daily streamflow records and the seasonal climate change adjustments derived in the Verde Reservoirs Sediment Mitigation Study (Reclamation 2021).

3.2.6 Local Inflow

The majority of water entering SRP's Reservoir System comes from runoff transported in the main river channels of the Salt River, Tonto Creek, and the Verde River. During certain winter and monsoonal events, some small creeks and normally dry washes can flash and provide measurable volumes of water that require operational attention. Sometimes these events may result in spill events from the lower Salt River Dams and Granite Reef Dam. Using a relationship at the gauged flows, local inflows (from normally dry washes and small creeks) were determined for Roosevelt Lake, the lower Salt River system, Horseshoe Reservoir, and Bartlett Reservoir. These local inflows were input to RPM upstream of Roosevelt Dam, at the lower Salt reservoirs, upstream of Horseshoe Dam, and at Bartlett Dam.

3.3 Project Reservoir Operations Planning Assumptions

SRP water resources management is based on the conjunctive management of multiple sources of water to ensure an adequate supply of water to satisfy the demands on SRP's Reservoir System. SRP uses a Project Reservoir Operations Planning (PROP) tool for short- to medium-term planning (1–3 years). The PROP uses reservoir conditions at the end of the winter runoff season (May 1) to forecast monthly storage levels, surface water releases, and groundwater pumping for the remainder of the current year (May–December) and the following 2 calendar years. This is accomplished by using the Storage Planning Diagram (SPD) shown in Figure 7. The SPD provides a relationship between SRP reservoir storage, groundwater pumping production, and water allocation to manage water supplies based on the most severe drought identified in the tree-ring record for the Salt River, Tonto Creek, and Verde River combined inflow (Phillips et al. 2009). The red line in Figure 7 represents the reservoir storage level at which the annual SRP shareholder allocation is reduced from 3 acre-feet (AF) per acre to 2 AF per acre. Table 3 is based on Figure 7 and shows the annual groundwater pumping/SRP reservoir storage relationship used in the RPM.

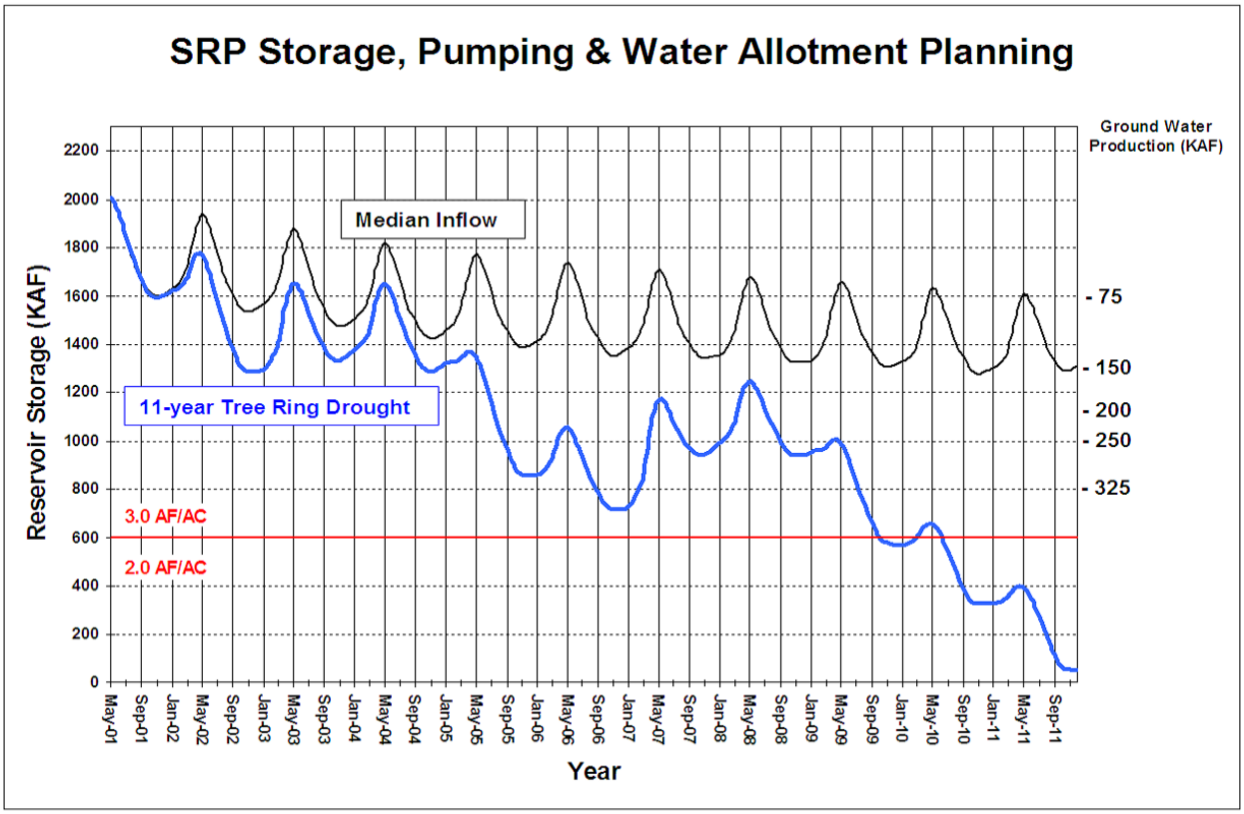

Figure 7. Storage Planning Diagram (Phillips et al. 2009)

As shown in Table 3, groundwater supplements surface water delivery from the SRP Reservoir System to the Phoenix metropolitan area. Managing the amount of groundwater pumping is critical for SRP reservoir storage planning. When storage is above 1.6 million acre-feet (MAF), groundwater pumping is at its minimum value of 75,000 acre-feet per year (AFY). As storage levels decrease, groundwater pumping increases. For reservoir operations planning, the maximum groundwater pumping capacity is set at 325,000 AFY.

Table 3. SRP storage levels and pumping triggers for RPM.

January 1 SRP Storage (kaf)	Groundwater Pumping Volume for Year (kaf)
> 1,500	75
1,400–1,500	100
1,300–1,400	125
1,200–1,300	150
1,133–1,200	175
1,067–1,133	200
1,000–1,067	225
933–1,000	250
867–933	275
800.5–867	300
< 800.5	325

3.4 Water Delivery Assumptions

The RPM consolidates all water uses for SRP's service area plus contractual deliveries outside the service area into one demand node. This demand node excludes New Conservation Storage, Fort McDowell Yavapai Nation (FMYN), Phoenix Gatewater, and upstream demands. Each of these accounts represents water uses outside of SRP's service area and have separate demand nodes in RPM and is described further in this section.

3.4.1 SRP Shareholder and Contractor Annual Deliveries

The following SRP system water delivery scenarios are used in the RPM:

SRP Shareholder and Contractors = 750,000 AF/year

Deliveries from the SRP System since 2016 have been between 725,000 and 775,000 AF/year. Historically, SRP System demand has been as high as 1.4 million AF/year but has declined since the 1980s. As agriculture acres continue to urbanize and residents continue water conservation practices, a demand of 750,000 AF/year is considered reasonable now and in the future.

3.4.2 Modified Roosevelt Dam New Conservation Space Annual Deliveries

New Conservation Space (NCS) has 272,500 AF of storage capacity in Roosevelt Lake that is available to six municipalities (NCS Cities) for storage of water from the Salt River. Based on most realistic use and allocation of NCS storage, the following annual NCS demands (if available) for each city are assumed for the RPM analysis.

Chandler = 3,000 AF/year

Glendale = 3,000 AF/year

Mesa = 4,500 AF/year

Phoenix = 15,000 AF/year

Scottsdale = 3,000 AF/year

Tempe = 1,500 AF/year

3.4.3 Planned Deviation Water Deliveries

For the planned deviation, deliveries are made from the accrued volume in FCS space and constrained to be made during the 120-day deviation. Daily deliveries from the FCS space are distributed over the 120-day period to ensure the entire volume is delivered by the end of the 120-day period.

3.4.4 Phoenix Gatewater Annual Deliveries

The City of Phoenix has indicated the following annual delivery amount (if available) from the Phoenix Gatewater account be used for planning purposes:

Phoenix Gatewater = 25,000 AF/year

3.4.5 Fort McDowell Yavapai Nation Annual Deliveries

The annual deliveries to the FMYN are based on the FMYN Water Rights Settlement agreements and the RPM uses the following for annual deliveries to the FMYN.

FMYN Demand = 7,200 AF/year

3.4.6 Upstream Demand

Diversion by the White Mountain Apache Tribe and San Carlos Apache Tribe occur upstream of Roosevelt Lake and are accounted for in the RPM analysis. The RPM analysis is set based on these agreements and uses the following diversions from unregulated flow upstream of the reservoirs.

White Mountain Apache Tribe = 25,800 AF/year

San Carlos Apache Tribe = 7,300 AF/year

3.4.7 Monthly Delivery Distribution

The current demand over the year is not constant and is modeled as a monthly pattern in the RPM model. Table 4 shows how annual demand is distributed over 12 months in the System, which is then distributed daily throughout the entire month. This demand pattern is used in the RPM model for all simulations and future years.

Table 4. Monthly distribution of annual demand.

Month	Percentage of Annual Demand
January	3.9%
February	4.4%
March	6.5%
April	9.5%

Month	Percentage of Annual Demand
May	11.1%
June	13.1%
July	13.5%
August	12.9%
September	8.8%
October	7.3%
November	6.3%
December	2.9%

3.5 Planned Deviation Operational Assumptions

For the proposed FCS deviation scenario, the operational rules required by the WCM were modified to allow the RPM to follow the operational releases proposed by the planned deviation and shown in Table 5. The difference between the current operations and planned deviation are smaller releases when Roosevelt Lake elevations are between 2,151 and 2,156 feet while following the existing release curve in the WCM for elevations greater than 2,156 feet. During the planned deviation, water accrues in the first 5 feet of the FCS and is released over the 120-day evacuation period. In the RPM, the date at which the deviation can start is static, and through operational experience and sensitivity analysis, March 1 was determined to be the most likely date for which reservoir elevations would be positioned for entering the FCS from subsequent runoff events. For the planned deviation scenario, the RPM is programmed to allow the use of the modified release curve identified in Table 5 for the first event inundating the FCS that occurs after March 1. Assuming that a planned deviation event would not occur until March 1 within a calendar year reflects the most-likely operational decision that SRP would make in exercising the added operational flexibility of the planned deviation. The 120-day evacuation period starts when the reservoir elevation exceeds elevation 2,151 feet and is only allowed to be used once per calendar year. Any subsequent runoff events that occur following the start of the 120-day period do not extend the duration of the allowable evacuation period.

Table 5. Proposed minimum release plan for the planned deviation.

Water Surface Elevation—Rising (feet amsl)	Minimum Release Rate—Rising	Water Surface Elevation—Falling (feet amsl)	Minimum Release Rate—Falling
2,151–2,156	460 cfs	2,151–2,156	460 cfs
2,153–2,156	460 cfs		
2,156–2,157	6,500 cfs	2,156–2,157	12,200 cfs
2,157–2,162	12,200 cfs		
2,162–2,172	39,500 cfs	2,157–2,170	39,500 cfs
2,172–2,175	53,100 cfs	2,170–2,175	53,100 cfs

3.6 Other Assumptions

3.6.1 Minimum Flow Requirement

For the Verde reservoir system, the minimum outflow from Bartlett Dam is 100 cubic feet per second (cfs) per paragraph 16 of the January 15, 1993 FMYN Water Settlement agreement, plus any water deliveries to FMYN. For the Lower Salt River reservoir releases, the minimum outflow is set to the operational minimum of 8 cfs.

3.6.2 Groundwater Pumping

The maximum pumping capacity is 325,000 AF/year. Minimum and maximum groundwater pumping values keep pumping within certain limits. It is assumed for the RPM analysis that minimum pumping will be 75,000 AF, consistent with the PROP planning rules discussed in Section 3.3. As storage levels decrease, groundwater pumping increases, as shown in Table 3 in Section 3.3. Maximum and minimum groundwater pumping values apply to all alternatives.

3.6.3 Central Arizona Project (CAP) Exchanges

CAP exchanges and inflows have been removed from the RPM for the model runs performed in simulations conducted for this analysis. Although the SRP System can exchange water with the CAP system, these exchanges are not guaranteed to be available for SRP use and are not considered for the analysis. CAP exchanges are operational in nature and do not occur on a consistent basis. The exchanges that do occur do not impact surface water deliveries and reservoir levels significantly because they are small in volume and exchanged back to SRP.

3.6.4 Reservoir Evaporation

Reservoir evaporation is computed by multiplying a monthly evaporation coefficient determined for each reservoir by the surface area of that reservoir for each day. Evaporation coefficients for the reservoirs are provided in Table 6. The computed evaporation is removed from the storage at each reservoir node in the RPM for each modeled timestep.

Table 6. Monthly reservoir evaporation coefficients.

Month	Bartlett/Horseshoe Evaporation Coefficients	Roosevelt/Lower Salt Evaporation Coefficients
January	0.08	0
February	0.14	0.07
March	0.27	0.19
April	0.49	0.46
May	0.72	0.67
June	0.85	0.83
July	0.75	0.75
August	0.61	0.56
September	0.58	0.46
October	0.43	0.27

Month	Bartlett/Horseshoe Evaporation Coefficients	Roosevelt/Lower Salt Evaporation Coefficients
November	0.24	0.11
December	0.13	0

3.6.5 River and Reservoir Loss

River loss is computed by multiplying a constant for annual loss, determined to be 28 kaf from historic observations by SRP, by the average of Bartlett and Lower Salt evaporation distribution coefficients shown in Table 6. The monthly value is then distributed evenly over the days in a month. This volume is tracked at a designated loss node at the confluence of the Salt and Verde Rivers. Reservoir seepage is computed by multiplying the beginning of month storage (since the wetted area does not change significantly month to month) by a seepage constant that is specific to each river system. The seepage constant for Verde River reservoirs is 0.0034 and the seepage constant for the Salt River reservoirs is 0.00077. River and reservoir loss computation methods do not change across the alternatives.

4 RESULTS OF RESERVOIR PLANNING MODEL RUNS

The RPM was used to assess expected Roosevelt Lake elevations for conservation space (CS) operations and FCS operations using the 106-year climate adjusted daily historical inflow record and model assumptions described within previous sections. Two scenarios of the RPM were evaluated: one that uses the current FCS operations following the WCM, and another that implements the allowable 120-day evacuation period of the proposed planned deviation. Operational logic within the CS is the same for both scenarios and only differs between scenarios within FCS based on the allowable use of the proposed planned deviation following the assumptions identified in Section 3.5.

4.1 Roosevelt Lake Elevation RPM output

SRP operates the Salt and Verde Reservoir System as described previously in Section 2.1. The lower Salt Reservoirs (Saguaro, Canyon, and Apache Lakes) typically maintain storage between 91% to 97% of capacity for operational purposes and typical storage ranges are outlined in Table 7. In the RPM, the lower Salt reservoirs are modeled together based on the rules outlined in Section 2.1 for approximately 354 kaf in the lower Salt and maintaining the balance of the total Salt storage in Roosevelt Lake. Roosevelt storage/elevation varies based on inflows into the reservoir and demand from the Salt system. Releases from Roosevelt Lake for Salt demand and spill (based on WCM releases within FCS) are passed through the lower Salt reservoirs downstream into the Lower Salt River. To achieve this, releases from Stewart Mountain Dam are made to match the releases made at Roosevelt Dam, consistent with actual operations. Total Roosevelt Storage and elevations are shown in Figure 8.

Table 7. Typical operational storage within the Lower Salt reservoirs.

Lower Salt Dam	Lower Salt Lake	Typical Operational Storage (kaf)	Max Capacity (kaf)
Stewart Mountain Dam	Saguaro Lake	63–67	69
Mormon Flat Dam	Canyon Lake	53–56	58
Horse Mesa Dam	Apache Lake	224–237	245
Total		**340–360**	**372**

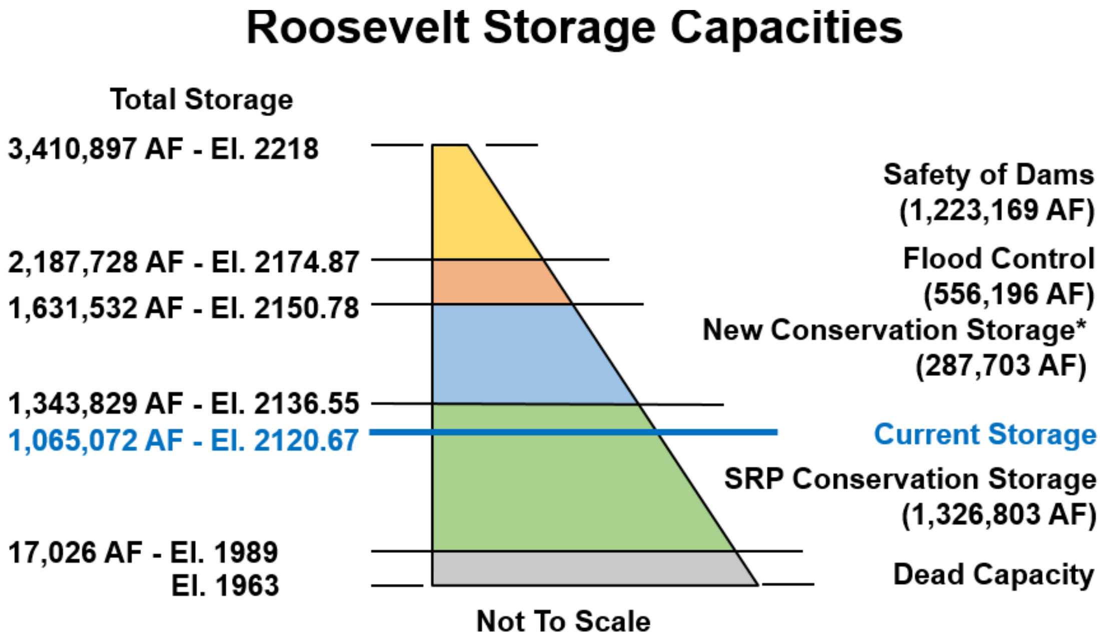

Figure 8. Roosevelt Lake Elevation (feet) and Storage Capacities (AF)

The RPM scenarios evaluated reservoir operations on a daily timestep for this analysis to ensure accuracy within the FCS due the dynamic day-to-day operations that occur during flood control conditions. The daily output of the RPM represents the best available information with which to model lake elevations and provide a deterministic modeling of 106 years of Roosevelt Lake elevations for analysis of FCS operations. FCS operations within Roosevelt Lake range from top of CS at 2,150.78 feet (2,151 feet) to top of FCS 2,174.87 feet (2,175 feet), and releases within the FCS follow the WCM and drawdown lake levels to top of CS within 20 days.

The proposed deviation would allow for a drawdown period of 120 days within the first 5 feet of FCS (2,151–2,156 feet). Roosevelt Lake elevation (feet) daily output for both scenarios of the 106 water years (WY) from the RPM are displayed in Figure 9. The Salt and Verde watershed historical experiences 20- to 30-year cycles of wet periods and drought periods, with four of these periods shown in Figure 9 with the Roosevelt Lake elevations typically higher in wet periods and entering lower elevations during longer periods of drought. Figures 10 and 11 show the two wet periods, and Figures 12 and 13 show the drought periods from Figure 9 to allow for more detail to be shown in Roosevelt Lake fluctuations.

Variability occurs within the operations of Roosevelt Lake elevations largely due to fluctuations of seasonal inflows from the Salt and Verde watershed. Figures 10–13 show both seasonal (year-to-year changes) and long-term (decadal) fluctuations and trends in Roosevelt Lake elevations. Seasonal elevations trends within Roosevelt Lake generally increase in elevation during the winter and spring months due to gain in storage from higher watershed runoff and lower demands. Reservoir elevations typically start to decline in the spring and summer due to higher demand and lower runoff and continue a downward trend through the fall. These seasonal patterns are shown throughout Figures 10–13. During a dry year, Roosevelt Lake elevations have a smaller and shorter winter increase period and longer summer decline period, while during wet years, Roosevelt Lake elevations have a greater and longer increase and shorter summer decline period.

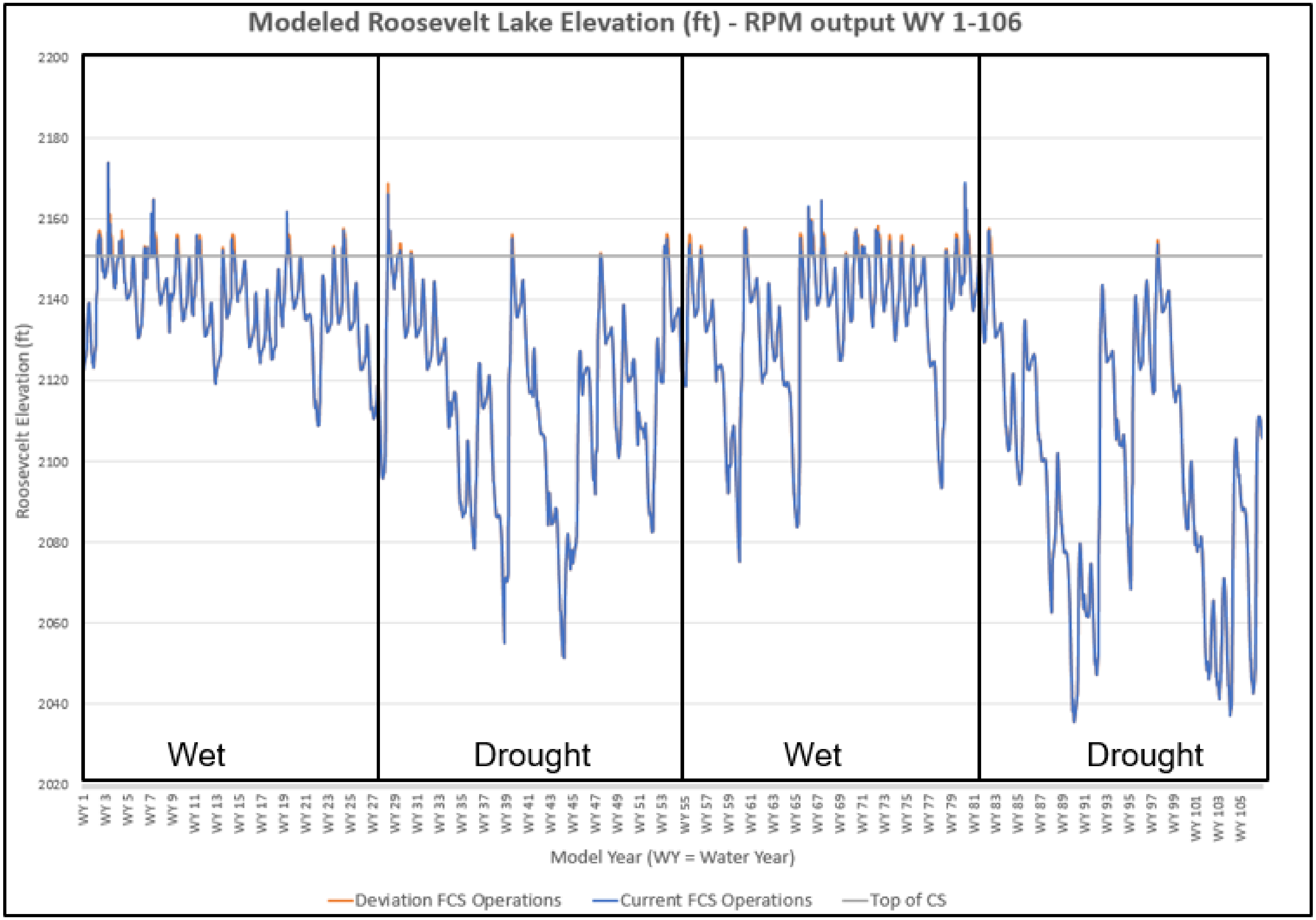

Figure 9. RPM Roosevelt Lake Elevation (feet) for Water Years 1 – 106

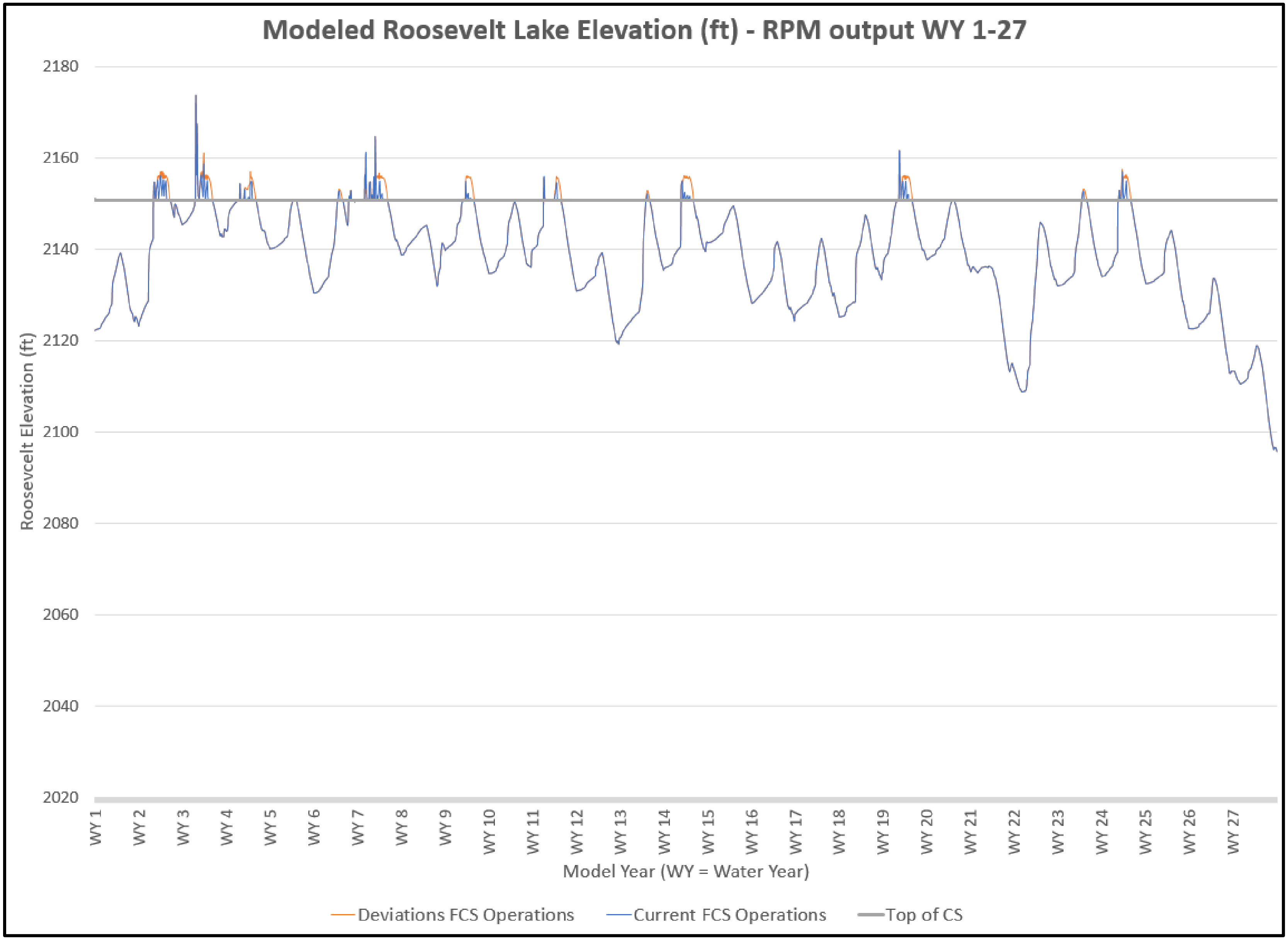

Figure 10. RPM Roosevelt Lake Elevation (feet) for Water Years 1 – 27

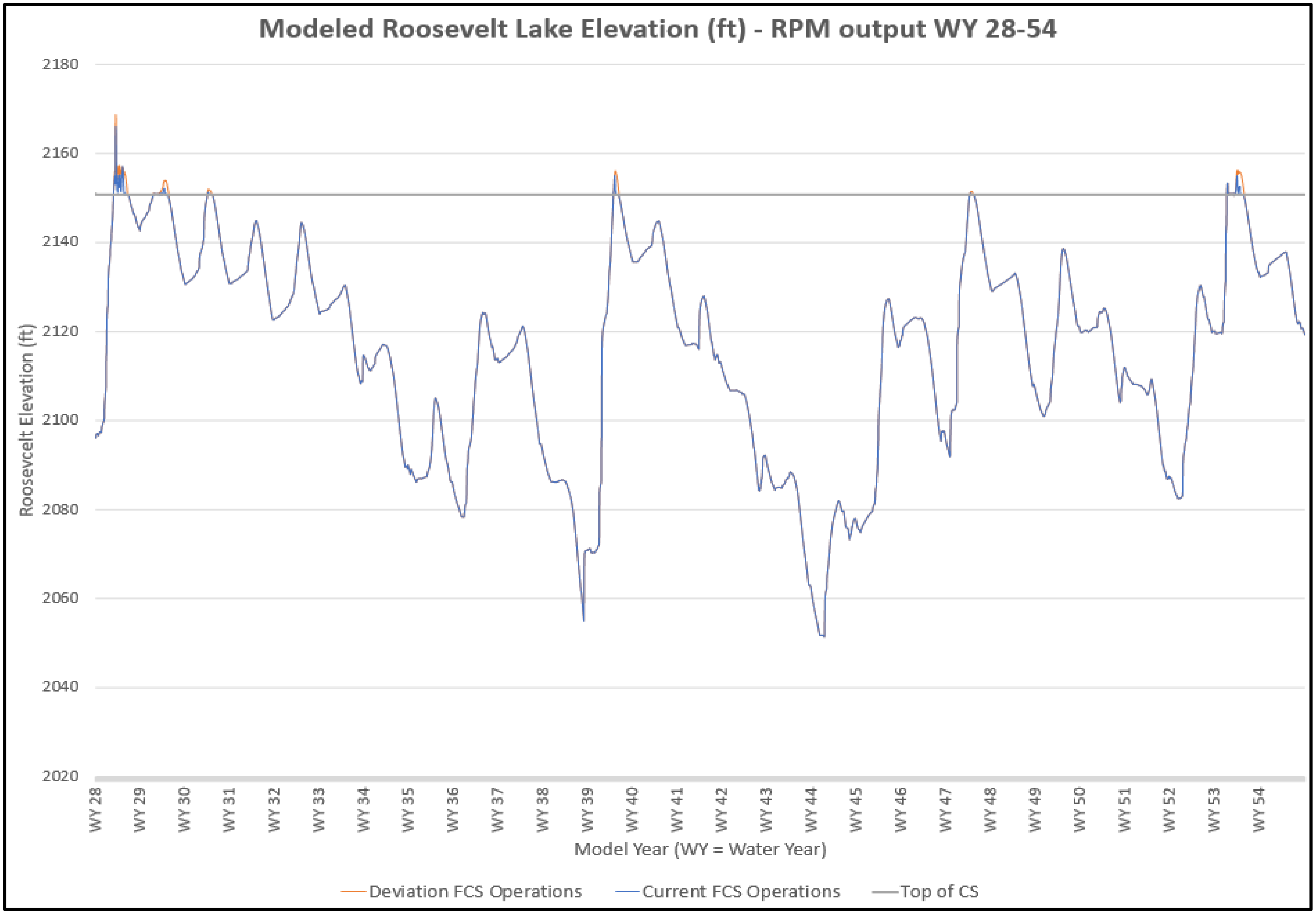

Figure 11. RPM Roosevelt Lake Elevation (feet) for Water Years 28 – 54

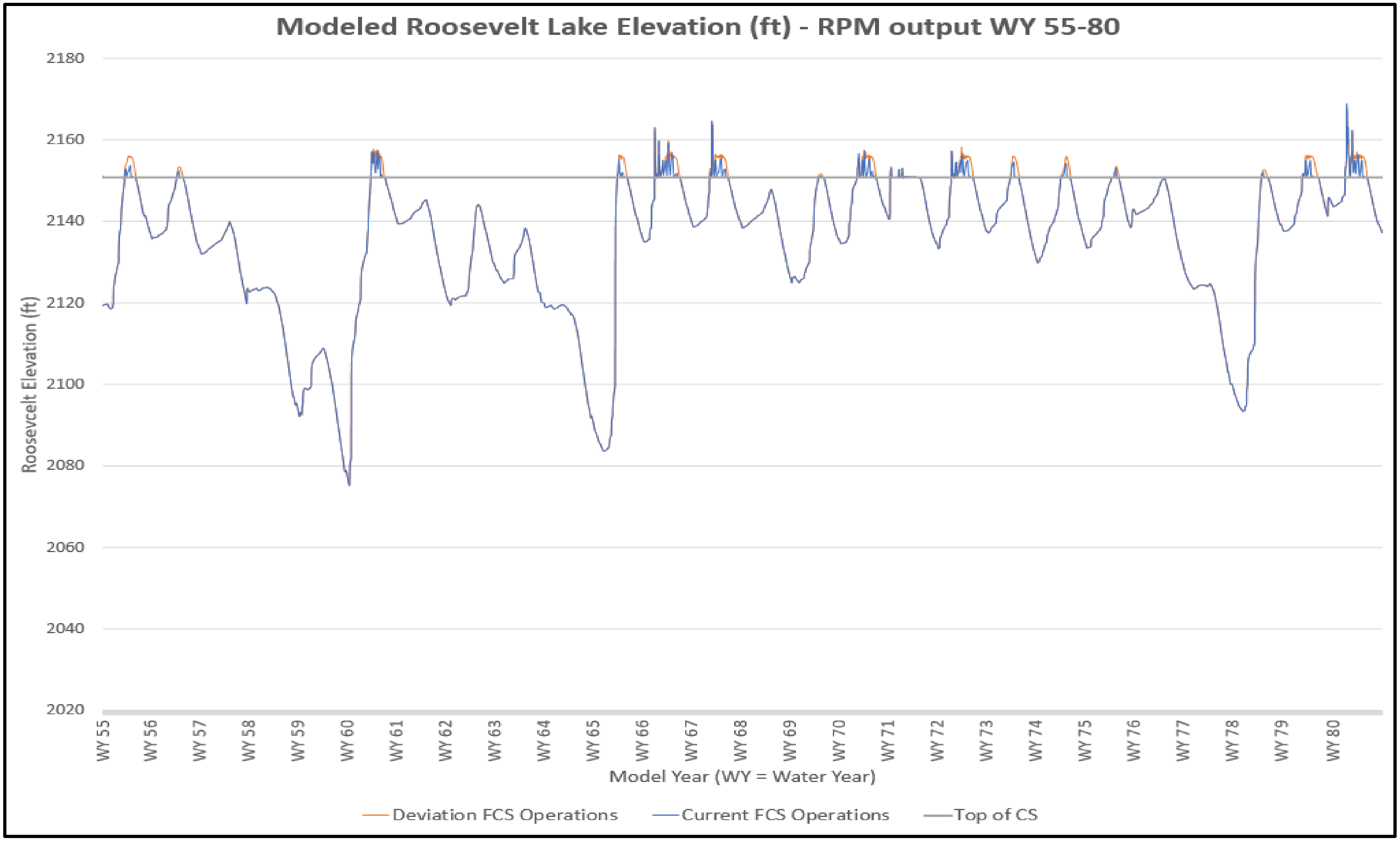

Figure 12. RPM Roosevelt Lake Elevation (feet) for Water Years 55 – 80

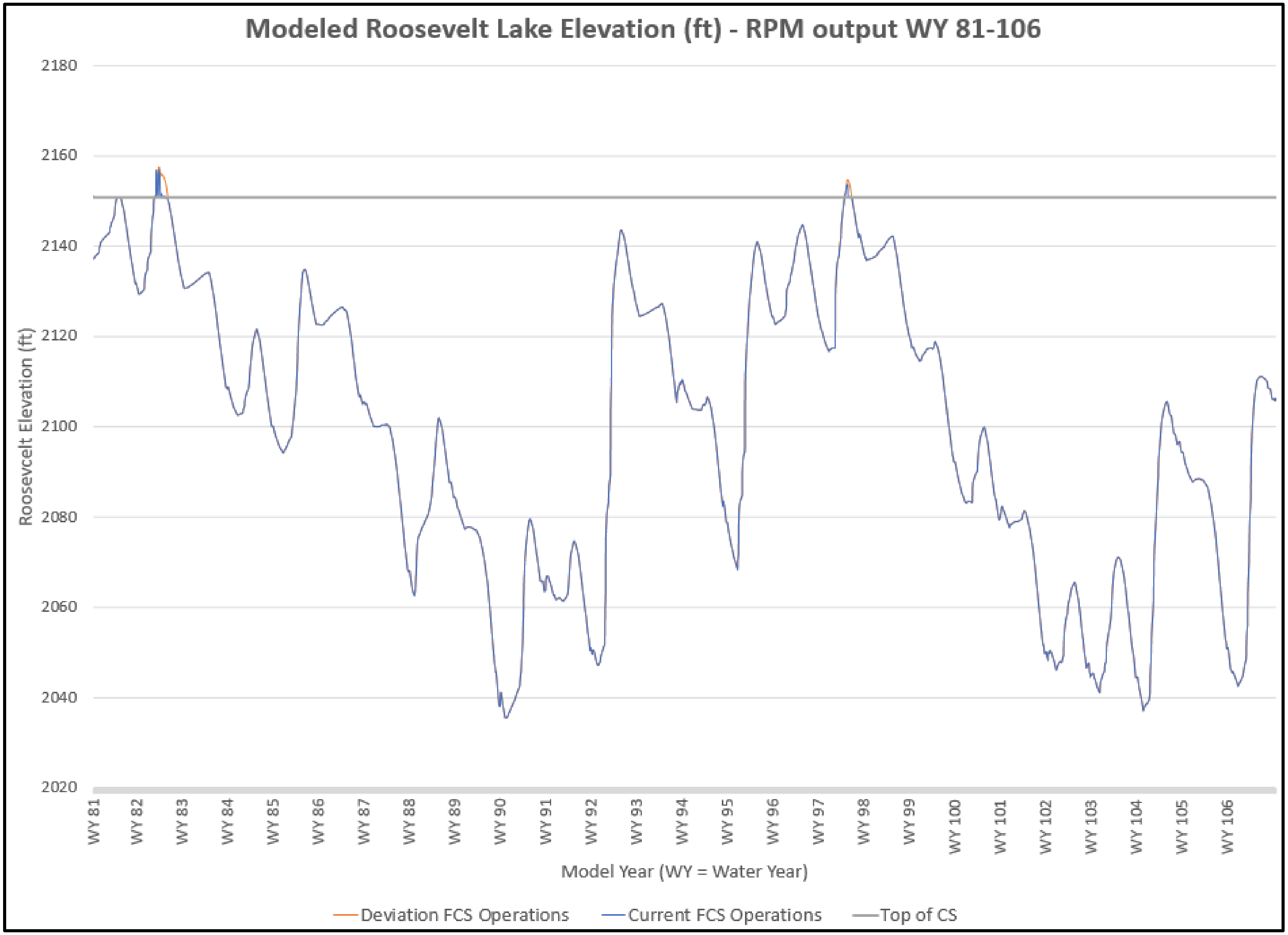

Figure 13. RPM Roosevelt Lake Elevation (feet) for Water Years 81 – 106

Longer-term trends in Roosevelt Lake elevations are largely dependent on runoff variability into the reservoir, as total annual demand is relatively constant each year. These long-term fluctuations result due to extended wet periods or drought periods that can last 25 to 30 years, as observed within the historical record. During wet periods (see Figures 10 and 11) Roosevelt Lake elevations tend to operate more frequently within upper elevations of the CS and more frequently enter FCS when there are more frequent years with higher watershed runoff. Throughout drought periods (see Figures 12 and 13), Roosevelt Lake elevations tend to decline over longer periods of time into lower elevations of the CS, with more frequent years with lower watershed runoff. As total storage declines (similar to Roosevelt storage declines), groundwater pumping increases as described previously to maintain storage within the reservoir system. While fewer wet years occur within drought periods, the few wet years between dry periods will increase Roosevelt Lake elevations back into upper elevations of CS with more infrequent use of FCS, often resulting in large overall increases due to starting the wet year at lower elevations within Roosevelt CS. Years in which Roosevelt Lake elevations enter FCS can be seen in Figures 10–13, and specific operations within FCS are described in more detail in Section 4.2.

For the purposes of overall statistical analysis of the data and for use in the HCP amendment analysis, the daily Roosevelt Lake elevations were also consolidated from a daily to a monthly timestep using the end of month value for months within the CS and the maximum monthly value for months within the FCS. Figure 14 illustrates how lake elevation may change within a given model year based on median values and various percentiles of modeled Roosevelt Lake elevations, but year-to-year fluctuations can be highly variable, as seen in Figures 9–13.

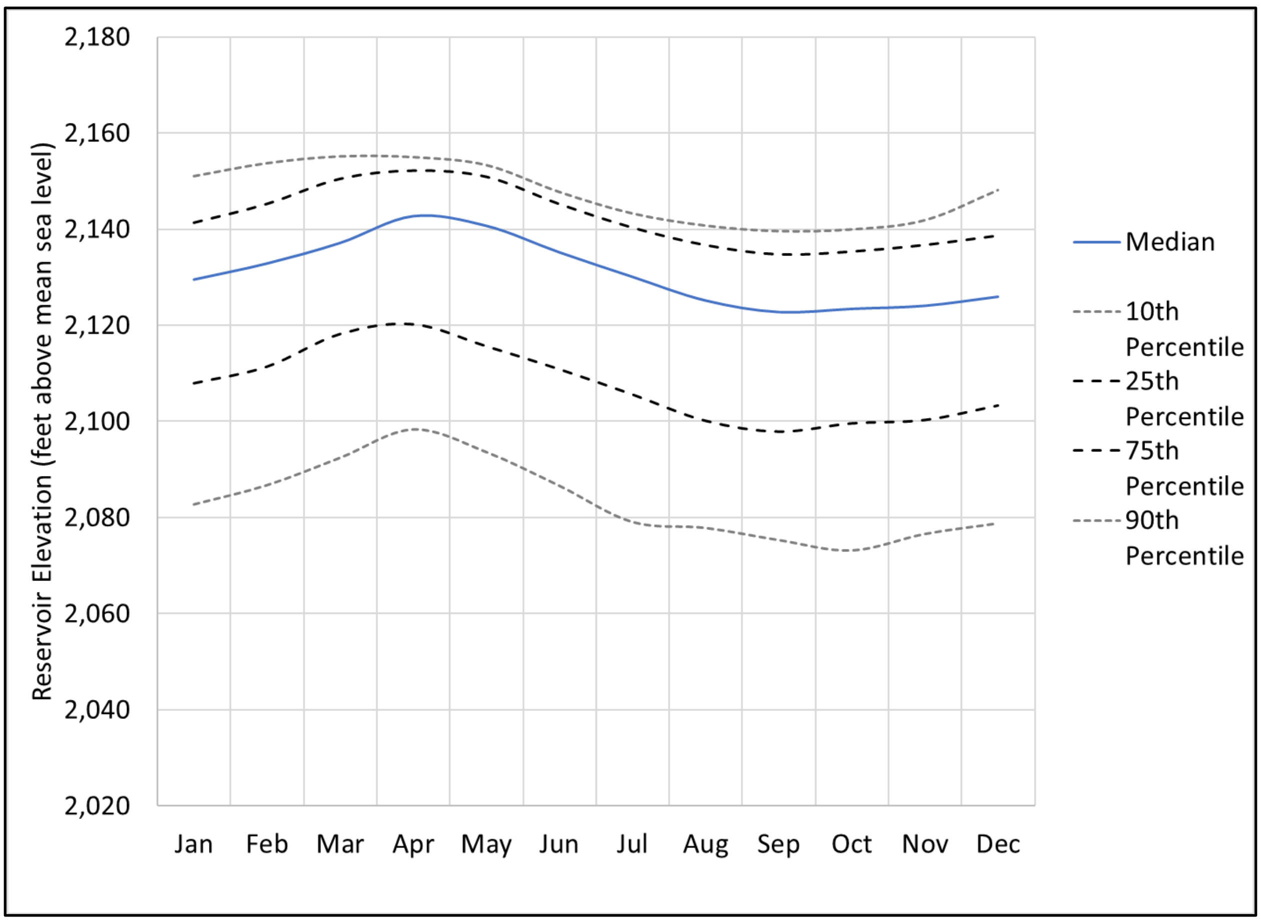

Figure 14. RPM Roosevelt Lake Elevation (feet) for Water Years 81 – 106

Based on the statistical analysis, the variations in lake elevation changes are categorized into changes that are typical, atypical, and extreme. Table 8 provides the characterization by water year type and summarizes the estimated lake elevation changes that would occur in the CS within years (by month) and between years (using June data as the basis for the annual elevation). Table 8 shows the magnitude and duration of estimated lake elevation changes. The general categories—typical, atypical, and extreme—convey the frequency that these types of lake elevation changes may occur, based on their percentiles in the RPM.

Table 8. General categories of estimated lake elevation level changes based on their magnitude, duration, and frequency of occurrence.

		Rise			Fall		
Frequency of Occurrence		**Common (75th percentile)**	**Occasional (90th percentile)**	**Rare (99th percentile)**	**Common (75th percentile)**	**Occasional (90th percentile)**	**Rare (99th percentile)**
General Categories		**Typical**	**Atypical**	**Extreme**	**Typical**	**Atypical**	**Extreme**
Intra-annual	Magnitude (feet)	20	40	80	20	30	40
	Duration (months)	6–7	7	8–9	6	7	9–10
Interannual	Magnitude (feet)	30	50	80	20	30	40
	Duration (years)	1–2	1–2	2–3	1–3	3–4	4–5

Typical daily changes in estimated Roosevelt Lake elevation are small (0.2 vertical foot per day) and rise or fall gradually over time. Over several months, the estimated Roosevelt Lake elevation changes can accumulate to result in moderate changes of approximately up to 20 to 30 feet. Rises in water level elevations typically are less predictable and more variable based on winter inflow events. More extreme rises in Roosevelt Lake elevations typically occur from very large storm events with larger inflows over a period of days to weeks that accumulate to large magnitude rises. During wet years, the duration of rise is longer due to higher inflows and longer duration of releases from the Verde Reservoir system to meet drawdown goals and water deliveries within SRP's water service area (shorter period of Salt system to meet demand). During dry years, the duration of rise is shorter due to lower inflows and longer periods of deliveries from the Salt Reservoir system due to SRP prioritizing water deliveries from the larger Salt Reservoir system to meet deliveries at Granite Reef Diversion Dam. Falling water level elevations occur at a more predictable and gradual rate during the summer period, as demand is relatively constant and inflows are typically lower in the summer. Duration can vary based on seasonal inflow depending on the length of time that the Salt Reservoir system is being used to meet demand (longer following dry winters, shorter following wet winters).

Occasionally, estimated atypical annual water level changes may occur that are of greater magnitude, exceeding 30 vertical feet, or have faster rates of change. These atypical water elevation changes occur at an estimated frequency of approximately once every 7 to 8 years, occurring more frequently during wet periods and less frequently during dry periods. In even rarer instances (i.e., once every 18 to 19 years), the water elevation may undergo an extreme change in elevation, exceeding 40 feet (see Table 4). These rare, extreme changes are more punctuated and are consequences of major weather events, such as exceptional precipitation events. Most of these extreme changes are the result of accumulated changes that take place over 4 to 10 months, though in some cases large increases can occur in just 1 to 2 months. These events tend to occur when the lake elevation either is exceptionally low (i.e., less than 2,100 feet) during wet years within longer drought periods, or exceptionally high (i.e., 2,151 feet) in wet periods.

The lake elevation may also reach 2,151 feet gradually through typical year-to-year accumulation, even though, within any year, the lake rises and falls following the trend shown in Figures 10–13.

4.2 Model Years within Roosevelt Lake FCS Operations

Daily Roosevelt Lake elevation data from the RPM for two scenarios are used to show the difference between current operation and the proposed deviation within the FCS. In the example model year (WY 2) shown in Figure 15, Roosevelt Lake elevation enters the FCS in late January and continues to operate using the current WCM, returning Roosevelt Lake elevation below top of CS (2,151 feet) within 20 days by mid-February. As inflows remain higher than demand from the Salt system or additional storms occur, Roosevelt Lake levels again increase into FCS in late February under current WCM operations.
As described in Section 3.5, the proposed deviation event would not be expected to occur before March 1, and thus the model does not initiate the use of the extended evacuation period until a runoff event occurring after March 1. Following March 1, the two RPM scenarios show the differences in Roosevelt Lake elevations that occur when the allowable 120-day evacuation period for the first 5 feet of FCS is implemented. Under the current WCM operation, Roosevelt Lake elevations would enter FCS as inflows remain higher than demand and/or additional storms occur and initiate releases according to the WCM and returning Roosevelt Lake elevation to top of CS (2,151 feet) within 20 days.

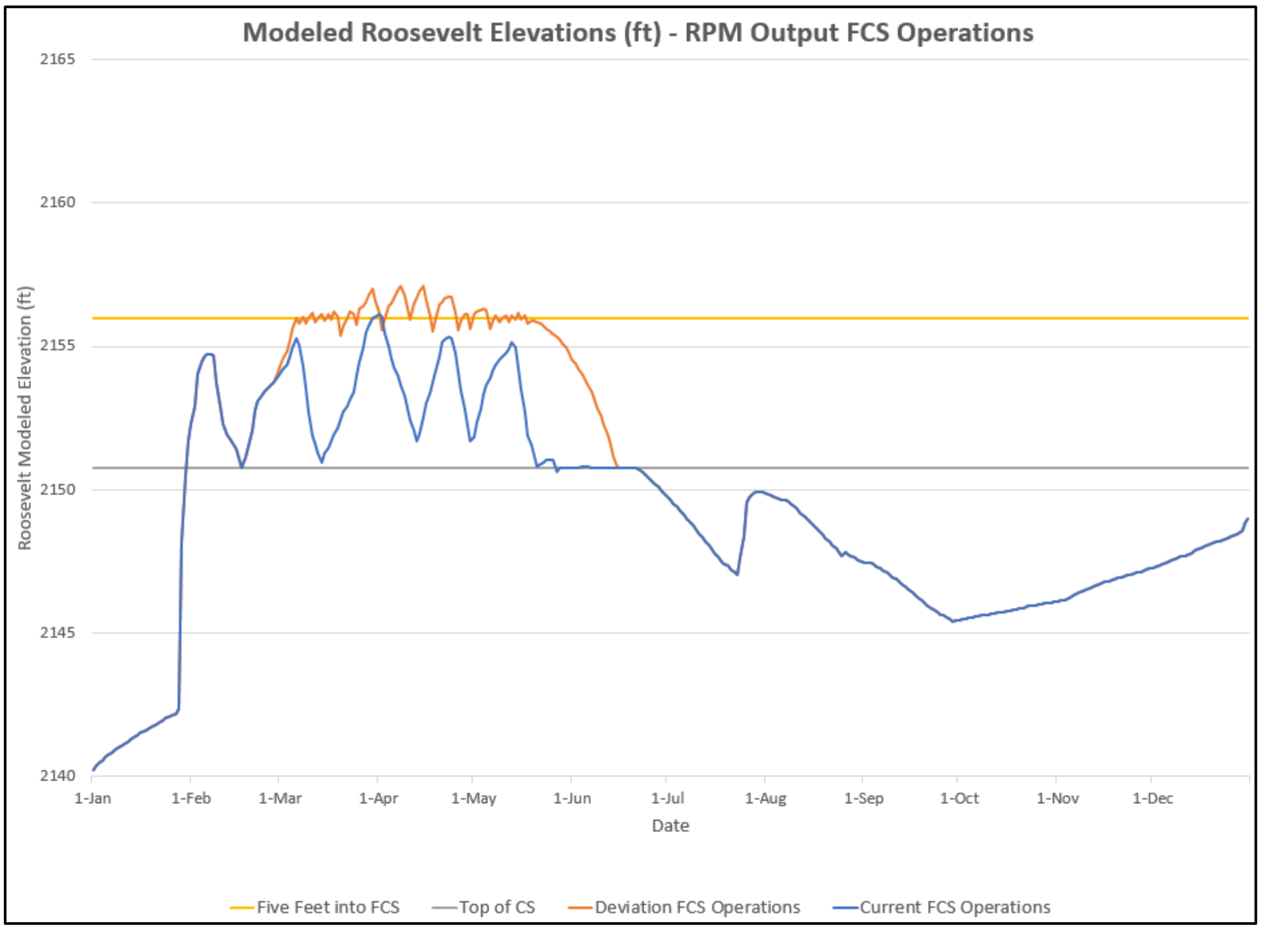

Figure 15. RPM Roosevelt Lake Elevation (feet) for Model Year within FCS for both RPM Scenarios (Current Operation and Proposed Deviation)

Figure 15 shows three additional FCS inflow events occurring under current operations between March and May with drawdown to top of CS within 20 days. If another storm event occurs prior to the 20-day drawdown period, SRP operations may increase releases from the WCM to meet drawdown period to top of CS prior to the 20-day period before the next storm event. Following the last FCS inflow event, Roosevelt Lake elevation then maintains levels near top of CS (2,151 feet) as releases match inflows on the Salt system. Once Verde system storage allows for the water deliveries to transition from the Verde system to the Salt system to meet demand, Roosevelt Lake elevations will begin to decline. During this same time, the planned deviation scenario shows that Roosevelt Lake elevations remain close to 2,156 feet (5 feet into FCS) with slight fluctuations (1 foot) throughout March through May, compared with the several FCS events occurring under current operations, reaching up to 5 feet into FCS with a drawdown within 20 days.

The proposed deviation scenario maintains Roosevelt Lake elevations near 2,156 feet between March and May with any inflow events causing Roosevelt Lake to exceed elevation 2,156 feet to initiate larger releases dictated by the WCM to return the reservoir elevation back below 2,156 feet. In this example, peak Roosevelt Lake elevations reach approximately 1 foot higher during this period under the proposed deviation than current FCS operations. In May, as inflows decrease, Roosevelt Lake levels begin to decline within the first 5 feet of FCS and return to top of CS by mid-June within the 120-day drawdown period from the FCS event that occurred under the proposed deviation. Following the end of the 120-day evacuation period, operations of the CS within Roosevelt Lake are the same for both the planned deviation and normal operations. The Roosevelt FCS example above represents a typical operation in which entry into FCS occurs prior to March 1, reaches a moderate elevation within FCS, and continues throughout the spring months. This illustrates the difference between current operation and proposed deviation throughout the common months when FCS operation typically occurs (December–May). Model years from the RPM in which Roosevelt enters FCS vary, with some years reaching higher elevations with longer durations within FCS, and other model years having smaller rises and shorter durations within FCS (see Figures 10–13).

RPM output for current FCS operations scenarios show Roosevelt Lake entering the FCS in 37 of 106 years (35% of years) and require current FCS operations in 143 of 1,272 months (11% of months). Of the 37 years with flood control operations within the 106-year period, the total duration of months of FCS operations is expected to increase by 21 months if the planned deviation operations were allowed in all 106 years. This would be an increase from 143 months in the FCS to 164 months in the FCS under the planned deviation over the 106-year period, or an average of less than 1 month per year with an FCS event.

In years with anticipated flood control operations, the volume of runoff and frequency of storm events are often sufficient to create multiple flood control operational events. The WCM requires evacuation of the FCS within 20 days, so results showing multi-month durations of FCS operations under the existing WCM are the result of 1) the occurrence of multiple runoff events (storms or snowmelt) resulting in multiple 20-day flood control operations occurring within weeks of each other, and/or 2) a single 20-day event occurring at the end of a month and lasting into the start of the next month. For a single 20-day event that straddles two months, it is not expected that the reservoir elevation would remain in the FCS for the entirety of multiple months (see Figure 15).

As proposed in the planned deviation, the evacuation period is extended from 20 to 120 days for a single event in a year. Additional months of FCS operations beyond what is created by a single 120-day event are a result of other runoff events (storms or snowmelt) that create a new flood control event prior to the deviation. If an additional event occurs while within the 120 days of the planned deviation, the area of the FCS above elevation 2,156 feet would be evacuated within 20 days and then the operations within the FCS would continue to operate as allowed by the planned deviation. Between March and June, when the proposed FCS deviation is modeled to occur, Roosevelt Lake elevations were above 2,151 feet on average

71 days, compared to an average 56 days for current FCS operations within the same time period. While many FCS events for the proposed deviation may be up to 120 days, instances in which Roosevelt only slightly enters into FCS or for a short duration, the time period may be considerably less than 120 days.

The RPM indicates the FCS operations may occur at any time of the year, but primarily in months between December and May. In years with FCS events, Roosevelt Lake elevation may be within FCS for range of 1 to 8 months with an average of 3.8 months (not continuously within FCS during this period). Approximately 45% of the months with modeled FCS operations are the months of April and May, and 41% of the months are January, February, or March. In months with current FCS operation, the peak monthly lake elevation averages 2,154 feet. The majority of monthly lake elevation peaks (93% of months with modeled FCS operations) are within the first 10 vertical feet of the FCS, up to 2,161 feet. Table 9 summaries the duration, month of occurrence, and magnitude of modeled FCS operations for model years in which FCS events occur under current FCS operations. Table 10 shows the change in expected duration of inundation of the FCS that would occur with the proposed FCS deviation as compared to current FCS operations identified in Table 9.

Of the 37 years with FCS events, approximately half (18 years) have zero additional months within FCS under the proposed deviation. Most of the remaining years with FCS events have only one additional month within FCS (17 years), with only 2 years have two additional months within FCS. Additional months within FCS under the proposed deviation typically occur in May and June compared to current operations and are within the first 5 feet of FCS. Peak monthly lake elevations within FCS under the proposed deviation are typically only 1 to 2 feet higher than under current operations, but current operations may have a large range of monthly lake rise due to the 20-day drawdown back to 2,151 feet (for example, range in peak monthly lake rise is <1–5 feet under current operations, but a range of 4–6 feet under the proposed deviation for model year 2). As shown in Table 10, the majority of the observed years do not have an increase in the number of months where the FCS is inundated, though there may not be the short breaks in inundation between storms as shown in the Current WCM scenario (see Figure 15).

Table 9. Duration, timing, and magnitude of estimated FCS operations for model years in which they occur for current FCS operations RPM scenario.

Model Year*	Number of Months with FCS Operations	Range of Months with FCS Operations	Range of Peak Monthly Lake Elevations (feet amsl)	Range of Peak Monthly Lake Rise into FCS (feet)
2	5	February–June	2,151–2,156	<1–5
3	5	January–May	2,151–2,174	<1–23
4	5	January–May	2,153–2,155	2–4
6	4	April–August	2,152–2,153	1–2
7	8	October–May	2,151–2,165	<1–14
9	4	February–May	2,151–2,155	<1–4
11	5	December–April	2,151–2,156	<1–5
13	1	May	2,152	1
14	4	February–May	2,152–2,155	1–4
19	4	January–April	2,151–2,162	<1–11
23	2	April–May	2,152–2,153	1–2
24	4	February–May	2,151–2,157	<1–6
28	5	February–June	2,151–2,166	<1–15
29	5	January–May	2,151–2,152	<1–1

Model Year*	Number of Months with FCS Operations	Range of Months with FCS Operations	Range of Peak Monthly Lake Elevations (feet amsl)	Range of Peak Monthly Lake Rise into FCS (feet)
30	2	April–May	2,151	<1–1
39	2	April–May	2,154–2,155	4
47	1	April	2,151	<1
53	6	December–May	2,151–2,155	<1–4
55	3	March–May	2,151–2,154	<1–3
56	1	April	2,152	2
60	4	March–June	2,151–2,157	1–7
65	3	March–May	2,151–2,155	<1–4
66	7	December–June	2,152–2,163	1–12
67	6	January–June	2,151–2,165	<1–14
69	2	April–May	2,151	<1
70	6	January–June	2,151–2,157	<1–6
71	7	October–April	2,151–2,153	<1–2
72	6	December–May	2,154–2,157	3–6
73	2	March–April	2,154–2,155	3–4
74	3	March–May	2,151–2,154	<1–3
75	2	April–May	2,153	2
78	2	April–May	2,152	1
79	5	February–June	2,151–2,155	<1–4
80	6	December–May	2,153–2,169	2–18
81	1	April	2,151	<1
82	3	February–April	2,152–2,157	1–6
97	2	April–May	2,154	3

* Based on water year (October–September)

Table 10. Comparison of the duration, timing, and magnitude of estimated FCS operations under the planned deviation FCS operations RPM scenario for model years in which they occur.

Model Year*	Additional Number of Months with Water Levels in FCS Caused by Deviation (compared to Table 5)	Range of Months with FCS Operations	Range of Peak Monthly Lake Rise into FCS (feet)	Range of Peak Monthly Lake Elevations (feet amsl)
2	0	February–June	2,155–2,157	4–6
3	1	January–June	2,153–2,174	2–23
4	1	January–June	2,151–2,157	<1–6
6	0	April–August	2,152–2,153	1–2
7	1	October–June	2,151–2,165	<1–14
9	0	February–May	2,151–2,156	<1–5
11	1	December–May	2,151–2,156	<1–5
13	1	May–June	2,151–2,153	<1–2

Model Year*	Additional Number of Months with Water Levels in FCS Caused by Deviation (compared to Table 5)	Range of Months with FCS Operations	Range of Peak Monthly Lake Rise into FCS (feet)	Range of Peak Monthly Lake Elevations (feet amsl)
14	1	February–June	2,151–2,156	<1–5
19	2	January–June	2,151–2,162	<1–11
23	0	April–May	2,153	3
24	0	February–May	2,153–2,158	2–7
28	0	February–June	2,152–2,169	1–18
29	0	January–May	2,151–2,154	<1–3
30	1	March–May	2,151–2,152	<1–1
39	1	April–June	2,153–2,156	2–5
47	1	April–May	2,151–2,152	<1–1
53	0	December–May	2,151–2,156	<1–5
55	1	March–June	2,151–2,156	1–5
56	2	March–May	2,151–2,153	<1–3
60	0	March–June	2,156–2,158	5–7
65	0	March–May	2,156	5–6
66	0	December–June	2,155–2,163	4–12
67	0	January–June	2,152–2,165	1–14
69	0	April–May	2,151–2,152	1
70	0	January–June	2,153–2,157	2–7
71	0	October–April	2,151–2,153	<1–3
72	1	December–June	2,153–2,158	2–7
73	1	March–May	2,154–2,156	3–5
74	1	March–June	2,151–2,156	<1–5
75	0	April–May	2,153–2,154	2–3
78	1	April–June	2,151–2,153	<1–2
79	0	February–June	2,152–2,156	1–5
80	1	December–June	2,153–2,168	2–17
81	0	April	2,151	<1
82	1	February–May	2,154–2,158	3–7
97	1	April–June	2,151–2,155	<1–4

* Based on water year (October–September)

4.3 Reservoir Spill and Downstream Conditions

Reservoir spill into the lower Salt River was analyzed to understand expected changes in downstream flows into the Salt River (magnitude, duration, extent of flow) for both the current operations and proposed planned deviation. The objective of SRP's spill operations for the Salt River reservoirs is to minimize spill releases over Granite Reef Diversion Dam (GRDD) when possible and minimize flood impacts during large flood events. The GRDD is located approximately 2 miles downstream of the confluence of Salt and Verde Rivers (Figure 16) and is the diversion point for all deliveries to the SRP water system from the Salt River. Any spill releases from GRDD into the lower Salt can occur from a combination of flows from the Salt River (releases from Stewart Mountain Dam), the Verde River (releases from Bartlett Dam), and/or local runoff. The maximum release capacity from Stewart Mountain Dam spillways is 209,000 cfs. Under current and historic operations, the average daily flow rates observed in the historic record (USGS Gauge 09502000) from 1935 to 2022 in the Salt River below Stewart Mountain Dam range from 8 to 64,000 cfs. It should also be noted that the highest average daily flow rate observed in the historic record in the Verde River below Bartlett Dam (USGS Gauge 09510000) was up to 101,000 cfs.

Local unregulated flows into the Verde River below Bartlett Dam (e.g., Sycamore Creek) and other small washes in the area can also contribute to the Verde River stream flow, which periodically add to flows in the lower Salt River and may require minor spill releases at GRDD even when spill releases are not being made at Stewart Mountain or Bartlett Dams. These smaller inflows below Bartlett and Stewart Mountain Dams are not considered in this analysis. The GRDD does not store water nor have conservation storage capacity and SRP operates GRDD to divert water from the Salt River into the SRP canal water system to ensure System water orders are met. Typically, there is no flow in the Salt River downstream of the GRDD except during localized runoff events or upstream reservoir releases that require spill releases at GRDD. The largest measured release from the GRDD (180,000 cfs) occurred in 1980. Those unrivaled flood flows occurred prior to the modifications made at Roosevelt Dam and washed out all but two motor vehicle bridges across the Salt River. One of the main objectives of adding the Roosevelt FCS during the dam modifications, and the system operation schedule outlined in the WCM when water is in the FCS, is to limit the discharge at GRDD to a maximum of 180,000 cfs.

4.3.1 Structures, Facilities, and Landmarks Downstream of Granite Reef Diversion Dam

There are a number of road crossings, structures, and mining operations in the Salt River bed below GRRD that are considered when water is spilled over GRDD. Below GRDD, the Salt River channel has been hardened with concrete, and levees have been constructed by U.S. Army Corps of Engineers and the Flood Control District of Maricopa County to allow for passage of flood events through the Phoenix metropolitan area. This section describes those main structures and associated water flow capacities where applicable. Figure 16 provides a map that identifies those structures for reference.

Figure 16. Location of Granite Reef Diversion Dam and Main Structures Along the Salt River

BRIDGES AND ROAD CROSSINGS

Most of the current bridged crossings for the Salt and Gila Rivers within the Phoenix metropolitan area are rated to handle flows up to 180,000 cfs or more, as they were modified in response to flood damage in the 1980s. There are a few road crossing locations along the river that have lower flow constraints, such as Gilbert Road approximately 6 miles downstream from GRDD. Gilbert Road bridge (southbound) is rated to approximately 75,000 cfs and the northbound Gilbert Road has culverts rated up to approximately 5,000 cfs. If flows in the Salt River below GRDD exceed 5,000 cfs, northbound Gilbert Road is closed, and the flows overtop the road. Additionally, several at-grade road crossings of the Salt or Gila Rivers are typically closed with minimal flows through the river channel. These at-grade crossings include McKellips Road in the east valley, and 67th Avenue, 91st Avenue, and El Mirage Road in the west valley.

GRANITE REEF UNDERGROUND STORAGE PROJECT

The Granite Reef Underground Storage Project (GRUSP) is one of Arizona's largest water-recharge facilities and is located in the bed of the Salt River. GRUSP is operated by SRP and ownership interest of the facility is jointly shared by SRP and the Cities of Chandler, Mesa, Phoenix, Scottsdale, and Tempe, and the Town of Gilbert. Water is delivered to the GRUSP recharge basins for recharge into the groundwater aquifer via a channel that diverts water from SRP’s South Canal and moves water across the Salt riverbed. The South Canal is one of two main diversion canals at the GRDD. GRUSP is located below the GRDD and is just upstream of Gilbert Road. The GRUSP delivery channel is an unlined earthen canal that crosses the Salt River from the South Canal and has culverts beneath the canal with a maximum capacity of 5,000 cfs for passing spill release flows in the Salt River channel. When water is spilled over the GRDD, flow rates are monitored closely in relation to the 5,000-cfs culvert capacity. When releases over GRDD are expected to exceed 5,000 cfs, SRP will proactively breach the GRUSP delivery channel to allow for spill water to pass, to reduce significant impact to the culverts and delivery channel infrastructure. Following one of these spill events at the GRDD, SRP and the GRUSP owners reconstruct the channel to allow for resumed operations at GRUSP at the expense of the owners.

TEMPE TOWN LAKE

Tempe Town Lake is a 2-mile-long lake that was created by the City of Tempe by damming a portion of the dry Salt River. Tempe Town Lake is located in the heart of Tempe, running from west of McClintock Road to east of Priest Road between Rio Salado Parkway and Curry Road. SRP notifies the City of Tempe of any spill releases that may reach the lake, and the City of Tempe manages the spill release by lowering the Town Lake dam gates when needed and raising them again to maintain the water within the lake. Tempe Town Lake gates can be lowered to pass up to approximately 200,000 cfs through the Salt River at that location.

OTHER ACTIVITY IN THE SALT RIVERBED BELOW GRDD

Other operations within the Salt River that may also be impacted by releases and are notified when a spill release event may occur are gravel mining operations, the Rio Salado Habitat Restoration Area (Central Avenue and Salt River), and the Tres Rios Wetlands (91st Avenue and Salt River).

SRP also provides notifications when releases are made from GRDD to agencies within the Phoenix metropolitan area responsible for public safety.

4.3.2 Releases at Granite Reef Diversion Dam

The 106-year modeled period was used to evaluate changes in releases over the GRDD under current operating plans as well as for the planned deviation. The RPM showed that under current operations, 51 years out of the 106 years modeled result in physical spill at the GRDD. Using the planned deviation operations, it is expected to decrease the number of spill years at the GRDD by 10%, with the number of years modeled under the planned deviation to result in spill at the GRDD in 46 of the 106 years modeled. These five events that result in no spill at GRDD are small-volume and short-duration events under the current operations, with the largest event being approximately 39,000 AF and lasting 17 days.

A summary of the overall modeled results for average spill duration, volume, and flow at the GRDD is shown in Table 11. The duration of modeled GRDD spill events for the proposed deviation are 11% shorter, on average, when compared to current operations. Shorter GRDD spill event durations occur during the deviation because the first 5 feet of FCS space slowly releases deliveries instead of requiring spill over the GRDD.

Table 11. Summary of modeled GRDD releases.

	Average		
	Duration [days]	**GRDD Spill Volume [AF]**	**GRDD Flow [daily cfs]**
Current operations	11	144,281	3,017
Proposed deviation	10	129,467	3,283
Percent difference	−11%	−10%	9%

Under the planned deviation, smaller storm events following the initial fill of the planned deviation space (elevations 2,151 to 2,156 feet) may require shorter, larger spill rates over the GRDD than would be required under current operations. Average modeled spill event flow rates at GRDD are expected to be 9% higher for the proposed deviation due to release rates from the Roosevelt FCS once water elevation 2,156 feet is achieved. These shorter releases are expected to have a slightly increased flow rate (in cfs) but result in a slight decrease in the total volume (in acre-feet) spilled over GRDD. Modeled results show that using the proposed deviation is expected to result in an average reduction of 10% of the total water volume spilled over the GRDD. Differences in flow at GRDD using the proposed deviation and current operations are small (less than 9%), as shown in Figure 17.

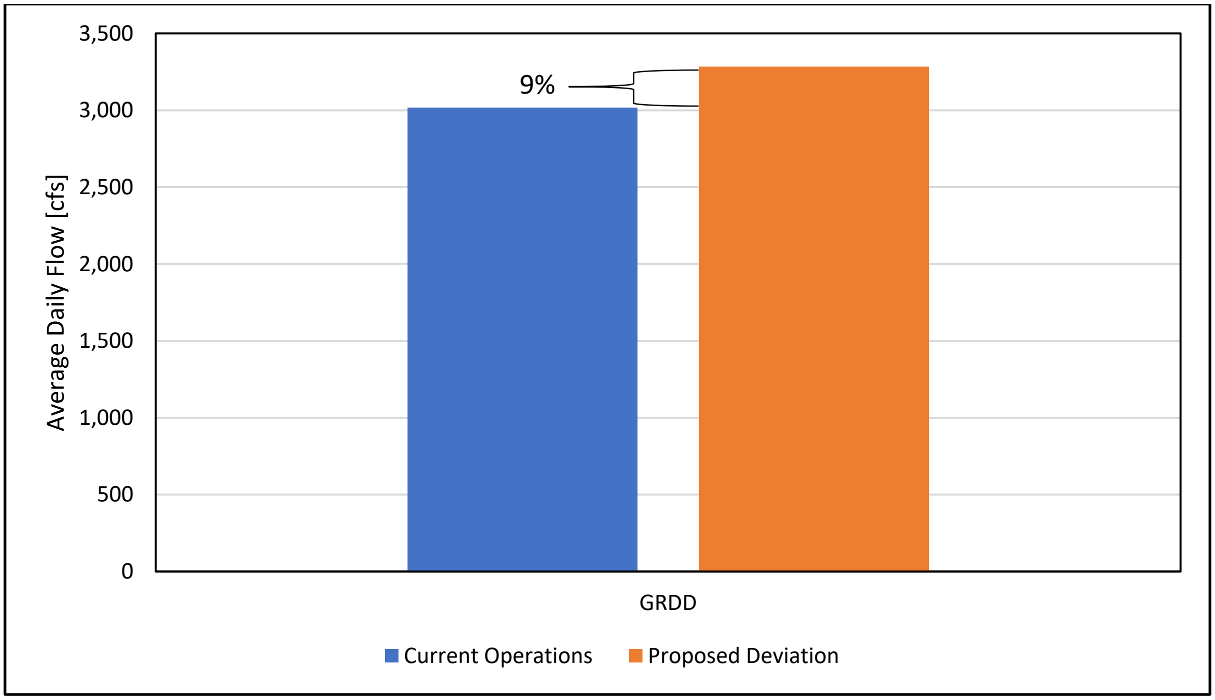

Figure 17. Release Rates at GRDD

To further illustrate the difference in the release rates, an example hydrograph from a single model year for releases of water over GRDD during the run-off season is provided as Figure 18. RPM model year 19 was chosen for this example as it is representative of the average spill year identified from the full 106-year modeling period as shown in Table 1. The hydrograph shows that spills over GRDD would be the same prior to the start of a planned deviation event, when the releases from the first 5 feet of the Roosevelt FCS are allowed to last 120 days, rather than 20 days. Following the start of the planned deviation event, the hydrographs for current operations and planned deviation vary from each other, but both are within the existing flow rates observed historically on the Salt River below Stewart Mountain Dam. The hydrograph shows an approximate 33% decrease in the number of days and total volume of water spilled over GRDD, but a 4% increase in the average release rate during the spill event once the deviation is implemented (after March 1). The largest flows and volume of spill for this year occur prior to the implementation of the deviation (prior to March 1) when both scenarios follow the current operations. Therefore, in years in which larger release rates occur, the peak release would be the same under both scenarios, and differences typically occur in the lower range of flow releases.

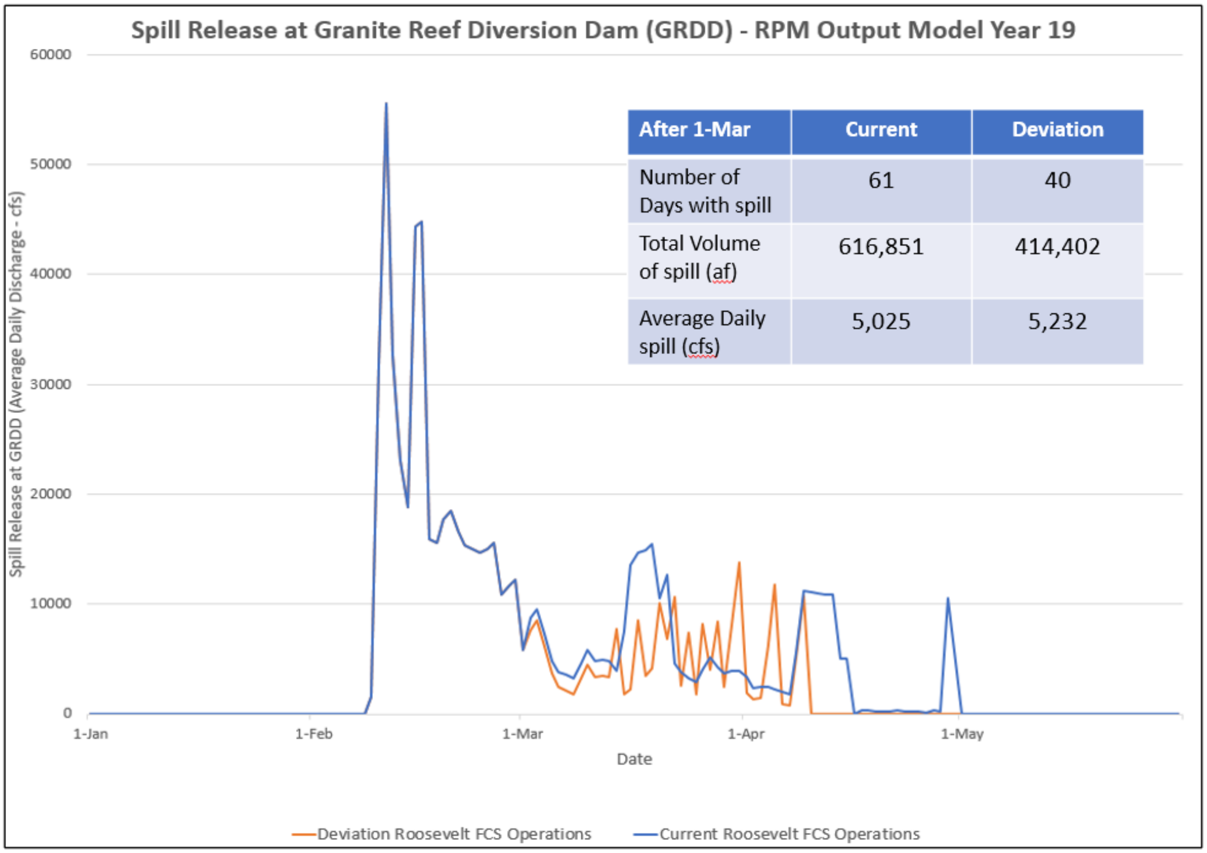

Figure 18. RPM Spill Releases at Granite Reef Diversion Dam for Model Year 19

4.3.3 Lower Salt River Reservoir Operations and Water Quality Considerations

As discussed in Section 2 of this appendix, the lower Salt River reservoirs (Saguaro Lake, Canyon Lake, and Apache Lake) are operated as a conduit for moving water from Roosevelt Lake to Stewart Mountain Dam for release and diversion at the GRDD. The three lower Salt River reservoirs are maintained around 95% of their capacity year-round, and flows within the reservoir system can regularly fluctuate because they are hydropower generating facilities. During flood operations, the reservoir levels remain in the 95% to 100% full range and continue to move water to be diverted to, and when necessary, spilled over GRDD. Under current and historic operations, the average daily flow rates observed in the historic record from 1935 to 2022 in the Salt River below Stewart Mountain Dam range from 8 to 64,000 cfs and up to 180,000 cfs below GRDD. The magnitude, duration, and timing of releases within the reservoirs and downstream of GRDD under the planned deviation are not likely to change from the ranges observed under current operational rules and plans.

- Magnitude of Flow. RPM model results show that overall, there is a slight (9%) increase in average flow rates below Stewart Mountain Dam under planned deviation operations. While the deviation may have brief periods of increased release over current operations, these differences in flow occur within the observed lower range (average modeled spill release rate at GRDD when the deviation is implemented is 3,283 cfs) of releases that could be expected to be released in any given year that spill occurs. Larger flows from Stewart Mountain Dam and GRDD typically occur prior to the implementation of the deviation, when the deviation matches current operation releases, and/or when there are significant contributions from other sources (i.e., Verde River). These larger-magnitude flows within the higher range of observed releases would happen regardless of the planned deviation. For example, the year in Figure 18 when peak flows from GRDD are over 50,000 cfs occurs in February, prior to implementation of the planned deviation.

- Duration of Flow. RPM model results show that overall, the average duration of GRDD spill events would decrease by 11% (from 11 days to 10 days) with the planned deviation. While the deviation is implemented, spill releases (within the lower range of flows) from GRDD would occur for a shorter duration that could start later but end sooner as water is slowly released from the first 5 feet of FCS over the 120-day period (not requiring spill). Overall, the deviation would have an average 10% lower volume of total spill when implemented due to the shorter duration of spill. Again, these differences occur in the lower range of observed releases that typically fluctuate throughout any given year with a spill event during the spring months, and would not significantly change flows during these times.
- Timing of Flow. RPM model results show that spill releases from GRDD would end sooner in the runoff season than under current operations, as shown in the example year (see Figure 18). Flow events that may continue spilling water from GRDD under current operations into May would not under the deviation. Rather, the additional water released from Stewart Mountain Dam over the 120-day period under the deviation (following the last spill event) would be delivered under normal water delivery operation. This would typically occur in the spring to summer months when higher water order demands occur. During these months, there is already high variability in deliveries below Stewart Mountain Dam. Any additional water released from the deviation during this time would be within the range of normal operations.

Overall, the analysis shows that changes in releases over GRDD from the planned deviation are limited to within the historic range of observed variability and normal operations. Differences typically occur in the lower range of releases, and while the proposed deviation may have periods of increased release within these lower ranges of flow, the overall total volume of water spill would be less with the shorter duration of flows from GRDD.

During flood events, the Verde River channel (release from Bartlett Dam) and local unregulated creeks and washes (i.e., Sycamore Creek) act as conduits for moving water and contribute additional flows beyond releases from Stewart Mountain Dam (flows from Salt River) to GRDD for diversion or spill. During physical spill events at GRDD, flows are such that water turbidity observed in both the Salt and Verde Rivers below Stewart Mountain Dam and Bartlett Dam is elevated above non-spill conditions due to decreased resonance time for water passing through the reservoirs and higher flows in the river channel. The unregulated flows from Sycamore Creek often have the largest impact on water quality measured near GRDD due to the flashy nature of the contributing ephemeral washes in response to large precipitation events. Additionally, desert soil conditions in the lower portions of the Sycamore Creek subwatershed and soils damaged by recent and historic fire conditions can result in higher turbidity and sediment loads impacting water quality during runoff events. The diversion point for municipal water treatment plants that use water from the Salt and Verde River system is GRDD, so changes in water quality from flood events are most critical above GRDD. Water quality from flood events on Sycamore Creek frequently cause impacts to water treatment plants served by the SRP system due to lack of reservoirs to attenuate sediments and other water quality constituents. The planned deviation will have no impact on flows of Sycamore Creek.

The periods of higher flows and flows with greater potential impacts to water quality and changes to channel metrics typically occur when other sources of water (besides Salt River below Stewart Mountain Dam) also contribute to spill at GRDD (Verde River below Bartlett Dam, and Sycamore Creek), and/or when operation occurs under current operations in both scenarios. These larger flow events and unregulated higher-turbidity flows along the lower Verde (Sycamore Creek) are typically the driver of poor water quality events, and slight changes in release from Stewart Mountain Dam from the planned deviation will have little to no measured impact.

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APPENDIX B

Monthly Estimates of Peak Lake Elevation Under Each Scenario and a Summary of Estimated Lake Elevations in June of Each Model Year

Table B1. Monthly Estimates of Peak Lake Elevations and NMGS Habitat Acreage under Current Water Control Manual Scenario and under Proposed Flood Control Space Deviation (highlighted cells indicate water levels in the flood control space above 2,150.77 feet amsl).*

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Oct - MY 001	2122.6	2122.6	322.9	195.8	195.8
Nov - MY 001	2123.8	2123.8	315.7	195.8	195.8
Dec - MY 001	2125.2	2125.2	301.7	195.8	195.8
Jan - MY 001	2126.9	2126.9	301.7	195.8	195.8
Feb - MY 001	2132.9	2132.9	260.9	195.8	195.8
Mar - MY 001	2136.4	2136.4	194.5	195.8	195.8
Apr - MY 001	2139.2	2139.2	170.4	195.8	195.8
May - MY 001	2136.0	2136.0	194.5	195.8	195.8
Jun - MY 001	2130.5	2130.5	295.9	195.8	195.8
Jul - MY 001	2126.5	2126.5	301.7	195.8	195.8
Aug - MY 001	2124.8	2124.8	315.7	195.8	195.8
Sep - MY 001	2123.2	2123.2	315.7	195.8	195.8
Oct - MY 002	2125.9	2125.9	301.7	195.8	195.8
Nov - MY 002	2127.8	2127.8	302.5	195.8	195.8
Dec - MY 002	2139.9	2139.9	170.4	195.8	195.8
Jan - MY 002	2150.5	2150.5	105.5	195.8	195.8
Feb - MY 002	2154.7	2154.7	105.5	166.9	166.9
Mar - MY 002	2156.0	2157.0	105.5	158.1	150.2
Apr - MY 002	2156.1	2157.1	105.5	158.1	150.2
May - MY 002	2155.1	2156.3	105.5	166.9	158.1
Jun - MY 002	2150.8	2154.8	105.5	195.8	166.9
Jul - MY 002	2149.9	2149.9	105.5	195.8	195.8
Aug - MY 002	2147.6	2147.6	100.5	195.8	195.8
Sep - MY 002	2145.4	2145.4	128.6	195.8	195.8
Oct - MY 003	2146.1	2146.1	128.6	195.8	195.8
Nov - MY 003	2147.2	2147.2	100.5	195.8	195.8
Dec - MY 003	2148.8	2148.8	100.5	195.8	195.8
Jan - MY 003	2173.8	2173.9	105.5	7.3	7.3
Feb - MY 003	2161.7	2161.7	105.5	111.6	111.6
Mar - MY 003	2158.8	2161.1	105.5	134.3	119.0
Apr - MY 003	2155.2	2156.4	105.5	166.9	158.1
May - MY 003	2151.1	2156.0	105.5	195.8	158.1
Jun - MY 003	2148.2	2152.7	100.5	195.8	182.8
Jul - MY 003	2144.1	2144.1	150.8	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Aug - MY 003	2142.8	2142.8	159.4	195.8	195.8
Sep - MY 003	2143.9	2143.9	150.8	195.8	195.8
Oct - MY 004	2148.5	2148.5	100.5	195.8	195.8
Nov - MY 004	2149.7	2149.7	105.5	195.8	195.8
Dec - MY 004	2150.8	2150.8	105.5	195.8	195.8
Jan - MY 004	2154.4	2154.4	105.5	175.7	175.7
Feb - MY 004	2153.0	2153.0	105.5	182.8	182.8
Mar - MY 004	2153.2	2153.6	105.5	182.8	175.7
Apr - MY 004	2154.9	2157.1	105.5	166.9	150.2
May - MY 004	2154.9	2155.8	105.5	166.9	158.1
Jun - MY 004	2147.2	2151.1	100.5	195.8	195.8
Jul - MY 004	2144.2	2144.2	150.8	195.8	195.8
Aug - MY 004	2142.1	2142.1	159.4	195.8	195.8
Sep - MY 004	2140.1	2140.1	170.4	195.8	195.8
Oct - MY 005	2140.3	2140.3	170.4	195.8	195.8
Nov - MY 005	2140.7	2140.7	170.4	195.8	195.8
Dec - MY 005	2141.3	2141.3	159.4	195.8	195.8
Jan - MY 005	2142.4	2142.4	159.4	195.8	195.8
Feb - MY 005	2143.8	2143.8	150.8	195.8	195.8
Mar - MY 005	2150.0	2150.0	105.5	195.8	195.8
Apr - MY 005	2150.8	2150.8	105.5	195.8	195.8
May - MY 005	2147.9	2147.9	100.5	195.8	195.8
Jun - MY 005	2143.0	2143.0	159.4	195.8	195.8
Jul - MY 005	2138.1	2138.1	181.3	195.8	195.8
Aug - MY 005	2134.0	2134.0	211.1	195.8	195.8
Sep - MY 005	2130.5	2130.5	295.9	195.8	195.8
Oct - MY 006	2130.7	2130.7	295.9	195.8	195.8
Nov - MY 006	2131.6	2131.6	260.9	195.8	195.8
Dec - MY 006	2133.1	2133.1	211.1	195.8	195.8
Jan - MY 006	2134.0	2134.0	211.1	195.8	195.8
Feb - MY 006	2139.1	2139.1	170.4	195.8	195.8
Mar - MY 006	2145.2	2145.2	128.6	195.8	195.8
Apr - MY 006	2152.8	2153.2	105.5	182.8	182.8
May - MY 006	2152.8	2153.2	105.5	182.8	182.8
Jun - MY 006	2146.1	2146.1	128.6	195.8	195.8
Jul - MY 006	2151.7	2151.6	105.5	189.8	189.8
Aug - MY 006	2152.9	2153.0	105.5	182.8	182.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Sep - MY 006	2150.6	2150.6	105.5	195.8	195.8
Oct - MY 007	2151.0	2151.0	105.5	195.8	195.8
Nov - MY 007	2156.3	2155.7	105.5	158.1	158.1
Dec - MY 007	2161.4	2160.7	105.5	119.0	119.0
Jan - MY 007	2154.8	2154.8	105.5	166.9	166.9
Feb - MY 007	2164.7	2164.8	105.5	88.0	88.0
Mar - MY 007	2154.6	2156.7	105.5	166.9	150.2
Apr - MY 007	2155.0	2156.1	105.5	166.9	158.1
May - MY 007	2151.1	2155.6	105.5	195.8	158.1
Jun - MY 007	2148.0	2152.2	100.5	195.8	189.8
Jul - MY 007	2143.2	2143.2	150.8	195.8	195.8
Aug - MY 007	2141.3	2141.3	159.4	195.8	195.8
Sep - MY 007	2138.8	2138.8	181.3	195.8	195.8
Oct - MY 008	2139.5	2139.5	170.4	195.8	195.8
Nov - MY 008	2141.0	2141.0	170.4	195.8	195.8
Dec - MY 008	2141.9	2141.9	159.4	195.8	195.8
Jan - MY 008	2142.9	2142.9	159.4	195.8	195.8
Feb - MY 008	2143.9	2143.9	150.8	195.8	195.8
Mar - MY 008	2144.9	2144.9	150.8	195.8	195.8
Apr - MY 008	2145.3	2145.3	128.6	195.8	195.8
May - MY 008	2141.3	2141.3	159.4	195.8	195.8
Jun - MY 008	2135.9	2135.9	194.5	195.8	195.8
Jul - MY 008	2132.7	2132.7	260.9	195.8	195.8
Aug - MY 008	2140.2	2140.2	170.4	195.8	195.8
Sep - MY 008	2139.7	2139.7	170.4	195.8	195.8
Oct - MY 009	2140.6	2140.6	170.4	195.8	195.8
Nov - MY 009	2141.3	2141.3	159.4	195.8	195.8
Dec - MY 009	2143.0	2143.0	150.8	195.8	195.8
Jan - MY 009	2146.4	2146.4	128.6	195.8	195.8
Feb - MY 009	2151.0	2151.1	105.5	195.8	195.8
Mar - MY 009	2155.0	2156.1	105.5	166.9	158.1
Apr - MY 009	2152.2	2156.1	105.5	189.8	158.1
May - MY 009	2150.9	2155.7	105.5	195.8	158.1
Jun - MY 009	2145.5	2145.5	128.6	195.8	195.8
Jul - MY 009	2140.8	2140.8	170.4	195.8	195.8
Aug - MY 009	2137.6	2137.6	181.3	195.8	195.8
Sep - MY 009	2134.7	2134.7	211.1	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Oct - MY 010	2134.9	2134.9	211.1	195.8	195.8
Nov - MY 010	2135.6	2135.6	194.5	195.8	195.8
Dec - MY 010	2137.7	2137.7	181.3	195.8	195.8
Jan - MY 010	2138.5	2138.5	181.3	195.8	195.8
Feb - MY 010	2140.9	2140.9	170.4	195.8	195.8
Mar - MY 010	2147.3	2147.3	100.5	195.8	195.8
Apr - MY 010	2150.4	2150.4	105.5	195.8	195.8
May - MY 010	2148.0	2148.0	100.5	195.8	195.8
Jun - MY 010	2142.9	2142.9	159.4	195.8	195.8
Jul - MY 010	2138.4	2138.4	181.3	195.8	195.8
Aug - MY 010	2136.4	2136.4	194.5	195.8	195.8
Sep - MY 010	2139.9	2139.9	170.4	195.8	195.8
Oct - MY 011	2140.7	2140.7	170.4	195.8	195.8
Nov - MY 011	2144.0	2144.0	150.8	195.8	195.8
Dec - MY 011	2155.8	2155.7	105.5	158.1	158.1
Jan - MY 011	2156.0	2155.4	105.5	158.1	166.9
Feb - MY 011	2151.0	2151.0	105.5	195.8	195.8
Mar - MY 011	2151.5	2152.1	105.5	195.8	189.8
Apr - MY 011	2154.6	2156.0	105.5	166.9	158.1
May - MY 011	2149.7	2155.4	105.5	195.8	166.9
Jun - MY 011	2144.9	2144.9	150.8	195.8	195.8
Jul - MY 011	2139.5	2139.5	170.4	195.8	195.8
Aug - MY 011	2134.6	2134.6	211.1	195.8	195.8
Sep - MY 011	2130.9	2130.9	295.9	195.8	195.8
Oct - MY 012	2131.1	2131.1	260.9	195.8	195.8
Nov - MY 012	2131.5	2131.5	260.9	195.8	195.8
Dec - MY 012	2132.7	2132.7	260.9	195.8	195.8
Jan - MY 012	2133.5	2133.5	211.1	195.8	195.8
Feb - MY 012	2134.1	2134.1	211.1	195.8	195.8
Mar - MY 012	2137.6	2137.6	181.3	195.8	195.8
Apr - MY 012	2139.3	2139.3	170.4	195.8	195.8
May - MY 012	2135.2	2135.2	194.5	195.8	195.8
Jun - MY 012	2129.4	2129.4	295.9	195.8	195.8
Jul - MY 012	2123.7	2123.7	315.7	195.8	195.8
Aug - MY 012	2119.6	2119.6	334.1	195.8	195.8
Sep - MY 012	2120.7	2120.7	334.1	195.8	195.8
Oct - MY 013	2122.4	2122.4	322.9	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Nov - MY 013	2123.5	2123.5	315.7	195.8	195.8
Dec - MY 013	2124.5	2124.5	315.7	195.8	195.8
Jan - MY 013	2125.4	2125.4	301.7	195.8	195.8
Feb - MY 013	2126.2	2126.2	301.7	195.8	195.8
Mar - MY 013	2131.3	2131.3	260.9	195.8	195.8
Apr - MY 013	2150.0	2150.0	105.5	195.8	195.8
May - MY 013	2152.2	2153.0	105.5	189.8	182.8
Jun - MY 013	2146.7	2151.0	128.6	195.8	195.8
Jul - MY 013	2142.1	2142.1	159.4	195.8	195.8
Aug - MY 013	2137.9	2137.9	181.3	195.8	195.8
Sep - MY 013	2135.7	2135.7	194.5	195.8	195.8
Oct - MY 014	2136.2	2136.2	194.5	195.8	195.8
Nov - MY 014	2136.8	2136.8	194.5	195.8	195.8
Dec - MY 014	2139.0	2139.0	181.3	195.8	195.8
Jan - MY 014	2140.1	2140.1	170.4	195.8	195.8
Feb - MY 014	2155.1	2155.1	105.5	166.9	166.9
Mar - MY 014	2154.0	2156.2	105.5	175.7	158.1
Apr - MY 014	2151.8	2156.1	105.5	189.8	158.1
May - MY 014	2151.7	2155.7	105.5	189.8	158.1
Jun - MY 014	2147.2	2151.1	100.5	195.8	195.8
Jul - MY 014	2142.9	2142.9	159.4	195.8	195.8
Aug - MY 014	2140.1	2140.1	170.4	195.8	195.8
Sep - MY 014	2141.4	2141.4	159.4	195.8	195.8
Oct - MY 015	2141.6	2141.6	159.4	195.8	195.8
Nov - MY 015	2142.1	2142.1	159.4	195.8	195.8
Dec - MY 015	2143.0	2143.0	159.4	195.8	195.8
Jan - MY 015	2143.6	2143.6	150.8	195.8	195.8
Feb - MY 015	2146.2	2146.2	128.6	195.8	195.8
Mar - MY 015	2148.4	2148.4	100.5	195.8	195.8
Apr - MY 015	2149.6	2149.6	105.5	195.8	195.8
May - MY 015	2146.3	2146.3	128.6	195.8	195.8
Jun - MY 015	2141.1	2141.1	159.4	195.8	195.8
Jul - MY 015	2135.9	2135.9	194.5	195.8	195.8
Aug - MY 015	2131.7	2131.7	260.9	195.8	195.8
Sep - MY 015	2128.2	2128.2	302.5	195.8	195.8
Oct - MY 016	2128.8	2128.8	302.5	195.8	195.8
Nov - MY 016	2129.7	2129.7	295.9	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Dec - MY 016	2130.6	2130.6	295.9	195.8	195.8
Jan - MY 016	2131.6	2131.6	260.9	195.8	195.8
Feb - MY 016	2132.8	2132.8	260.9	195.8	195.8
Mar - MY 016	2135.4	2135.4	194.5	195.8	195.8
Apr - MY 016	2141.7	2141.7	159.4	195.8	195.8
May - MY 016	2138.4	2138.4	181.3	195.8	195.8
Jun - MY 016	2132.9	2132.9	260.9	195.8	195.8
Jul - MY 016	2127.6	2127.6	302.5	195.8	195.8
Aug - MY 016	2126.2	2126.2	301.7	195.8	195.8
Sep - MY 016	2125.8	2125.8	301.7	195.8	195.8
Oct - MY 017	2126.9	2126.9	301.7	195.8	195.8
Nov - MY 017	2127.5	2127.5	302.5	195.8	195.8
Dec - MY 017	2128.2	2128.2	302.5	195.8	195.8
Jan - MY 017	2129.4	2129.4	295.9	195.8	195.8
Feb - MY 017	2131.0	2131.0	260.9	195.8	195.8
Mar - MY 017	2137.4	2137.4	181.3	195.8	195.8
Apr - MY 017	2142.2	2142.2	159.4	195.8	195.8
May - MY 017	2139.7	2139.7	170.4	195.8	195.8
Jun - MY 017	2134.4	2134.4	211.1	195.8	195.8
Jul - MY 017	2130.5	2130.5	295.9	195.8	195.8
Aug - MY 017	2128.5	2128.5	302.5	195.8	195.8
Sep - MY 017	2125.2	2125.2	301.7	195.8	195.8
Oct - MY 018	2125.3	2125.3	301.7	195.8	195.8
Nov - MY 018	2126.9	2126.9	301.7	195.8	195.8
Dec - MY 018	2127.9	2127.9	302.5	195.8	195.8
Jan - MY 018	2128.5	2128.5	302.5	195.8	195.8
Feb - MY 018	2139.4	2139.4	170.4	195.8	195.8
Mar - MY 018	2142.1	2142.1	159.4	195.8	195.8
Apr - MY 018	2146.4	2146.4	128.6	195.8	195.8
May - MY 018	2145.6	2145.6	128.6	195.8	195.8
Jun - MY 018	2140.7	2140.7	170.4	195.8	195.8
Jul - MY 018	2135.8	2135.8	194.5	195.8	195.8
Aug - MY 018	2134.5	2134.5	211.1	195.8	195.8
Sep - MY 018	2135.0	2135.0	211.1	195.8	195.8
Oct - MY 019	2138.9	2138.9	181.3	195.8	195.8
Nov - MY 019	2142.3	2142.3	159.4	195.8	195.8
Dec - MY 019	2148.1	2148.1	100.5	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Jan - MY 019	2151.0	2151.0	105.5	195.8	195.8
Feb - MY 019	2161.7	2161.7	105.5	111.6	111.6
Mar - MY 019	2155.0	2156.2	105.5	166.9	158.1
Apr - MY 019	2155.0	2156.1	105.5	166.9	158.1
May - MY 019	2150.6	2155.9	105.5	195.8	158.1
Jun - MY 019	2146.2	2151.0	128.6	195.8	195.8
Jul - MY 019	2142.2	2142.2	159.4	195.8	195.8
Aug - MY 019	2139.9	2139.9	170.4	195.8	195.8
Sep - MY 019	2137.7	2137.7	181.3	195.8	195.8
Oct - MY 020	2138.4	2138.4	181.3	195.8	195.8
Nov - MY 020	2138.8	2138.8	181.3	195.8	195.8
Dec - MY 020	2140.1	2140.1	170.4	195.8	195.8
Jan - MY 020	2141.4	2141.4	159.4	195.8	195.8
Feb - MY 020	2143.1	2143.1	150.8	195.8	195.8
Mar - MY 020	2147.9	2147.9	100.5	195.8	195.8
Apr - MY 020	2150.7	2150.7	105.5	195.8	195.8
May - MY 020	2149.5	2149.5	105.5	195.8	195.8
Jun - MY 020	2145.3	2145.3	128.6	195.8	195.8
Jul - MY 020	2141.1	2141.1	159.4	195.8	195.8
Aug - MY 020	2137.3	2137.3	181.3	195.8	195.8
Sep - MY 020	2135.1	2135.1	194.5	195.8	195.8
Oct - MY 021	2135.8	2135.8	194.5	195.8	195.8
Nov - MY 021	2135.1	2135.1	194.5	195.8	195.8
Dec - MY 021	2135.9	2135.9	194.5	195.8	195.8
Jan - MY 021	2136.2	2136.2	194.5	195.8	195.8
Feb - MY 021	2136.4	2136.4	194.5	195.8	195.8
Mar - MY 021	2135.8	2135.8	194.5	195.8	195.8
Apr - MY 021	2133.2	2133.2	211.1	195.8	195.8
May - MY 021	2128.6	2128.6	302.5	195.8	195.8
Jun - MY 021	2122.2	2122.2	322.9	195.8	195.8
Jul - MY 021	2115.8	2115.8	368.3	195.8	195.8
Aug - MY 021	2114.1	2114.1	376.4	195.8	195.8
Sep - MY 021	2113.5	2113.5	376.4	195.8	195.8
Oct - MY 022	2110.6	2110.6	382.0	195.8	195.8
Nov - MY 022	2108.8	2108.8	388.3	195.8	195.8
Dec - MY 022	2109.1	2109.1	382.0	195.8	195.8
Jan - MY 022	2114.2	2114.2	376.4	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Feb - MY 022	2124.2	2124.2	315.7	195.8	195.8
Mar - MY 022	2135.2	2135.2	194.5	195.8	195.8
Apr - MY 022	2145.4	2145.4	128.6	195.8	195.8
May - MY 022	2144.9	2144.9	150.8	195.8	195.8
Jun - MY 022	2141.3	2141.3	159.4	195.8	195.8
Jul - MY 022	2136.3	2136.3	194.5	195.8	195.8
Aug - MY 022	2133.4	2133.4	211.1	195.8	195.8
Sep - MY 022	2132.0	2132.0	260.9	195.8	195.8
Oct - MY 023	2132.2	2132.2	260.9	195.8	195.8
Nov - MY 023	2132.9	2132.9	260.9	195.8	195.8
Dec - MY 023	2133.6	2133.6	211.1	195.8	195.8
Jan - MY 023	2134.3	2134.3	211.1	195.8	195.8
Feb - MY 023	2140.8	2140.8	170.4	195.8	195.8
Mar - MY 023	2147.0	2147.0	128.6	195.8	195.8
Apr - MY 023	2152.7	2153.3	105.5	182.8	182.8
May - MY 023	2151.7	2153.3	105.5	189.8	182.8
Jun - MY 023	2145.3	2145.3	128.6	195.8	195.8
Jul - MY 023	2140.2	2140.2	170.4	195.8	195.8
Aug - MY 023	2136.3	2136.3	194.5	195.8	195.8
Sep - MY 023	2134.0	2134.0	211.1	195.8	195.8
Oct - MY 024	2134.5	2134.5	211.1	195.8	195.8
Nov - MY 024	2135.5	2135.5	194.5	195.8	195.8
Dec - MY 024	2136.9	2136.9	194.5	195.8	195.8
Jan - MY 024	2139.1	2139.1	170.4	195.8	195.8
Feb - MY 024	2153.0	2153.0	105.5	182.8	182.8
Mar - MY 024	2157.1	2157.6	105.5	150.2	142.3
Apr - MY 024	2155.1	2156.4	105.5	166.9	158.1
May - MY 024	2151.0	2155.6	105.5	195.8	158.1
Jun - MY 024	2145.7	2145.7	128.6	195.8	195.8
Jul - MY 024	2140.7	2140.7	170.4	195.8	195.8
Aug - MY 024	2135.8	2135.8	194.5	195.8	195.8
Sep - MY 024	2132.5	2132.5	260.9	195.8	195.8
Oct - MY 025	2132.7	2132.7	260.9	195.8	195.8
Nov - MY 025	2132.9	2132.9	260.9	195.8	195.8
Dec - MY 025	2133.6	2133.6	211.1	195.8	195.8
Jan - MY 025	2134.2	2134.2	211.1	195.8	195.8
Feb - MY 025	2135.0	2135.0	211.1	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Mar - MY 025	2142.4	2142.4	159.4	195.8	195.8
Apr - MY 025	2144.1	2144.1	150.8	195.8	195.8
May - MY 025	2140.6	2140.6	170.4	195.8	195.8
Jun - MY 025	2135.0	2135.0	194.5	195.8	195.8
Jul - MY 025	2129.2	2129.2	295.9	195.8	195.8
Aug - MY 025	2125.1	2125.1	301.7	195.8	195.8
Sep - MY 025	2122.7	2122.7	322.9	195.8	195.8
Oct - MY 026	2122.6	2122.6	322.9	195.8	195.8
Nov - MY 026	2122.9	2122.9	322.9	195.8	195.8
Dec - MY 026	2123.8	2123.8	315.7	195.8	195.8
Jan - MY 026	2124.6	2124.6	315.7	195.8	195.8
Feb - MY 026	2125.9	2125.9	301.7	195.8	195.8
Mar - MY 026	2129.6	2129.6	295.9	195.8	195.8
Apr - MY 026	2133.4	2133.4	211.1	195.8	195.8
May - MY 026	2130.0	2130.0	295.9	195.8	195.8
Jun - MY 026	2124.1	2124.1	315.7	195.8	195.8
Jul - MY 026	2117.7	2117.7	340.4	195.8	195.8
Aug - MY 026	2112.9	2112.9	387.9	195.8	195.8
Sep - MY 026	2113.3	2113.3	376.4	195.8	195.8
Oct - MY 027	2111.7	2111.7	387.9	195.8	195.8
Nov - MY 027	2110.5	2110.5	382.0	195.8	195.8
Dec - MY 027	2111.0	2111.0	387.9	195.8	195.8
Jan - MY 027	2111.9	2111.9	387.9	195.8	195.8
Feb - MY 027	2114.3	2114.3	376.4	195.8	195.8
Mar - MY 027	2117.7	2117.7	340.4	195.8	195.8
Apr - MY 027	2118.3	2118.3	340.4	195.8	195.8
May - MY 027	2114.0	2114.0	376.4	195.8	195.8
Jun - MY 027	2107.6	2107.6	388.3	195.8	195.8
Jul - MY 027	2101.0	2101.0	432.9	195.8	195.8
Aug - MY 027	2096.1	2096.1	469.4	195.8	195.8
Sep - MY 027	2095.9	2095.9	469.4	195.8	195.8
Oct - MY 028	2097.2	2097.2	436.2	195.8	195.8
Nov - MY 028	2099.3	2099.3	435.7	195.8	195.8
Dec - MY 028	2120.5	2120.5	334.1	195.8	195.8
Jan - MY 028	2138.9	2138.9	181.3	195.8	195.8
Feb - MY 028	2151.9	2152.2	105.5	189.8	189.8
Mar - MY 028	2166.1	2168.7	105.5	80.7	48.4

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Apr - MY 028	2155.2	2157.3	105.5	166.9	150.2
May - MY 028	2157.1	2157.0	105.5	150.2	150.2
Jun - MY 028	2151.1	2155.0	105.5	195.8	166.9
Jul - MY 028	2147.1	2147.1	100.5	195.8	195.8
Aug - MY 028	2144.6	2144.6	150.8	195.8	195.8
Sep - MY 028	2143.5	2143.5	150.8	195.8	195.8
Oct - MY 029	2145.4	2145.4	128.6	195.8	195.8
Nov - MY 029	2146.8	2146.8	128.6	195.8	195.8
Dec - MY 029	2149.3	2149.3	105.5	195.8	195.8
Jan - MY 029	2151.1	2151.2	105.5	195.8	195.8
Feb - MY 029	2151.1	2151.1	105.5	195.8	195.8
Mar - MY 029	2151.1	2152.3	105.5	195.8	189.8
Apr - MY 029	2152.2	2154.0	105.5	189.8	175.7
May - MY 029	2151.0	2153.8	105.5	195.8	175.7
Jun - MY 029	2143.9	2143.9	150.8	195.8	195.8
Jul - MY 029	2138.4	2138.4	181.3	195.8	195.8
Aug - MY 029	2133.8	2133.8	211.1	195.8	195.8
Sep - MY 029	2130.6	2130.6	295.9	195.8	195.8
Oct - MY 030	2131.2	2131.2	260.9	195.8	195.8
Nov - MY 030	2131.8	2131.8	260.9	195.8	195.8
Dec - MY 030	2133.2	2133.2	211.1	195.8	195.8
Jan - MY 030	2137.4	2137.4	181.3	195.8	195.8
Feb - MY 030	2140.4	2140.4	170.4	195.8	195.8
Mar - MY 030	2150.5	2151.0	105.5	195.8	195.8
Apr - MY 030	2151.3	2152.0	105.5	195.8	189.8
May - MY 030	2150.9	2151.4	105.5	195.8	195.8
Jun - MY 030	2143.5	2143.5	150.8	195.8	195.8
Jul - MY 030	2137.9	2137.9	181.3	195.8	195.8
Aug - MY 030	2133.7	2133.7	211.1	195.8	195.8
Sep - MY 030	2130.7	2130.7	295.9	195.8	195.8
Oct - MY 031	2131.2	2131.2	260.9	195.8	195.8
Nov - MY 031	2131.7	2131.7	260.9	195.8	195.8
Dec - MY 031	2132.5	2132.5	260.9	195.8	195.8
Jan - MY 031	2133.2	2133.2	211.1	195.8	195.8
Feb - MY 031	2135.5	2135.5	194.5	195.8	195.8
Mar - MY 031	2140.9	2140.9	170.4	195.8	195.8
Apr - MY 031	2145.0	2145.0	150.8	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
May - MY 031	2141.9	2141.9	159.4	195.8	195.8
Jun - MY 031	2136.4	2136.4	194.5	195.8	195.8
Jul - MY 031	2130.3	2130.3	295.9	195.8	195.8
Aug - MY 031	2124.7	2124.7	315.7	195.8	195.8
Sep - MY 031	2122.7	2122.7	322.9	195.8	195.8
Oct - MY 032	2123.4	2123.4	315.7	195.8	195.8
Nov - MY 032	2124.2	2124.2	315.7	195.8	195.8
Dec - MY 032	2125.2	2125.2	301.7	195.8	195.8
Jan - MY 032	2126.5	2126.5	301.7	195.8	195.8
Feb - MY 032	2128.4	2128.4	302.5	195.8	195.8
Mar - MY 032	2135.9	2135.9	194.5	195.8	195.8
Apr - MY 032	2143.6	2143.6	150.8	195.8	195.8
May - MY 032	2142.6	2142.6	159.4	195.8	195.8
Jun - MY 032	2137.3	2137.3	181.3	195.8	195.8
Jul - MY 032	2131.7	2131.7	260.9	195.8	195.8
Aug - MY 032	2127.7	2127.7	302.5	195.8	195.8
Sep - MY 032	2124.0	2124.0	315.7	195.8	195.8
Oct - MY 033	2124.6	2124.6	315.7	195.8	195.8
Nov - MY 033	2124.9	2124.9	315.7	195.8	195.8
Dec - MY 033	2126.0	2126.0	301.7	195.8	195.8
Jan - MY 033	2127.0	2127.0	301.7	195.8	195.8
Feb - MY 033	2127.6	2127.6	302.5	195.8	195.8
Mar - MY 033	2129.1	2129.1	295.9	195.8	195.8
Apr - MY 033	2130.3	2130.3	295.9	195.8	195.8
May - MY 033	2125.6	2125.6	301.7	195.8	195.8
Jun - MY 033	2118.9	2118.9	340.4	195.8	195.8
Jul - MY 033	2112.0	2112.0	387.9	195.8	195.8
Aug - MY 033	2108.3	2108.3	388.3	195.8	195.8
Sep - MY 033	2114.4	2114.4	376.4	195.8	195.8
Oct - MY 034	2112.0	2112.0	387.9	195.8	195.8
Nov - MY 034	2111.7	2111.7	387.9	195.8	195.8
Dec - MY 034	2114.3	2114.3	376.4	195.8	195.8
Jan - MY 034	2115.8	2115.8	368.3	195.8	195.8
Feb - MY 034	2117.1	2117.1	340.4	195.8	195.8
Mar - MY 034	2116.9	2116.9	368.3	195.8	195.8
Apr - MY 034	2114.2	2114.2	376.4	195.8	195.8
May - MY 034	2109.5	2109.5	382.0	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Jun - MY 034	2102.4	2102.4	432.9	195.8	195.8
Jul - MY 034	2094.9	2094.9	447.8	195.8	195.8
Aug - MY 034	2089.5	2089.5	449.6	195.8	195.8
Sep - MY 034	2089.1	2089.1	449.6	195.8	195.8
Oct - MY 035	2088.2	2088.2	460.0	195.8	195.8
Nov - MY 035	2086.2	2086.2	470.7	195.8	195.8
Dec - MY 035	2087.0	2087.0	470.7	195.8	195.8
Jan - MY 035	2087.2	2087.2	460.0	195.8	195.8
Feb - MY 035	2088.1	2088.1	460.0	195.8	195.8
Mar - MY 035	2092.8	2092.8	452.5	195.8	195.8
Apr - MY 035	2104.8	2104.8	421.8	195.8	195.8
May - MY 035	2102.8	2102.8	432.9	195.8	195.8
Jun - MY 035	2096.9	2096.9	469.4	195.8	195.8
Jul - MY 035	2090.9	2090.9	449.6	195.8	195.8
Aug - MY 035	2086.4	2086.4	470.7	195.8	195.8
Sep - MY 035	2084.2	2084.2	470.3	195.8	195.8
Oct - MY 036	2081.2	2081.2	482.7	195.8	195.8
Nov - MY 036	2078.4	2078.4	479.0	195.8	195.8
Dec - MY 036	2081.0	2081.0	481.3	195.8	195.8
Jan - MY 036	2093.8	2093.8	447.8	195.8	195.8
Feb - MY 036	2099.7	2099.7	435.7	195.8	195.8
Mar - MY 036	2110.8	2110.8	382.0	195.8	195.8
Apr - MY 036	2121.0	2121.0	334.1	195.8	195.8
May - MY 036	2123.9	2123.9	315.7	195.8	195.8
Jun - MY 036	2121.7	2121.7	322.9	195.8	195.8
Jul - MY 036	2117.4	2117.4	340.4	195.8	195.8
Aug - MY 036	2113.7	2113.7	376.4	195.8	195.8
Sep - MY 036	2113.1	2113.1	376.4	195.8	195.8
Oct - MY 037	2113.6	2113.6	376.4	195.8	195.8
Nov - MY 037	2114.2	2114.2	376.4	195.8	195.8
Dec - MY 037	2115.2	2115.2	368.3	195.8	195.8
Jan - MY 037	2116.2	2116.2	368.3	195.8	195.8
Feb - MY 037	2117.9	2117.9	340.4	195.8	195.8
Mar - MY 037	2120.2	2120.2	334.1	195.8	195.8
Apr - MY 037	2120.0	2120.0	334.1	195.8	195.8
May - MY 037	2114.9	2114.9	376.4	195.8	195.8
Jun - MY 037	2107.9	2107.9	388.3	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Jul - MY 037	2101.3	2101.3	432.9	195.8	195.8
Aug - MY 037	2094.8	2094.8	447.8	195.8	195.8
Sep - MY 037	2092.3	2092.3	452.5	195.8	195.8
Oct - MY 038	2088.7	2088.7	460.0	195.8	195.8
Nov - MY 038	2086.3	2086.3	470.7	195.8	195.8
Dec - MY 038	2086.2	2086.2	470.7	195.8	195.8
Jan - MY 038	2086.5	2086.5	470.7	195.8	195.8
Feb - MY 038	2086.7	2086.7	470.7	195.8	195.8
Mar - MY 038	2086.3	2086.3	470.7	195.8	195.8
Apr - MY 038	2083.9	2083.9	470.3	195.8	195.8
May - MY 038	2079.6	2079.6	481.3	195.8	195.8
Jun - MY 038	2071.3	2071.3	490.2	195.8	195.8
Jul - MY 038	2062.0	2062.0	543.7	195.8	195.8
Aug - MY 038	2069.8	2069.8	503.9	195.8	195.8
Sep - MY 038	2071.0	2071.0	503.9	195.8	195.8
Oct - MY 039	2070.2	2070.2	503.9	195.8	195.8
Nov - MY 039	2070.6	2070.6	503.9	195.8	195.8
Dec - MY 039	2081.0	2081.0	481.3	195.8	195.8
Jan - MY 039	2121.0	2121.0	334.1	195.8	195.8
Feb - MY 039	2124.1	2124.1	315.7	195.8	195.8
Mar - MY 039	2136.6	2136.6	194.5	195.8	195.8
Apr - MY 039	2154.5	2154.7	105.5	175.7	166.9
May - MY 039	2155.1	2156.1	105.5	166.9	158.1
Jun - MY 039	2147.4	2152.7	100.5	195.8	182.8
Jul - MY 039	2142.5	2142.5	159.4	195.8	195.8
Aug - MY 039	2138.8	2138.8	181.3	195.8	195.8
Sep - MY 039	2135.6	2135.6	194.5	195.8	195.8
Oct - MY 040	2135.7	2135.7	194.5	195.8	195.8
Nov - MY 040	2136.7	2136.7	194.5	195.8	195.8
Dec - MY 040	2137.7	2137.7	181.3	195.8	195.8
Jan - MY 040	2138.7	2138.7	181.3	195.8	195.8
Feb - MY 040	2139.3	2139.3	170.4	195.8	195.8
Mar - MY 040	2143.8	2143.8	150.8	195.8	195.8
Apr - MY 040	2144.6	2144.6	150.8	195.8	195.8
May - MY 040	2140.8	2140.8	170.4	195.8	195.8
Jun - MY 040	2135.3	2135.3	194.5	195.8	195.8
Jul - MY 040	2130.2	2130.2	295.9	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Aug - MY 040	2125.1	2125.1	301.7	195.8	195.8
Sep - MY 040	2120.9	2120.9	334.1	195.8	195.8
Oct - MY 041	2118.8	2118.8	340.4	195.8	195.8
Nov - MY 041	2116.8	2116.8	368.3	195.8	195.8
Dec - MY 041	2117.0	2117.0	340.4	195.8	195.8
Jan - MY 041	2117.4	2117.4	340.4	195.8	195.8
Feb - MY 041	2117.1	2117.1	340.4	195.8	195.8
Mar - MY 041	2125.2	2125.2	301.7	195.8	195.8
Apr - MY 041	2128.0	2128.0	302.5	195.8	195.8
May - MY 041	2124.1	2124.1	315.7	195.8	195.8
Jun - MY 041	2117.7	2117.7	340.4	195.8	195.8
Jul - MY 041	2113.6	2113.6	376.4	195.8	195.8
Aug - MY 041	2112.9	2112.9	387.9	195.8	195.8
Sep - MY 041	2111.3	2111.3	387.9	195.8	195.8
Oct - MY 042	2108.6	2108.6	388.3	195.8	195.8
Nov - MY 042	2106.8	2106.8	411.7	195.8	195.8
Dec - MY 042	2106.8	2106.8	411.7	195.8	195.8
Jan - MY 042	2106.8	2106.8	411.7	195.8	195.8
Feb - MY 042	2106.4	2106.4	411.7	195.8	195.8
Mar - MY 042	2105.7	2105.7	411.7	195.8	195.8
Apr - MY 042	2102.1	2102.1	432.9	195.8	195.8
May - MY 042	2096.7	2096.7	469.4	195.8	195.8
Jun - MY 042	2090.0	2090.0	449.6	195.8	195.8
Jul - MY 042	2084.2	2084.2	470.3	195.8	195.8
Aug - MY 042	2091.8	2091.8	452.5	195.8	195.8
Sep - MY 042	2089.9	2089.9	449.6	195.8	195.8
Oct - MY 043	2086.5	2086.5	470.7	195.8	195.8
Nov - MY 043	2084.4	2084.4	470.3	195.8	195.8
Dec - MY 043	2085.1	2085.1	470.7	195.8	195.8
Jan - MY 043	2085.3	2085.3	470.7	195.8	195.8
Feb - MY 043	2086.8	2086.8	470.7	195.8	195.8
Mar - MY 043	2088.3	2088.3	460.0	195.8	195.8
Apr - MY 043	2087.7	2087.7	460.0	195.8	195.8
May - MY 043	2084.2	2084.2	470.3	195.8	195.8
Jun - MY 043	2077.2	2077.2	479.0	195.8	195.8
Jul - MY 043	2070.1	2070.1	503.9	195.8	195.8
Aug - MY 043	2063.1	2063.1	526.5	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Sep - MY 043	2060.2	2060.2	558.8	195.8	195.8
Oct - MY 044	2055.9	2055.9	597.0	195.8	195.8
Nov - MY 044	2051.8	2051.8	591.8	195.8	195.8
Dec - MY 044	2051.7	2051.7	591.8	195.8	195.8
Jan - MY 044	2065.5	2065.5	525.3	195.8	195.8
Feb - MY 044	2073.8	2073.8	492.7	195.8	195.8
Mar - MY 044	2078.9	2078.9	479.0	195.8	195.8
Apr - MY 044	2081.9	2081.9	482.7	195.8	195.8
May - MY 044	2079.6	2079.6	481.3	195.8	195.8
Jun - MY 044	2076.2	2076.2	480.2	195.8	195.8
Jul - MY 044	2073.2	2073.2	492.7	195.8	195.8
Aug - MY 044	2077.1	2077.1	479.0	195.8	195.8
Sep - MY 044	2076.5	2076.5	480.2	195.8	195.8
Oct - MY 045	2075.0	2075.0	480.2	195.8	195.8
Nov - MY 045	2077.1	2077.1	479.0	195.8	195.8
Dec - MY 045	2078.6	2078.6	479.0	195.8	195.8
Jan - MY 045	2079.6	2079.6	481.3	195.8	195.8
Feb - MY 045	2084.3	2084.3	470.3	195.8	195.8
Mar - MY 045	2104.1	2104.1	421.8	195.8	195.8
Apr - MY 045	2121.1	2121.1	322.9	195.8	195.8
May - MY 045	2127.0	2127.0	301.7	195.8	195.8
Jun - MY 045	2125.5	2125.5	301.7	195.8	195.8
Jul - MY 045	2120.3	2120.3	334.1	195.8	195.8
Aug - MY 045	2116.4	2116.4	368.3	195.8	195.8
Sep - MY 045	2119.0	2119.0	340.4	195.8	195.8
Oct - MY 046	2121.5	2121.5	322.9	195.8	195.8
Nov - MY 046	2122.2	2122.2	322.9	195.8	195.8
Dec - MY 046	2122.9	2122.9	322.9	195.8	195.8
Jan - MY 046	2123.1	2123.1	315.7	195.8	195.8
Feb - MY 046	2123.2	2123.2	315.7	195.8	195.8
Mar - MY 046	2122.0	2122.0	322.9	195.8	195.8
Apr - MY 046	2118.3	2118.3	340.4	195.8	195.8
May - MY 046	2112.5	2112.5	387.9	195.8	195.8
Jun - MY 046	2105.2	2105.2	411.7	195.8	195.8
Jul - MY 046	2097.9	2097.9	436.2	195.8	195.8
Aug - MY 046	2097.5	2097.5	436.2	195.8	195.8
Sep - MY 046	2094.8	2094.8	447.8	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Oct - MY 047	2096.4	2096.4	469.4	195.8	195.8
Nov - MY 047	2102.3	2102.3	432.9	195.8	195.8
Dec - MY 047	2119.7	2119.7	334.1	195.8	195.8
Jan - MY 047	2133.9	2133.9	211.1	195.8	195.8
Feb - MY 047	2137.9	2137.9	181.3	195.8	195.8
Mar - MY 047	2149.4	2149.4	105.5	195.8	195.8
Apr - MY 047	2151.1	2151.5	105.5	195.8	189.8
May - MY 047	2148.7	2151.1	100.5	195.8	195.8
Jun - MY 047	2143.6	2143.6	150.8	195.8	195.8
Jul - MY 047	2138.0	2138.0	181.3	195.8	195.8
Aug - MY 047	2132.8	2132.8	260.9	195.8	195.8
Sep - MY 047	2129.1	2129.1	295.9	195.8	195.8
Oct - MY 048	2129.8	2129.8	295.9	195.8	195.8
Nov - MY 048	2130.3	2130.3	295.9	195.8	195.8
Dec - MY 048	2130.9	2130.9	295.9	195.8	195.8
Jan - MY 048	2131.5	2131.5	260.9	195.8	195.8
Feb - MY 048	2132.0	2132.0	260.9	195.8	195.8
Mar - MY 048	2132.7	2132.7	260.9	195.8	195.8
Apr - MY 048	2131.5	2131.5	260.9	195.8	195.8
May - MY 048	2126.7	2126.7	301.7	195.8	195.8
Jun - MY 048	2120.2	2120.2	334.1	195.8	195.8
Jul - MY 048	2113.3	2113.3	376.4	195.8	195.8
Aug - MY 048	2107.7	2107.7	388.3	195.8	195.8
Sep - MY 048	2106.1	2106.1	411.7	195.8	195.8
Oct - MY 049	2102.8	2102.8	432.9	195.8	195.8
Nov - MY 049	2100.9	2100.9	435.7	195.8	195.8
Dec - MY 049	2103.1	2103.1	421.8	195.8	195.8
Jan - MY 049	2108.1	2108.1	388.3	195.8	195.8
Feb - MY 049	2117.0	2117.0	368.3	195.8	195.8
Mar - MY 049	2125.1	2125.1	301.7	195.8	195.8
Apr - MY 049	2138.0	2138.0	181.3	195.8	195.8
May - MY 049	2137.0	2137.0	181.3	195.8	195.8
Jun - MY 049	2132.0	2132.0	260.9	195.8	195.8
Jul - MY 049	2126.7	2126.7	301.7	195.8	195.8
Aug - MY 049	2121.4	2121.4	322.9	195.8	195.8
Sep - MY 049	2119.7	2119.7	334.1	195.8	195.8
Oct - MY 050	2120.2	2120.2	334.1	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Nov - MY 050	2119.8	2119.8	334.1	195.8	195.8
Dec - MY 050	2120.7	2120.7	334.1	195.8	195.8
Jan - MY 050	2121.0	2121.0	334.1	195.8	195.8
Feb - MY 050	2124.4	2124.4	315.7	195.8	195.8
Mar - MY 050	2125.0	2125.0	315.7	195.8	195.8
Apr - MY 050	2124.0	2124.0	315.7	195.8	195.8
May - MY 050	2119.7	2119.7	334.1	195.8	195.8
Jun - MY 050	2113.2	2113.2	376.4	195.8	195.8
Jul - MY 050	2106.3	2106.3	411.7	195.8	195.8
Aug - MY 050	2109.3	2109.3	382.0	195.8	195.8
Sep - MY 050	2111.4	2111.4	387.9	195.8	195.8
Oct - MY 051	2109.3	2109.3	382.0	195.8	195.8
Nov - MY 051	2108.1	2108.1	388.3	195.8	195.8
Dec - MY 051	2108.2	2108.2	388.3	195.8	195.8
Jan - MY 051	2107.9	2107.9	388.3	195.8	195.8
Feb - MY 051	2107.1	2107.1	388.3	195.8	195.8
Mar - MY 051	2106.0	2106.0	411.7	195.8	195.8
Apr - MY 051	2109.3	2109.3	382.0	195.8	195.8
May - MY 051	2104.3	2104.3	421.8	195.8	195.8
Jun - MY 051	2096.9	2096.9	469.4	195.8	195.8
Jul - MY 051	2089.9	2089.9	449.6	195.8	195.8
Aug - MY 051	2086.9	2086.9	470.7	195.8	195.8
Sep - MY 051	2087.1	2087.1	460.0	195.8	195.8
Oct - MY 052	2084.5	2084.5	470.3	195.8	195.8
Nov - MY 052	2082.4	2082.4	482.7	195.8	195.8
Dec - MY 052	2082.9	2082.9	482.7	195.8	195.8
Jan - MY 052	2095.3	2095.3	469.4	195.8	195.8
Feb - MY 052	2102.2	2102.2	432.9	195.8	195.8
Mar - MY 052	2111.4	2111.4	387.9	195.8	195.8
Apr - MY 052	2126.0	2126.0	301.7	195.8	195.8
May - MY 052	2130.4	2130.4	295.9	195.8	195.8
Jun - MY 052	2127.6	2127.6	302.5	195.8	195.8
Jul - MY 052	2122.9	2122.9	322.9	195.8	195.8
Aug - MY 052	2119.8	2119.8	334.1	195.8	195.8
Sep - MY 052	2119.5	2119.5	334.1	195.8	195.8
Oct - MY 053	2119.7	2119.7	334.1	195.8	195.8
Nov - MY 053	2121.6	2121.6	322.9	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Dec - MY 053	2151.3	2151.3	105.5	195.8	195.8
Jan - MY 053	2153.4	2153.3	105.5	182.8	182.8
Feb - MY 053	2151.1	2151.1	105.5	195.8	195.8
Mar - MY 053	2155.1	2156.2	105.5	166.9	158.1
Apr - MY 053	2152.7	2156.2	105.5	182.8	158.1
May - MY 053	2150.9	2154.9	105.5	195.8	166.9
Jun - MY 053	2144.3	2144.3	150.8	195.8	195.8
Jul - MY 053	2138.7	2138.7	181.3	195.8	195.8
Aug - MY 053	2134.5	2134.5	211.1	195.8	195.8
Sep - MY 053	2132.2	2132.2	260.9	195.8	195.8
Oct - MY 054	2132.6	2132.6	260.9	195.8	195.8
Nov - MY 054	2133.2	2133.2	211.1	195.8	195.8
Dec - MY 054	2135.5	2135.5	194.5	195.8	195.8
Jan - MY 054	2136.2	2136.2	194.5	195.8	195.8
Feb - MY 054	2136.7	2136.7	194.5	195.8	195.8
Mar - MY 054	2137.5	2137.5	181.3	195.8	195.8
Apr - MY 054	2137.9	2137.9	181.3	195.8	195.8
May - MY 054	2133.3	2133.3	211.1	195.8	195.8
Jun - MY 054	2127.2	2127.2	302.5	195.8	195.8
Jul - MY 054	2122.0	2122.0	322.9	195.8	195.8
Aug - MY 054	2120.6	2120.6	334.1	195.8	195.8
Sep - MY 054	2119.3	2119.3	334.1	195.8	195.8
Oct - MY 055	2119.6	2119.6	334.1	195.8	195.8
Nov - MY 055	2118.5	2118.5	340.4	195.8	195.8
Dec - MY 055	2126.2	2126.2	301.7	195.8	195.8
Jan - MY 055	2135.9	2135.9	194.5	195.8	195.8
Feb - MY 055	2147.2	2147.2	100.5	195.8	195.8
Mar - MY 055	2152.8	2154.9	105.5	182.8	166.9
Apr - MY 055	2153.7	2156.2	105.5	175.7	158.1
May - MY 055	2151.1	2155.8	105.5	195.8	158.1
Jun - MY 055	2146.4	2151.3	128.6	195.8	195.8
Jul - MY 055	2141.6	2141.6	159.4	195.8	195.8
Aug - MY 055	2139.0	2139.0	181.3	195.8	195.8
Sep - MY 055	2135.7	2135.7	194.5	195.8	195.8
Oct - MY 056	2136.1	2136.1	194.5	195.8	195.8
Nov - MY 056	2136.7	2136.7	194.5	195.8	195.8
Dec - MY 056	2137.6	2137.6	181.3	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Jan - MY 056	2143.7	2143.7	150.8	195.8	195.8
Feb - MY 056	2146.2	2146.2	128.6	195.8	195.8
Mar - MY 056	2150.5	2150.8	105.5	195.8	195.8
Apr - MY 056	2152.4	2153.4	105.5	189.8	182.8
May - MY 056	2149.5	2153.0	105.5	195.8	182.8
Jun - MY 056	2144.5	2144.5	150.8	195.8	195.8
Jul - MY 056	2139.2	2139.2	170.4	195.8	195.8
Aug - MY 056	2134.7	2134.7	211.1	195.8	195.8
Sep - MY 056	2132.0	2132.0	260.9	195.8	195.8
Oct - MY 057	2132.4	2132.4	260.9	195.8	195.8
Nov - MY 057	2133.3	2133.3	211.1	195.8	195.8
Dec - MY 057	2134.2	2134.2	211.1	195.8	195.8
Jan - MY 057	2134.9	2134.9	211.1	195.8	195.8
Feb - MY 057	2135.5	2135.5	194.5	195.8	195.8
Mar - MY 057	2137.6	2137.6	181.3	195.8	195.8
Apr - MY 057	2139.9	2139.9	170.4	195.8	195.8
May - MY 057	2136.9	2136.9	194.5	195.8	195.8
Jun - MY 057	2131.2	2131.2	260.9	195.8	195.8
Jul - MY 057	2125.4	2125.4	301.7	195.8	195.8
Aug - MY 057	2120.3	2120.3	334.1	195.8	195.8
Sep - MY 057	2122.7	2122.7	322.9	195.8	195.8
Oct - MY 058	2123.3	2123.3	315.7	195.8	195.8
Nov - MY 058	2123.0	2123.0	322.9	195.8	195.8
Dec - MY 058	2123.6	2123.6	315.7	195.8	195.8
Jan - MY 058	2123.9	2123.9	315.7	195.8	195.8
Feb - MY 058	2123.4	2123.4	315.7	195.8	195.8
Mar - MY 058	2122.2	2122.2	322.9	195.8	195.8
Apr - MY 058	2119.1	2119.1	334.1	195.8	195.8
May - MY 058	2113.8	2113.8	376.4	195.8	195.8
Jun - MY 058	2106.9	2106.9	411.7	195.8	195.8
Jul - MY 058	2099.6	2099.6	435.7	195.8	195.8
Aug - MY 058	2094.9	2094.9	447.8	195.8	195.8
Sep - MY 058	2092.4	2092.4	452.5	195.8	195.8
Oct - MY 059	2098.6	2098.6	436.2	195.8	195.8
Nov - MY 059	2098.6	2098.6	436.2	195.8	195.8
Dec - MY 059	2104.4	2104.4	421.8	195.8	195.8
Jan - MY 059	2106.8	2106.8	411.7	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Feb - MY 059	2107.7	2107.7	388.3	195.8	195.8
Mar - MY 059	2108.6	2108.6	388.3	195.8	195.8
Apr - MY 059	2104.9	2104.9	421.8	195.8	195.8
May - MY 059	2099.7	2099.7	435.7	195.8	195.8
Jun - MY 059	2093.1	2093.1	447.8	195.8	195.8
Jul - MY 059	2085.7	2085.7	470.7	195.8	195.8
Aug - MY 059	2078.6	2078.6	479.0	195.8	195.8
Sep - MY 059	2075.5	2075.5	480.2	195.8	195.8
Oct - MY 060	2109.4	2109.4	382.0	195.8	195.8
Nov - MY 060	2117.2	2117.2	340.4	195.8	195.8
Dec - MY 060	2126.8	2126.8	301.7	195.8	195.8
Jan - MY 060	2131.7	2131.7	260.9	195.8	195.8
Feb - MY 060	2144.5	2144.5	150.8	195.8	195.8
Mar - MY 060	2157.1	2157.8	105.5	150.2	142.3
Apr - MY 060	2157.4	2157.6	105.5	150.2	142.3
May - MY 060	2157.1	2157.4	105.5	150.2	150.2
Jun - MY 060	2151.4	2155.6	105.5	195.8	158.1
Jul - MY 060	2146.4	2146.4	128.6	195.8	195.8
Aug - MY 060	2142.6	2142.6	159.4	195.8	195.8
Sep - MY 060	2139.4	2139.4	170.4	195.8	195.8
Oct - MY 061	2139.5	2139.5	170.4	195.8	195.8
Nov - MY 061	2140.1	2140.1	170.4	195.8	195.8
Dec - MY 061	2140.7	2140.7	170.4	195.8	195.8
Jan - MY 061	2142.3	2142.3	159.4	195.8	195.8
Feb - MY 061	2142.8	2142.8	159.4	195.8	195.8
Mar - MY 061	2144.4	2144.4	150.8	195.8	195.8
Apr - MY 061	2145.1	2145.1	128.6	195.8	195.8
May - MY 061	2141.1	2141.1	159.4	195.8	195.8
Jun - MY 061	2135.4	2135.4	194.5	195.8	195.8
Jul - MY 061	2129.9	2129.9	295.9	195.8	195.8
Aug - MY 061	2125.1	2125.1	301.7	195.8	195.8
Sep - MY 061	2121.3	2121.3	322.9	195.8	195.8
Oct - MY 062	2120.7	2120.7	334.1	195.8	195.8
Nov - MY 062	2120.7	2120.7	334.1	195.8	195.8
Dec - MY 062	2121.5	2121.5	322.9	195.8	195.8
Jan - MY 062	2121.8	2121.8	322.9	195.8	195.8
Feb - MY 062	2122.7	2122.7	322.9	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Mar - MY 062	2131.4	2131.4	260.9	195.8	195.8
Apr - MY 062	2141.9	2141.9	159.4	195.8	195.8
May - MY 062	2143.6	2143.6	150.8	195.8	195.8
Jun - MY 062	2139.6	2139.6	170.4	195.8	195.8
Jul - MY 062	2135.3	2135.3	194.5	195.8	195.8
Aug - MY 062	2130.6	2130.6	295.9	195.8	195.8
Sep - MY 062	2127.9	2127.9	302.5	195.8	195.8
Oct - MY 063	2126.2	2126.2	301.7	195.8	195.8
Nov - MY 063	2125.1	2125.1	301.7	195.8	195.8
Dec - MY 063	2125.9	2125.9	301.7	195.8	195.8
Jan - MY 063	2126.0	2126.0	301.7	195.8	195.8
Feb - MY 063	2132.6	2132.6	260.9	195.8	195.8
Mar - MY 063	2134.5	2134.5	211.1	195.8	195.8
Apr - MY 063	2138.2	2138.2	181.3	195.8	195.8
May - MY 063	2135.4	2135.4	194.5	195.8	195.8
Jun - MY 063	2129.6	2129.6	295.9	195.8	195.8
Jul - MY 063	2123.6	2123.6	315.7	195.8	195.8
Aug - MY 063	2120.1	2120.1	334.1	195.8	195.8
Sep - MY 063	2118.8	2118.8	340.4	195.8	195.8
Oct - MY 064	2119.3	2119.3	334.1	195.8	195.8
Nov - MY 064	2118.5	2118.5	340.4	195.8	195.8
Dec - MY 064	2118.9	2118.9	340.4	195.8	195.8
Jan - MY 064	2119.6	2119.6	334.1	195.8	195.8
Feb - MY 064	2119.1	2119.1	334.1	195.8	195.8
Mar - MY 064	2117.6	2117.6	340.4	195.8	195.8
Apr - MY 064	2116.2	2116.2	368.3	195.8	195.8
May - MY 064	2111.5	2111.5	387.9	195.8	195.8
Jun - MY 064	2104.5	2104.5	421.8	195.8	195.8
Jul - MY 064	2097.5	2097.5	436.2	195.8	195.8
Aug - MY 064	2091.8	2091.8	452.5	195.8	195.8
Sep - MY 064	2088.8	2088.8	460.0	195.8	195.8
Oct - MY 065	2085.9	2085.9	470.7	195.8	195.8
Nov - MY 065	2083.7	2083.7	470.3	195.8	195.8
Dec - MY 065	2084.2	2084.2	470.3	195.8	195.8
Jan - MY 065	2088.1	2088.1	460.0	195.8	195.8
Feb - MY 065	2102.4	2102.4	432.9	195.8	195.8
Mar - MY 065	2155.3	2156.4	105.5	166.9	158.1

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Apr - MY 065	2153.6	2156.3	105.5	175.7	158.1
May - MY 065	2151.0	2155.6	105.5	195.8	158.1
Jun - MY 065	2146.1	2146.1	128.6	195.8	195.8
Jul - MY 065	2141.6	2141.6	159.4	195.8	195.8
Aug - MY 065	2137.9	2137.9	181.3	195.8	195.8
Sep - MY 065	2135.0	2135.0	211.1	195.8	195.8
Oct - MY 066	2135.4	2135.4	194.5	195.8	195.8
Nov - MY 066	2144.2	2144.2	150.8	195.8	195.8
Dec - MY 066	2163.1	2162.6	105.5	103.5	103.5
Jan - MY 066	2159.8	2159.7	105.5	126.3	126.3
Feb - MY 066	2155.1	2155.1	105.5	166.9	166.9
Mar - MY 066	2159.3	2159.8	105.5	134.3	126.3
Apr - MY 066	2159.0	2159.6	105.5	134.3	126.3
May - MY 066	2156.4	2156.2	105.5	158.1	158.1
Jun - MY 066	2151.8	2155.1	105.5	189.8	166.9
Jul - MY 066	2145.5	2145.5	128.6	195.8	195.8
Aug - MY 066	2141.8	2141.8	159.4	195.8	195.8
Sep - MY 066	2138.6	2138.6	181.3	195.8	195.8
Oct - MY 067	2139.1	2139.1	170.4	195.8	195.8
Nov - MY 067	2139.9	2139.9	170.4	195.8	195.8
Dec - MY 067	2140.9	2140.9	170.4	195.8	195.8
Jan - MY 067	2151.0	2152.0	105.5	195.8	189.8
Feb - MY 067	2164.6	2164.5	105.5	88.0	88.0
Mar - MY 067	2155.1	2156.6	105.5	166.9	150.2
Apr - MY 067	2155.5	2156.4	105.5	166.9	158.1
May - MY 067	2152.8	2156.2	105.5	182.8	158.1
Jun - MY 067	2150.8	2154.2	105.5	195.8	175.7
Jul - MY 067	2144.4	2144.4	150.8	195.8	195.8
Aug - MY 067	2141.0	2141.0	159.4	195.8	195.8
Sep - MY 067	2138.4	2138.4	181.3	195.8	195.8
Oct - MY 068	2138.9	2138.9	181.3	195.8	195.8
Nov - MY 068	2139.9	2139.9	170.4	195.8	195.8
Dec - MY 068	2140.7	2140.7	170.4	195.8	195.8
Jan - MY 068	2141.5	2141.5	159.4	195.8	195.8
Feb - MY 068	2142.3	2142.3	159.4	195.8	195.8
Mar - MY 068	2144.7	2144.7	150.8	195.8	195.8
Apr - MY 068	2147.9	2147.9	100.5	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
May - MY 068	2144.5	2144.5	150.8	195.8	195.8
Jun - MY 068	2138.9	2138.9	181.3	195.8	195.8
Jul - MY 068	2133.5	2133.5	211.1	195.8	195.8
Aug - MY 068	2128.5	2128.5	302.5	195.8	195.8
Sep - MY 068	2124.9	2124.9	315.7	195.8	195.8
Oct - MY 069	2126.0	2126.0	301.7	195.8	195.8
Nov - MY 069	2125.3	2125.3	301.7	195.8	195.8
Dec - MY 069	2126.2	2126.2	301.7	195.8	195.8
Jan - MY 069	2129.5	2129.5	295.9	195.8	195.8
Feb - MY 069	2136.1	2136.1	194.5	195.8	195.8
Mar - MY 069	2147.8	2147.8	100.5	195.8	195.8
Apr - MY 069	2151.1	2151.5	105.5	195.8	195.8
May - MY 069	2151.1	2151.6	105.5	195.8	189.8
Jun - MY 069	2145.8	2145.8	128.6	195.8	195.8
Jul - MY 069	2140.7	2140.7	170.4	195.8	195.8
Aug - MY 069	2136.7	2136.7	194.5	195.8	195.8
Sep - MY 069	2134.5	2134.5	211.1	195.8	195.8
Oct - MY 070	2134.8	2134.8	211.1	195.8	195.8
Nov - MY 070	2137.2	2137.2	181.3	195.8	195.8
Dec - MY 070	2148.1	2148.1	100.5	195.8	195.8
Jan - MY 070	2152.9	2152.9	105.5	182.8	182.8
Feb - MY 070	2156.6	2155.5	105.5	150.2	158.1
Mar - MY 070	2157.3	2157.5	105.5	150.2	150.2
Apr - MY 070	2155.4	2157.1	105.5	166.9	150.2
May - MY 070	2155.3	2156.1	105.5	166.9	158.1
Jun - MY 070	2151.2	2154.9	105.5	195.8	166.9
Jul - MY 070	2145.1	2145.1	128.6	195.8	195.8
Aug - MY 070	2142.3	2142.3	159.4	195.8	195.8
Sep - MY 070	2142.0	2142.0	159.4	195.8	195.8
Oct - MY 071	2153.0	2153.5	105.5	182.8	182.8
Nov - MY 071	2150.9	2150.9	105.5	195.8	195.8
Dec - MY 071	2153.0	2153.0	105.5	182.8	182.8
Jan - MY 071	2152.0	2152.0	105.5	189.8	189.8
Feb - MY 071	2151.0	2151.0	105.5	195.8	195.8
Mar - MY 071	2151.0	2151.0	105.5	195.8	195.8
Apr - MY 071	2150.9	2151.0	105.5	195.8	195.8
May - MY 071	2148.4	2148.4	100.5	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Jun - MY 071	2143.1	2143.1	150.8	195.8	195.8
Jul - MY 071	2138.3	2138.3	181.3	195.8	195.8
Aug - MY 071	2135.1	2135.1	194.5	195.8	195.8
Sep - MY 071	2133.5	2133.5	211.1	195.8	195.8
Oct - MY 072	2138.1	2138.1	181.3	195.8	195.8
Nov - MY 072	2140.4	2140.4	170.4	195.8	195.8
Dec - MY 072	2157.3	2157.3	105.5	150.2	150.2
Jan - MY 072	2156.3	2156.3	105.5	158.1	158.1
Feb - MY 072	2154.5	2154.5	105.5	166.9	166.9
Mar - MY 072	2156.7	2158.3	105.5	150.2	142.3
Apr - MY 072	2155.0	2156.2	105.5	166.9	158.1
May - MY 072	2154.1	2156.2	105.5	175.7	158.1
Jun - MY 072	2147.6	2152.9	100.5	195.8	182.8
Jul - MY 072	2142.9	2142.9	159.4	195.8	195.8
Aug - MY 072	2139.0	2139.0	170.4	195.8	195.8
Sep - MY 072	2137.1	2137.1	181.3	195.8	195.8
Oct - MY 073	2138.7	2138.7	181.3	195.8	195.8
Nov - MY 073	2141.6	2141.6	159.4	195.8	195.8
Dec - MY 073	2143.6	2143.6	150.8	195.8	195.8
Jan - MY 073	2144.6	2144.6	150.8	195.8	195.8
Feb - MY 073	2149.1	2149.1	105.5	195.8	195.8
Mar - MY 073	2154.2	2156.1	105.5	175.7	158.1
Apr - MY 073	2154.5	2156.1	105.5	166.9	158.1
May - MY 073	2148.1	2153.9	100.5	195.8	175.7
Jun - MY 073	2142.9	2142.9	159.4	195.8	195.8
Jul - MY 073	2137.8	2137.8	181.3	195.8	195.8
Aug - MY 073	2133.1	2133.1	211.1	195.8	195.8
Sep - MY 073	2129.8	2129.8	295.9	195.8	195.8
Oct - MY 074	2131.4	2131.4	260.9	195.8	195.8
Nov - MY 074	2134.7	2134.7	211.1	195.8	195.8
Dec - MY 074	2138.5	2138.5	181.3	195.8	195.8
Jan - MY 074	2140.2	2140.2	170.4	195.8	195.8
Feb - MY 074	2143.5	2143.5	150.8	195.8	195.8
Mar - MY 074	2151.2	2151.8	105.5	195.8	189.8
Apr - MY 074	2154.2	2155.9	105.5	175.7	158.1
May - MY 074	2154.2	2155.9	105.5	175.7	158.1
Jun - MY 074	2146.0	2151.0	128.6	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Jul - MY 074	2140.6	2140.6	170.4	195.8	195.8
Aug - MY 074	2136.9	2136.9	194.5	195.8	195.8
Sep - MY 074	2133.5	2133.5	211.1	195.8	195.8
Oct - MY 075	2133.9	2133.9	211.1	195.8	195.8
Nov - MY 075	2136.6	2136.6	194.5	195.8	195.8
Dec - MY 075	2137.8	2137.8	181.3	195.8	195.8
Jan - MY 075	2141.2	2141.2	159.4	195.8	195.8
Feb - MY 075	2147.3	2147.3	100.5	195.8	195.8
Mar - MY 075	2150.5	2150.5	105.5	195.8	195.8
Apr - MY 075	2152.8	2153.2	105.5	182.8	182.8
May - MY 075	2153.0	2153.5	105.5	182.8	175.7
Jun - MY 075	2145.1	2145.1	128.6	195.8	195.8
Jul - MY 075	2140.3	2140.3	170.4	195.8	195.8
Aug - MY 075	2140.4	2140.4	170.4	195.8	195.8
Sep - MY 075	2141.7	2141.7	159.4	195.8	195.8
Oct - MY 076	2142.2	2142.2	159.4	195.8	195.8
Nov - MY 076	2142.8	2142.8	159.4	195.8	195.8
Dec - MY 076	2143.4	2143.4	150.8	195.8	195.8
Jan - MY 076	2144.6	2144.6	150.8	195.8	195.8
Feb - MY 076	2146.3	2146.3	128.6	195.8	195.8
Mar - MY 076	2149.5	2149.5	105.5	195.8	195.8
Apr - MY 076	2150.5	2150.5	105.5	195.8	195.8
May - MY 076	2146.7	2146.7	128.6	195.8	195.8
Jun - MY 076	2141.1	2141.1	159.4	195.8	195.8
Jul - MY 076	2135.5	2135.5	194.5	195.8	195.8
Aug - MY 076	2131.1	2131.1	260.9	195.8	195.8
Sep - MY 076	2127.3	2127.3	302.5	195.8	195.8
Oct - MY 077	2125.0	2125.0	315.7	195.8	195.8
Nov - MY 077	2123.4	2123.4	315.7	195.8	195.8
Dec - MY 077	2124.0	2124.0	315.7	195.8	195.8
Jan - MY 077	2124.4	2124.4	315.7	195.8	195.8
Feb - MY 077	2124.3	2124.3	315.7	195.8	195.8
Mar - MY 077	2124.7	2124.7	315.7	195.8	195.8
Apr - MY 077	2122.8	2122.8	322.9	195.8	195.8
May - MY 077	2117.9	2117.9	340.4	195.8	195.8
Jun - MY 077	2111.2	2111.2	387.9	195.8	195.8
Jul - MY 077	2105.4	2105.4	411.7	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Aug - MY 077	2100.1	2100.1	435.7	195.8	195.8
Sep - MY 077	2097.8	2097.8	436.2	195.8	195.8
Oct - MY 078	2094.9	2094.9	447.8	195.8	195.8
Nov - MY 078	2093.4	2093.4	447.8	195.8	195.8
Dec - MY 078	2098.7	2098.7	436.2	195.8	195.8
Jan - MY 078	2108.0	2108.0	388.3	195.8	195.8
Feb - MY 078	2110.4	2110.4	382.0	195.8	195.8
Mar - MY 078	2142.6	2142.6	159.4	195.8	195.8
Apr - MY 078	2152.1	2152.6	105.5	189.8	182.8
May - MY 078	2152.1	2152.6	105.5	189.8	182.8
Jun - MY 078	2147.9	2151.0	100.5	195.8	195.8
Jul - MY 078	2143.3	2143.3	150.8	195.8	195.8
Aug - MY 078	2139.5	2139.5	170.4	195.8	195.8
Sep - MY 078	2137.5	2137.5	181.3	195.8	195.8
Oct - MY 079	2137.8	2137.8	181.3	195.8	195.8
Nov - MY 079	2138.7	2138.7	181.3	195.8	195.8
Dec - MY 079	2141.9	2141.9	159.4	195.8	195.8
Jan - MY 079	2146.1	2146.1	128.6	195.8	195.8
Feb - MY 079	2151.7	2151.7	105.5	189.8	189.8
Mar - MY 079	2155.0	2156.3	105.5	166.9	158.1
Apr - MY 079	2155.0	2156.2	105.5	166.9	158.1
May - MY 079	2151.2	2155.9	105.5	195.8	158.1
Jun - MY 079	2150.8	2152.0	105.5	195.8	189.8
Jul - MY 079	2143.8	2143.8	150.8	195.8	195.8
Aug - MY 079	2145.8	2145.8	128.6	195.8	195.8
Sep - MY 079	2143.6	2143.6	150.8	195.8	195.8
Oct - MY 080	2144.1	2144.1	150.8	195.8	195.8
Nov - MY 080	2144.8	2144.8	150.8	195.8	195.8
Dec - MY 080	2153.0	2152.6	105.5	182.8	182.8
Jan - MY 080	2168.9	2168.1	105.5	48.4	57.5
Feb - MY 080	2162.4	2162.3	105.5	111.6	111.6
Mar - MY 080	2156.1	2157.1	105.5	158.1	150.2
Apr - MY 080	2156.3	2156.5	105.5	158.1	158.1
May - MY 080	2155.1	2156.0	105.5	166.9	158.1
Jun - MY 080	2148.1	2153.8	100.5	195.8	175.7
Jul - MY 080	2143.3	2143.3	150.8	195.8	195.8
Aug - MY 080	2139.5	2139.5	170.4	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Sep - MY 080	2137.2	2137.2	181.3	195.8	195.8
Oct - MY 081	2138.2	2138.2	181.3	195.8	195.8
Nov - MY 081	2140.9	2140.9	170.4	195.8	195.8
Dec - MY 081	2142.0	2142.0	159.4	195.8	195.8
Jan - MY 081	2142.8	2142.8	159.4	195.8	195.8
Feb - MY 081	2145.5	2145.5	128.6	195.8	195.8
Mar - MY 081	2150.1	2150.1	105.5	195.8	195.8
Apr - MY 081	2150.8	2150.8	105.5	195.8	195.8
May - MY 081	2148.2	2148.2	100.5	195.8	195.8
Jun - MY 081	2142.8	2142.8	159.4	195.8	195.8
Jul - MY 081	2137.1	2137.1	181.3	195.8	195.8
Aug - MY 081	2131.9	2131.9	260.9	195.8	195.8
Sep - MY 081	2129.4	2129.4	295.9	195.8	195.8
Oct - MY 082	2130.0	2130.0	295.9	195.8	195.8
Nov - MY 082	2134.4	2134.4	211.1	195.8	195.8
Dec - MY 082	2138.6	2138.6	181.3	195.8	195.8
Jan - MY 082	2150.8	2150.8	105.5	195.8	195.8
Feb - MY 082	2156.9	2156.8	105.5	150.2	150.2
Mar - MY 082	2157.0	2157.6	105.5	150.2	142.3
Apr - MY 082	2151.6	2155.9	105.5	189.8	158.1
May - MY 082	2149.3	2154.3	105.5	195.8	175.7
Jun - MY 082	2144.6	2144.6	150.8	195.8	195.8
Jul - MY 082	2139.0	2139.0	170.4	195.8	195.8
Aug - MY 082	2134.0	2134.0	211.1	195.8	195.8
Sep - MY 082	2130.6	2130.6	295.9	195.8	195.8
Oct - MY 083	2130.9	2130.9	295.9	195.8	195.8
Nov - MY 083	2131.5	2131.5	260.9	195.8	195.8
Dec - MY 083	2132.1	2132.1	260.9	195.8	195.8
Jan - MY 083	2132.8	2132.8	260.9	195.8	195.8
Feb - MY 083	2133.6	2133.6	211.1	195.8	195.8
Mar - MY 083	2134.1	2134.1	211.1	195.8	195.8
Apr - MY 083	2132.5	2132.5	260.9	195.8	195.8
May - MY 083	2127.5	2127.5	302.5	195.8	195.8
Jun - MY 083	2120.9	2120.9	334.1	195.8	195.8
Jul - MY 083	2114.5	2114.5	376.4	195.8	195.8
Aug - MY 083	2108.6	2108.6	388.3	195.8	195.8
Sep - MY 083	2107.3	2107.3	388.3	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Oct - MY 084	2104.3	2104.3	421.8	195.8	195.8
Nov - MY 084	2102.6	2102.6	432.9	195.8	195.8
Dec - MY 084	2102.9	2102.9	432.9	195.8	195.8
Jan - MY 084	2106.3	2106.3	411.7	195.8	195.8
Feb - MY 084	2108.9	2108.9	388.3	195.8	195.8
Mar - MY 084	2118.0	2118.0	340.4	195.8	195.8
Apr - MY 084	2121.5	2121.5	322.9	195.8	195.8
May - MY 084	2118.6	2118.6	340.4	195.8	195.8
Jun - MY 084	2112.6	2112.6	387.9	195.8	195.8
Jul - MY 084	2106.0	2106.0	411.7	195.8	195.8
Aug - MY 084	2100.2	2100.2	435.7	195.8	195.8
Sep - MY 084	2098.1	2098.1	436.2	195.8	195.8
Oct - MY 085	2095.7	2095.7	469.4	195.8	195.8
Nov - MY 085	2094.2	2094.2	447.8	195.8	195.8
Dec - MY 085	2095.7	2095.7	469.4	195.8	195.8
Jan - MY 085	2097.6	2097.6	436.2	195.8	195.8
Feb - MY 085	2103.8	2103.8	421.8	195.8	195.8
Mar - MY 085	2118.9	2118.9	340.4	195.8	195.8
Apr - MY 085	2132.1	2132.1	260.9	195.8	195.8
May - MY 085	2134.7	2134.7	211.1	195.8	195.8
Jun - MY 085	2130.7	2130.7	295.9	195.8	195.8
Jul - MY 085	2126.0	2126.0	301.7	195.8	195.8
Aug - MY 085	2122.7	2122.7	322.9	195.8	195.8
Sep - MY 085	2122.5	2122.5	322.9	195.8	195.8
Oct - MY 086	2123.0	2123.0	315.7	195.8	195.8
Nov - MY 086	2123.9	2123.9	315.7	195.8	195.8
Dec - MY 086	2124.9	2124.9	315.7	195.8	195.8
Jan - MY 086	2125.6	2125.6	301.7	195.8	195.8
Feb - MY 086	2126.2	2126.2	301.7	195.8	195.8
Mar - MY 086	2126.2	2126.2	301.7	195.8	195.8
Apr - MY 086	2125.0	2125.0	315.7	195.8	195.8
May - MY 086	2119.9	2119.9	334.1	195.8	195.8
Jun - MY 086	2112.9	2112.9	387.9	195.8	195.8
Jul - MY 086	2107.3	2107.3	388.3	195.8	195.8
Aug - MY 086	2105.0	2105.0	421.8	195.8	195.8
Sep - MY 086	2105.3	2105.3	411.7	195.8	195.8
Oct - MY 087	2102.3	2102.3	432.9	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Nov - MY 087	2100.1	2100.1	435.7	195.8	195.8
Dec - MY 087	2100.0	2100.0	435.7	195.8	195.8
Jan - MY 087	2100.4	2100.4	435.7	195.8	195.8
Feb - MY 087	2100.5	2100.5	435.7	195.8	195.8
Mar - MY 087	2100.2	2100.2	435.7	195.8	195.8
Apr - MY 087	2096.9	2096.9	469.4	195.8	195.8
May - MY 087	2091.1	2091.1	452.5	195.8	195.8
Jun - MY 087	2083.5	2083.5	470.3	195.8	195.8
Jul - MY 087	2075.1	2075.1	480.2	195.8	195.8
Aug - MY 087	2067.9	2067.9	510.0	195.8	195.8
Sep - MY 087	2064.6	2064.6	526.5	195.8	195.8
Oct - MY 088	2066.4	2066.4	525.3	195.8	195.8
Nov - MY 088	2076.0	2076.0	480.2	195.8	195.8
Dec - MY 088	2078.2	2078.2	479.0	195.8	195.8
Jan - MY 088	2080.2	2080.2	481.3	195.8	195.8
Feb - MY 088	2083.2	2083.2	470.3	195.8	195.8
Mar - MY 088	2092.2	2092.2	452.5	195.8	195.8
Apr - MY 088	2101.6	2101.6	432.9	195.8	195.8
May - MY 088	2099.6	2099.6	435.7	195.8	195.8
Jun - MY 088	2093.7	2093.7	447.8	195.8	195.8
Jul - MY 088	2087.6	2087.6	460.0	195.8	195.8
Aug - MY 088	2084.5	2084.5	470.3	195.8	195.8
Sep - MY 088	2082.4	2082.4	482.7	195.8	195.8
Oct - MY 089	2079.9	2079.9	481.3	195.8	195.8
Nov - MY 089	2077.4	2077.4	479.0	195.8	195.8
Dec - MY 089	2077.8	2077.8	479.0	195.8	195.8
Jan - MY 089	2077.6	2077.6	479.0	195.8	195.8
Feb - MY 089	2077.1	2077.1	479.0	195.8	195.8
Mar - MY 089	2075.3	2075.3	480.2	195.8	195.8
Apr - MY 089	2071.3	2071.3	490.2	195.8	195.8
May - MY 089	2065.3	2065.3	525.3	195.8	195.8
Jun - MY 089	2055.9	2055.9	597.0	195.8	195.8
Jul - MY 089	2046.7	2046.7	606.9	195.8	195.8
Aug - MY 089	2038.2	2038.2	603.7	195.8	195.8
Sep - MY 089	2038.4	2038.4	603.7	195.8	195.8
Oct - MY 090	2035.5	2035.5	603.3	195.8	195.8
Nov - MY 090	2037.2	2037.2	603.7	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Dec - MY 090	2039.2	2039.2	602.6	195.8	195.8
Jan - MY 090	2041.6	2041.6	607.0	195.8	195.8
Feb - MY 090	2047.5	2047.5	602.3	195.8	195.8
Mar - MY 090	2071.8	2071.8	490.2	195.8	195.8
Apr - MY 090	2079.1	2079.1	481.3	195.8	195.8
May - MY 090	2077.7	2077.7	479.0	195.8	195.8
Jun - MY 090	2071.6	2071.6	490.2	195.8	195.8
Jul - MY 090	2065.7	2065.7	525.3	195.8	195.8
Aug - MY 090	2063.5	2063.5	526.5	195.8	195.8
Sep - MY 090	2066.8	2066.8	525.3	195.8	195.8
Oct - MY 091	2063.9	2063.9	526.5	195.8	195.8
Nov - MY 091	2061.7	2061.7	543.7	195.8	195.8
Dec - MY 091	2062.1	2062.1	543.7	195.8	195.8
Jan - MY 091	2061.4	2061.4	543.7	195.8	195.8
Feb - MY 091	2062.7	2062.7	543.7	195.8	195.8
Mar - MY 091	2071.9	2071.9	490.2	195.8	195.8
Apr - MY 091	2074.6	2074.6	492.7	195.8	195.8
May - MY 091	2071.4	2071.4	490.2	195.8	195.8
Jun - MY 091	2064.7	2064.7	526.5	195.8	195.8
Jul - MY 091	2057.9	2057.9	580.5	195.8	195.8
Aug - MY 091	2050.5	2050.5	600.7	195.8	195.8
Sep - MY 091	2050.6	2050.6	600.7	195.8	195.8
Oct - MY 092	2047.3	2047.3	602.3	195.8	195.8
Nov - MY 092	2049.5	2049.5	600.7	195.8	195.8
Dec - MY 092	2059.6	2059.6	558.8	195.8	195.8
Jan - MY 092	2086.5	2086.5	470.7	195.8	195.8
Feb - MY 092	2127.3	2127.3	302.5	195.8	195.8
Mar - MY 092	2136.8	2136.8	194.5	195.8	195.8
Apr - MY 092	2143.1	2143.1	150.8	195.8	195.8
May - MY 092	2142.1	2142.1	159.4	195.8	195.8
Jun - MY 092	2137.3	2137.3	181.3	195.8	195.8
Jul - MY 092	2131.9	2131.9	260.9	195.8	195.8
Aug - MY 092	2127.9	2127.9	302.5	195.8	195.8
Sep - MY 092	2124.5	2124.5	315.7	195.8	195.8
Oct - MY 093	2124.8	2124.8	315.7	195.8	195.8
Nov - MY 093	2125.1	2125.1	301.7	195.8	195.8
Dec - MY 093	2125.7	2125.7	301.7	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Jan - MY 093	2126.2	2126.2	301.7	195.8	195.8
Feb - MY 093	2126.6	2126.6	301.7	195.8	195.8
Mar - MY 093	2127.3	2127.3	302.5	195.8	195.8
Apr - MY 093	2124.5	2124.5	315.7	195.8	195.8
May - MY 093	2119.1	2119.1	334.1	195.8	195.8
Jun - MY 093	2111.9	2111.9	387.9	195.8	195.8
Jul - MY 093	2106.3	2106.3	411.7	195.8	195.8
Aug - MY 093	2109.4	2109.4	382.0	195.8	195.8
Sep - MY 093	2108.3	2108.3	388.3	195.8	195.8
Oct - MY 094	2106.1	2106.1	411.7	195.8	195.8
Nov - MY 094	2104.0	2104.0	421.8	195.8	195.8
Dec - MY 094	2103.9	2103.9	421.8	195.8	195.8
Jan - MY 094	2103.8	2103.8	421.8	195.8	195.8
Feb - MY 094	2105.0	2105.0	411.7	195.8	195.8
Mar - MY 094	2106.6	2106.6	411.7	195.8	195.8
Apr - MY 094	2104.2	2104.2	421.8	195.8	195.8
May - MY 094	2098.6	2098.6	436.2	195.8	195.8
Jun - MY 094	2090.8	2090.8	449.6	195.8	195.8
Jul - MY 094	2083.0	2083.0	470.3	195.8	195.8
Aug - MY 094	2078.8	2078.8	479.0	195.8	195.8
Sep - MY 094	2075.0	2075.0	480.2	195.8	195.8
Oct - MY 095	2071.1	2071.1	490.2	195.8	195.8
Nov - MY 095	2068.3	2068.3	510.0	195.8	195.8
Dec - MY 095	2084.4	2084.4	470.3	195.8	195.8
Jan - MY 095	2111.9	2111.9	387.9	195.8	195.8
Feb - MY 095	2126.6	2126.6	301.7	195.8	195.8
Mar - MY 095	2136.0	2136.0	194.5	195.8	195.8
Apr - MY 095	2140.7	2140.7	170.4	195.8	195.8
May - MY 095	2138.8	2138.8	181.3	195.8	195.8
Jun - MY 095	2133.6	2133.6	211.1	195.8	195.8
Jul - MY 095	2128.6	2128.6	302.5	195.8	195.8
Aug - MY 095	2124.4	2124.4	315.7	195.8	195.8
Sep - MY 095	2122.7	2122.7	322.9	195.8	195.8
Oct - MY 096	2123.4	2123.4	315.7	195.8	195.8
Nov - MY 096	2124.2	2124.2	315.7	195.8	195.8
Dec - MY 096	2130.5	2130.5	295.9	195.8	195.8
Jan - MY 096	2133.8	2133.8	211.1	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Feb - MY 096	2137.6	2137.6	181.3	195.8	195.8
Mar - MY 096	2142.5	2142.5	159.4	195.8	195.8
Apr - MY 096	2144.6	2144.6	150.8	195.8	195.8
May - MY 096	2142.1	2142.1	159.4	195.8	195.8
Jun - MY 096	2136.6	2136.6	194.5	195.8	195.8
Jul - MY 096	2130.9	2130.9	295.9	195.8	195.8
Aug - MY 096	2125.3	2125.3	301.7	195.8	195.8
Sep - MY 096	2121.5	2121.5	322.9	195.8	195.8
Oct - MY 097	2118.7	2118.7	340.4	195.8	195.8
Nov - MY 097	2116.8	2116.8	368.3	195.8	195.8
Dec - MY 097	2117.5	2117.5	340.4	195.8	195.8
Jan - MY 097	2134.3	2134.3	211.1	195.8	195.8
Feb - MY 097	2140.2	2140.2	170.4	195.8	195.8
Mar - MY 097	2149.5	2149.5	105.5	195.8	195.8
Apr - MY 097	2153.7	2154.7	105.5	175.7	166.9
May - MY 097	2153.7	2154.8	105.5	175.7	166.9
Jun - MY 097	2146.5	2151.3	128.6	195.8	195.8
Jul - MY 097	2142.0	2142.0	159.4	195.8	195.8
Aug - MY 097	2139.6	2139.6	170.4	195.8	195.8
Sep - MY 097	2136.9	2136.9	194.5	195.8	195.8
Oct - MY 098	2137.2	2137.2	181.3	195.8	195.8
Nov - MY 098	2137.6	2137.6	181.3	195.8	195.8
Dec - MY 098	2138.6	2138.6	181.3	195.8	195.8
Jan - MY 098	2139.5	2139.5	170.4	195.8	195.8
Feb - MY 098	2140.4	2140.4	170.4	195.8	195.8
Mar - MY 098	2141.7	2141.7	159.4	195.8	195.8
Apr - MY 098	2142.2	2142.2	159.4	195.8	195.8
May - MY 098	2137.9	2137.9	181.3	195.8	195.8
Jun - MY 098	2131.9	2131.9	260.9	195.8	195.8
Jul - MY 098	2125.9	2125.9	301.7	195.8	195.8
Aug - MY 098	2121.0	2121.0	334.1	195.8	195.8
Sep - MY 098	2117.5	2117.5	340.4	195.8	195.8
Oct - MY 099	2116.0	2116.0	368.3	195.8	195.8
Nov - MY 099	2114.6	2114.6	376.4	195.8	195.8
Dec - MY 099	2116.1	2116.1	368.3	195.8	195.8
Jan - MY 099	2117.3	2117.3	340.4	195.8	195.8
Feb - MY 099	2117.6	2117.6	340.4	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Mar - MY 099	2118.6	2118.6	340.4	195.8	195.8
Apr - MY 099	2117.0	2117.0	368.3	195.8	195.8
May - MY 099	2112.0	2112.0	387.9	195.8	195.8
Jun - MY 099	2105.0	2105.0	411.7	195.8	195.8
Jul - MY 099	2098.1	2098.1	436.2	195.8	195.8
Aug - MY 099	2092.1	2092.1	452.5	195.8	195.8
Sep - MY 099	2089.2	2089.2	449.6	195.8	195.8
Oct - MY 100	2085.6	2085.6	470.7	195.8	195.8
Nov - MY 100	2083.2	2083.2	470.3	195.8	195.8
Dec - MY 100	2083.6	2083.6	470.3	195.8	195.8
Jan - MY 100	2087.4	2087.4	460.0	195.8	195.8
Feb - MY 100	2089.8	2089.8	449.6	195.8	195.8
Mar - MY 100	2097.5	2097.5	436.2	195.8	195.8
Apr - MY 100	2099.9	2099.9	435.7	195.8	195.8
May - MY 100	2096.3	2096.3	469.4	195.8	195.8
Jun - MY 100	2089.8	2089.8	449.6	195.8	195.8
Jul - MY 100	2084.0	2084.0	470.3	195.8	195.8
Aug - MY 100	2079.4	2079.4	481.3	195.8	195.8
Sep - MY 100	2081.8	2081.8	482.7	195.8	195.8
Oct - MY 101	2079.4	2079.4	481.3	195.8	195.8
Nov - MY 101	2078.2	2078.2	479.0	195.8	195.8
Dec - MY 101	2078.9	2078.9	479.0	195.8	195.8
Jan - MY 101	2079.1	2079.1	481.3	195.8	195.8
Feb - MY 101	2079.6	2079.6	481.3	195.8	195.8
Mar - MY 101	2081.0	2081.0	482.7	195.8	195.8
Apr - MY 101	2077.6	2077.6	479.0	195.8	195.8
May - MY 101	2072.3	2072.3	490.2	195.8	195.8
Jun - MY 101	2064.2	2064.2	526.5	195.8	195.8
Jul - MY 101	2055.6	2055.6	597.0	195.8	195.8
Aug - MY 101	2049.7	2049.7	600.7	195.8	195.8
Sep - MY 101	2049.9	2049.9	600.7	195.8	195.8
Oct - MY 102	2049.4	2049.4	600.7	195.8	195.8
Nov - MY 102	2046.1	2046.1	606.9	195.8	195.8
Dec - MY 102	2048.0	2048.0	602.3	195.8	195.8
Jan - MY 102	2051.3	2051.3	591.8	195.8	195.8
Feb - MY 102	2058.5	2058.5	580.5	195.8	195.8
Mar - MY 102	2063.8	2063.8	526.5	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Apr - MY 102	2065.6	2065.6	525.3	195.8	195.8
May - MY 102	2061.3	2061.3	543.7	195.8	195.8
Jun - MY 102	2053.4	2053.4	589.0	195.8	195.8
Jul - MY 102	2046.5	2046.5	606.9	195.8	195.8
Aug - MY 102	2044.6	2044.6	613.3	195.8	195.8
Sep - MY 102	2044.7	2044.7	613.3	195.8	195.8
Oct - MY 103	2042.1	2042.1	607.0	195.8	195.8
Nov - MY 103	2044.1	2044.1	613.3	195.8	195.8
Dec - MY 103	2047.7	2047.7	602.3	195.8	195.8
Jan - MY 103	2055.1	2055.1	597.0	195.8	195.8
Feb - MY 103	2065.4	2065.4	525.3	195.8	195.8
Mar - MY 103	2070.7	2070.7	503.9	195.8	195.8
Apr - MY 103	2070.6	2070.6	503.9	195.8	195.8
May - MY 103	2066.5	2066.5	525.3	195.8	195.8
Jun - MY 103	2059.2	2059.2	558.8	195.8	195.8
Jul - MY 103	2051.5	2051.5	591.8	195.8	195.8
Aug - MY 103	2044.4	2044.4	613.3	195.8	195.8
Sep - MY 103	2041.8	2041.8	607.0	195.8	195.8
Oct - MY 104	2037.1	2037.1	603.7	195.8	195.8
Nov - MY 104	2038.6	2038.6	603.7	195.8	195.8
Dec - MY 104	2048.2	2048.2	602.3	195.8	195.8
Jan - MY 104	2074.8	2074.8	492.7	195.8	195.8
Feb - MY 104	2090.8	2090.8	449.6	195.8	195.8
Mar - MY 104	2102.0	2102.0	432.9	195.8	195.8
Apr - MY 104	2105.4	2105.4	411.7	195.8	195.8
May - MY 104	2102.8	2102.8	432.9	195.8	195.8
Jun - MY 104	2098.7	2098.7	436.2	195.8	195.8
Jul - MY 104	2096.1	2096.1	469.4	195.8	195.8
Aug - MY 104	2094.5	2094.5	447.8	195.8	195.8
Sep - MY 104	2092.1	2092.1	452.5	195.8	195.8
Oct - MY 105	2089.4	2089.4	449.6	195.8	195.8
Nov - MY 105	2087.8	2087.8	460.0	195.8	195.8
Dec - MY 105	2088.4	2088.4	460.0	195.8	195.8
Jan - MY 105	2088.5	2088.5	460.0	195.8	195.8
Feb - MY 105	2088.1	2088.1	460.0	195.8	195.8
Mar - MY 105	2086.6	2086.6	470.7	195.8	195.8
Apr - MY 105	2082.6	2082.6	482.7	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
May - MY 105	2076.6	2076.6	480.2	195.8	195.8
Jun - MY 105	2067.8	2067.8	510.0	195.8	195.8
Jul - MY 105	2058.5	2058.5	580.5	195.8	195.8
Aug - MY 105	2050.8	2050.8	600.7	195.8	195.8
Sep - MY 105	2046.5	2046.5	606.9	195.8	195.8
Oct - MY 106	2045.0	2045.0	613.3	195.8	195.8
Nov - MY 106	2042.6	2042.6	607.0	195.8	195.8
Dec - MY 106	2044.3	2044.3	613.3	195.8	195.8
Jan - MY 106	2048.2	2048.2	602.3	195.8	195.8
Feb - MY 106	2072.8	2072.8	490.2	195.8	195.8
Mar - MY 106	2102.4	2102.4	432.9	195.8	195.8
Apr - MY 106	2110.1	2110.1	382.0	195.8	195.8
May - MY 106	2111.1	2111.1	387.9	195.8	195.8
Jun - MY 106	2110.7	2110.7	382.0	195.8	195.8
Jul - MY 106	2108.5	2108.5	388.3	195.8	195.8
Aug - MY 106	2106.2	2106.2	411.7	195.8	195.8
Sep - MY 106	2105.9	2105.9	411.7	195.8	195.8

Note: It should be noted that the WCM and RMP use elevations in decimal degrees; however, the HCP Amendment analysis used elevations rounded up since GIS contours are not available in decimal degrees.

Table B2. Summary of Estimated Lake Elevations and NMGS Habitat in June of Each Model Year (highlighted cells indicate water levels in the flood control space above 2,150.77 feet amsl).

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Jun - MY 001	2130.5	2130.5	295.9	195.8	195.8
Jun - MY 002	2150.8	2154.8	105.5	195.8	166.9
Jun - MY 003	2148.2	2152.7	100.5	195.8	182.8
Jun - MY 004	2147.2	2151.1	100.5	195.8	195.8
Jun - MY 005	2143.0	2143.0	159.4	195.8	195.8
Jun - MY 006	2146.1	2146.1	128.6	195.8	195.8
Jun - MY 007	2148.0	2152.2	100.5	195.8	189.8
Jun - MY 008	2135.9	2135.9	194.5	195.8	195.8
Jun - MY 009	2145.5	2145.5	128.6	195.8	195.8
Jun - MY 010	2142.9	2142.9	159.4	195.8	195.8
Jun - MY 011	2144.9	2144.9	150.8	195.8	195.8
Jun - MY 012	2129.4	2129.4	295.9	195.8	195.8
Jun - MY 013	2146.7	2151.0	128.6	195.8	195.8
Jun - MY 014	2147.2	2151.1	100.5	195.8	195.8
Jun - MY 015	2141.1	2141.1	159.4	195.8	195.8
Jun - MY 016	2132.9	2132.9	260.9	195.8	195.8
Jun - MY 017	2134.4	2134.4	211.1	195.8	195.8
Jun - MY 018	2140.7	2140.7	170.4	195.8	195.8
Jun - MY 019	2146.2	2151.0	128.6	195.8	195.8
Jun - MY 020	2145.3	2145.3	128.6	195.8	195.8
Jun - MY 021	2122.2	2122.2	322.9	195.8	195.8
Jun - MY 022	2141.3	2141.3	159.4	195.8	195.8
Jun - MY 023	2145.3	2145.3	128.6	195.8	195.8
Jun - MY 024	2145.7	2145.7	128.6	195.8	195.8
Jun - MY 025	2135.0	2135.0	194.5	195.8	195.8
Jun - MY 026	2124.1	2124.1	315.7	195.8	195.8
Jun - MY 027	2107.6	2107.6	388.3	195.8	195.8
Jun - MY 028	2151.1	2155.0	105.5	195.8	166.9
Jun - MY 029	2143.9	2143.9	150.8	195.8	195.8
Jun - MY 030	2143.5	2143.5	150.8	195.8	195.8
Jun - MY 031	2136.4	2136.4	194.5	195.8	195.8
Jun - MY 032	2137.3	2137.3	181.3	195.8	195.8
Jun - MY 033	2118.9	2118.9	340.4	195.8	195.8
Jun - MY 034	2102.4	2102.4	432.9	195.8	195.8
Jun - MY 035	2096.9	2096.9	469.4	195.8	195.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Jun - MY 036	2121.7	2121.7	322.9	195.8	195.8
Jun - MY 037	2107.9	2107.9	388.3	195.8	195.8
Jun - MY 038	2071.3	2071.3	490.2	195.8	195.8
Jun - MY 039	2147.4	2152.7	100.5	195.8	182.8
Jun - MY 040	2135.3	2135.3	194.5	195.8	195.8
Jun - MY 041	2117.7	2117.7	340.4	195.8	195.8
Jun - MY 042	2090.0	2090.0	449.6	195.8	195.8
Jun - MY 043	2077.2	2077.2	479.0	195.8	195.8
Jun - MY 044	2076.2	2076.2	480.2	195.8	195.8
Jun - MY 045	2125.5	2125.5	301.7	195.8	195.8
Jun - MY 046	2105.2	2105.2	411.7	195.8	195.8
Jun - MY 047	2143.6	2143.6	150.8	195.8	195.8
Jun - MY 048	2120.2	2120.2	334.1	195.8	195.8
Jun - MY 049	2132.0	2132.0	260.9	195.8	195.8
Jun - MY 050	2113.2	2113.2	376.4	195.8	195.8
Jun - MY 051	2096.9	2096.9	469.4	195.8	195.8
Jun - MY 052	2127.6	2127.6	302.5	195.8	195.8
Jun - MY 053	2144.3	2144.3	150.8	195.8	195.8
Jun - MY 054	2127.2	2127.2	302.5	195.8	195.8
Jun - MY 055	2146.4	2151.3	128.6	195.8	195.8
Jun - MY 056	2144.5	2144.5	150.8	195.8	195.8
Jun - MY 057	2131.2	2131.2	260.9	195.8	195.8
Jun - MY 058	2106.9	2106.9	411.7	195.8	195.8
Jun - MY 059	2093.1	2093.1	447.8	195.8	195.8
Jun - MY 060	2151.4	2155.6	105.5	195.8	158.1
Jun - MY 061	2135.4	2135.4	194.5	195.8	195.8
Jun - MY 062	2139.6	2139.6	170.4	195.8	195.8
Jun - MY 063	2129.6	2129.6	295.9	195.8	195.8
Jun - MY 064	2104.5	2104.5	421.8	195.8	195.8
Jun - MY 065	2146.1	2146.1	128.6	195.8	195.8
Jun - MY 066	2151.8	2155.1	105.5	189.8	166.9
Jun - MY 067	2150.8	2154.2	105.5	195.8	175.7
Jun - MY 068	2138.9	2138.9	181.3	195.8	195.8
Jun - MY 069	2145.8	2145.8	128.6	195.8	195.8
Jun - MY 070	2151.2	2154.9	105.5	195.8	166.9
Jun - MY 071	2143.1	2143.1	150.8	195.8	195.8
Jun - MY 072	2147.6	2152.9	100.5	195.8	182.8

Month and Model Year	Water Level Elevation (feet amsl)		NMGS Habitat (acres)		
	Current WCM	Proposed FCS Deviation	CS	FCS (under current WCM)	FCS (under proposed deviation)
Jun - MY 073	2142.9	2142.9	159.4	195.8	195.8
Jun - MY 074	2146.0	2151.0	128.6	195.8	195.8
Jun - MY 075	2145.1	2145.1	128.6	195.8	195.8
Jun - MY 076	2141.1	2141.1	159.4	195.8	195.8
Jun - MY 077	2111.2	2111.2	387.9	195.8	195.8
Jun - MY 078	2147.9	2151.0	100.5	195.8	195.8
Jun - MY 079	2150.8	2152.0	105.5	195.8	189.8
Jun - MY 080	2148.1	2153.8	100.5	195.8	175.7
Jun - MY 081	2142.8	2142.8	159.4	195.8	195.8
Jun - MY 082	2144.6	2144.6	150.8	195.8	195.8
Jun - MY 083	2120.9	2120.9	334.1	195.8	195.8
Jun - MY 084	2112.6	2112.6	387.9	195.8	195.8
Jun - MY 085	2130.7	2130.7	295.9	195.8	195.8
Jun - MY 086	2112.9	2112.9	387.9	195.8	195.8
Jun - MY 087	2083.5	2083.5	470.3	195.8	195.8
Jun - MY 088	2093.7	2093.7	447.8	195.8	195.8
Jun - MY 089	2055.9	2055.9	597.0	195.8	195.8
Jun - MY 090	2071.6	2071.6	490.2	195.8	195.8
Jun - MY 091	2064.7	2064.7	526.5	195.8	195.8
Jun - MY 092	2137.3	2137.3	181.3	195.8	195.8
Jun - MY 093	2111.9	2111.9	387.9	195.8	195.8
Jun - MY 094	2090.8	2090.8	449.6	195.8	195.8
Jun - MY 095	2133.6	2133.6	211.1	195.8	195.8
Jun - MY 096	2136.6	2136.6	194.5	195.8	195.8
Jun - MY 097	2146.5	2151.3	128.6	195.8	195.8
Jun - MY 098	2131.9	2131.9	260.9	195.8	195.8
Jun - MY 099	2105.0	2105.0	411.7	195.8	195.8
Jun - MY 100	2089.8	2089.8	449.6	195.8	195.8
Jun - MY 101	2064.2	2064.2	526.5	195.8	195.8
Jun - MY 102	2053.4	2053.4	589.0	195.8	195.8
Jun - MY 103	2059.2	2059.2	558.8	195.8	195.8
Jun - MY 104	2098.7	2098.7	436.2	195.8	195.8
Jun - MY 105	2067.8	2067.8	510.0	195.8	195.8
Jun - MY 106	2110.7	2110.7	382.0	195.8	195.8

Note: It should be noted that the WCM and RMP use elevations in decimal degrees; however, the HCP Amendment analysis used elevations rounded up since GIS contours are not available in decimal degrees.

APPENDIX C

Bureau of Reclamation Consultation History

April 2022

Bureau of Reclamation's History of Endangered Species Act (ESA) Compliance at Roosevelt Dam and Lake

Over the last 39 years, there have been several activities and actions at Roosevelt Dam and Lake requiring compliance with Section 7 of the ESA compliance. Modifications to Roosevelt Dam were authorized by Section 30l(a)(3) of the Colorado River Basin Project Act of 1968 (Public Law 90-537) (CRBPA) and the Safety of Dams (SOD) Act of 1978 (Public Law 95-578). The CRBPA authorized construction of the Central Arizona Project (CAP) Regulatory Storage Division. The Regulatory Storage Division addressed regulatory storage of CAP water, new water conservation, and flood control of the Salt and Gila Rivers through metropolitan Phoenix. The SOD Act authorized modifications to preserve the structural safety of dams and related facilities built by Reclamation, including Roosevelt. Because construction and operation of the CAP Regulatory Storage Division and portions of the SOD program involved activities at the same facilities in overlapping time frames, the purposes of both authorizations were combined in the Central Arizona Water Control Study (CAWCS). Plan 6 was identified as Reclamation's preferred alternative in a Final Environmental Impact Statement (FEIS) prepared for the CAP Regulatory Storage Division (Reclamation 1984). The Roosevelt Dam component of the FEIS provided for flood control, additional water conservation capacity, and correction of safety of dam deficiencies by modifying Roosevelt Dam.

1983 - The U.S. Fish and Wildlife Service (FWS) issued its Biological Opinion (BO) on March 3, 1983, for Plan 6, which was for the construction or modification of four dams in Maricopa, Yavapai, and Gila Counties in Arizona. Those dams consist of the New Waddell Dam on the Agua Fria River and Cliff Dam on the Verde River (which was later dropped), and modifications to Roosevelt Dam and Stewart Mountain Dam on the Salt River (FWS 1983). The FWS determined that CAWCS would likely jeopardize the continued existence of the bald eagle (*Haliaeetus leucocephalus*) population in the Southwest (FWS 1983). For Roosevelt Dam, the decision was based on expected effects associated with an increase in human activity from the use of a borrow area at Meddler Point, Recreation Site 12, incidental recreation encroachment into Pinal Creek nest area upstream of Recreation Site 12, and increased use of the north shore of Roosevelt Lake that could lower productivity or cause abandonment of the Pinal Bald Eagle Breeding Territory. These potential impacts, in conjunction with other CAWCS impacts at Lake Pleasant (associated with New Waddell Dam), Saguaro Lake (associated with Stewart Mountain Dam), and Horseshoe Lake (associated with Cliff Dam), resulted in FWS concluding that these activities were likely to jeopardize the continued existence of the bald eagle in the Southwest. The Reasonable and Prudent Alternatives (RPA) identified in the 1983 BO that were applicable to the Roosevelt Dam modifications included:

1. The Reclamation shall work with the FWS and the U.S. Forest Service (USFS) to obtain a three-party Memorandum of Understanding (MOU) to implement management strategies and actions to avoid possible adverse impacts on nesting bald eagles in the project area.

2. In accordance with an Interagency Agreement between FWS and Reclamation currently in effect, continued participation and support by Reclamation at a minimum of current funding levels through fiscal year 1987, to gather information on the foraging and nesting ecology and prey base of the

Stewart Mountain, Chalk Mountain, and Pinal Creek eagle pairs. Additionally, Reclamation would support USFS' efforts to maintain nest wardens and provide liaisons between construction forces and the nest wardens to determine effects of observed impacts and coordinate remedial and/or avoidance measures.

3. At Meddler Point, either refrain from borrow excavation, or remove materials during the eagle non-breeding season (June through October) and stockpile such materials near the dam (outside the eagle breeding and foraging territory). Excavation of borrow to be conducted in such a manner as to produce no change of hydrologic characteristics of the river in that area. If adjacent to the river channel, the borrow area should be graded and shaped to provide habitat suitable for eagles to forage fish and restricted from human use during the eagle breeding season.

These RPAs were fully implemented by Reclamation either before construction began on the dam in 1992 or after construction was complete.

1989 - Following issuance of the BO in 1983, two new bald eagle breeding areas were discovered near Roosevelt: Sheep (15 miles upstream of the mouth of Tonto Creek) and Pinto (in a cottonwood tree in an abandoned heron rookery, west of Meddler Point). On July 20, 1989, Reclamation reinitiated consultation under Section 7 as a result of the new information (Reclamation 1989b).

Reclamation's 1989 BA concluded that the increased lake conservation pool may affect the Pinto Territory by killing the trees in the nesting area, and that the 100-year flood event may affect the territory by inundating the nest during the breeding season if it remained active in future years. Reclamation concluded that the proposed actions at Roosevelt Lake were not likely to affect the Sheep Territory because the nest was located 15 miles from the area of impact. Reclamation also determined that the proposed recreation development may affect the bald eagle, although potential disturbance to eagles associated with recreation development planned for the north shore of the lake would be substantially reduced by the decision to eliminate the proposed development at Recreation Site 4 (Rock Island), and to replace it with limited boat-in camping in areas acceptable to the involved resource agencies.

1990 – The FWS issued a BO in 1990 analyzing the effects for modifying Roosevelt Dam on the Sheep and Pinto Breeding Areas. The BO also addressed bald eagle use of a large cottonwood gallery at the mouth of Tonto Creek. The FWS concluded that the Roosevelt Dam modifications were not likely to jeopardize the continued existence of bald eagles in the Southwest (FWS 1990). The BO described the eventual loss of all or a portion of the cottonwoods, including nesting trees, below elevation 2,151 feet but described the offsetting benefits of additional shallow water habitat and fringe wetland areas created by higher reservoir levels, and the improvement of riparian habitat in the Tonto Creek Riparian Unit (TCRU) established by Reclamation as mitigation for Modified Roosevelt Dam.

The FWS proposed two Reasonable and Prudent Measures (RPM) to minimize incidental take to the Pinto nest:

1) Construction of a bald eagle nesting platform in the Pinto nest area at least 4 years before the nest tree was anticipated to collapse.

2) Close the Pinto Creek Nest area to recreational traffic during the breeding season, if and when it became active. Since the proposed closure would be on Tonto National Forest lands, FWS acknowledged that the closure would require USFS' permission and participation (FWS 1990).

In addition to the RPMs, three conservation recommendations were identified by FWS to:

1) Conduct winter bald eagle surveys along the shores of Roosevelt.

2) Construct additional nesting and perching platforms to replace cottonwood trees killed by inundation in the Pinto breeding area.

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3) Purchase of Rockhouse Farm property near the Salt River inlet to create riparian habitat (Reclamation 1992). Reclamation agreed to implement both RPMs and all three conservation recommendations.

Shortly after issuance of the BO, Reclamation worked with the USFS for the closure of the Pinto Creek nest site to recreation; however, it was not implemented until 2005. The construction of a nest platform became unnecessary as by the time the nest tree fell the eagles had moved on to another tree to construct a nest. The Conservation Recommendations to conduct winter surveys was conducted from 1989 to 1992, and the purchase of the Rock House Farm Property was completed in 1992.

1992 - Reclamation reinitiated consultation with the FWS on September 2, 1992, following the discovery of another bald eagle nest at the mouth of Tonto Creek in a grove of cottonwoods located below elevation 2,151 feet (Reclamation 1992a). The 1992 BA addressed effects to this new bald eagle breeding area from the proposed Indian Point Recreation Site (that includes a campground, boating site, and a cultural resource site – Cline terrace Platform Mound), the proposed Tonto Creek crossing at A-Cross Road, and future Lake Roosevelt operating levels.

Shortly after reinitiating consultation, Reclamation notified FWS on September 15, 1992, of an additional activity that should be considered under the 1992 BA for the Tonto Creek Bald Eagle Breeding Area. Within the vicinity of the Tonto Creek bald eagle nest, riprap material needed to be placed along the slopes of State Route 188 to protect the road's fill slopes from a 200-year flood event (Reclamation 1992b).

By December 1992, the eagles at the Tonto Creek Breeding Area were observed building a new nest on the north side of Tonto Creek in a cottonwood tree upstream from the already known nest, but downriver from A-Cross Road (AZGFD 1992).

1993 - The FWS issued a BO on January 21, 1993, that determined that the Roosevelt modifications, specifically the proposed A-Cross Road crossing alternatives, Indian Point Recreation Site, TRCU, and modified Roosevelt Lake operating levels, were not likely to jeopardize the continued existence of bald eagles in the Southwest (FWS 1993a). It was determined that the proposed actions would eventually result in the destruction of the current nest trees and may result in the destruction of nests, possibly including eggs or nestlings. The proposed actions would also result in increasing the level of potentially disruptive human activity in the Tonto Breeding Area and facilitate access to the breeding area.

The BO stipulated three RPMs to minimize incidental take to the Tonto nests:

1) A seasonal closure around the breeding area.

2) Annual monitoring support for the Tonto Breeding Area.

3) Notification to FWS and assistance in rescue efforts if inundation of eggs or nestlings may occur.

The BO also included the following Conservation Recommendations:

1) Relocate Indian Point Campground outside one mile of the existing nest.

2) Close Indian Point Cultural Resource site during the bald eagle nesting season.

3) Reclamation and the USFS establish and maintain future and potential nesting habitat areas in the TCRU, to be available when the current nesting sites are no longer used or useable, and to plant cottonwood poles to accelerate establishment of future potential nest trees where regeneration is lacking.

4) Reclamation and the USFS develop and construct a bald eagle viewing station that would be staffed.

Reclamation implemented the RPMs and Conservation Recommendations. The RPM for annual monitoring of the Tonto Breeding Area began in 1992 and continues today. The seasonal closure was in place by 2005. Through collaboration among Nestwatchers, SRP, Arizona Game and Fish Department, FWS, Reclamation, and USFS, eagle rescues are coordinated around Roosevelt Lake. The Conservation Recommendation to relocate the Indian Point Campground was not accomplished, but the footprint was scaled back (see narrative under 1996). The USFS has been maintaining future nesting habitat in the TCRU since 1994 through livestock fencing and signage. A viewing station was not completed.

On January 27, 1993, FWS issued an addendum to the January 21, 1993, BO for proposed riprapping of SR 188 along Tonto Creek. The addendum determined that the proposed action would not likely jeopardize the continued existence of the southwestern population of bald eagle (FWS 1993b). FWS determined that the proposed action would result in incidental take of bald eagles through harassment of nesting and bald eagles during construction. Because all anticipated incidental take was dependent on the timing of the proposed project, no RPMs were identified. However, one Conservation Recommendation was provided. FWS recommended that no construction activities associated with the proposed project take place within one mile of existing nest trees in Tonto Creek, between December 15, 1993, and June 30, 1994. Reclamation agreed to implement the conservation recommendation and included it as stipulation to the construction contract.

1995 - Southwestern willow flycatchers (flycatchers) (*Empidonax traillii extimus*) were discovered nesting at the reservoir in 1993. The species was listed as endangered on March 29, 1995. Reclamation again requested Section 7 consultation with the FWS on September 14, 1995, to consider the effect of modifications to Roosevelt Dam on flycatchers. The BA prepared by Reclamation addressed the impacts of the increased height of the dam, and the indirect effects of the inundation, scouring floods, low water levels, and fires on flycatcher habitat within the new conservation space and flood control space. The BA concluded that the modifications to the dam may affect the flycatcher.

In the 1995 BA, Reclamation informed FWS that the U.S. Army Corps of Engineers (USACE) was currently developing criteria for flood control operations. Reclamation followed up with a letter dated April 29, 1996, that clarified the role of USACE in developing the Water Control Manual in relation to the assessment of effects made in the BA (FWS 1996b).

1996 – Reclamation sent FWS an amendment to their 1992 BA for the Tonto Creek bald eagle territory on May 13, 1996 (Reclamation 1996a). The amendment was regarding the design changes to Indian Point Campground.

On May 24, 1996, Reclamation submitted an amendment to their BA for the impacts to the flycatcher associated with the dam modifications (Reclamation 1996b). The amendment identified additional mitigation measures that would be undertaken by Reclamation. Those measures include providing staff and funding to assist FWS in accelerating, expanding, and implementing conservation and recovery actions for the flycatcher. Through this expanded program, Reclamation was committed to:

1. Be an advocate for the southwestern willow flycatcher; to act as an information center on flycatcher biology/ecology, management, and research; to generate interest and raise funds; and to immediately accomplish on-the-ground conservation actions.

2. Identify and develop conservation strategies in cooperation with the FWS, Reclamation, and other Federal, State, Tribal, and other entities, for incorporation into a FWS recovery plan; to assess flycatcher distribution, site specific conditions, habitat and population trends, and potential management actions.

3. Evaluate potential management conflicts, and develop management opportunities and partnerships within occupied and unoccupied flycatcher habitat.

4. Coordinate with appropriate FWS staff to provide all necessary information for the - Section 7 consultation process to minimize impacts to flycatchers and regulate incidental take.

5. Prepare management agreements with agencies, local management entities, and private landowners.

On July 2, 1996, FWS issued an amendment to the January 21, 1993 BO in regard to the Indian Point Recreation Site. This amendment was in response to a meeting held with the Tonto National Forest on February 9, 1996, and Reclamation's amended BA memorandum dated May 13, 1996, regarding modifications to the design of the Indian Point recreation site. RPMs 1 and 2 along with the terms and conditions for these RPMs remained unchanged under the BO. However, FWS provided clarification on RPM 2, as requested by Reclamation. The clarification stated that Reclamation was obligated to provide funding to the Nestwatch Program for 1) for the life of the Indian Point Recreation facility; or 2) until the bald eagle is delisted; or 3) until such time as it can be clearly demonstrated that the Tonto Breeding area has been abandoned for bald eagle nesting; or 4) until Reclamation can demonstrate that there have been no recreation-related incidents reported by Nestwatchers that resulted in abandonment of the nest or loss of young at the Indian Point Recreation Site for ten consecutive years (FWS 1996a).

FWS issued another BO on the operation of the modified Roosevelt Dam, including the flood control operation identified in the Water Control Manual, and its effects on the flycatcher on July 23, 1996. The BO covered more than what was originally presented in the BA due to follow up discussions on the Water Control Manual and effects to the flycatcher from the dam modifications. The BO concluded that the proposed action is likely to jeopardize the continued existence of the flycatcher (FWS 1996b). FWS anticipated that up to 90 flycatchers would be taken annually due to temporary or permanent habitat modification, including partial or total inundation of habitat during portions of the flycatcher's breeding season, is anticipated to result in take, in the form of delayed or lost breeding attempts, and/or decreased productivity and survivorship of adults that attempt to breed in modified habitat or disperse in search of suitable breeding habitat elsewhere. FWS did not clearly differentiate between impacts related to operation of the dam for water conservation purposes as opposed to operation for flood control; however, the BO discussion centers on the potential effects from long-term storage of water within the conservation pool. There were one RPA and four RPMs identified in the BO.

The one RPA had six components as follows:

1.a) Use of new conservation space at Roosevelt Lake to be used after the 1996 flycatcher breeding season.
1.b) Acquisition and management of flycatcher replacement habitat.
1.c) Establishment of a $1.25 million management fund to accomplish on-the-ground activities that benefit flycatchers.
1.d) Establishment of a flycatcher conservation coordinator position for 10 years.
1.e) Reclamation is to fund a comprehensive flycatcher research program for a period of 10 consecutive years. This consisted of: 1) flycatcher population surveys and nest monitoring at five sites for 10 years; 2) flycatcher banding at five sites for 5 years; 3) flycatcher dispersal and emigration studies for 6 years; 4) flycatcher genetic sampling for 2 years; 5) aerial photos at Roosevelt Lake every other year, aerial photo reports comparing the amount of suitable habitat and habitat types, and habitat monitoring including vegetation sampling reports.
1.f) cowbird trapping at four occupied flycatcher sites for 10 years.

The RPMs identified in the BO included:

1. Managing water levels at Roosevelt Lake so that flycatcher habitat is not inundated during the 1996 breeding season. The terms and conditions for this RPM include not permitting long-term storage of water in the new conservation space (elevation 2136 to 2151 feet) until after September 1, 1996. Flood events occurring prior to September 1, 1996, that require use of the conservation space between 2136 and 2151 feet shall be managed on a short-term basis only. Specifically, the space between 2136 and 2151 feet shall be used in a manner similar to that between 2151 and 2175 feet as specified in USACE operation manual for Roosevelt Dam. USACE operating criteria require flood water above 2151 feet to be evacuated within 20 days.

2. Reclamation shall implement a cowbird trapping program at Cook's Lake, Cook's Seep, PZ Ranch, and any property acquired as mitigation under RPA 2b. Cowbird trapping shall be implemented annually from April 1 through July 15 beginning in 1996 and conducted for 10 years (through 2005), except at any property acquired as mitigation under RPA 2b where trapping shall commence in 1997 and be conducted for 10 years (through 2006).

3. Have all flycatcher-related research and monitoring conducted by skilled personnel with appropriate training and permits.
4. Reduce take by ensuring appropriate coordination and oversight of RPA and RPMs. To reduce take and provide for coordination and overall management of activities specified under RPMs and the RPA, Reclamation shall fund for a period of no less than 10 years beginning October 1, 1996, one employee assigned as the Conservation Coordinator.

The conservation recommendations identified in the BO included:

1. Funding the Arizona Partners in Flight southwestern willow flycatcher survey program coordinated by the Arizona Game and Fish Department to survey lands withdrawn by Reclamation on the lower Colorado River (from Lake Mead to the border with Mexico) to determine the breeding season status of flycatchers in that region.

2. By December of 1998, identifying all areas with native and non-native riparian habitat potentially suitable for the flycatcher on all lands withdrawn by Reclamation in Arizona, New Mexico, and southern Utah. For areas that currently have suitable habitat, complete surveys through the Arizona Partners In Flight southwestern willow flycatcher survey program or equivalent programs in New Mexico and Utah to determine flycatcher breeding status. For all areas with suitable habitat, as well as those with potential habitat, identify the current condition of riparian habitats (i.e. size, shape, vegetative species composition and structure, and hydrological conditions of habitat patches) even if management has been turned over to another agency, current land-use practices, and management strategies to maintain suitable habitat for the flycatcher or to restore habitat. Synthesize the above data on suitable and potential habitat, breeding status, and management actions for all three states in a report containing tabular, graphical, and GIS-based data, where appropriate. Include in the report a timetable for implementing specific management actions that will benefit extant flycatcher populations, maintain suitable habitat, or restore potential, degraded habitat.

3. Support ongoing work by the National Biological Service to identify sub-specific patterns of genetic variation in the willow flycatcher complex (all subspecies) and to derive range wide estimates of population fragmentation (i.e. estimates of heterozygosity, distance measures, immigration rates) within the flycatcher.

Reclamation agreed to implement the RPA, RPMs and Conservation Recommendations. Most of them were completed by 2009 (see narrative under 2009). The remaining items were finished in 2014 and 2020 (see narrative under 2014 and 2021).

1999 – On April 13, 1999, Reclamation requested an amendment to the 1996 BO for the flycatcher. The request was in relation to RPA 1e, which describes mandatory research and management activities at a number of sites, including Cook's Lake. Reclamation noted that habitat at the Cook's Lake wetland is particularly sensitive and there is evidence that normal use by field crews is degrading flycatcher habitat. On June 7, 1999, FWS amended its 1996 BO by removing research and management requirements from Cook's Lake wetland, and adding those tasks to the Indian Hills and Kearney sites.

2001 - On January 5, 2001, Reclamation sent a memorandum to FWS about an increase in flycatcher numbers and distribution changes at Roosevelt Lake. The memorandum summarized discussions regarding whether an increase in the number of territories would require reinitiation of formal consultation. Reclamation stated that it did not have a discretionary Federal action subject to Section 7 under ESA for the operation of the existing (pre-modified) conservation space at Roosevelt (below elevation 2136-ft), where the increase in flycatcher numbers were occurring. Reclamation concluded that it would not reinitiate Section 7 consultation for the increase in the flycatcher population. Salt River Project (SRP) concurred with Reclamation's assessment in a correspondence dated February 2, 2001, and indicated that it would apply for an Incidental Take Permit under Section 10 of the ESA for effects to flycatchers associated with their operation of the conservation space. FWS sent a follow up response to SRP on March 2, 2001, indicating that a Section 10(a)(1)(B) incidental take permit was the appropriate vehicle for addressing and authorizing incidental take of flycatchers as a result of SRP's operation of the original conservation space.

2002 - SRP applied to FWS for an incidental take permit pursuant to Section 10(a)(1)(B) of the ESA. As part of the permit application, SRP developed and would implement the Roosevelt Habitat Conservation Plan (RHCP) to meet the requirements of a Section 10(a)(1)(B) permit. The area covered by the permit included Roosevelt Dam and Lake up to elevation 2,151 feet. The Draft HCP incorporated Reclamation's RPA and RPMs from the previous BOs into the baseline.

On September 17, 2002, Reclamation reinititated Section 7 consultation on the effects of modifications of Roosevelt Dam on the endangered flycatcher and threatened bald eagle. The agency concluded that in order to integrate the RPAs and RPMs as specified in the 1983, 1990, 1993, and 1996 BOs with the conservation measures that would be implemented as part of the RHCP, it should reinitiate formal Section 7 consultation with the FWS. Reclamation's request to reinitiate formal consultation was on the effects of construction for the new conservation space (between elevations 2136 feet and 2151 feet) resulting from the modification to Roosevelt Dam on federally-listed species. Pursuant to discussions with FWS and SRP, and consistent with the agreed upon approach for the draft RHCP, Reclamation reiterated its commitment to continue to carry out the measures identified in the RPAs and RPMs from the 1996 BO and amendment on the flycatcher and from the 1983, 1990, and 1993 BOs and their amendments on the bald eagle as a component of the integrated draft RHCP. Reclamation actively participated with FWS and SRP in the development of the draft RHCP, and it was the agency's conclusion that with implementation of the draft RHCP, including Reclamation's implementation of measures identified in the existing BOs on the flycatcher and bald eagle, the draft RHCP would minimize and mitigate, to the maximum extent practicable, any "take" of listed species resulting from the operation of the entire conservation storage at Roosevelt Dam. The effects consulted on in the earlier BOs were anticipated to result from the inundation of the newly created conservation space made possible by Reclamation's modifications to Roosevelt Dam. These effects would now be covered by the incidental take permit issued to SRP for its long-term operation of all the conservation storage space at Roosevelt Dam and Lake. Accordingly, Reclamation believed there would be no remaining effect of the Federal action which is not addressed in the draft RHCP.

In December 2002, FWS issued a FEIS for the RHCP, which included a final version of the RHCP in Volume II.

2003 – On September 2, 2003, Reclamation sent a request for concurrence to FWS for a possible change to the Cowbird Management Program required by the 1996 BO. The 1996 BO required Reclamation to implement a Cowbird Management Program to trap along the San Pedro River from 1997 through 2006. However, Reclamation sought concurrence to manage cowbirds as recommended by the Southwestern Willow Flycatcher Recovery Plan (FWS 2002) for the remaining years of the program. This would require suspending trapping in 2004 to determine the baseline parasitism rate on flycatchers. Reclamation would then resume trapping in the following year if the parasitism rate on flycatchers exceeded 20 percent, which is within the 20 - 30 percent rate recommended in the Southwestern Willow Flycatcher Recovery Plan (FWS 2002).

Within this same year, FWS also issued an Incidental Take Permit to SRP on February 27, 2003, for their operation of the conservation space, which included the existing conservation space and the new conservation space created by Reclamation's modifications to the dam.

2004 – Reclamation sent a memorandum to FWS on March 26, 2004, that provided additional justification to demonstrate Reclamation's request to change the approach to cowbird trapping and to confirm that the change in approach would continue to remove jeopardy as FWS intended, and as a result, should not trigger reinitiation (Reclamation 2004a). Reclamation proposed to alter RPA 1f for the remaining 3 years (2004, 2005, 2006) of the 10-year trapping requirement. Reclamation proposed to not trap in 2004, 2005, and 2006 unless parasitism exceeded 20 percent of all sites combined on the lower Gila River (San Pedro/Gila River confluence to Kelvin Bridge) and lower San Pedro River (Catalina Wash to Gila River). If parasitism exceeded 20 percent in 2004, trapping would resume in 2005 and 2006, and Reclamation would add an additional year in 2007. If parasitism does not exceed 20 percent in 2004, but does in 2005, Reclamation would trap in 2006 and 2007. If parasitism does not exceed 20 percent in 2004 or 2005, then no additional trapping would occur. The additional year of trapping in 2007 was proposed to offset the loss of reproductive output if parasitism exceeded 20 percent in an untrapped year. Although this additional year of trapping would be conducted after this loss has already occurred, it may minimize the reproductive loss in 2007 that may occur if not for trapping.

FWS concurred with Reclamation's request for a change in approach for RPA 1f (Cowbird Management) and issued an amendment to the 1996 BO on August 12, 2004. The alternative proposal for the Cowbird Management RPA was determined by FWS to not jeopardize the continued existence of the flycatcher (FWS 2004a).

In 2004, Reclamation sent a follow-up correspondence to FWS on August 26 to withdraw the agency's reinitiation request for Section 7 consultation sent on September 17, 2002. Based on the agency's discussion with FWS and SRP on June 6, 2003, and in light of the ongoing implementation of the RPAs and RPMs by Reclamation, and the implementation of the RHCP by SRP as a condition of the Section 10 take authorization, it was agreed that all effects from Reclamation's modifications to Roosevelt Dam, and from SRP's operation of Roosevelt Dam have been analyzed, and all necessary take has been authorized. Accordingly, it was mutually agreed that reinitiation of formal Section 7 consultation was not appropriate or required to achieve the integration of Reclamation's RPAs and RPMs with the RHCP actions undertaken by SRP (Reclamation 2004b).

On September 28, 2004, FWS replied to Reclamation's correspondence on August 26, 2004, by concurring that no further consultation is needed (FWS 2004b).

2007 - On June 28, 2007, the bald eagle was delisted. Removing the bald eagle did not mean an end to federal protection for the species. It just meant their management was once again governed solely by the Bald and Golden Eagle Protection Act.

A MOU was signed in 2007, 2014 and again in 2019 by Reclamation (Lower Colorado Region, Phoenix Area Office), USACE (South Pacific Division), FWS (Southwest Region), Arizona Game and Fish Commission, and SRP among other entities. The purpose of the MOU is to continue the conservation partnership to maintain, and where feasible and appropriate, enhance the breeding bald eagle population in Arizona. The baseline for measuring the adequacy of this conservation effort is the bald eagle's status in Arizona in the year the MOU for the Conservation Assessment and Strategy for the Bald Eagle was originally signed (2007).

At the time of the bald eagle delisting, Reclamation had met all but one of the RPMs and RPAs and most of the Conservation Recommendations in the 1983, 1990, 1993, and 1996 BOs for eagles. Conservations Recommendations are discretionary. Also, many of the RPMs and Conservation Recommendations were the responsibility of the USFS as they fell within their jurisdiction.

The one RPM not completed was for the construction of a bald eagle nest platform in the Pinto Breeding Area. The RPM specifically identified that the bald eagle nesting platform be constructed at least four years in advance of the time it is estimated for the Pinto Creek nest to collapse. Some progress was made for identifying a suitable nest platform location, but there were few location options for a platform. Pole planting was then considered an alternative to provide habitat. Reclamation installed groundwater monitoring wells in 2003 to see if the preferred locations for the pole plantings were viable. However, before the groundwater monitoring wells were installed, the nest tree died due to senescence and desiccation associated with low reservoir levels. The original Pinto nest tree did not fall until 2016. The Pinto eagles built a new nest in 2017 in a mature cottonwood. Since its discovery, the Pinto nest has been used annually.

Reclamation did not pursue a Bald and Golden Eagle Protection Act permit once the eagle was delisted because: 1) most of the mitigation requirements for eagles was fulfilled by delisting, 2) Reclamation planned to provide voluntary funding for bald eagle management in the state, and 3) the only remaining effects to bald eagles associated with Modified Roosevelt Dam were in relation to operations, which SRP had responsibility for in accordance with the September 6, 1917 contract with the U.S. Secretary of the Interior and through the 1996 Water Control Agreement between USACE, Reclamation, and SRP.

2009 – On February 5, 2009, Reclamation reported to FWS that all but one of the RPA tasks identified in the 1996 BO for flycatchers were complete and that it proposed a change to the remaining RPA (1c). Under RPA 1c, the BO established the creation of a 1.25-million-dollar flycatcher management fund to accomplish on-the-ground management that benefited flycatchers. As of February 2009, approximately $773,409 had been expended for purchase and start-up costs for two Gila River properties (part of Fort Thomas Preserve) and two San Pedro River properties (Spirit Hollow Annex near San Manuel) totaling 546.32 acres. However, additional opportunities to purchase properties without also providing funding for long-term management was not available. Reclamation proposed to reserve the approximately $476,591 remaining in the Flycatcher Management Fund for FWS to continue implementing the tasks in the Flycatcher Recovery Plan.

The 1996 BO also established the creation of a 10-year Conservation Coordinator position under RPA l d to assist the FWS in initiating recovery and conservation planning and to ensure the components of the RPA were accomplished. All but one of the RPA tasks in the BO were completed by the end of the 10-year term for the Conservation Coordinator in 2008. Reclamation informed FWS that it would no longer be funding or conducting the tasks formerly accomplished by the Conservation Coordinator, including database management, flycatcher training, information synthesis, etc. Through informal discussions with FWS, Reclamation and FWS jointly developed a strategy for continuing these and additional conservation tasks. The Conservation Coordinator transferred to FWS and had the expertise to facilitate the transition of the tasks from Reclamation to FWS. This allowed FWS to devote additional resources to the conservation of this species.

The 1996 BO stated that FWS would have primary responsibility for developing and identifying management actions to be funded through the Flycatcher Management Fund. If FWS agreed with Reclamation's proposal to use the remainder of the Flycatcher Management Fund to implement some of the tasks in the Recovery Plan, Reclamation would draft an Interagency Agreement to identify a more detailed scope of work.

FWS approved the change request for RPA 1c in February 19, 2009. The modification to this RPA allowed Reclamation to transfer the remaining $476,591 in the Flycatcher Management Fund to FWS to implement various tasks identified in the Flycatcher Recovery Plan from 2009 through 2013. This was accomplished by an Interagency Agreement (No. 09AA320240).

2014 - Under the Interagency Agreement, only $165,406 was expended before the period of performance end date in 2013. With the remaining $311,185 to complete the on-the-ground activities mutually agreed upon by FWS and Reclamation, a new Interagency Agreement (No. R14PG00066) was developed in 2014. The new agreement was to fund and maintain California, Arizona, New Mexico range wide databases for the flycatcher as needed, coordinate survey areas with cooperators, review completed data forms, and prepare proposals for database development. The funds were used to update the Flycatcher Habitat Suitability Model to allow land resource managers to track and predict change in suitable habitat over time and throughout its range. A Tamarisk Leaf Beetle Module was also developed to use in conjunction with the range wide habitat suitability model. Additionally, training was provided on the model to land and resource managers. This Interagency Agreement was extended beyond the period of performance end date of September 30, 2019, to add the creation of a database to be housed with Point Blue for the input of range wide flycatcher data. The database was completed by April 30, 2020.

2021 - On July 27, 2021, FWS sent a memorandum to Reclamation confirming completion of all obligations under the 1996 BO for the flycatcher and provided a close-out report for the Interagency Agreement (No. R14PG00066) for the Flycatcher Management Fund. The close-out report described the activities conducted for the benefit of the flycatcher under RPA 1c. Those activities included updating and expanding the geographic area covered by the Flycatcher Habitat Suitability Model and converting the Flycatcher Access Database to an online data entry, storage, and retrieval database. A total of $52,819.98 had been de-obligated with the completion of the Interagency Agreement.

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APPENDIX D

Information on the Legal Authority and Contracts Governing Modified Roosevelt Dam Operations

Summary of Authorities Dictating Federal And Non-Federal Roles and Responsibilities for Operation and Maintenance of the Modified Roosevelt Dam Flood Control Space ("FCS") and Responsibilities for Compliance with Sections 7 and 10 of the Endangered Species Act ("ESA"):

Main Points:

- Modified Roosevelt Dam ("Modified Roosevelt"), including the FCS, was constructed under the authority of the federal reclamation laws and continues to be cared for, operated and maintained under these laws.
- Modified Roosevelt, in its entirety, is a feature of the Salt River Federal Reclamation Project.
- The U.S. Bureau of Reclamation ("Reclamation"), as owner of the Project works, is the agency ultimately responsible for operation and maintenance of Modified Roosevelt.
- Per the September 6, 1917 Agreement and subsequent agreements among SRP, the United States and others, ongoing responsibility for the "care, operation and maintenance" of Modified Roosevelt (including the FCS) has been delegated to the Salt River Project Agricultural Improvement and Power District ("SRP").
- As operator of Modified Roosevelt, including the FCS, SRP is responsible for addressing "incidental take" of listed species resulting from Modified Roosevelt operations, through compliance with the Endangered Species Act ("ESA"), section 10(a)(1)(B).
- SRP's existing Habitat Conservation Plan ("HCP") and Incidental Take Permit ("ITP"), issued by the U.S. Fish and Wildlife Service ("USFWS") in 2003, covers operation of Modified Roosevelt conservation storage. SRP now proposes the addition of Modified Roosevelt FCS operations to its existing HCP/ITP to address effects of FCS operations on species listed after 2003, which occupy the FCS.
- The Army Corps of Engineers ("COE's") role at Modified Roosevelt extends to prescribing regulatory operating criteria for flood control purposes and approving or denying requests by SRP (in consultation with Reclamation) for deviations from those criteria.[1] The COE has no involvement in or responsibility for actual, ongoing operation of Modified Roosevelt, including the FCS.
- The proposed HCP/ITP amendment will address current FCS operations by SRP, and, if approved by the COE, the planned, temporary deviation in FCS operations described in the amendment.
- An integrated ESA Section 7(a)(2) consultations will address both the COE's proposed action to approve the planned deviation and the USFWS's proposed action to amend the HCP/ITP to cover FCS operations (current and planned deviation).

The following summary of relevant provisions of the authorizing agreements for Modified Roosevelt, the Water Control Manual and the Water Control Agreement, provides the legal foundation for the delineation of roles, responsibilities and ESA compliance mechanisms outlined above.

[1] See 1996 Water Control Agreement among the COE, Reclamation and SRP, Paragraph 7: "Any deviations from the approved Water Control Plan other than for emergencies, as stated above, shall be approved by the COE prior to the action being taken. The request for deviation shall be made by SRP after consultation with the USBR."

1. **The 1997 Water Control Manual for the Roosevelt FCS Recognizes that Modified Roosevelt is a "Reclamation" Dam, Part of a Multi-Purpose Federal Reclamation Project, Whose Operation and Maintenance has Been Turned Over to SRP, Per the September 6, 1917 Agreement Between SRP and the United States .[2]**

The 1997 Water Control Manual sets out in detail the historical and legislative underpinnings of Modified Roosevelt Dam, which leave no question as to its nature as a multi-purpose federal reclamation project. As the Water Control Manual recognizes, one of the purposes of the project was flood control:

> In 1968, the Congress authorized the USBR to construct the Central Arizona Project (CAP) as a part of the Colorado River Basin Project Act. One of the proposed fixtures of the CAP was the construction of Orme Dam at the confluence of the Salt and Verde Rivers, or a suitable alternative. **While the primary CAP-related purpose of Orme Dam was to provide seasonal storage and regulation of Colorado River water, it was also designed to provide extensive flood protection to the Phoenix metropolitan area and other downstream communities.** In 1977, as a result of growing public opposition, Orme Dam was deleted from the CAP. The Central Arizona Water Control Study (CAWCS) was formulated to develop a suitable alternative to Orme Dam.
> The development of alternatives was aimed at meeting the major planning objectives of flood control and CAP regulatory storage, together with other study purposes such as water conservation, recreation, fish and wildlife preservation, enhancement of social conditions, and energy management opportunities. The passage of the Reclamation Safety of Dams (SOD) Act of 1978 (PL-95-578) widened the focus of the CAWCS to include the evaluation of the structural safety of USBR dams. Under this dam safety program, **Theodore Roosevelt Dam was identified as having significant safety deficiencies. It was listed among the 13 dams originally identified in testimony for passage of the Reclamation Safety of Dams Act as requiring modifications to safely accommodate the Probable Maximum Flood (PMF) and Maximum Credible Earthquake (MCE)**.
>
> In 1981, the Department of the Interior selected one of the CAWCS alternatives known as "Plan 6" as the proposed action for purposes of detailed planning, design and completion of the CAP. Plan 6 included a modified Roosevelt Dam on the Salt River, a modified Stewart Mountain Dam also on the Salt River, Cliff Dam on the Verde River[3] and New Waddell Dam on the Agua Fria River.
>
> ….
>
> Modified Roosevelt Dam...is intended to provide flood control, water conservation, and dam safety, along with other project purposes and benefits consistent with the CAWCS.
>
> Water Control Manual, at 3-3 (emphasis added).

In addition to describing the legal foundations for Modified Roosevelt, the Water Control Manual sets forth the legal roles of Reclamation, SRP and the COE with respect to the operation of the dam. **These provisions of the Manual emphasize the central role of Reclamation and SRP in ongoing dam operations, contrasted with the limited role of the COE:**

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[2] The 1917 Agreement, as well as the 1993 Modified Roosevelt Operating Agreement, were described in the 2002 HCP. This Appendix provides additional detail regarding these agreements, the 1986 Plan 6 Agreement, the Water Control Agreement and the Water Control Manual, as these authorities pertain to the FCS.

[3] Cliff Dam was deleted from the plan in 1987, as a result of environmental concerns. Water Control Manual, at 3-3.

> Under the Federal Act of 1902, the USBR is charged with the responsibility of administering Federal multi-purpose projects and facilities including those on the Salt River System which includes Modified Roosevelt Dam. **While ultimately responsible for the operation and maintenance of the dam, the USBR has delegated these responsibilities to the SRP through a September 6, 1917 contract signed by both the USBR and the SRP.**
>
> Water Control Manual, section 1-06b., p. 1-3 (emphasis added).
>
> Modified Roosevelt Dam, including Theodore Roosevelt Lake and the reservoir lands behind the dam, **is owned by the Federal Government through the USBR.** The operation of the dam was turned over to SRP in 1917.
>
> Water Control Manual, section 1-04, p. 1-2 (emphasis added).
>
> The Salt River Project is charged with the responsibility for the operation and maintenance of Modified Roosevelt Dam.
>
> Water Control Manual, section 1-05, p. 1-2.
>
> Under Section 7 of the Flood Control Act of 1944, the COE is charged with the responsibility of prescribing regulations for the use of storage allocated for flood control at all reservoirs constructed in whole or in part with Federal funds. The Modified Roosevelt Dam water control plan in this manual is a result of coordinated effort by the COE and the USBR; however, the COE is responsible for providing the flood control regulations (operating criteria) and has the authority for final approval. Any deviation from the flood control operating instructions must be approved by the COE.
>
> Water Control Manual, section 1-06a, p. 1-2.
>
> **The SRP operates and maintains Modified Roosevelt Dam pursuant to contracts with the USBR dated September 6, 1917, and delivers water stored therein, in accordance with state water law, decrees and contracts.**
>
> Water Control Manual, section 1-06d, p. 1-3 (emphasis added).

These provisions expressly identify Reclamation as the owner of Modified Roosevelt and the agency ultimately responsible for its operation and maintenance. No distinction is made between Roosevelt Dam conservation storage and Roosevelt Flood Control Space with respect to ownership and operation of the dam. Rather, there is one dam, which is subject to Reclamation's operational authority. And Reclamation has delegated to SRP the authority to operate Modified Rosevelt per the 1917 Agreement. The COE's role at Modified Roosevelt is limited to prescribing regulatory operating criteria for flood control purposes.

1. **The 1996 Water Control Agreement Reinforces the Conclusion that Reclamation has Delegated the Operation and Maintenance of Modified Roosevelt to SRP per the September 6, 1917 Agreement.**

Through the 1996 Water Control Agreement, Reclamation and SRP agreed to comply with the flood control operating criteria in the COE Water Control Manual. The recitals to the Water Control Agreement set out the respective authorities and obligations of Reclamation, SRP and the COE.

Like the statements in the Water Control Manual, cited above, the Water Control Agreement recitals reinforce the conclusion that operation of Modified Roosevelt Dam remains subject to the federal reclamation laws, as well as all prior agreements between Reclamation and SRP addressing

the care, operation and maintenance of Salt River Project works. The role of the COE, in contrast, is not operational, but is limited to prescribing regulations for flood control:

> WHEREAS, **SRP currently operates and maintains Theodore Roosevelt Dam (hereafter Modified Roosevelt Dam) on the Salt River in Arizona, pursuant to agreements with the USBR and the Salt River Valley Water Users' Association dated September 6, 1917,** and March 22, 1937, as amended on February 28, 1944, and September 12, 1949; AND
>
> WHEREAS, as provided in the above referenced agreement dated September 6, 1917, **the USBR holds title to Modified Roosevelt Dam in accordance with the Reclamation Act of June 17, 1902,** as amended; AND
>
> WHEREAS, Congress authorized the USBR to construct the Central Arizona Project (CAP) as part of the Colorado River Basin Project Act of 1968, for the purposes of water conservation and flood control, and as a result of the Central Arizona Water Control Study (CAWCS) and the Reclamation Safety of Dams Act of 1978, flood control became a designated feature of Modified Roosevelt Dam; AND
>
> WHEREAS, as contained in Section 7 of the Flood Control Act of 1944 (58 Stat. 890, 33 U.S.C. § 709) **the COE is responsible to prescribe regulations for the use of storage allocated for flood control at all reservoirs constructed wholly or in part with federal funds.**

1. **The Plan 6 Agreement and the Modified Roosevelt Operating Agreement, which respectively authorized the construction and operation of Modified Roosevelt, Reaffirm and Further Cement Reclamation's (and, by Delegation, SRP's) Authority to Operate Modified Roosevelt Dam.**

The provisions of the agreements for the construction and operation of Modified Roosevelt likewise declare that the dam is a "reclamation" facility, whose modifications are to be constructed and operated under federal reclamation law. These provisions are discussed below.

A. The 1986 Plan 6 Agreement

The 1986 "Plan 6 Agreement," providing for the construction of Modified Roosevelt, cites as legal authority "the Colorado River Basin Project Act of September 30, 1968 (82 Stat. 885), the Reclamation Safety of Dams Act of 1978, (92 Stat. 2471, as amended by 98 Stat. 1481), the Hoover Power Plant Act of 1984 (August 17, 1984, 98 Stat. 1333), collectively known as **Federal Reclamation law,…."**
The Flood Control Act of 1944 is not cited as a basis for the Plan 6 Agreement.

Paragraph k to the Plan 6 Agreement defines the Project Works of Plan 6, which includes Modified Roosevelt, as follows:

> k. "Project Works" shall mean and include all authorized works and facilities of the **Central Arizona Project** and those facilities of the **Salt River Reclamation Project which are Features of Plan Six;…**[4]

[4] Two "project works" potentially included as facilities of the Salt River Reclamation Project are Modified Roosevelt and Stewart Mountain Dam, both of which were subjects of planned modifications under Plan 6. The Plan 6 Agreement, like the Water Control Manual, does not distinguish between the original Roosevelt Dam, authorized pursuant to the Reclamation Act of 1902 for the benefit of the Salt River Project, and the modifications to Roosevelt Dam authorized as part of the CAP (through the "suitable alternative" language) and, later, pursuant to the Reclamation Safety of Dams Act.

Regarding care and operation of Modified Roosevelt and other Salt and Verde River facilities, Paragraph 12.b of the Plan 6 Agreement provides:

> The care, operation, and maintenance of the facilities constructed within the Salt and Verde Rivers **shall be pursuant to the terms, covenants and conditions of the "Contract Between United States of America and Salt River Valley Water Users' Association" dated September 6, 1917, and contracts amendatory thereof and supplementary thereto.** The details of the implementation of said care, operation and maintenance shall be the subject of appropriate amendments and supplements to said September 6, 1917, contract, as amended and supplemented, or other agreements between the United States and SRP, and the United States and SRP agree to expeditiously negotiate appropriate amendments, supplements and other agreements.

(Emphasis added)

B. The 1993 Modified Roosevelt Operating Agreement

As provided in the 1993 Modified Roosevelt Operating Agreement:

> 14.5 Pursuant to the 1917 agreement between the United States and SRP,
>
> **SRP shall retain sole responsibility and authority for decisions, relating to operation, maintenance, and replacement of Modified Roosevelt Dam and the SRP Reservoir System**, including maintenance scheduling and the selection of periods when maintenance will be done; provided that nothing herein shall alter any existing obligations of SRP to consult with or obtain approvals from USBR in regard to such activities pursuant to applicable contracts and federal law.

(Emphasis added)

As the discussion of the controlling documents in this memorandum reveals, **the parties to the pertinent agreements, including the Plan 6 Agreement, the Modified Roosevelt Operating Agreement, and the Water Control Agreement, contemplated that the September 6, 1917 Contract between the United States and SRP would govern the operation of Modified Roosevelt Dam.** The Water Control Manual likewise contains a provision making the 1917 Agreement applicable to Modified Roosevelt operations, including operation of the FCS. The Water Control Manual further states that SRP delivers the water stored in Modified Roosevelt **"in accordance with state water law, decrees and contracts."** Water Control Manual, section 1-06d, p. 1-3 (emphasis added). Additionally, the Plan 6 Agreement defines the "project works" of Plan 6 to include those features of the Salt River Reclamation Project to be modified by Plan 6. Plan 6 Agreement, paragraph k.

C. The 1986 Plan 6 Agreement and the 1993 Modified Roosevelt Operating Agreement Cement SRP's Authority to Operate Modified Roosevelt as Part of the Salt River Reclamation Project.

The Modified Roosevelt agreements, described above, reaffirm SRP's ongoing operational responsibility for and authority over Modified Roosevelt operations, which originated in the September 6, 1917 Agreement. Under the Modified Roosevelt agreements:

1) **Modified Roosevelt, in its entirety, is a feature of the Salt River Reclamation Project works.**

2) **The care, operation and maintenance of the Salt River Reclamation Project works (including Modified Roosevelt) have been turned over to SRP, per the 1917 Agreement, the Water Control Agreement, the Modified Roosevelt Operating Agreement and the Plan 6 Agreement.**

Consistent with these conclusions, the 2002 HCP and USFWS's 2003 Biological Opinion concluded that SRP, as the operator of Modified Roosevelt, has responsibility for compliance with the ESA, per Section 10(a)(1)(B), to address the impacts of those operations.

1. **The Duty of the COE to Prescribe Flood Control Regulations, Per Section 7 of the 1944 Flood Control Act, is Narrow as to Reclamation facilities and is not Intended to Delegate to the Army Operational Control of the FCS.**

Section 7 of the 1944 Flood Control Act provides that, after the Act's effective date, "it shall be the duty of the Secretary of the Army to prescribe regulations for the use of storage allocated for flood control or navigation at all reservoirs constructed wholly or in part with Federal funds provided on the basis of such purposes, and the operation of any such project shall be in accordance with such regulations…." 33 U.S.C. § 709. While the class of reservoirs subject to Section 7 regulation is broad (all reservoirs constructed wholly or in part with federal funds), the scope of regulatory authority granted by the statute is narrow. **Particularly with respect to "non-Corps" reservoirs, the breadth of the Army's jurisdiction and authority extends no further than the subject matter of its flood control regulations (33 C.F.R. § 208.11) and the policies and procedures for preparation of water control plans for each reservoir (33 C.F.R. § 222.5(j))**.

33 C.F.R. § 208.11 entails the COE's preparation of the water control plan and water control manual, and execution of an agreement with the dam owner (and operator, if applicable) providing that these entities will abide by the manual and the plan. In cases of emergency affecting navigation and flood control, the regulations permit the COE to prescribe additional regulations, to be followed by the operator. 33 C.F.R. § 208.11(d)(2). Otherwise, if the "project owner [or operator] is responsible for real-time implementation of the water control plan, consultation and assistance will be provided by the Corps of Engineers when appropriate and to the extent possible." *Id.* The everyday operations of the dam, including operations in keeping with the water control plan and manual, remain the responsibility of the project owner (or operator). *Id.*

Requests by the project owner (or operator) to temporarily deviate from or modify the Water Control Manual are subject to approval by the COE. In the case of modifications to the Water Control Manual for Modified Roosevelt, Reclamation must also approve the request. 33 C.F.R § 208.11(d)(9).

33 C.F.R. § 222.5, which provides additional detail regarding the preparation of water control plans, distinguishes expressly between "Corps projects" and "non-Corps projects".[5] Non-Corps projects are described as "certain reservoir projects constructed or operated by other Federal, non-Federal or private agencies." 33 C.F.R. § 222.5(d)(2). Appendix E to section 222.5, which lists these "non-Corps" reservoirs, includes "Modified Theodore Roosevelt Dam and Lake", with "USBR" listed as the owner.[6] With respect to "non-Corps" projects, such as Modified Roosevelt, 33 C.F.R. § 222.5(b) states that the COE's responsibilities extend to "prescribing flood control and navigation regulations." *Id.*

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[5] As of September 25, 2020, the citation to 33 C.F.R. § 222.5 was the most current for this regulation. A Federal Register citation for that date refers to 85 FR 60682; however, the cited page contains no reference to 33 C.F.R. § 222.5. The regulation itself is current. If the applicable citation number is changed administratively, this memo may need to be updated to reflect that change.

[6] Corps reservoirs in Arizona include Alamo Lake (Bill Williams River), Painted Rock Dam (Gila River) and Whitlow Ranch Dam (Queen Creek).

Regarding the "magnitude and nature of storage allocations for flood control or navigation purposes in non-Corp projects," section 222.5(j)(4) states that the **"conditions of project authorizations or other legislative provisions" supply the governing law.** Recognizing that flood control storage allocations may affect the duties of the COE to regulate navigation and flood control, the regulations provide a **limited role** for the COE in settling upon such allocations, as follows:

> **Storage allocations made for flood control or navigation purposes in non-Corps projects are not subject to modifications by the Corps of Engineers as a prerequisite for prescribing 33 CFR 208.11 regulations.** However, regulations developed for use of such storage should be predicated on a mutual understanding between representatives of the Corps and the operating agency concerning the conditions of the allocations **in order to assure reasonable achievement of basic objectives intended**.

33 C.F.R. § 222.5(j)(6) (emphasis added).[7]

Consistent with the regulations governing "non-Corps" projects, the Water Control Manual and the Water Control Agreement for Modified Roosevelt constrain the role of the COE to the discharge of its regulatory duties under Section 7 of the 1944 Flood Control Act. **At the same time, the Water Control Manual reserves to SRP the operational control of its reservoirs,** consistent with ranges of releases prescribed by the water control plan, as follows:

> The Water Control Manual was formulated to correspond with various release mechanisms at Modified Roosevelt Dam. However, **it is not the objective of this manual to instruct the operators of Modified Roosevelt Dam—the Salt River Project (SRP)—on how to make the specified releases, but rather to establish the required flood control releases which are compatible with outlet capabilities.** As a consequence, the water control plan presented in the manual shows releases for ranges of water surface elevations, but does not specify the facilities by which releases are to be made. **The SRP will select the best means of making the scheduled releases during periods when the lake level is within flood control and surcharge pools.**

Water Control Manual, Preface (emphasis added).

[7] The regulations state that, "[i]n the event field representatives of the Corps of Engineers, and the operating agency are unable to reach necessary agreements after all reasonable possibilities have been explored, appropriate background explanations and recommendations should be submitted to DAEN-CWE-HW for consideration." 33 C.F.R. § 222.5(j)(6).

APPENDIX E

Movement of Nonnative Fish into Tonto Creek above A-Cross Road

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Salt River Project

Northern Mexican Gartersnake

Study 6: Movement of Nonnative Fish into Tonto Creek, Above A-Cross Road

Gila County, Arizona

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Contents

Tables

Figures

Appendices

Executive Summary

The United States Fish and Wildlife Service (USFWS) listed the Northern Mexican Gartersnake (NMGS) as a threatened subspecies under the Endangered Species Act on July 8, 2014 and made the final designation of NMGS critical habitat on April 28, 2021. A portion of the 29 stream miles of designated critical habitat includes lower Tonto Creek which is adjacent to but not within the Salt River Project's (SRP) conservation space (2,151 ft) for Roosevelt Lake. A multi-seasonal nonnative fishery study of the Tonto Creek Delta documented the presence of nonnative fish, including Largemouth Bass (*Micropterus salmoides*), in isolated pool habitat of Tonto Creek between A-Cross Road and the Tonto Creek Delta in 2019 and 2020. These fish persisted in the isolated pool habitat through fall 2019 primarily due to the influence of shallow groundwater on the residual pools. The seasonally wet 2019-2020 winter and rising lake levels changed the aquatic habitat from isolated pools to an expansive delta in the spring nearly reaching an elevation of 2,151 ft. Nonnative fish, including the Largemouth Bass, were observed in the shallow littoral zone of the Tonto Creek Delta and in Tonto Creek within 300 meters of A-Cross Road. Recent studies and other supporting information raised the concern for the movement of Largemouth Bass, Smallmouth Bass, *Micropterus dolomieu*; Channel Catfish, *Ictalurus punctatus*; and Yellow Bullhead, *Ameiurus natalis* (nonnative fish) upstream of A-Cross Road when suitable flow conditions exist in Tonto Creek. When suitable aquatic habitat conditions exist, there is a potential for interaction to occur between these nonnative fish and NMGS. The types of interaction can include but are not limited to nonnative fish predation on NMGS, harm caused by nonnative fish aggressive behaviors (e.g., chasing or defending) toward perceived threats during nest guarding, interspecific competition for prey resources, or NMGS predation on the spiny-rayed fish that may result in spine punctures to the snake. Many of these interactions are highly dependent on the age-class of the species present in the aquatic habitat.

The primary objective of this study was to evaluate the hydraulic conditions that would support the movement of Largemouth Bass and the other nonnative fish into lower Tonto Creek, and to characterize the magnitude and frequency of stream flow conditions that may facilitate the movement of fish, either upstream or downstream, in lower Tonto Creek. The Tonto Creek study area was defined as the 16.6 stream mile reach from the USGS Tonto Creek Above Gun Creek gage (09499000) downstream to A-Cross Road. This location separates the upper and lower Tonto Creek Basins based on the underlying geological features and represents the upstream boundary of the Gun Creek – Tonto Creek Watershed (HUC 10 Watershed). A lower flow threshold that results in surface water connectivity from the USGS Tonto Creek gage downstream to Roosevelt Lake was determined to be 20 cfs, as measured at the gage which is independent of lake elevation. Streamflow less than 20 cfs, results in intermittent flow conditions along the study reach that are influenced by dry-wet year weather conditions, groundwater pumping, and evapotranspiration rates along the riparian corridor. Even though 20 cfs creates surface water connectivity in the study, this flow rate is not suitable to allow fish passage through a downstream riffle near A-Cross Road, nor was 34 cfs as observed during a spring 2020 site visit.

Biologically-based environmental flow methodologies, along with fish physiological constraints, were used to estimate a range of flow conditions that would support fish passage through the downstream riffle near A-Cross Road, and either inhibit upstream movement, or potentially result in displacement of fish from upstream sources. Based on the empirical analysis of hydraulic data measured at the Tonto Creek gage, suitable flow days were conditionally defined to occur when mean daily flows from 200 to 1,100 cfs exist at the gage between March 1 and June 30 of each year. This range of flows is based on the quantity of flow (200 cfs) required to achieve at least 0.5 ft of water depth across the downstream riffle near A-Cross Road allowing for the passage of adult fish, and the quantity of flow (1,100 cfs) that exceeds the Largemouth Bass' physiological swimming ability at a riffle. Small size classes, young-of-year and juvenile Largemouth Bass do not exhibit the behavioral or physiological adaptations to move upstream through shallow riffle habitat created by flow sufficient to create surface water connectivity throughout the study reach. The temporal constraints are based on the overlap of life-history information for the Largemouth Bass spawning and NMGS active seasons, as well as the seasonal flow conditions in Tonto Creek. This analysis focused on the Largemouth Bass' behavior and physiological abilities, although most of the information provided herein is also applicable to the Smallmouth Bass, Bullhead and Channel Catfish. These species are present in Roosevelt Lake and when suitable flow conditions exist in Tonto Creek, these species may expand their range looking for suitable spawning habitat conditions.

The opportunity for movement of nonnative fish from Roosevelt Lake into Tonto Creek primarily occurs during wet-typical and wet seasonal flow conditions, when on average 16 and 27 suitable flow days are present, respectively, for fish movement upstream of A-Cross Road. There is no opportunity for fish movement upstream during dry seasonal flow conditions and considering the average number of days for dry-typical seasonal conditions (i.e., spring), the opportunity for movement is negligible, during these conditions as well. If upstream fish movement occurs during the wet-typical and wet flow conditions, then aquatic habitat (i.e., pools) may persist through June or beyond, although the channel will likely exhibit intermittency or may become dry by early summer. When nonnative fish species occupy aquatic habitat upstream of A-Cross Road, the successful spawning and recruitment of fry to young-of-year and juvenile fish has been observed, although self-sustaining populations of nonnative fish do not occur in the study reach due to the periodic drying of the channel.

The analysis indicates there is a potential for interaction to occur between nonnative fish and NMGS during wet-typical and wet seasonal conditions when flows are suitable to allow the movement of nonnative fish upstream of A-Cross Road. However, considering the age-class and size relationships between Largemouth Bass and NMGS, and both species preferential food resources, the likelihood of Largemouth Bass predation on NMGS is low, but the probability of occurrence is not zero. Similarly, considering the abundance of other prey items (i.e., anurans, other native/nonnative fish) compared to bass or catfish abundances, and the snake's preferential food resources, the likelihood of resource competition or NMGS predation on these fish is low to moderate, but the probability of occurrence is likely low, but not zero.

Salt River Project

Northern Mexican Gartersnake
Movement of Nonnative Fish into Tonto Creek Above A-Cross Road
Gila County, Arizona

June 2021

Background

The United States Fish and Wildlife Service (USFWS) listed the Northern Mexican Gartersnake (NMGS) as a threatened subspecies under the Endangered Species Act on July 8, 2014 (USFWS 2014) and made the final designation of 20,326 acres as NMGS critical habitat on April 28, 2021, (USFWS 2021). A portion of the proposed critical habitat area includes the Tonto Creek Unit (3,176 acres, along 29 stream miles), Gila County, which is adjacent to but not within the Salt River Project's (SRP) conservation space for Roosevelt Lake. Tonto Creek is an intermittent stream that originates near the Mogollon Rim, northeast of Payson, and flows into the northeast arm of Roosevelt Lake, hereafter referred to as the Tonto Creek Delta.

Telemetry studies have documented the presence of NMGS in the lower Tonto Creek Basin, indicating that an individual's home range may be as large as 19 hectares and extend over 800 meters along Tonto Creek (Nowak et al. 2019). Nowak also observed that NMGS actively use the wetland/riparian habitat corridor that is often within 95 meters of water's edge, and that NMGS over-winter in both riparian and upland habitats up to 383 meters from the water's edge (Nowak et al. 2019).

A 2019-2020 multi-seasonal nonnative fishery study of the Tonto Creek Delta (Jones 2020, ERO-GEI 2020) documented the presence of nonnative fish, including Largemouth Bass (*Micropterus salmoides,* LMB), in isolated pool habitat of Tonto Creek between A-Cross Road and the Tonto Creek Delta. These fish persisted in the isolated pool habitat through the 2019 summer and into late October 2019 primarily due to the influence of shallow groundwater on the residual pools. The seasonally wet 2019-2020 winter and rising lake levels changed the aquatic habitat from isolated pools to an expansive delta in the spring and summer 2020. Nonnative fish, including the Largemouth Bass, were observed in the shallow littoral zone of the Tonto Creek Delta and in Tonto Creek within 300 meters of A-Cross Road (Jones 2020, ERO-GEI 2020). The observations from this study, along with visual observations of nonnative fish occupying aquatic habitat in Tonto Creek upstream of A-Cross road, and historical studies documenting nonnative fish in Tonto Creek (Abarca and Weedman 1993, Avenetti et al. 2012, Jones and Rector 2020) raises the concern for potential impacts of nonnative fish on NMGS along the Tonto Creek study reach upstream of A-Cross Road. The purpose of this report is to summarize the available information on the Tonto Creek stream corridor and to evaluate the potential for movement of Largemouth Bass, Smallmouth Bass, *Micropterus dolomieu*; Channel Catfish, *Ictalurus punctatus*; and Yellow Bullhead, *Ameiurus natalis* (nonnative fish) into Tonto Creek upstream of the prevailing Roosevelt Lake inundation zone of 2,151 feet in elevation (e.g., A-Cross Road). If these nonnative fish move upstream, then there is potential for interaction to occur between the NMGS and fish. This report also serves to characterize the potential impacts to the NMGS when interaction may occur.

Management of the natural resources in the lower Tonto Creek basin falls under the purview of multiple federal, tribal, state, and non-governmental agencies with the U.S. Forest Service's Tonto National Forest Land Management Plan (Draft 2019 Plan) being the most encompassing of the land-based resources, including the riparian corridor. The Draft 2019 Plan and its corresponding Draft Environmental Impact Statement, outlines different management alternatives to rehabilitate and maintain riparian habitat conditions by primarily focusing on improving riparian vegetation structure with overstory targets (USFS 2019). The Draft 2019 Plan currently lacks specificity to the lower Tonto Creek basin, in terms of riparian natural resource management. However, the draft management plan has the greatest potential to maintain or restore the riparian corridor in the lower Tonto Creek basin with respect to the native species that create or rely on the habitat.

The management of aquatic resources in the Tonto Creek basin are not specifically guided by the watershed-based fishery management plan implemented by Arizona Game and Fish Department (AGFD), although management occurs within the basin. The watershed-based management plan focuses on data collection and analysis, consideration of management emphasis, analysis of potential conflicts and mitigation, and stakeholder/public input. The adaptive management approach considers sport fish, native fish, amphibians, and reptiles (including endangered species) that are associated with riparian habitats (AFGD 2019). Despite the lack of a defined management plan for the entire basin, the upper Tonto Creek basin is managed as a sport fishery for coldwater species in the headwater's region and for warmwater species near Gisela, AZ, whereas Roosevelt Lake, the downstream boundary of lower Tonto Creek basin, is managed as a warmwater fishery. The lower Tonto Creek basin receives little to no management as a sport fishery, primarily due to the intermittent flow nature of the channel and the intermittent/ephemeral tributaries to this water body. Nonetheless, the aquatic resources can be influenced by the management of both upstream and downstream waters. The AFGD Roosevelt Lake Fisheries Management Plan 2019-2029 (AGFD 2019) includes three primary objectives to improve the sport fishery and to conserve the larger specimens of each species:

- Maintain the Largemouth Bass population to meet or exceed Hawg Concept standards,
- Maintain the Flathead Catfish population to meet or exceed Fat Cat Concept standards, and
- Maintain the Black Crappie population to meet or exceed the Featured Species Concept standards.

The management for these objectives is designed to maintain a robust sport fishery in terms of both numbers of fish caught and their relative size classes with the emphasis of incentive-based conservation programs that encourage that catch-and-release of large fish (i.e., Largemouth Bass greater than 5, 8, or 10 pounds each or 21, 24, or 26 inches in length, respectively).

The goal to maintain self-sustaining populations in Roosevelt Lake with the aid of a robust sport fish stocking program (e.g., Florida Bass, *Micropterus floridanus*), creates an opportunity for nonnative fish to seek suitable spawning habitats within the Tonto Creek Delta, and when hydrological conditions are suitable, potentially upstream of the 2,151 feet (ft) elevation Roosevelt Lake inundation zone. Furthermore, the management of the upper basin as a sport fishery, as well as the historical and illegal stocking of nonnative fish allows for the potential downstream movement of nonnative fish into lower Tonto Creek. When the critical habitat designation in lower Tonto Creek is placed in the context of occupied habitat by either the NMGS or nonnative predatory fish (i.e., Largemouth Bass, Smallmouth Bass, Channel Catfish) there is a potential for niche space overlap and the indirect effects of harm or injury to the NMGS. These effects could be through nonnative fish predation on the NMGS or competition for prey resources such as amphibians or fish, or the NMGS predation on nonnative fish. The primary objective of this study is to evaluate the potential for movement of Largemouth Bass into lower Tonto Creek, upstream of A-Cross Road, and to characterize the frequency of stream flow conditions that may facilitate the movement of fish, either upstream or downstream, in lower Tonto Creek.

Lower Tonto Creek

Land-use and Habitat

For the purposes of the Roosevelt Habitat Conservation Plan (RHCP) amendment we have selected a lower portion of the 29 stream miles designated as critical habitat for the NMGS to focus our study objectives and to describe the potential for effects to occur to NMGS. We selected an upstream boundary for the study reach as the United States Geological Survey (USGS) Tonto Creek Above Gun Creek (09499000) stream gage (Appendix A, Figure A-1). This location separates the upper and lower Tonto Creek Basins based on the underlying geological features and represents the upstream boundary of the Gun Creek – Tonto Creek Watershed (HUC 10 Watershed). The lower basin is defined as the drainage area (~280 square miles) downstream of the gaging station to an elevation of 2,151 feet (ft) at A-Cross Road. This portion of Tonto Creek is approximately 16 river miles in length and bounded by the Sierra Ancha Mountain range to the east and Mazatzal Mountains to the west. Land ownership within a 1 mile buffer along Tonto Creek is 93 percent forested lands managed by the U.S. Forest Service Tonto National Forest (Voeltz 2002). Low intensity livestock grazing, and recreational use are the primary uses on the forest lands (USDA 2019), with six percent of the buffered area being occupied by residential homes, ranches, and small communities along Highway 188 near lower Tonto Creek (Towne 2013, Voeltz 2002). The Coconino National Forest and Apache-Sitgreaves National Forests occupy less than one percent of the buffered area along lower Tonto Creek. Other land and water uses along lower Tonto Creek include in-channel sand and gravel mining, groundwater pumping, irrigation, rural development of townships, and dispersed and locally intense recreation that includes in-channel use by off-road vehicles (Voeltz 2002).

Lower Tonto Creek is an intermittent stream channel contained within a broad alluvial basin that supports shallow, wide, and braided flows during portions of the hydrological cycle (Voeltz 2002, Towne 2013). The meandering braided channel can create scour pool habitat interspersed between shallow run-riffle habitat that can support the movement of native and nonnative fish when sufficient flow is present. Riffles serve as hydraulic control features in the gravel-bed channel that helps maintain the pooled habitats when low flows occur. Manmade features such as road crossings, channelized rip-rap reaches, and in-channel gravel operations can also alter the aquatic habitat to prolong the presence of water in some pooled habitat features. Isolated pools can serve as refugia for native and nonnative fish (Labbe and Fausch 2000), including habitat for anurans and aquatic invertebrates during periods of intermittency, although the permanency of isolated pools is highly variable and dependent upon multiple environmental conditions. Natural and manmade features can also serve as barriers to fish movement and may limit the upstream extent of habitat occupied by nonnative fish moving upstream from Roosevelt Lake. For example, the East del Chi Road crossing (15.2 river miles upstream of A-Cross Road) may represent the upstream limit for fish movement during relatively lower flow conditions due to the fish barrier created by three nine-ft diameter culverts at the crossing. Upstream of the culvert crossing, the channelized rip-rap reach is designed to contain a volume of water that can pass through the culvert system (Appendix A, Photo 17, Photo 20). Based on visual observations in summer 2021, the system could convey up to approximately 2,000 cfs (measured at gage 09499000) at which rate over-bank flows existed, causing severe erosion at the crossing. When flows are less than approximately 2,000 cfs, the flows are generally confined within the rip-rap channel and will pass through the culvert system and into the scour-plunge pool downstream of the crossing. The difference in elevation between the bottom of the culverts and the water's surface in the plunge pool, creates a falling water condition that prevents the upstream movement of nonnative fish into the culvert system. When over bank flows exist in the rip-rap channel or when flows reroute past the culvert system, then the barrier may be less effective in preventing nonnative fish movement upstream.

The riparian corridor is contained within the broad alluvial basin that is periodically inundated by seasonal surface flows and supported by the shallow alluvium. The broad alluvial basin is immediately bounded by upland habitat. The riparian vegetation includes a mixed of native species—grasses, willow, cottonwood, and Mesquite—and has been impacted by nonnative invasives (such as Tamarisk). There are also large stands of Mesquite surrounding the riparian corridor. Upland vegetation consists of semi-arid plants like creosote bush, various cacti, mesquite, and juniper and pinon pine in the higher elevations.

Hydrological Regime

The Lower Tonto Creek channel is underlain by up to 65 feet of alluvium that is seasonally influenced by snow-melt runoff, storm flows, infiltration and ground water recharge, and evapotranspiration (Schumann and Thomsen 1972). The highly permeable alluvium, with groundwater levels of ~40 feet below the surface is the principal source water for many domestic and irrigation wells, including stock ponds (Towne 2013, Schumann and Thomsen 1972). Groundwater discharge, evapotranspiration, and groundwater pumping from wells regularly lower the water level in the alluvium to below streambed levels during part of the year (Abarca and Weedman 1993).

During a portion of the year (winter), Tonto Creek is a gaining stream in the lower basin, although by mid-summer the stream becomes a losing stream and is dry in many years, lending to the intermittent nature of the stream. Factors that contribute to the intermittency include ground water pumping, infiltration, and evaporation/evapotranspiration in the channel and riparian zone, respectively. In some tributary streams, flow from source springs percolate through the permeable alluvium leaving a major portion of the tributary dry much of the year (Feth and Hem 1963). Peak discharges in Tonto Creek occur during the winter/spring as a result of regional storms, with runoff sometimes augmented by snowmelt. Winter storms account for most of the annual floods above the median peak discharge on Tonto Creek, although intermittent flows can occur in the spring and the channel may become dry by late June. Monsoonal storms account for large runoff events during the summer. Many ephemeral streams (dry washes) are also tributary to Tonto Creek and these streams briefly flow during localized precipitation events and maintain no connection to shallow groundwater (Levick et al. 2008). There are also spatially and temporally intermittent tributaries to Tonto Creek that maintain flows in headwater portions of the channel due to groundwater inputs, although perennial flow conditions are rarely observed at the confluence with Tonto Creek, unless augmented by rainfall.

For this study, Greenback Creek is one of the more notable intermittent tributaries to Tonto Creek given its location in the lower basin and its designation as critical habitat for the Spikedace (50 CFR Part 17, FWS–R2–ES–2010–0072; 4500030114). Other tributaries designated as critical habitat for the Spikedace include Rye Creek, Spring Creek, and Rock Creek, but these waterbodies are located upstream of the current study reach. Greenback Creek has the potential to support the reestablishment of Spikedace (*Meda fulgida*), as well as the potential to be influenced by Roosevelt Lake levels, if the flood control space is inundated to 2,175 ft in elevation. The flood control space (FCS) is defined as the area between 2,151 ft and 2,175 ft elevations which includes the Greenback Creek confluence with Tonto Creek and may be inundated when hydrological conditions necessitate the expansion of the reservoir. The proposed amendment to the Roosevelt Habitat Conservation Plan would expand the permit area to include current operation of the FCS up to 2,175 ft and allow for a deviation in those operations to occur 3 out of the next 5 years. The deviation provides 120 days for evacuation of the first five feet of the FCS in the event that inflows increase Reservoir lake levels to 2,175 ft. Above elevation 2,156 ft, there would be no change in current FCS operations, which require evacuation of the space within 20 days. A decreasing water level would disrupt fish spawning behavior and nest success in the FCS and greatly reduce the recruitment of the 0 to 1 year age-class of nonnative fish. The temporary use of the FCS would not create permanent aquatic habitat within this area to support resident populations of nonnative fish in Tonto Creek near Greenback Creek.

Historically, Spikedace occurred in Tonto Creek and likely the reach currently identified as part of the FCS, although at the time of the designation in 2012 this species did not occupy either Greenback Creek or Tonto Creek. As a result, Greenback Creek is classified as a 2b stream that would allow Spikedace to increase their species distribution within their historical range, if successfully reintroduced (50 CFR Part 17, FWS–R2–ES–2010–0072; 4500030114). Tonto Creek is also designated as critical habitat for Spikedace from the confluence with Greenback Creek upstream to the confluence with Houston Creek (near Gisela), while Tonto Creek downstream of Greenback Creek confluence is unsuitable for Spikedace due to the influence of Roosevelt Lake.

Spikedace occupy perennial streams and rivers with moderate to fast velocity water flowing over gravel and cobble substrate in riffle and run habitat. This habitat type also includes the sheer zones between the faster and slower waters found along sand and gravel bars (Rinne 1991, Barber et al. 1970). Despite the designation of Spikedace critical habitat along 9.4 miles of Greenback Creek, the lower floodplain portion of the creek is characterized as an intermittent channel from the confluence with Tonto Creek upstream to the mouth of Blue Peak Canyon (approximately 4.6 miles). The upper portion of Greenback Creek supports perennial flow due to the influence of Lime Springs. While the intermittent portion of the creek conveys seasonal stormwater runoff, the alluvial characteristics of the floodplain channel does not support perennial flows. There are no records of Spikedace occurrence in Greenback Creek, and considering the intermittent flow and habitat conditions in Tonto Creek near the confluence, there is not local Spikedace population that could migrate into and occupy Greenback Creek. The reintroduction of Spikedace into lower Tonto Creek, above the confluence with Greenback Creek, or the introduction of Spikedace into Greenback Creek would require stocking of the native species. Furthermore, the episodic nature of stormwater runoff prevents the movement of nonnative fish from Tonto Creek into the lower floodplain reach of Greenback Creek due to the high flow events.

Considering that the FCS has been a component of Reservoir operations since the designation of Spikedace critical habitat in 2012, the potential inundation of the FCS would not affect the Spikedace habitat in Tonto Creek or Greenback Creek. The intermittent flow characteristics of both Tonto Creek and Greenback Creek, in concert with the episodic storm flows, are not conducive for the movement of nonnative fish into the designated Spikedace habitat of Greenback Creek.

Streamflow

The Tonto Creek above Gun Creek discharge data is available beginning from December 1940, although we have selected the last 30 years of record (October 1990 to September 2020, water years) to summarize hydrological conditions. This period of record is consistent with other approaches used to assess environmental conditions for the HCP permit renewal period which is also 30 years. The daily mean discharge (cfs) was downloaded for the period of record and summarized using quartile analysis to characterize the discharge observed for each day of the water year (i.e., Oct 1 = day 1 or Jan 1 = day 93) based on dry, dry-typical, wet-typical, or wet year type conditions. For example, the quartile analysis summarizes each of the 30 daily mean discharge values for October 1 of each water year, as being in the minimum to 25th centile range (Dry); 25-50th centile range (Dry-typical); 50-75th centile range (Wet-typical); or 75th to maximum range (Wet). This approach characterizes the seasonal flow conditions observed during the water year and highlights the winter snow melt/precipitation part of the hydrograph observed each water year, the transition to a dry channel in June and July, as well as the monsoon precipitation season during the late summer (Figure 1). From early December through mid-April, streamflow is always observed at the gage with the minimum discharge value being approximately 8 cfs for a dry day condition, whereas by late June the discharge can be zero even for wet-typical day conditions. Only during the wet day conditions, is there measurable flow (~5 cfs) during the late June period (identified by the vertical red line on Figure 1). Based on Study 2–Assess Roosevelt Reservoir Operation (Lake Level Fluctuation) Effects on Gartersnake Habitat–a flow connectivity threshold at A-Cross Road was determined to be 20 cfs (identified by the horizontal red line on Figure 1). At this threshold, surface water connectivity occurs from the gage downstream to Roosevelt Lake. When flows are less than the threshold, then intermittent flow conditions can occur creating isolated pools in the lower basin.

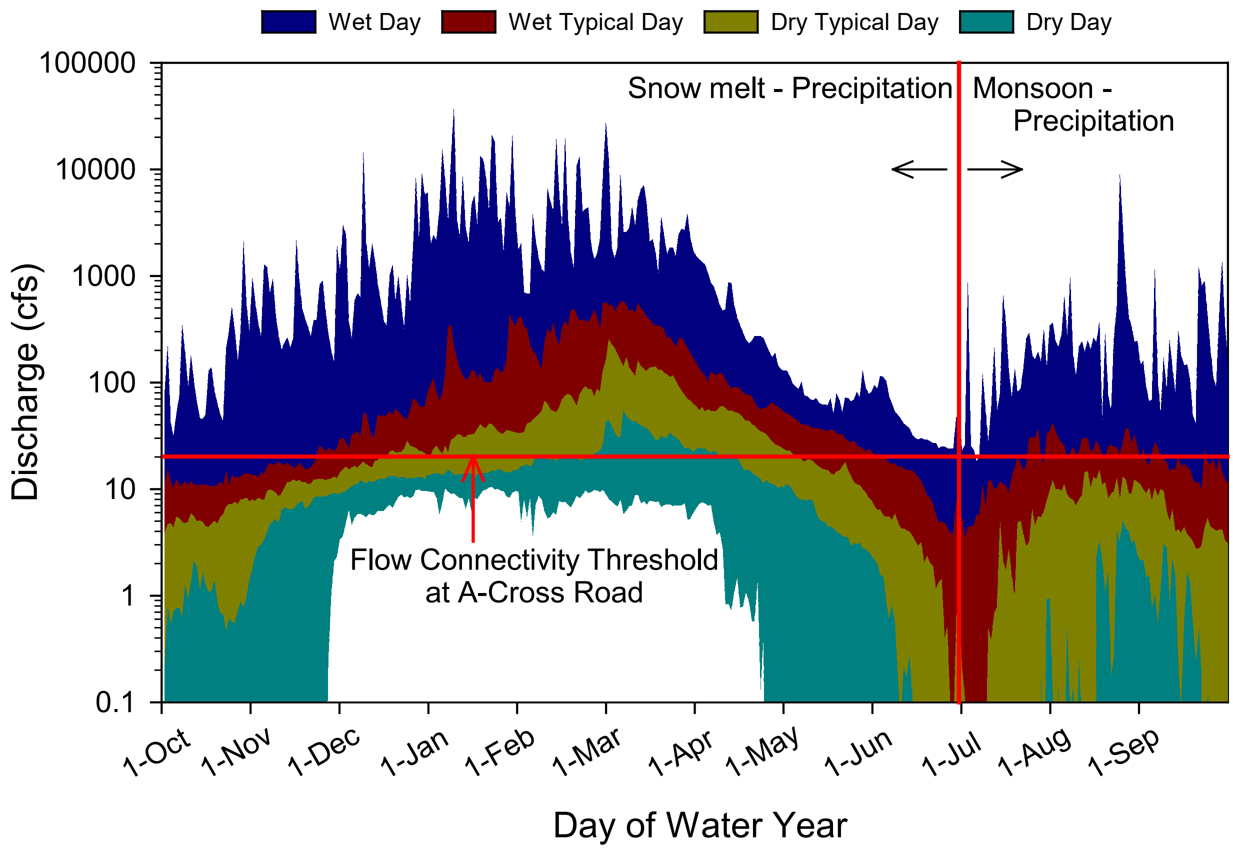

Figure 1. Quartile analysis of daily mean discharge for Tonto Creek Above Gun Creek stream gage, water years 1990 to 2020. Vertical red line denotes change in hydrograph from snow melt and precipitation driven to monsoon precipitation driven often separated by dry channel conditions. The horizontal line denotes the minimum discharge amount needed to maintain surface water connectivity at A-Cross Road.

Study 2 (SWCA 2020) evaluated the threshold of streamflow at the USGS gage that resulted in continuous flow at the Tonto Creek Delta as well as the Flowtography data collected by SPR, which photographed Tonto Creek on a daily basis just upstream of A-Cross Road. It was estimated that discontinuous flow (i.e., no connectivity) occurred approximately 60 percent of the time from 2015 to 2019 at A-Cross Road, or continuous flow (i.e., connectivity) occurred approximately 40 percent of the time. When the flow conditions observed from 2015-2019 are placed in the context of the 30-year period used for this analysis, the five-year period represents typical flow conditions for Tonto Creek. One year (2018) is representative of drought conditions, two years (2015, 2016) are representative of flow conditions observed in drier years, two years (2017, 2019) are representative of flow conditions observed in wetter years, and one year (2020) is representative of the flow conditions observed in the wettest years.

Considering the 30-year period of record selected for this analysis, the flow-duration curve indicates that 21.1 cfs occurred at least 40 percent of the time over the 30-year record (Figure 2). In addition, twenty satellite images from Google Earth were also examined in the same fashion as presented in Table 6 of Study 2, and the images benchmarked continuous flow conditions in the low 20 cfs range which validated the flow connectivity threshold. Tonto Creek was visited on April 28, 2020, at multiple locations (Appendix A, Figure A-1) when 34 cfs (daily mean) was reported at the Tonto Creek gage, and it was noted that surface water connectivity was maintained from the gage downstream to the Tonto Creek Delta. A similar site visit on July 28, 2020, following a localized rainfall event, noted a dry channel at the A-Cross Road, Bar X Road, and East del Chi Road crossings even though the gage reported 3.3 cfs (daily mean). The localized rainfall event was insufficient to maintain surface water connectivity in Tonto Creek which became dry (zero cfs) on July 6, 2020.

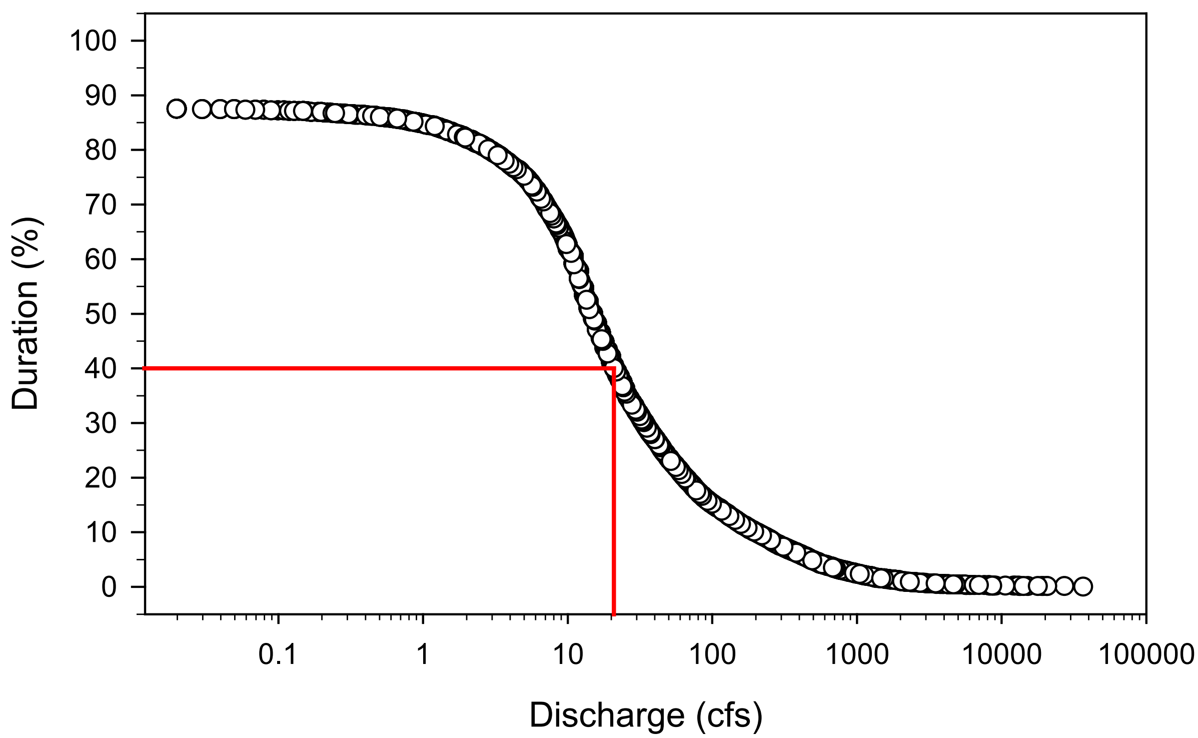

Figure 2. Flow duration curve of daily mean discharge for Tonto Creek Above Gun Creek stream gage, water years 1990 to 2020. Red drop lines denote 21.1 cfs or higher occurred 40 percent of the time.

Fishery

Historical fishery records for the lower Tonto Creek basin are few in numbers and generally limited in their spatial extent. Some of the earliest descriptions of the native fishery are by F.M. Chamberlain (1904) with subsequent studies by Madsen (1935), Minckley (1973) and Robertson and Burraychak (1974) indicate that twelve native fish likely occupied Tonto Creek: Longfin Dace, *Agosia chrysogaster*;

Sonora Sucker, *Catostomus insignis*; Desert Sucker, *Catostomus clarki*; Flannelmouth Sucker, *Catostomus latipinnis*; Speckled Dace, *Rhinichthys osculus*; Gila Chub, *Gila intermedia*; Roundtail Chub, *Gila robusta*; Gila Topminnow, *Poeciliopsis occidentalis*, Razorback Sucker, *Xyrauchen texanus*; Colorado Pikeminnow, *Ptychocheilus lucius*; Spikedace, and Loach Minnow, *Tiaroga cobitis*.

In 1991, the United States Department of Agriculture Forest Service, Tonto National Forest, and the AGFD began a two year study documenting the presence of native and nonnative fish in the Tonto Creek basin (Abarca and Weedman 1993) to evaluate the health of the stream ecosystem and to advance the goals of the Tonto National Forest Plan (USFS 1985). The study established 30 sampling locations in the Tonto Creek basin from the headwaters downstream to Roosevelt Lake, including many of its tributaries. Nine of the sampling locations were placed on Tonto Creek between the USGS Tonto Creek gage and A-Cross Road. Within this reach, the study documented the presence of five native species–Longfin Dace, Sonora Sucker, Roundtail Chub, Desert Sucker, and Speckled Dace, and eight nonnative species–Red Shiner, *Cyprinella lutrensis*; Fathead Minnow, *Pimephales promelas*; Common Carp, *Cyprinus carpio*; Smallmouth Bass, Largemouth Bass, Channel Catfish, Western Mosquitofish, *Gambusia affinis*; Yellow Bullhead. Downstream of Tonto Creek gage, these nonnative species comprised 8.1 percent of the total number of fish collected (n = 9,874), while native species were the most abundant fish collected. Largemouth Bass, Smallmouth Bass, Channel Catfish, and Yellow Bullhead were collected in small numbers (68 fish) from the Tonto Creek gage downstream to A-Cross Road (Appendix E in Abarca and Weedman 1993).

Abarca and Weedman (1993) also established seven sampling locations on Tonto Creek, upstream of the Tonto Creek gage and downstream of the confluence of Gibson Creek, near the Town of Gisela. The upper extent of this reach represents the transition from a warm water to cool water habitat more suitable for trout. Within this reach, seven nonnative fish species were documented–Red Shiner, Fathead Minnow, Common Carp, Channel Catfish, Mosquitofish, Smallmouth Bass and Largemouth Bass. In Rye Creek, a tributary to Tonto Creek downstream of the Town of Gisela, two native species–Longfin Dace and Desert Sucker–dominated the fishery in terms of abundance, although Red Shiner, Fathead Minnow, and Channel Catfish were also present in small numbers. The nine nonnative fish species observed during the study all resided in Roosevelt Lake at the time and had access to Tonto Creek, except for periods of intermittency (Abarca and Weedman 1993). Historically, the AGFD stocked Smallmouth Bass in Tonto Creek, upstream of the Tonto Creek gage, and other nonnative fish species were likely introduced by fisherman or other agencies (Abarca and Weedman 1993) that participated in the implementation of fish management plans or funded fish stocking events in the basin prior to 1990. Recent online fishing reports (nationalprostaff.com and coueswhitetail.com) indicate that the Smallmouth Bass fishery remains productive near the Town of Gisela.

In 2012, the AGFD completed a Tonto Creek fishery survey from the Town of Gisela downstream to the confluence with Gun Creek and observed one native species–Sonora Sucker, and seven nonnative species–Bluegill, *Lepomis macrochirus*, Channel Catfish, Common Carp, Green Sunfish, Red Shiner, Smallmouth Bass, and Yellow Bullhead (Avenetti et al. 2012). Green Sunfish, Yellow Bullhead, and Sonora Sucker were the only species present in sufficient numbers for length frequency analysis to show that each population contained multiple size classes indicating that spawning and successful recruitment were occurring in Tonto Creek, upstream of the Tonto Creek gage. The Arizona Department of Environmental Quality's Tonto Creek mercury fish tissue study (Jones and Rector 2012) also sampled Smallmouth Bass, Common Carp, Green Sunfish, Bullhead Catfish, *Ameiurus sp.*, and Largemouth Bass for tissue analysis between the Town of Gisela and Roosevelt Lake. The majority of Smallmouth Bass were collected near the Town of Gisela, although some were present, including Bullhead Catfish and Largemouth Bass, at the Bar X Crossing closer to Roosevelt Lake.

In 2019, the Salt River Project collected one native species–Sonora Sucker, and eight nonnative species–Largemouth Bass, Bluegill, Common Carp, Gizzard Shad (*Dorosoma cepedianum)*, Yellow bullhead, Green Sunfish, Smallmouth Bass and Channel Catfish from Tonto Creek near A-Cross Road downstream to the Roosevelt Lake Delta (Study 4 Nonnative Fish Survey Report 2020, ERO-GEI 2020, Jones 2020). The primary goals of Study 4 were to characterize nonnative fish species composition and the size class structure of the Largemouth Bass population, and their prey consumption habits within Tonto Creek from A-Cross Road (elevation 2,151 ft) downstream to a location above the prevailing water level of Roosevelt Lake. Largemouth Bass were present in each of the thirteen pools sampled, although 75 percent of the bass sampled were less than 100 mm in total length. Of the 140 LMB collected from Tonto Creek, only five fish were larger than 200 mm in total length, while the maximum length sampled was 220 mm. This size class of fish aligns with the commonly reported size class of Largemouth Bass that become sexually mature. Most bass become sexually mature at 1 year of age and a total length ranging from 200 to 250 mm (Lorenzoni et al. 2001, Chew 1975, Swingle and Smith 1950). Although some populations of Florida Bass (*Micropterus floridanus*) have indicated that individuals may become sexually mature after nine months and a total length of approximately 175 mm (Clugston 1964, Nieman et al. 1979). The abundance of young-of-year and juvenile Largemouth Bass found in Tonto Creek during the October sampling event, indicates that spawning had taken place earlier in the spring. Stomach content analysis of 36 LMB ranging from 76 to 220 mm in total length showed that 95 percent of the stomach contents was identified as invertebrates, two percent was fish, two percent was organic matter, and once percent of the stomachs were empty (ERO-GEI 2020). No snakes, or fragments of snakes were observed during gastric lavage or the microscopic examination of 231 stomach contents collected during the study which included nonnative fish sampled from Tonto Creek, Tonto Creek Delta, and Roosevelt Lake (ERO-GEI 2020). This stomach content analysis indicated that either NMGS were not present or LMB did not selectively prey on NMGS just prior to sampling, and that the interaction between the two species is uncommon.

Collectively, these few studies characterize the change in the Tonto Creek fishery from one dominated by native species in the early 1900's to one dominated by nonnative species in more contemporary times. This change highlights the competitive advantage that many nonnative species have over native species. Once nonnative fish are introduced into a system, their upstream movement through the network of streams, including intermittent or ephemeral streams, can occur when suitable flow conditions exist (Stefferud and Stefferud 2007). The hydrological regime of Tonto Creek is the primary driver that structures the physical habitat (i.e., pools and riffles), provides surface flow connectivity, frames the biological interactions, and ultimately selects for specific life histories of aquatic organisms (Mims and Olden 2010). Perennial aquatic habitat exists upstream of the Tonto Creek gage and when suitable flow conditions exist downstream of the gage, then both Tonto Creek and Roosevelt Lake, as well as other more permanent water features (i.e., gravel pits), act as sources of nonnative fish that can occupy the more temporary aquatic habitats in Tonto Creek. These studies also indicate that nonnative fish spawning activities occur in perennial aquatic habitat upstream of the Tonto Creek gage and in more temporary habitat downstream of the gage when suitable flow conditions exist in the creek.

Nonnative Fish Life History

Life history theories examine the evolutionary traits of nonnative fish and their adaptive responses to environmental variation (i.e., flow and temperature), reproductive success and mortality, resource (i.e., prey) availability (Mims and Olden 2012, Roff 1992, Benton and Grant 1999). Life history theories also examine how fish may adopt strategies of hybridization and migration to maximize reproductive success in variable environments (Roff 1998, Orzack and Tuljapurkar 1989). Life history strategies for native and nonnative fish have been described as being opportunistic, periodic, or equilibrium with each category being characterized by the seasonality, variability, and predictability of the hydrological regime (Winemiller and Rose 1992, Winemiller 2005, Mims and Olden 2012). Opportunistic strategists are generally small-bodied species with early maturation and low juvenile survivorship and are common to streams with frequent and intense hydrological disturbance (e.g., intermittent/ ephemeral) streams. In Tonto Creek, the opportunistic strategists include many of the native sucker and dace species. Periodic strategists are large body size, late maturation with low juvenile survivorship fish that are favored by seasonally variable flow conditions (Mims and Olden 2012). In Tonto Creek, the Common Carp is characterized as a periodic strategist. Equilibrium strategists are typically medium in body size with intermediate times to maturity and high juvenile survivorship due to high parental care. The equilibrium strategists in Tonto Creek include the Largemouth Bass, Smallmouth Bass, Bullhead species, and Channel Catfish. The highly variable and less predictable flow regime favors the opportunistic strategists over the periodic and equilibrium strategists which are more adapted to perennial flow conditions (Minckley and Meffe, 1987; Poff et al., 1997). However, provided suitable flow conditions, equilibrium strategists can expand their range in intermittent streams such as Tonto Creek to seek out new resources and to reproduce.

For example, the movement of equilibrium strategists (Largemouth Bass) was observed in California Gulch which is a small intermittent stream in south-central Arizona. Despite the very limited seasonal flow condition, several nonnative fish species, including Largemouth Bass, are known to exist in the stream when precipitation-induced flows occur (Stefferud 2000, Stefferud and Stefferud 2007). The nonnative fish originated from nearby impoundments and persisted in the channel’s residual pool habitat until it becomes dry. Similarly, in Sycamore Canyon, an adjacent watershed and tributary to California Gulch, Largemouth Bass were collected from the stream deep within the perennial-interrupted channel. Considering that biologists made no prior observations of Largemouth Bass in Sycamore Canyon or nearby stock tanks during previous fish surveys, the biologists theorized that the bass may have migrated from California Gulch, a distance of approximately 17 miles via a “normally dry” stream. The next closest observation of Largemouth Bass was approximately 25 miles further downstream in Rio Altar, Mexico. These few historical observations of Largemouth Bass movement through intermittent stream channels in Arizona supports the premise that Largemouth Bass can migrate upstream in Tonto Creek when suitable flow conditions exist.

Another example of Largemouth Bass migration upstream includes the Texas Parks and Wildlife Department’s experience with stocking Florida Bass in their managed reservoirs. The nonnative Florida Bass have hybridized with native bass populations (Spotted Bass, *Micropterus punctulatus*; Guadalupe Bass, *Micropterus treculii*; and Largemouth Bass) in wadeable streams upstream of the reservoirs (Ray et al. 2012). Nonnative bass (*M. floridanus*) genetic alleles were found within the once native bass populations within four years of being stocked (Maceina et al . 1988). While the stocking of nonnative Florida Bass has enhanced the sport fishing opportunities, it has also altered the genetic purity of three native bass species found in Texas.

Given the potential for equilibrium species to expand their range, we have focused our analysis on the Largemouth Bass, although most of the information provided herein is also applicable to the Smallmouth Bass, Bullhead and Channel Catfish. These species are present in Roosevelt Lake and when suitable flow conditions exist in Tonto Creek, these species may expand their range looking for suitable spawning habitat conditions. Both the bass and catfish are early spring spawners in Arizona, and typically build nests in shallow water habitats (i.e., <1m) with suitable gravel substrate and cover. The nest building and guarding behavior species are frequent inhabitants of regulated rivers with static, stable, flow regimes (Mims and Olden 2012). Seasonal (winter/spring) high flows in Tonto Creek that are common among wet-year type conditions can either entice bass or catfish movement upstream or displace fish from upstream reaches. When these fish occupy aquatic habitat between the USGS gage and A-Cross Road, their survival is dependent upon maintaining flowing conditions or residual pool habitat where the fish can seek refuge during seasonally intermittent conditions (summer/fall). Thus, the variable flow regime in Tonto Creek makes it difficult for bass and catfish to persist year-round, especially when the channel becomes dry. Furthermore, the seasonal high-flow events in Tonto Creek can disrupt nest building or spawning success for both bass and catfish.

Experimental summer floods on a flow regulated river in Maine resulted in a 50% nest failure of nonnative smallmouth bass, and recruitment of juvenile smallmouth bass was negatively correlated with flow variability (Kleinschmidt Associates 2008). Historically, the natural flow regime in arid lands was a key factor favoring native species over nonnative species (Minckley and Meffe, 1987; Poff et al., 1997); however, the modification of lotic flow regimes, which includes the addition of lakes and reservoirs, has facilitated the expansion of nonnative fish into native fish habitat. Minckley and Meffe (1987) found that flooding, as part of a natural hydrograph, may temporarily remove nonnative fish species, thereby reducing the competitive resource pressures on native fish species. A similar study on the Verde River in Arizona, examining the short-term effects of flooding on native and nonnative fish species, observed that nonnative equilibrium fish species may have been eliminated from the system during flood events, while opportunistic native species increased their spawning activities that improved recruitment (Stefferud and Rinne 1996, Rinne and Stefferud 1998). These same flood type conditions occur in Tonto Creek which likely results in the displacement of nonnative fish downstream and poor nesting success of nonnative fish.

The sustainability of native fish populations has relied on the natural variability of the flow regime, especially flood flow conditions, to displace nonnative fish because the opportunistic native species are well adapted to flood event conditions (Stefferud and Stefferud 2007). Nonnative fish are less likely to successfully move through a “normally dry” reach if the reach is long (e.g., >10 miles), if episodic high flows occur (e.g., flash flooding), and if the water velocity is high enough (e.g., constricted canyon reaches) to inhibit upstream movement (Stefferud and Stefferud 2007). In addition, natural or manmade barriers that prevent the upstream movement of nonnative fish may reduce that likelihood of interaction between native and nonnative fish to near zero (Stefferud and Stefferud 2007), although the unintended consequences of fish stocking may have a persistent influence on native populations.

Largemouth Bass Life History

Largemouth Bass are native to North America and originally ranged from southern Quebec and Ontario through the Great Lakes and into the southern states along the Gulf of Mexico and into north-eastern Mexico and the western Great Plains (Hubbs and Lagler 1964). Owing to extensive introductions, the Largemouth Bass have been highly successful in expanding their range and occupying a variety of aquatic habitats throughout the United States. Largemouth Bass have adapted to both lotic and lentic environments but prefer lakes and reservoirs that provide clear water with structure (i.e., natural or artificial) and cover. Bass will seek out deeper habitats during the daylight hours and typically feed at night in the shallow littoral zones. It is generally reported that intermediate levels of submerged aquatic vegetation (~30% coverage) are considered optimal for Largemouth Bass populations (Maceina, 1996; Miranda and Pugh, 1997; Mittelbach and Persson 1998).

1. Biology and Predation

Largemouth Bass are solitary, visual, ambush type predators that require consistently low turbidity to increase foraging opportunities (Philipp and Ridgway 2003, Buck 1956, Stuber et al. 1982), although they can sense vibrations and may depend on olfactory cues (Scott and Crossman 1973). Their jaw structure (distance between the cleithrum bones), gape size, and physiological behavior functionally limits the prey size to be consumed (Johnson and Post 1996, Lawrence 1958). Suction feeding is the method by which LMB ingest their prey whole by a sudden enlargement of the oral and buccopharyngeal cavity

(Nyberg 1971). While LMB may swim to their prey (Nyberg 1971), they do not feed by taking a bite out of its intended prey, rather they ingest the prey whole. Young-of-year bass rely on invertebrates and zooplankton as their main prey item, and typically switch to piscivory when their TL is between 50 to 100 mm [i.e., 0 to 1 year age-class, (Keast 1985, Olson 1996)]. When piscivorous, fish can comprise between 75 and 95 percent of their diet (Applegate and Mullan 1967). Dietary studies have shown that LMB prefer smaller fish prey items compared to the size of their gape opening and seldom feed on fishes with maximum body depths equal to or slightly greater than their gape-width (Hambright 1991, Gillen et al. 1981, Lawrence 1957). These studies have also shown that the body depth of the fish prey item is the primary determining factor on foraging selectivity (Hambright 1991), although allometric relationships show a strong relationship between body depth and total length of prey items selected (Einfalt et al. 2015, Lawrence 1957). The total length of the prey consumed is strongly correlated to the size of the bass and its gape opening, such that larger bass can forage on larger the prey items given the increase in their gape size. Based on Largemouth Bass feeding selectivity studies and allometric prey relationships, Lawrence (1957) estimated the total lengths of forage fish that Largemouth Bass could consume (Figure 3). Juvenile Largemouth Bass (< 100 mm) could consume prey typically less than 50 mm in length, while a 300 mm bass (age-2 year class) could selectively feed on other bass up to approximately 150 mm in total length or smaller forage fish depending on the species.

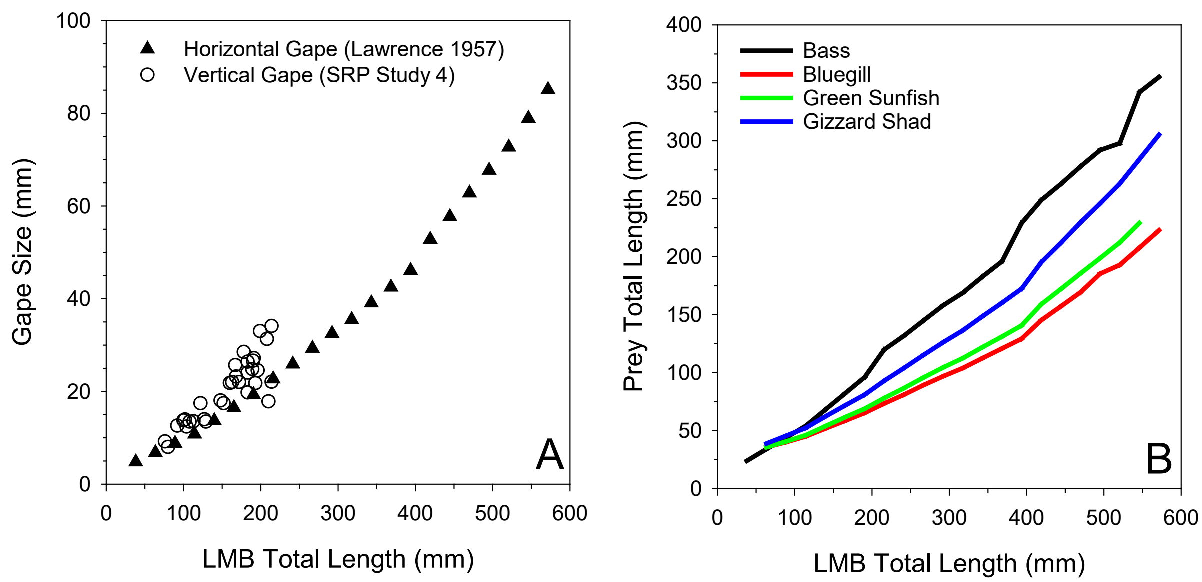

Figure 3. Largemouth Bass (LMB) gape size and total length relationship (A) and the estimated prey total length based on allometric relationships for LMB and their prey (B). Figures are based on data presented in ERO-GEI 2020 and Lawrence 1957.

In 2019, the Salt River Project's Study 4: Nonnative Fish Survey Report (ERO-GEI 2020, Jones 2020) documented the presence of Largemouth Bass in pool habitats between A-Cross Road and the Roosevelt Lake margin. The total length, vertical gape size, and dietary composition of Largemouth Bass and other nonnative fish was determined for individuals with a gape size greater than 12.5 mm (~100 mm total length). The lengths of 36 bass sampled, ranged from 76 to 220 mm, with invertebrates comprising 80 percent of their dietary contents and fish comprising 15 percent. Other dietary categories included organic matter (3 %) and two percent of the bass stomachs were empty, while no NMGS were observed in the stomach contents. The abundance of invertebrates in the Largemouth Bass diet was primarily attributed to the smaller size-class of fish found in Tonto Creek, combined with the limited fish prey-base in Tonto Creek. In Roosevelt Lake, piscivory on Threadfin Shad, *Dorosoma petenense*; and Gizzard Shad, *Dorosoma cepedianum* was the predominant feeding strategy for the Largemouth Bass, although Invertebrates remained a dietary component of even the larger bass. Similarly, no NMGS were observed in stomach contents collected from the littoral zone of the delta or lake. The allometric relationship between total length and gape size for the LMB along with selective feeding studies and stomach content analyses indicate that bass less than 200 mm in length are limited by their gape size to prey upon and swallow neonate NMGS. However, the gape size for the 200 to 300 mm or even larger LMB is more realistic to allow the fish to prey upon neonate or juvenile NMGS, or at least be aggressive towards adult NMGS.

A Largemouth Bass dietary study performed in upper Michigan examined the stomach contents of 3,873 fish collected over a 22 year period. Largemouth Bass were sampled twice monthly during the summer months using gastric lavage which revealed that 0.03 percent of the prey items consumed were terrestrial vertebrates (Hodgson and Hansen 2005). The most common terrestrial vertebrates were frogs and newts, while turtles, snakes, and birds were considered rare in the LMB diet. The predominant prey items were zooplankton, benthic and terrestrial insects, and fish. Young-of-year fish were the most abundant age class of fish consumed. Other observations of Largemouth Bass predation on snakes include two occurrences at Bubbling Springs Fish Hatchery, AZ where 400-500 mm size class LMB were observed preying on a neonate and adult NMGS on separate occasions (Young and Boyarski 2013). While these observations show that predation on snakes is possible, the impact of such events on the local population of snakes, such as the Tonto Creek population, is unknown (Young and Boyarski 2013). Young and Boyarski (2013) noted the frequency of LMB predation on snakes appears to be low, and in the case of the Michigan field-based study, the frequency of occurrence for predation on all terrestrial vertebrates was 2.1 percent (Hodgson and Hansen 2005).

2. Reproduction

The Largemouth Bass' active spawning season typically begins when surface water temperatures reach 60-62°F, with movement patterns and distances often being highly correlated with water temperature (Hanson et al. 2007). The fish move from deeper overwintering habitat in Roosevelt Lake to the warmer shallow littoral zone habitat. Largemouth Bass spawning can occur from February 1 to April 30 in Roosevelt Lake, and Channel Catfish spawning often occurs over a shorter window from April to early June. However, the movement of LMB into Tonto Creek would occur later in the spawning season considering cooler surface water temperatures of spring runoff. Largemouth Bass exhibit different seasonal movement patterns tied to spring spawning or late fall foraging to increase overwinter energy reserves (Miranda and Hubbard 1994, Mackereth et al., 1999), with some individuals occupying discrete home ranges while others can be transient (Hanson et al. 2007). During the spawning season, Largemouth Bass can expand their home ranges, as well as their foraging distances (Savitz 1983), in preparation for reproductive activities (Hanson et al. 2007). Based on observations of LMB size classes during Study 4 (ERO-GEI 2020) and the allometric gape size and feeding strategy discussed above, the movement of LMB upstream from the Roosevelt Lake into Tonto Creek is most likely limited to the first or second year class of fish that are sexually mature, ranging in length from approximately 200 to 300 mm that are actively seeking out new resources for feeding and reproduction. The periodic intermittent/dry characteristics of Tonto Creek is not suitable for the recruitment of 0 age fish to become sexually mature adults and to sustainably maintain a Largemouth Bass population within the study reach.

The male LMB will build the nest and entice the female to release eggs for fertilization (spawning). Once fertilization occurs, the female LMB will leave the nest because they typically can have one or more successive spawning events. The male LMB will guard the eggs from predation and once hatched (2-10 days depending on water temperature), they will protect the fry until they disperse from the nest (up to 14 days). During nest building and spawning activities, the male LMB will generally not feed while it guards and defends the nest from predation. As a result, male LMB predation on NMGS may be nonexistent during the spawning season, although the male can be very aggressive when defending the nest from predators. The female LMB will continue to feed during spawning activities to maintain her fecundity for successive spawning events.

While LMB may expand their range during spawning, many individuals show a strong fidelity to their home areas in reservoirs (Mesing and Wicker 1986, Lewis and Flickenger, 1967) and return once spawning is complete. Larger bass (i.e., >300 mm or third year class) will show a stronger preference for spawning in shallow littoral zones with structure and cover, rather than expanding their spawning activities into an intermittent stream system.

Along with increased home range activity observed during the spring spawning season in a reservoir, Hanson et al. (2007) noted that swimming velocities for Largemouth Bass were the greatest during the spring as compared to swimming speeds observed during the fall and winter periods. Fish were more active and moved faster in preparation for their reproductive activities. During the spring, approximately 55 percent of the swimming velocity observations were between 0 and 0.4 feet per second (ft/sec), and 40 percent of the observations were between 0.4 and 2.0 ft/sec. Fish swimming speeds are categorized as burst, prolonged, or sustained speeds (Beamish 1978). Burst speeds are the highest swimming velocities used to capture prey, avoid predation, or navigate high water velocities with very short endurance times (< 20 sec). Sustained speeds are used for routine activities such as foraging, holding, or schooling that can be maintained without fatigue. Prolonged speeds are the intermediate swimming category that measure fish endurance that results in fatigue after 30 minutes. Critical swimming velocity is a sub-category of prolonged swimming that measures the fishes sustained speed over a progression of increasing velocities and time until the fish ceases to swim (Bret 1964, Beamish 1970).

The Largemouth Bass' critical swimming velocity is 1.2 ± 0.3 ft/sec, with a time to fatigue of 18 minutes and the Smallmouth Bass' critical swimming velocity is 2.9 ± 0.6 ft/sec, with a time to fatigue of 17 minutes (Farlinger and Beamish 1977). These species specific critical velocities represent an upper swimming threshold and have been used to derive swimming distance – water velocity curves to evaluate the level of protection needed for fish passage projects (Katopodis and Gervais 2016). Catfish (Ictaluridae) exhibit similar swimming abilities as the bass and have been grouped with the sunfish when evaluating swimming velocities for fish passage (Katopodis and Gervais 2016). The Channel Catfish's critical swimming velocity is 2.6 ± 0.7 ft/sec, with a time to fatigue of 12 minutes (Beecham et al. 2007).

Considering the Largemouth Bass' equilibrium life history strategy, including the other nest spawners—Smallmouth Bass, Bullhead and Channel Catfish—along with the potential to expand their range during spawning season, it is possible for these species to move upstream in Tonto Creek when suitable flow conditions exist. As a result, there is potential for niche overlap between the nonnative fish and the Northern Mexican Gartersnake (NMGS) during their active season when aquatic habitat is present in Tonto Creek.

Northern Mexican Gartersnake

The NMGS is a semi-aquatic, riparian obligate species with an active season determined by the egress and ingress of NMGS from their brumation sites Emmons and Nowak 2016; USFWS 2014, 2020). Egress and ingress dates vary among individuals and are typically temperature/weather dependent in the spring and fall (Emmons 2017; Emmons and Nowak 2016; Nowak et al. 2015; Rosen and Schwalbe 1988). For the purposes of the RHCP, the NMGS active season is defined as March 1 through November 30 and their inactive season is defined as December 1 through the last day of February. NMGS mating typically occurs in the spring (e.g., April and May) or fall (e.g., September or October), gestation typically occurs between April and May, and females typically give birth between June and August (Emmons and Nowak 2016; Nowak and Boyarski 2012; Nowak et al. 2019; Rosen and Schwalbe 1998; Sprague 2017). NMGS are most active in July and August, followed by June and September (USFWS 2014), although they can be active as early as March in the study area (Nowak et al. 2019). During their active season, NMGS engage in foraging, mating, gestation, and dispersal through the wetland corridor (Emmons and Nowak 2016; Emmons et al. 2016; Nowak and Boyarski 2012; Nowak et al. 2019; Rosen and Schwalbe 1998; Sprague 2017).

During the active season, NMGS use a variety of aquatic habitats including perennial, spatially intermittent or ephemeral streams of low to moderate gradient that possess in-channel and off-channel pools, backwater habitat subject to periodic flooding for foraging, sheltering, and breeding (USFWS 2020). They also use riparian habitats with structural complexity, wetlands, cienegas, stock tanks, fish hatchery ponds, riparian woodlands, and gallery forests for those same activities (Emmons 2017; Emmons and Nowak 2016; Myrand 2019; Nowak et al. 2019; Sprague 2017; USFWS 2014; USFWS 2020).

The NMGS is an active predator that opportunistically feeds on anurans and fish, and occasionally invertebrates, small mammals, and lizards (USFWS 2020). Important prey items include adult and tadpole native Leopard Frogs (*Lithobates sp*.), Gila Topminnow , Desert Pupfish (*Cyprinodon macularius*), Gila Chub, and Roundtail Chub (Rosen and Schwalbe 1988). Drummond and Macías Garcia (1989) observed that NMGS fed primarily on frogs, and when frogs became unavailable, studied individuals ceased foraging rather than seek alternative prey. However, Emmons et al. (2016) documented NMGS consuming large-bodied nonnative species of spiny-rayed fish (fish lengths–LMB 64 mm & 115 mm; Black Bullhead 90 mm), suggesting that the subspecies may have more flexible foraging behavior than previously thought. USFWS notes viable populations of NMGS occur in areas where native aquatic prey species are unavailable and forage on available nonnative species including American bullfrogs and nonnative soft-rayed and spiny-rayed fish (USFWS 2020). Based on confirmed prey of NMGS (Emmons et al. 2016; Nowak et al. 2019), the Tonto Creek delta contains potential prey for NMGS including adult and tadpole American Bullfrogs, lowland Leopard Frogs (*Lithobates yavapaiensis*), Woodhouse's Toads (*Anaxyrus woodhousii*), Western Mosquitofish, Red Shiner, and Largemouth Bass (ERO and GEI 2020; Nowak et al. 2019).

Niche Overlap

Considering the LMB spawning activities in Roosevelt Lake range from February 1 to April 30, and the NMGS active season, March 1 to November 30, when riparian and aquatic habitats are used for foraging, breeding, and sheltering, there is a window of opportunity from March 1 to June 30 for potential niche overlap between the species in Tonto Creek (Figure 4) and possibly later into the summer/fall if residual pool habitat exists during some year-type flow conditions. This window of opportunity is predicated on the basis of:

- Suitable flow conditions being present in Tonto Creek to create habitat (i.e., pools-riffles-runs) that facilitates fish passage,
- The movement of nonnative fish into the reach between the USGS Tonto Creek gage and A-Cross Road, either from upstream or downstream sources, and
- The interaction between nonnative fish and NMGS, whether in a predator-prey relationship or competition for food resources, given suitable flow conditions exist or may persist through June.

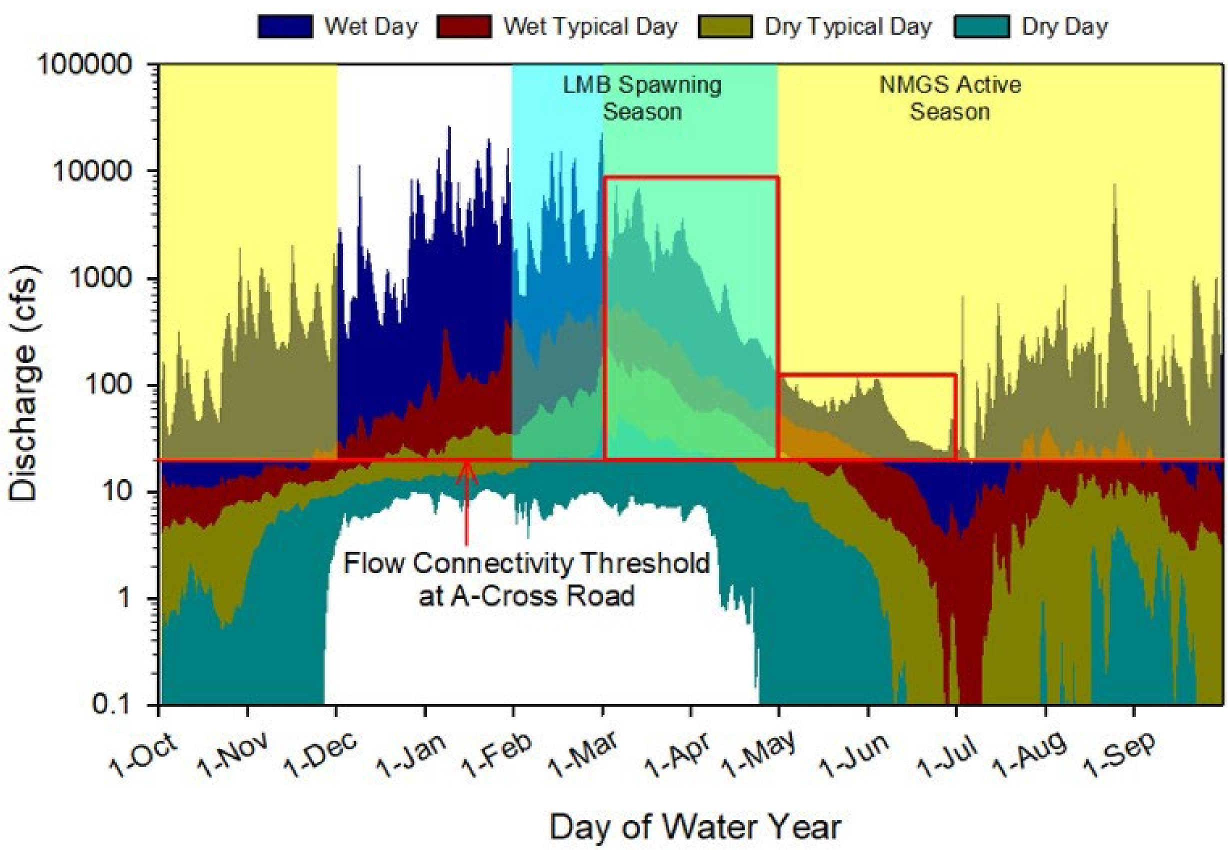

Figure 4. Life history traits for the LMB (blue highlight) and NMGS (yellow highlight) overlaid on the hydrological conditions for Tonto Creek. Niche overlap may occur when suitable fish flow conditions exist (left box) and may persist through the end of June (right box).

Between February 1 and March 1, there is little potential for nonnative fish movement out of Roosevelt Lake and into Tonto Creek, upstream of the A-Cross Road, considering other environmental conditions such as water temperature which greatly affects fish movement. Winter rainfall and spring snowmelt conditions maintain cooler water temperatures in Tonto Creek while the shallow littoral zone of Roosevelt Lake is more conducive for warming during the early part of the bass spawning season. Beyond June 30, Tonto Creek typically becomes intermittent or even dry, except during some wet and wet-typical flow year conditions that may prolong niche overlap. However, considering the flow connectivity threshold, the uncertainty in water permanency, and observations of a dry channel despite measurable low flows (i.e., <5 cfs) at the gage, the analysis was temporally constrained by March 1 to June 30. Higher flow conditions can exist beyond June 30, but these flows are associated with episodic monsoon rainfall events that provide limited opportunity for bass and catfish movement due to flow duration, the timing of the flow events, and other environmental factors such as water temperature.

The source of nonnative fish can be either from upstream or downstream habitats. Upstream of the USGS gage, the perennial flow conditions create suitable habitat to support fish year-round. Other aquatic features that support persistent aquatic habitats include gravel pit operations, stock tanks, cienagas, all of which may support nonnative fish during a portion of the year. Downstream sources include Roosevelt Lake and the Tonto Creek Delta which supports a nonnative fishery that is well maintained by the robust shad forage-base (USFWS 2021).

Biologically Based Environmental Flows

Biological based environmental flows are the flows required to sustain aquatic ecosystems through the critical low flow period of the year. The assessment toolbox contains a variety of statistical and modeling approaches depending on the level of complexity for the system. The natural hydrological variability often creates a challenging scenario for determining what level of flow is needed to sustain aquatic life use throughout the system over the long-term. However, in the context of Tonto Creek, our scope is considerably limited, as we desire to evaluate the potential for fish movement within an intermittent system that is bound by life-history and life-stage constraints of the LMB and NMGS. We have narrowly defined our questions to be:

- What is the quantity of flow that supports nonnative fish movement upstream of A-Cross Road and what is the quantity of flow when displacement of nonnative fish may occur from the habitat?
- How long will aquatic habitat persist in an intermittent stream to potentially allow niche overlap between nonnative fish and NMGS?

Two hydrological methods were selected–Wetted Perimeter and R2-Cross–to evaluate and answer the questions above. The Wetted Perimeter Method is used to identify low-flow thresholds by evaluating the bankfull channel perimeters when the channel is wetted at different flow levels (Figure 5). This method can be used to identity dry-season low flows that protect productive (i.e., benthic macroinvertebrate) riffle habitats. Riffles are characterized as a hydraulic control with relatively faster velocities as compared to slow water habitats (pools and runs) typically observed upstream of the riffle (Figure 5). Cross-sectional transects are established at the apex of the riffle (i.e., hydraulic control location) with physical measurements of the channel's width, depth, cross-sectional area, slope, bed elevations, and water surface elevations. This method is often combined with other environmental flow methods to develop a more comprehensive understanding of biologically based flows (CDFW 2020).

The R2CROSS methodology (CPW 2011) builds upon the Wetted Perimeter method and more specifically targets fish passage through hydraulic control features by assessing three key criteria within typical riffle habitat–water velocity, water depth, and the percentage of total wetted perimeter width (Espegren 1996). Maintaining these three criteria (Table 1) at adequate levels in riffles should ensure that fish passage can occur and that sufficient habitat in pools and runs are also maintained at levels that will support most life stages of fish and aquatic invertebrates (Nehring 1979; Espegren 1996). Typically, the hydraulic output information from this methodology forms the basis for establishing the minimum instream flows that preserves the natural environment to a reasonable degree.

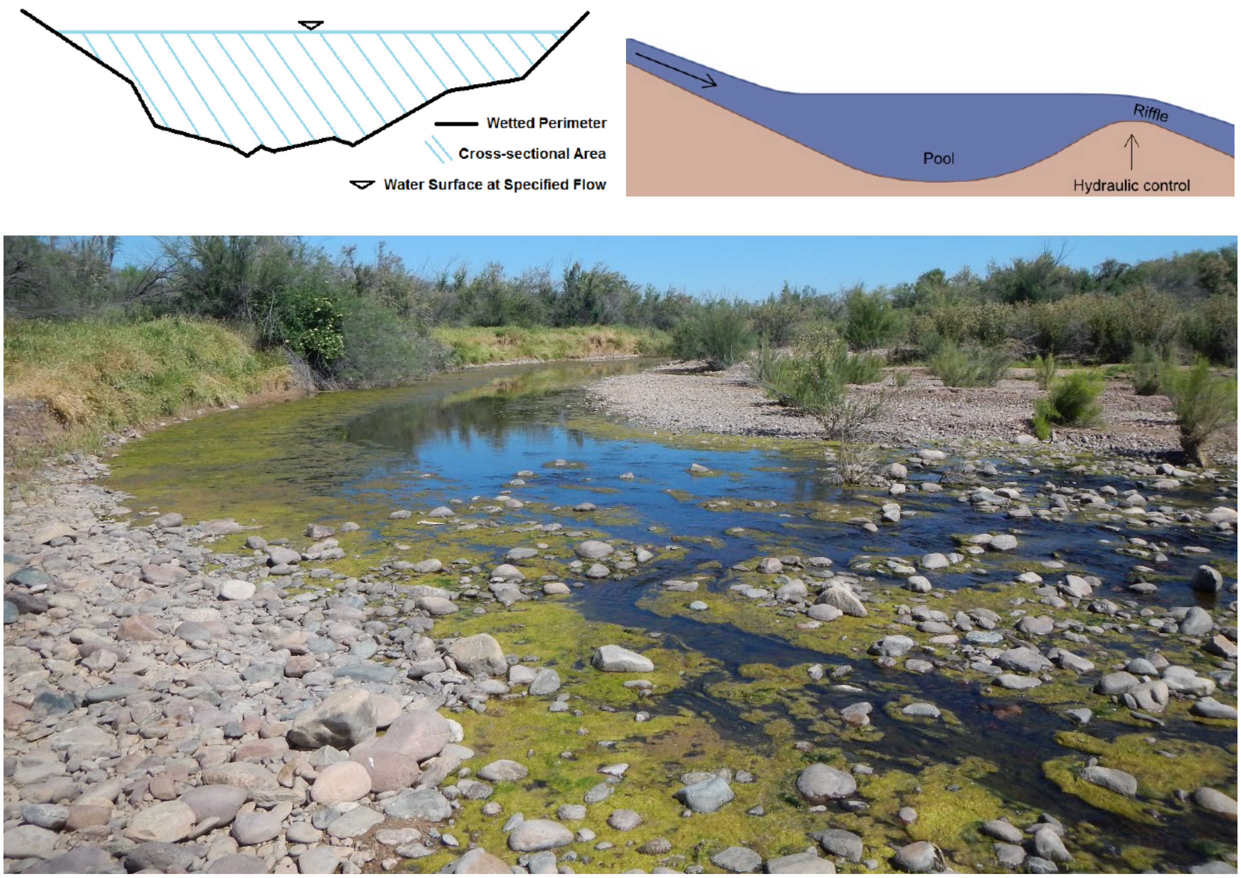

Figure 5. Schematic representation of Wetted Perimeter method (top left) and hydraulic control feature of riffle downstream of a pool (top right). Photo of pool-riffle habitat just upstream of A-Cross Road.

Table 1. Criteria used to determine minimum flow requirements for fish passage through riffle habitat (Nehring 1979).

Stream Top Width (ft)	Average Water Depth (ft)	Percent Wetted Perimeter (%)	Average Water Velocity (ft/sec)
1-20	0.2	50	1.0
21-40	0.2-0.4	50	1.0
41-60	0.4-0.6	50-60	1.0
61-100	0.6-1.0	≥ 70	1.0

To evaluate the potential for nonnative fish movement upstream of A-Cross Road, two hydraulic criteria–Average Water Depth and Average Water Velocity–became the focus of the analysis. The most downstream riffle in the study reach (Appendix A, Photo 4, Photo 5) is the primary limiting factor for fish movement upstream of A-Cross Road. If fish can move through the most downstream riffle, then it is assumed that fish may pass through riffles further upstream. The downstream riffle contains cobble size substrate that further effects the flow through this riffle when considering the channel roughness (i.e., Manning’s n). We hypothesize that a suitable flow level, as measured at the USGS gage, is required to create an average water depth of 0.5 ft with an average water velocity of at least 1.0 ft/sec at the downstream riffle near A-Cross Road to support the movement of adult fish upstream through the riffle (Appendix A, Photo 4, Photo 5). Small size classes, young-of-year and juvenile Largemouth Bass do not exhibit the behavioral or physiological adaptations to move upstream through shallow riffle habitat such those observed at the downstream boundary in April 2020.

Typically, both of the environmental flow methods require multiple transect surveys over a range of flow conditions to adequately estimate a minimum instream flow threshold that supports fish passage through riffles, pools and runs which can be labor intensive to collect the hydraulic data. Fortunately, most all gaging stations collect the same hydraulic data relied upon by the environmental flow methods discussed above. The USGS has been collecting the hydraulic data–channel width (ft), channel area (ft^2), average channel velocity (ft/sec), and channel discharge (cfs) at the Tonto Creek gage since 1976. The empirical relationships allow for calculating the average water depth, channel area, and channel width as a function of flow. Therefore, the two key hydraulic criteria–average water depth and average water velocity–can be estimated for the downstream riffle near A-Cross Road. It is assumed that hydraulic control is similar throughout the study reach and that flow relationships are proportional throughout the study reach. For example, Study 2 determined that a flow level of 20 cfs, as measured at the Tonto Creek gage, is sufficient to create surface water connectivity at A-Cross Road. However, visual observations of the flow conditions at the downstream riffle (Appendix A, Photo 4, Photo 5) on April 28, 2020, when the USGS reported 34 cfs, indicate that the discharge amount is insufficient to meet the hydraulic criteria for fish passage even though there was surface water connectivity. Therefore, the relationships at the USGS gage for average water depth and average water velocity with channel discharge is assumed to be the same further downstream near A-Cross Road, although factors such as water diversions or alluvial pumping may affect the quantity of water in the downstream reach.

The USGS Tonto Creek gage was queried for 30 years (1990-2020 WY) of hydraulic data at the transect where discharge measurements are performed as a QA/QC of the gaged instrument data. This resulted in 595 measurable flow events with corresponding hydraulic parameters. Relationships between channel width, channel area, channel velocity and flow were evaluated, and a variable curve fitting routine was applied to each data relationship to evaluate the strength of the relationship and to provide a tool to estimate proportional relationships (Figure 6).

Considering the question of how much flow is required to create a water depth of approximately 0.5 ft at the downstream riffle (Appendix A, Photo 4, Photo 5), the best fit nonlinear equation was used to estimate the average water depth (0.9 ft) at the Tonto Creek gage when discharge was 34 cfs (i.e., flow measured on April 28, 2020). This water depth would be suitable for fish passage at the Tonto Creek gage, although visual observations indicated this flow amount is too low for fish passage at the downstream riffle near A-Cross Road. Therefore, at least an additional 0.5 ft of water depth would need to occur at the downstream riffle to support fish passage.

To estimate the discharge associated with an increase in water depth, the best fit nonlinear regression equation was rearranged and the water depth of 1.4 ft (e.g., 0.9 + 0.5 ft at the gage) was used to calculate the average discharge amount of 200 cfs (Table 2, Figure 7). The estimated 200 cfs level should satisfy the average water depth criteria for the downstream riffle to support fish passage upstream, although this flow level should also meet the average water velocity criteria too. Similarly, using the line of best fit regression equation for the average water velocity and discharge relationship, 200 cfs results in an average water velocity of 1.4 ft/sec (Figure 7). Average water velocity is a measure of central tendency, with higher and lower velocities in the channel, therefore, this streamflow appears to also meet the average water velocity criteria for fish passage through a riffle. The average water velocity of 1.4 cfs is also within the bounds of the Largemouth Bass's critical swimming speed, as well as the Smallmouth Bass and Channel Catfish critical swimming speeds too. Therefore, 200 cfs should meet the environmental hydraulic criteria–average water depth and average water velocity–which is within the physiological swimming capabilities of nonnative fish to move upstream through the riffle near A-Cross Road.

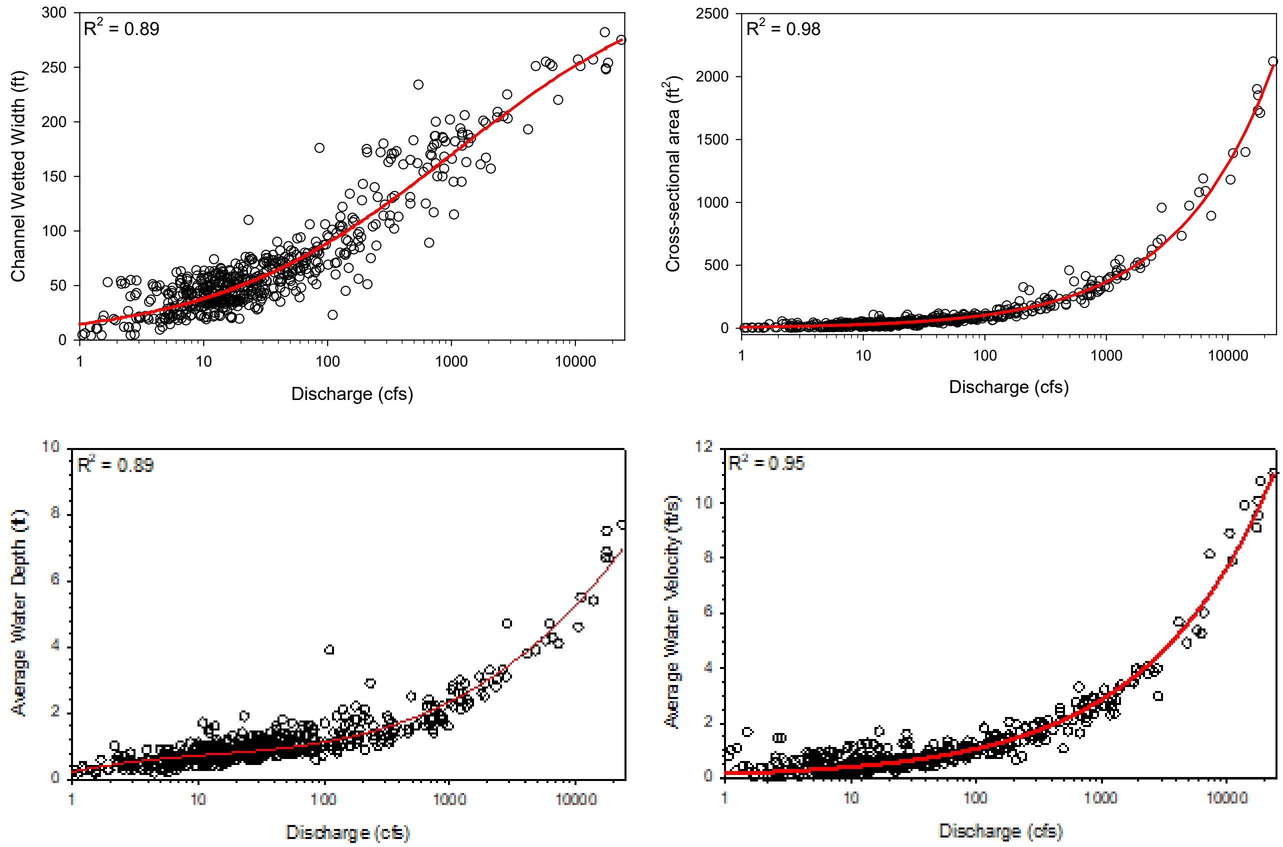

Figure 6. Relationships between hydraulic parameters and discharge for transect measurements at the USGS Tonto Creek gage, 1900-2020. Red lines correspond to the line of best fit for each relationship and the R-squared value.

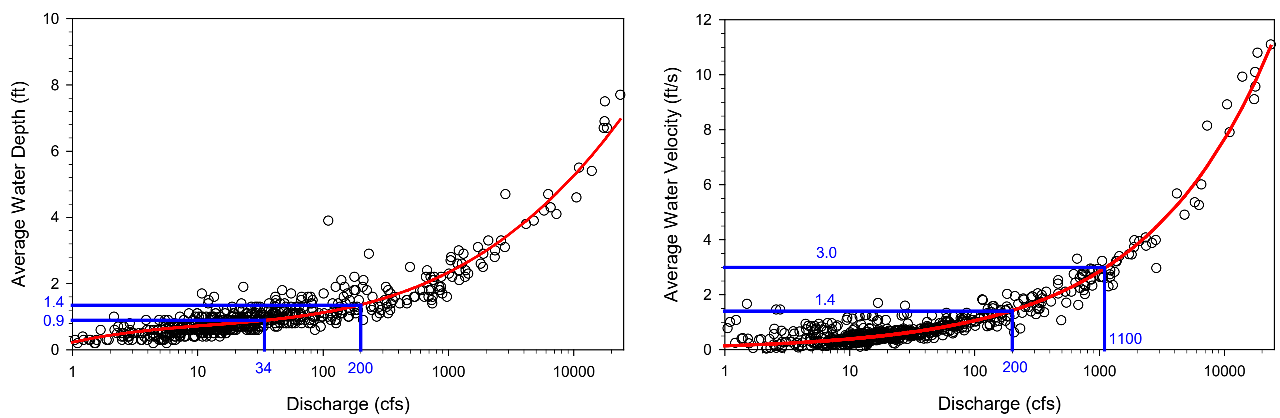

Figure 7. Relationships between hydraulic parameters and discharge for transect measurements at the USGS Tonto Creek gage, 1900-2020. Blue lines correspond to flow conditions used to place lower and upper bounds on suitable fish flow conditions that would support fish upstream movement near A-Cross Road.

Table 2. Best fit nonlinear regression equations for hydraulic parameter relationships with discharge (flow cfs).

Hydraulic Parameter Relationship with Discharge (cfs)	Nonlinear Regression Equation	R-square
Channel Wetted Width (ft)	Y = if(b<0,0,a), if(b>0, 343/(1+(X/1,049)^-0.446), 343*(X/1,049))^(abs(-0.446))/(1+(X/1,049))^(abs(-0.446)))	0.89
Cross-sectional Area (ft^2)	Y = 8.42*X^0.548	0.98
Average Water Depth (ft)	Y = 0.228+0.365*ln(X) - 0.094*(ln(X))^2+0.012*(ln(X))^3	0.89
Average Water Velocity (ft/sec)	Y = 0.148*X^0.429	0.95

X = Discharge in cubic feet per second
Y = Hydraulic parameter

During the analysis, a secondary question became—How much streamflow would likely overcome the Largemouth Bass's swimming ability and potentially inhibit upstream movement through the riffle or result in downstream displacement? The upper bound on the Largemouth Bass' critical swimming velocity is 1.5 ft/sec and when placed in the context of displacement velocities, an upper bound of water velocity was set at 3.0 ft/sec for the Tonto Creek gage. Again, the average water velocity is a measure of central tendency, with water velocities greater than and less than 3.0 ft/sec in the channel and represents a conservative estimate for flow conditions that would inhibit Largemouth Bass movement upstream, and potentially displace fish from upstream sources. Using the average water velocity to discharge relationship, the estimated streamflow condition that would inhibit upstream movement and potentially result in displacement downstream is 1,100 cfs (Figure 7).

Suitable flow conditions that would support fish movement upstream of A-Cross Road is conditionally defined as flows greater than 200 cfs or less than 1,100 cfs at the Tonto Creek gage and is temporally constrained from March 1 to June 30. This period includes the presumptive niche overlap period and extends to a date when Tonto Creek typically becomes seasonally dry at the Tonto Creek gage (Figure 8). The end of June to mid-July marks a seasonally dry transition period from a snow-melt/precipitation driven hydrograph to the summer monsoon precipitation driven hydrograph. During this seasonal transition, the Tonto Creek gage often indicates low (<5 cfs) to zero flow conditions and only during wet-day conditions is flow typically present between 5 and 23 cfs. During dry day conditions, the Tonto Creek gage typically indicates zero flow conditions from mid-June to mid-August.

To evaluate the potential for niche overlap, the 30-year daily average streamflow record was evaluated for flow conditions that would meet the 200 to 1,100 cfs conditions within the temporal bounds. If suitable fish flow days exist within the window of opportunity when LMB may expand their range during spawning season, then there is a possibility that fish may move upstream and occupy habitat within the study reach. The number of fish moving upstream is likely low considering the LMB spawning strategies, preference for shallow littoral zone habitat, and past observations (ERO-GEI 2020, Jones 2020, Abarca and Weedman 1993, Avenetti et al. 2012, Jones and Rector 2020), but the value is not zero. If LMB and other nonnative fish move upstream, then their presence in aquatic habitat is predicated on the persistence of the aquatic habitat which is dependent on multiple factors, many discussed herein, but remains unstudied in Tonto Creek. This assessment resulted in the number of days when flow conditions were suitable for fish passage to occur at the downstream riffle near A-Cross Road (Table 3) or when flow conditions may result in downstream displacement due to high velocity flow conditions [i.e., flooding, Table 3, Figure 9). The number of suitable flow days is summarized by dry-wet seasonal type conditions [(e.g., sum of acre-feet per day between March 1 and June 30 for each year), Figure 8]. For example, quartile analysis was performed on the volume of flow passing the gage between March 1 and June 30 and summarized by seasonally dry, dry-typical, wet-typical, and wet conditions (Table 3). This analysis focused on the flow conditions that meet average water depth and average velocity conditions for fish passage during the period of interest which were summarized by seasonal dry-wet type conditions rather than the entire water year because flow conditions can be highly variable throughout a water year. For example, winter rainfall and snow-melt runoff may create seasonably wet conditions in Tonto Creek, however, changing weather patterns may result in a hot, dry spring, summer, and fall (e.g., 2020 water year) that creates a dry channel.

On average, 27 days suitable fish flow days occur (range 10-47 days) during a wet seasonal conditions and 16 days during a wet-typical conditions [range 7 – 27 days (Table 3)]. The average number of suitable fish flow days decreases considerably during dry-typical (4 days) conditions and is zero for dry year conditions. In the context of dry-wet seasonal flow conditions, there are more opportunities for fish to move upstream of A-Cross Road during wet-typical and wet seasonal conditions than during dry-typical. In addition, the persistence of aquatic habitat is longer during wet-typical and wet seasonal conditions allowing for potential niche overlap to occur between nonnative fish and NMGS.

To evaluate the persistence of aquatic habitat, the occurrence of three consecutive zero flow days was determined for the Tonto Creek gage and was temporally bounded by the end of June when the channel is often dry at the gage (Figure 8). On average, measurable flow occurred 92 days past the last 200 cfs day in each water year, and when the number of days was summed over the 30 seasonal periods, approximately 53 percent of the days from March 1 to June 30 indicated that aquatic habitat would be present. When translated to an annual basis, the number of measurable flow days past the last 200 cfs day at the gage amounted for 18 percent of time over the 30-year period of record.

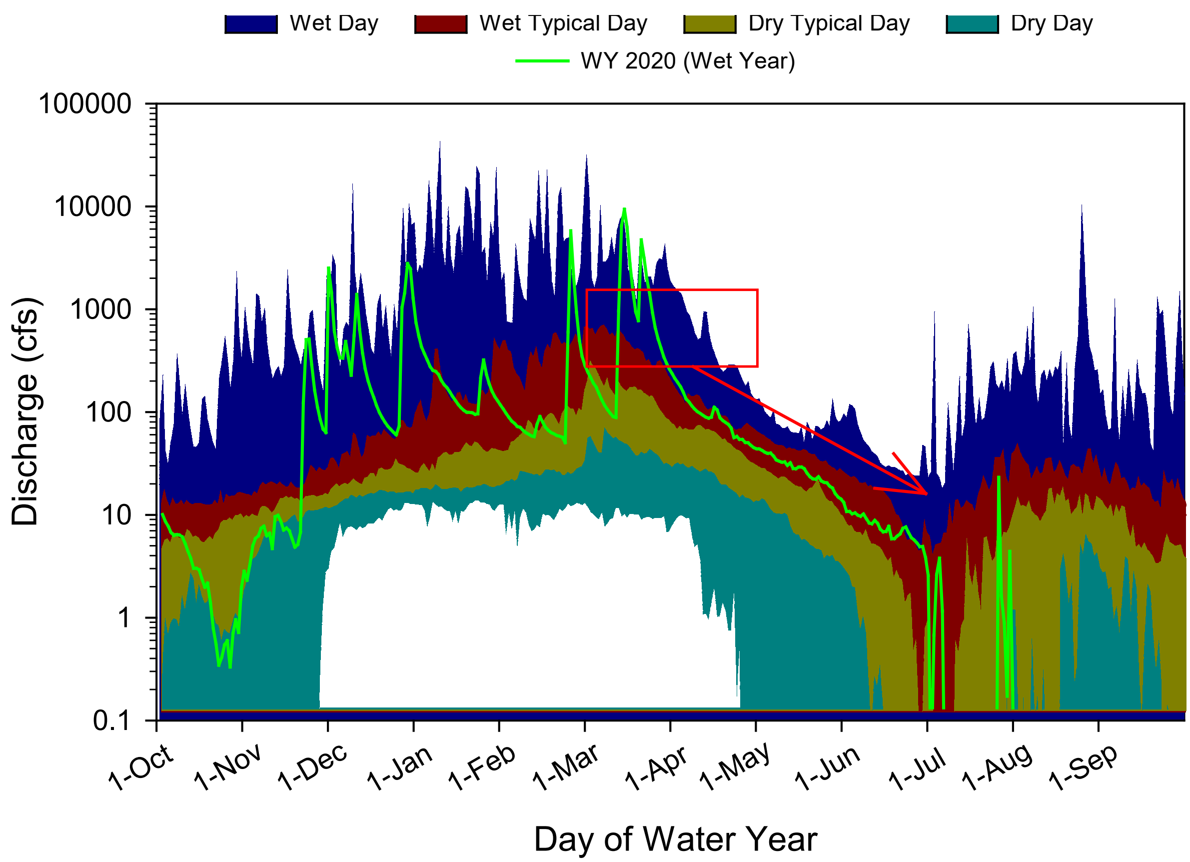

Figure 8. Window of opportunity (box) for niche overlap to occur when suitable flow conditions may exist for fish movement upstream of A-Cross Road, including the potential for niche overlap to persist if nonnative fish occupy aquatic habitat. Water year 2020 (Wet Year) is provided for illustrative purposes of the evaluation.

Table 3. Dry-wet seasonal flow conditions and the number of suitable flow days that support upstream movement of fish or result in downstream displacement of fish.

Seasonal Condition (March 1 to June 30)	Sample Size (n)	Seasonal Flow Volume (acre-feet)	Average Number and (Range) of 200-1,100 cfs Flow Days	Average Number and (Range) of >1,100 cfs Flow Days
Dry	8	< 4,294	0 (0)	0 (0)
Dry-typical	7	4,295 – 20,100	4 (0 – 14)	0 (0 – 1)
Wet-typical	7	20,101 – 48,355	16 (7 – 27)	2 (0 – 5)
Wet	8	> 48,356	27 (10 – 47)	8 (4 – 17)

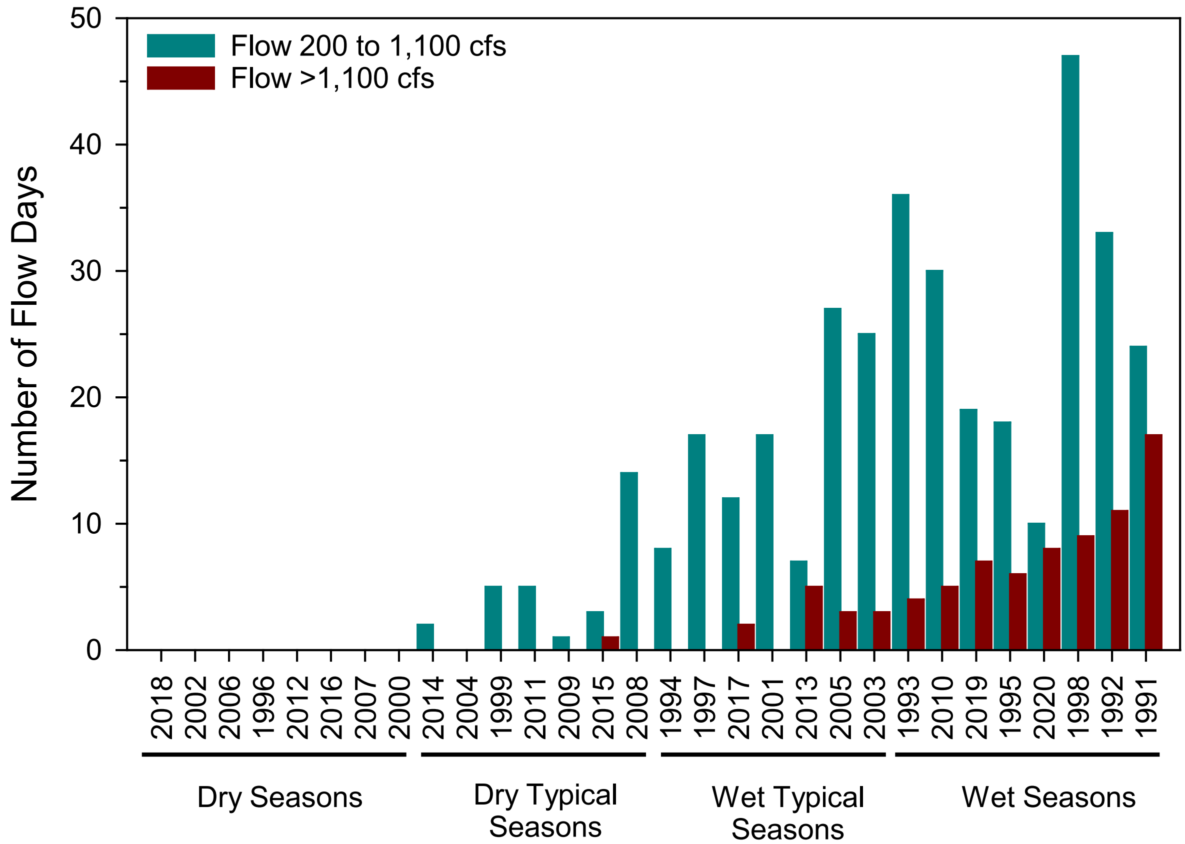

Figure 9. Number of suitable flow days (200-1,100 cfs) for fish movement and number of flow days when fish displacement (>1,100 cfs) may occur during the potential niche overlap period from March 1 to June 30 of each year.

During some wet seasonal conditions (e.g., 1991 and 1992 WY), streamflow was measured at the gage during the entire water year, even though portions of Tonto Creek downstream of the gage exhibited intermittency (Abarca and Weedman 1993). During other wet seasonal conditions (e.g., 2020 WY), Tonto Creek became a dry streambed by early July which persisted through late fall, even though monsoon rainfall was recorded at the gage (July 24-29, 2020, Figure 8). During this event, the channel remained dry at the East del Chi Drive Crossing which is approximately 1.4 river miles downstream of the gage (Appendix A, Photo 17). When this location was previously visited on April 28, 2020, 34 cfs was sufficient to maintain a plunge pool habitat (Appendix A, Photo 12) downstream of the East del Chi Drive crossing that contained nonnative fish–carp, bass, sunfish, and catfish (Appendix A, Photo 13). These observations indicate that when wet seasonal conditions exist during the spring, the summer and fall hydrological conditions can be highly variable in Tonto Creek with antecedent flow conditions, along with other environmental factors greatly affecting intermittency or water permanency.

Potential Impacts

If nonnative fish move upstream of A-Cross Road into Tonto Creek or are displaced from upstream sources in Tonto Creek or adjacent features such as gravel pits or stock tanks, then there is a potential for niche overlap to occur with the NMGS in aquatic habitats. The movement of LMB (or catfish) upstream from the Roosevelt Lake is most likely limited to the first or second year class of fish that are sexually mature, ranging in length from approximately 200 – 300 mm. Larger bass (i.e., >300 mm or third year class) will show a stronger preference for spawning in shallow littoral zones with structure and cover, rather than expanding their spawning activities into an intermittent stream system. The first and second year size-class of LMB possess a gape size that may allow for predation on neonate NMGS; however, there are multiple factors that would directly influence the bass' predation or its less invasive aggression towards NMGS while spawning. Foremost, LMB are ambush predators that swallow their prey whole, and consumption is limited by the width of their gape which is dependent on the fishes allometric size relationships [(length and body depth) Lawrence 1958, Brose et al. 2005]. LMB in the 200-300 mm size class typically exhibit a maximum prey length from 108 to 163 mm, or approximately 41 percent of their total length (Lawrence 1956 and 1957). Neonate NMGS are typically less than 220 mm (i.e., snout ventral length) and could fall into the maximum prey length of the bass depending on the timing of their gestation period (i.e., spring or fall), which also influences neonate prey availability. For example, a neonate born in the spring will have less time to grow and may be a smaller size that influences the predator-prey relationship. Juvenile and adult NMGS are less likely to be considered prey resources, given their size classes of 220 – 450 mm and > 450 mm, respectively. Other factors that influence the interaction between nonnative fish and NMGS include the successful spawning of nonnative fish. The male will aggressively guard and defend the nest against perceived predators, but the male typically does not prey on the perceived threat (Eddy and Underhill 1974). This form of interaction would be less invasive to NMGS as compared to predation. Considering these size class relationships between LMB and NMGS, when niche overlap occurs in the Tonto Creek study area, the likelihood of LMB predation on neonate NMGS is low, but the probability of occurrence is not zero.

The predator-prey relationship likely switches between bass and juvenile/adult NMGS depending on the size class of either species. For example, when LMB successfully occupy aquatic habitat upstream of A-Cross Road, then spawning and recruitment of fry to young-of-year and juvenile fish can occur. These smaller fish [i.e., 60-120 mm in length (Nowak et al. 2019; Emmons et al. 2016)] become a prey resource for juvenile/adult NMGS, along with other native or nonnative fish (i.e., catfish, minnows, suckers) that may occupy the aquatic habitat during the seasonally wet conditions. The availability of other prey items such as the abundance of anurans (adult or tadpole) or invertebrates also influences the competition for prey resources by either species. Depending on the age-class of LMB, YOY fish are invertivores and generally switch to piscivory during their juvenile life-stage. Similarly, depending on the NMGS age-class, invertebrates, anurans, or fish can be the primary prey items. The spiny-rayed catfish or other centrarchids can potentially cause bodily injury to the NMGS when preyed upon by spine punctures through the snake's skin or when spiny-rays become lodged in the digestive tract. However, considering the abundance of other soft-bodied prey items such as the tadpoles, frogs, and toads in Tonto Creek compared to LMB or catfish, the likelihood of resource competition or NMGS predation on these fish is low, but the probability of occurrence is not zero.

The analysis indicates there is a potential for interaction between nonnative fish and NMGS (i.e., harm to or competition for resources) to occur during wet-typical and wet seasonal flow conditions when are suitable to support the movement of nonnative fish upstream of A-Cross Road. Over the 30 seasons (i.e., March 1 to June 30) used for the analysis, measurable flow occurred approximately 53 percent of the time, indicating that aquatic habitat would be present to potentially support nonnative fish or NMGS. When translated to an annual basis (i.e., October 1 to September 30, water year), the number of measurable flow days past the last 200 cfs day amounted to 18 percent of the time over the 30-year period of record. There is a negligible and no chance for interaction between nonnative fish and NMGS to occur during dry-typical and dry seasonal flow conditions, respectively. Owing to the highly variable flow conditions and the uncertainty associated with the duration of aquatic habitat past the last 200 cfs flow day in each year, there is more certainty applied to the seasonal flow conditions (i.e., seasonal volume, ac-ft) that would support the upstream movement of nonnative fish from Roosevelt Lake into Tonto Creek above 2,151 ft elevation. However, these same seasonal flow conditions also allow for the displacement of fish from upstream sources such as Tonto Creek and gravel pit operations along the creek.

Summary

To evaluate the potential for upstream movement of nonnative fish from Roosevelt Lake into Tonto Creek, above the elevation of 2,151 ft (or 2,175 ft flood control space), an upstream boundary was established at the USGS Tonto Creek Above Gun Creek (09499000) gage. This location separates the upper and lower Tonto Creek Basins based on the underlying geological features and represents the upstream boundary of the Gun Creek – Tonto Creek Watershed (HUC 10 Watershed). A lower flow threshold that results in surface water connectivity from the USGS Tonto Creek gage downstream to Roosevelt Lake was determined to be 20 cfs, as measured at the gage which is independent of lake elevation. Streamflow less than 20 cfs, results in intermittent flow conditions along the study reach that are influenced by dry-wet year type conditions, groundwater pumping, and evapotranspiration rates along the riparian corridor. Even though 20 cfs creates hydrological connectivity, this flow rate is not suitable to allow fish passage through the downstream riffle near A-Cross Road, nor was 34 cfs as observed during a spring 2020 site visit. Biologically-based environmental flow methodologies, along with fish physiological constraints, were used to estimate a range of flow conditions that would support fish passage through the downstream riffle near A-Cross Road, and either inhibit upstream movement, or potentially result in displacement of fish from upstream sources. Based on the empirical analysis of hydraulic data measured at the Tonto Creek gage, this flow range is conditionally defined to occur when mean daily flows from 200 to 1,100 cfs exist at the gage between March 1 and June 30 of each year. The magnitude of flows is based on the quantity of flow (200 cfs) required to achieve at least 0.5 ft of water depth across the downstream riffle near A-Cross Road, and the quantity of flow (1,100 cfs) that exceeds the LMB physiological swimming ability at a riffle. The temporal constraints are based on the overlap of life-history information for the LMB spawning and NMGS active seasons, as well as the seasonal flow conditions in Tonto Creek.

The opportunity for LMB movement, including other nonnative fish, upstream occurs almost exclusively during wet-typical and wet seasonal flow conditions, when on average 16 and 27 suitable flow days are present, respectively, for fish movement upstream of A-Cross Road. There is no opportunity for fish movement upstream during dry seasonal flow conditions and considering the average number of days for dry-typical seasonal conditions, the opportunity for movement is negligible, during these conditions as well. If upstream fish movement occurs during the wet-typical and wet flow conditions, then aquatic habitat (i.e., pools) may persist through June or longer, although the channel will likely exhibit intermittency or even become dry by early summer. Furthermore, when nonnative fish species occupy aquatic habitat upstream of A-Cross Road, the successful spawning and recruitment of fry to young-of-year and juvenile fish has been observed, even though self-sustaining populations of nonnative fish likely do not occur in Tonto Creek, between Tonto Creek gage and A-Cross Road, due to the periodic drying of the channel.

Historically, during wet seasonal conditions in 1991 and 1992, Largemouth Bass, Smallmouth Bass, Channel Catfish, and Yellow Bullhead were collected in small numbers (68 fish) from aquatic habitats between the USGS Tonto Creek gage and A-Cross Road, representing 8.1 percent of the total number of fish collected (9,870 native and nonnative fish) within this reach. More recently, during wet seasonal conditions in 2020, a small number of bass and catfish (species not determined) were observed in a plunge pool habitat at the East del Chi Road crossing (15.2 river miles upstream of A-Cross Road). This habitat represents the upstream limit for fish movement during lower flow conditions (i.e., < 2,000 cfs) due to the fish barrier created by three large diameter culverts and falling water conditions into the scour plunge pool downstream of the crossing. When flows are greater than approximately 2,000 cfs, over-bank or rerouted flows may exist which may allow fish passage upstream. However, this flow rate is greater than the 1,100 cfs rate that maintains a swimmable water velocity in riffle habitats for bass and catfish. As a result, flows greater than 2,000 cfs may result in the displacement of fish from sources upstream of the culvert system. The sources for nonnative fish collected in 1991/1992 or nonnative fish observed in 2020 is unknown, although flow conditions were suitable for both upstream fish passage and downstream fish displacement. Regardless of the source, the presence of these nonnative species creates a potential for niche overlap with NMGS such that nonnative fish predation on NMGS, NMGS predation on spiny-rayed fish or competition for food resources could occur along the study reach upstream of A-Cross Road.

The analysis indicates there is a potential for interaction to occur between nonnative fish, (e.g., Largemouth Bass, Smallmouth Bass, Channel Catfish and Yellow Bullhead) and NMGS to occur during wet-typical and wet seasonal conditions when flows are suitable to allow the movement of nonnative fish upstream of A-Cross Road. The types of interaction between the species may include but are not limited to nonnative fish predation on NMGS, harm caused by nonnative fish aggression (e.g., chasing or defending) during spawning activities, interspecific competition for prey resources, or NMGS predation on nonnative fish. Many of these interactions are highly dependent on the age-class of either species present in the aquatic habitat. Considering the size class relationships between LMB and NMGS, and the fish's preferential food resources, the likelihood of LMB predation on NMGS is low, but the probability of occurrence is not zero. Similarly, considering the abundance of other prey items (i.e., anurans, other native/nonnative fish) compared to LMB or catfish abundances, and the snake's preferential food resources, the likelihood of resource competition or NMGS predation on these fish is low to moderate, and the probability of occurrence is likely low, but not zero.

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Appendix

Appendix A. Site visit locations and photographs of Tonto Creek habitat features.

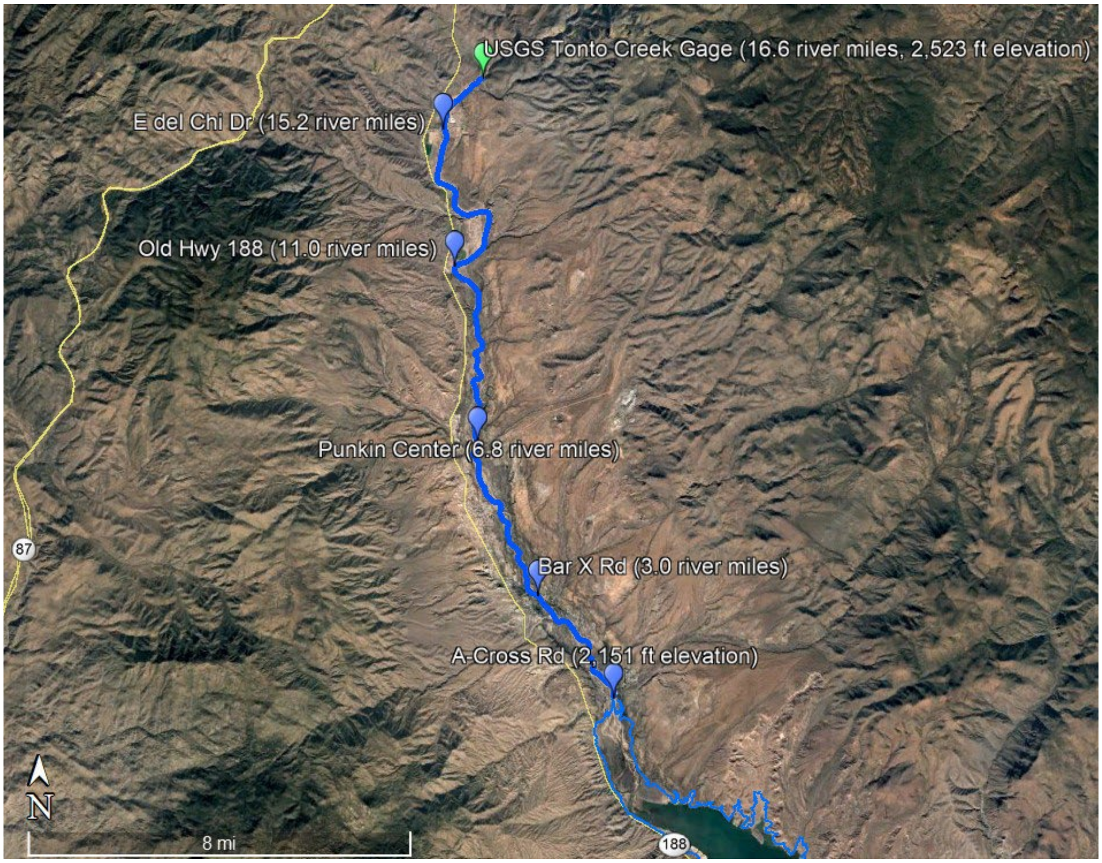

Figure A-1. Map of study reach from A-Cross Road upstream to the USGS Tonto Creek gage (09499000), with site visit locations and river miles upstream of A-Cross Road.

Photo 2. View upstream A-Cross Rd., 4/28/20.

Photo 3. View downstream A-Cross Rd., 4/28/20.

Photo 4. Riffle upstream of A-Cross Rd, 4/28/20.

Photo 5. Pool-riffle upstream of A-Cross Rd, 4/28/20.

Photo 6. View upstream at Punkin Center crossing, 6.8 river miles upstream of A-Cross Rd. 4/28/20.

Photo 7. View downstream of hydraulic control feature at Punkin Center crossing, 4/28/20.

Photo 8. View upstream of riffle habitat near Old Hwy 188, 11.0 river miles upstream of A-Cross Rd, 4/28/20.

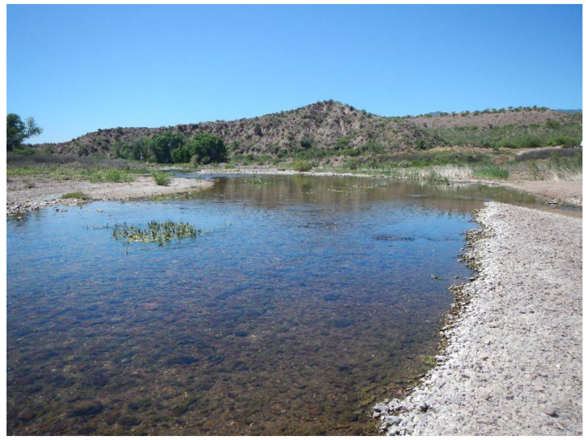

Photo 9. View downstream of run habitat near Old Hwy 188, 4/28/20.

Photo 10. View upstream of East del Chi Dr, 15.2 river miles upstream of A-Cross Rd, 4/28/20.

Photo 11. View downstream of riffle (hydraulic control feature) at East del Chi Dr., 4/28/20.

Photo 12. Plunge pool habitat containing fish at East del Chi Dr crossing, 4/28/20.

Photo 13. Carp, bass, sunfish, and catfish observed in plunge pool at East del Chi Dr crossing, 4/28/20.

Photo 14. Bass and carp observed in plunge pool at East del Chi Dr crossing, 4/28/20.

Photo 15. Gravel pit operation and hydraulically modified channel 0.6 river miles downstream of USGS Tonto Creek gage, 4/28/20.

Photo 16. View upstream of dry channel at Bar X crossing, 3.0 river miles upstream of A-Cross Rd, 7/28/20.

Photo 17. View upstream of channelized reach at East del Chi Dr crossing, 15.2 river miles upstream of A-Cross Rd, 7/28/20.

Photo 18. View of dry plunge pool habitat at East del Chi Dr crossing, 7/28/20.

Photo 19. View of dead fish in dry plunge pool habitat at East del Chi Dr crossing, 7/28/20.

Photo 20. View of culvert system that is a barrier to upstream fish passage at East del Chi Dr crossing, 7/28/20. Each culvert is approximately 6 ft in diameter.

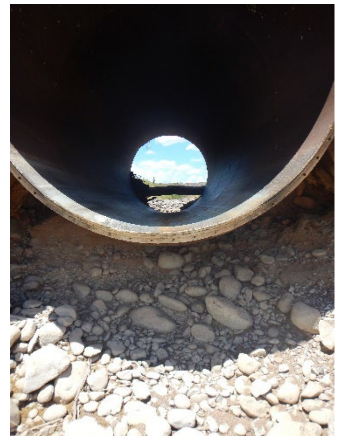

Photo 21. Eye level view of culvert at East del Chi Dr crossing, 7/28/20.

APPENDIX F

Nonnative Fish Survey Report

ERO

GEI Consultants

Consultants in Natural Resources and the Environment

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Salt River Project

Northern Mexican Gartersnake

Study 4: Nonnative Fish Survey Report

Gila County, Arizona

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January 25, 2022

Contents

Tables

Figures

Appendices

Executive Summary

A primary objective of Study 4 was to characterize nonnative fish species composition and the size class structure of the Largemouth Bass population and their prey consumption habits within Tonto Creek from A-Cross Road (elevation 2,151 feet[ft]) downstream to a location above the prevailing water level of Roosevelt Lake, including the shallow lake margins of the Tonto Creek Delta. The study occurred over two consecutive years, capturing the seasonal differences in aquatic habitat, fishery use, and prey consumption during fall 2019 and spring and summer 2020. Over the course of the study, the aquatic habitat availability, structure, and its interface with terrestrial habitat in Tonto Creek greatly changed due to the change from the low water level in October 2019 (2,120 ft) to a maximum water elevation of 2,150.29 ft in mid-April 2020. The seasonally wet winter and rising lake levels changed the aquatic habitat from isolated pools in the fall 2019 to an expansive delta in the spring and summer 2020.

In October 2019, the pool habitat in Tonto Creek was supported by hyporheic flows that helped maintain surface water connectivity between the pools closer to the reservoir. However, the pools further upstream near A-Cross Road lacked the surface water connectivity and became isolated pooled habitat. Depending on the sinuosity of the braided stream channel, either the left or right bank habitat was limited to a dry cobble bed channel with wide, unvegetated gravel bars, while the opposite bank was covered by a mix of cottonwood, tamarisk, willow and other shrubs. The expanse of the dry channel often limited the direct terrestrial–aquatic habitat interface at water's edge, which could limit Northern Mexican Gartersnake [*Thamnophis eques megalops,* (NMGS)] access to the wet portions of Tonto Creek during periods of low reservoir level and residual pool habitat.

The Inundation zone in April and July 2020, changed the terrestrial–aquatic habitat interface such that the eastern stream bank of Tonto Creek became a contiguous boundary between aquatic and terrestrial wetland/upland habitat. The terrestrial wetland habitat along the western stream bank became inundated with the aquatic habitat extending to the upland habitat corridor along Highway 188. This variability in aquatic habitat types (i.e., isolated pool vs continuous lake margin) likely influenced the amount of edge habitat available for potential NMGS use, as well as the seasonal nonnative fishery use and prey selection.

A primary goal of Study 4 was to determine whether nonnative fish are capable of preying on the NMGS where their habitat preferences may overlap. The Salt River Project's (SRP) overarching hypothesis was *Nonnative fish species (gape size ½ to ¾ inch) capable of preying on NMGS will not persist in stream segments and isolated backwaters of Tonto Creek within the conservation space where NMGS habitat exists*.

This multi-season study collected nonnative predatory fish from Tonto Creek, the Tonto Creek delta, and the shoreline areas of Roosevelt Lake when the NMGS is expected to actively use the aquatic–wetland edge habitat to forage on anurans, fish, and aquatic invertebrates. The fall and spring sampling events

occurred when the NMGS also engage in mating while the summer sampling event occurred during the birthing period (June to August). During the summer, neonate and juvenile NMGS are likely more reliant on aquatic habitat to help with thermoregulation during the seasonally high ambient air temperatures as well as to access a forage base during this sensitive life-stage. Sampling occurred during both daylight and nighttime hours to effectively sample the different aquatic habitat uses.

In October, nonnative fish, including Largemouth Bass, were collected from each pool sampled in Tonto Creek with the furthest upstream pool approximately 200 meters from A-Cross Road. A subset of Largemouth Bass was measured for vertical gape opening to ensure that fish near the lower gape limit were adequately being sampled and to evaluate the relationship between gape size and total length. The relationship showed that the two variables are highly correlated and that a vertical gape opening of 12.5 mm corresponds to a total length of 100 mm for Largemouth Bass in Tonto Creek. Based on gape size, 25 percent of the Largemouth Bass collected in Tonto Creek were considered capable of preying on NMGS, although the predominant dietary category observed in these fish was invertebrates. The majority of bass collected were less than 100 mm in total length and categorized as young-of-year or juvenile bass.

In April and July, nearly all of the nonnative predatory fish, including Largemouth Bass, collected from the shoreline habitat in the Tonto Creek Delta and Roosevelt Lake were considered capable of predation on NMGS based on their gape size. The furthest upstream reaches sampled in April and July were approximately 300 and 600 meters from A-Cross Road, respectively.

A total of 231 fish stomachs were analyzed during the study, with 1,995 dietary particles being counted and classified as either Organic Matter, Invertebrate, Fish, Snake, or Other, along with 35 Empty stomachs. In nonnative predatory fish, Invertebrates accounted for 57 percent of the dietary contents, while Organic Matter and Fish accounted for 23 percent and 17 percent, respectively. Based on the stomach content analysis, there was no documented predation on NMGS by Largemouth Bass or other nonnative fish during this study. In addition, over the course of the study, field biologists logged approximately 7.2 kilometers (km) of foot travel through terrestrial wetland edge habitat and 15.2 km of electrofishing wadeable pool and shallow littoral zone habitat in Tonto Creek, the Delta, and Roosevelt Lake and there were no visual observations of NMGS.

While the study confirmed that nonnative fish persist in isolated pool habitat in Tonto Creek and along the shoreline in the delta, the study did not document nonnative fish predation on NMGS during their seasonally active phase. The presence of shallow groundwater between A-Cross Road and the Reservoir, maintained the residual pool habitat and influenced water temperature, creating suitable habitat for nonnative fish, including multiple predatory species, as well as supporting a forage base of young-of-year fish, anurans, and aquatic invertebrates. The persistence of the residual pool habitat is likely influenced by dry and wet year conditions as well as lake elevation, although the duration of these conditions was not evaluated. Nonnative fish, including Largemouth Bass utilized the shallow littoral zone habitat in Tonto Creek Delta and Roosevelt Lake during the variable lake elevations sampled. The littoral zone habitat supported a robust forage base of larval fish, and juvenile Threadfin Shad and Gizzard Shad which is supported by the stomach content analysis of fish collected from the delta and lake margins. The presence of nonnative fish, including Largemouth Bass, in the shallow water habitat indicate the potential for niche overlap with NMGS, although the likelihood of predation on the NMGS is low based on our field observations and fish stomach content analysis. When residual pool habitat persists in Tonto Creek, the nonnative predatory fish are more likely to have a greater influence on NMGS through competition for the same forage base rather than by direct predation on NMGS given the smaller size class of fish. These aquatic habitats become isolated, limiting fish movement and thereby reducing the prey base over time due to predation. However, in the shallow shoreline margins of the Tonto Creek delta and Roosevelt Lake, where fish populations can easily move from shallow to open water habitat, the competition for the same forage base is negligible given that Largemouth Bass appear more reliant on the robust shad fishery in Roosevelt Lake.

Salt River Project

Northern Mexican Gartersnake
Study 4: Nonnative Fish Survey Report
Gila County, Arizona

December 28, 2020

Nonnative Fish and Prey Composition – Study 4

The objective of Study 4 was to identify nonnative fish species composition, size class structure, and their prey consumption habits within Tonto Creek from the intersection of A-Cross Road (elevation 2,151 feet[ft]) downstream to a location above the prevailing water level of Roosevelt Lake, including the Tonto Creek Delta region within Roosevelt Lake. The study occurred over two consecutive years, capturing the seasonal differences in habitat, fishery use, and prey consumption during the fall in 2019 and spring and summer in 2020. The study goal was to determine whether nonnative fish are capable of preying on the Northern Mexican Gartersnake (*Thamnophis eques megalops*, [NMGS]) where their habitat preferences may overlap. The Salt River Project's (SRP) overarching hypothesis was *Nonnative fish species (gape size ½ to ¾ inch) capable of preying on NMGS will not persist in stream segments and isolated backwaters of Tonto Creek within the conservation space where NMGS habitat exists*.

Study 4 objectives, goals, and implementation considered the NMGS life history strategies and seasonal use of habitat within the SRP's conservation space along Tonto Creek and the delta region of Roosevelt Lake. The NMGS is an active predator that opportunistically forages on anurans, fish, and invertebrates (USFWS 2020) that occupy the zone between aquatic and riparian habitats, as well as other small mammals and lizards in terrestrial habitat. The NMGS is a semi-aquatic, riparian obligate species that actively uses this habitat between the seasonal egress and ingress of their brumation site (Emmons and Nowak 2016; USFWS 2014, 2020). While the brumation period varies among populations, ingress typically occurs in late fall with the onset of cooler temperatures (e.g. late November) and ends in early spring (e.g. late February or early March, [Emmons 2017; Emmons and Nowak 2016; Nowak et al. 2015; Rosen and Schwalbe 1988]). For the purposes of the Roosevelt Habitat Conservation Plan, the NMGS active season is defined as March 1 through November 30. During the active season, NMGS mating and gestation occurs with birthing occurring between June and August (Emmons and Nowak 2016; Nowak and Boyarski 2012; Nowak et al. 2019; Rosen and Schwalbe 1998). During the summer months, aquatic-wetland habitat can be a key feature to help neonate and juvenile NMGS thermoregulate body temperature during high ambient air temperatures (Nowak et al. 2019) as well as provide a forage base.

NMGS are primarily diurnal and typically active at air temperatures ranging from 71° to 91° Fahrenheit (Brennan 2008; USFWS 2014).

Based on this information, nonnative fish sampling occurred in October 2019, April 2020, and July 2020 when adult, juvenile, and neonate NMGS seasonal habitat preferences could overlap with nonnative fish. Wadeable stream habitat (i.e., < 4 ft) and boatable shoreline habitat (i.e. < 6 ft) were targeted during the nonnative fish surveys. Other biological considerations such as fish allometry and fish gape size guided study objectives.

Predatory fish length, body size, and gape size are considered important factors in prey selection, capture efficiency, and dietary consumption (Hoyle and Keast 1987, Keast and Webb 1966, Wainwright and Richard 1995, and Gaeta et al. 2018). In general, as predatory fish grow, the mean size of the prey consumed increase. This relationship is attributed to an increase fish gape size and other physiological factors such as increased visual acuity and swimming ability (Keast and Webb 1966 and Kaiser and Hughes 1993). Despite this general understanding of fish allometry and morphometry, there are few studies that document Largemouth Bass predator-prey relationships in the context of gape size (Hambright 1991, Gaeta et al. 2018). Therefore, following a discussion with the U.S. Fish and Wildlife Service, a lower gape size limit of ½ inch (~12.5 mm) was selected which–theoretically–would include fish capable of preying on juvenile and neonate NMGS and fish capable of preying on other species (e.g. anurans) considered to be a prey base for the NMGS.

Owing to the variable lake elevations observed from October 2019 through July 2020, the areal extent of aquatic habitat greatly changed in the study area. In October 2019, shallow ground water supported the existence of isolated and connected pool habitat that was wadeable in Tonto Creek, with a relatively narrow interface between the Tonto Creek channel and Roosevelt lake being considered the Tonto Creek Delta (i.e., habitat between Orange Peel and Indian Point). However, as lake levels increased to a maximum of 2,150.29 ft in April 2020, the delta expanded up the Tonto Creek channel (i.e., bank full width), nearly reaching A-Cross Road, creating a habitat that was only accessible by boat (See Figure 2 for lake margins in the Tonto Creek Arm during sampling). For discussion purposes, we have categorized the inundated Tonto Creek channel as the Tonto Creek Delta for the April and July sampling events, while the expansive inundation zone west of the Tonto Creek channel remained categorized as Roosevelt Lake.

Survey Methods

October 2019

Field reconnaissance by the Arizona Game and Fish Department (AGFD) identified and mapped isolated backwaters, pool habitat, and the lake margin habitat where wadeable habitat transitioned to deeper waters requiring boat survey. The wadeable aquatic habitat suitable for backpack electrofishing was mapped with a handheld Global Positioning System (GPS) unit on October 9, 2019 and thirteen pools in Tonto Creek were identified as suitable habitat for the nonnative fish and for backpack electrofishing

(Figure 1). This effort helped guide the surveys performed in Tonto Creek on October 15 and 23, 2019. The littoral zone habitat in the delta region suitable for boat electrofishing was not mapped prior to sampling; however, GPS mapping of the habitat occurred during both backpack and boat surveys. The boat electrofishing occurred over six reaches along the lake margin and delta region during the night of October 15, 2019.

April 2020

Owing to the seasonally wet 2019-2020 winter, water elevation in Roosevelt Lake peaked on April 18, 2020 at 2,150.29 ft, inundating the previously wadeable habitat in Tonto Creek. On April 28, the water elevation was 2,150.15 ft when Roosevelt Lake and the Tonto Creek Delta were surveyed using boat electrofishing equipment. Inundation greatly increased the amount of floating woody debris and organic matter in the Tonto Creek Delta, and for safety reasons, it was decided to boat electrofish during the daylight hours rather than at night. Many studies have documented differences in capture efficiencies for bass, crappie, sunfish, and shad between day and night boat electrofishing as well as among the spring-summer-fall seasons (McInerny and Cross 2004, Dumont and Dennis, 2011, Blackwell et al. 2017). Generally, capture per unit effort (CPUE) for bass typically increases at night because bass move from deeper water into the shallow littoral habitat to forage, plus biologists can see better through the water and see stunned fish better at night with the aid of floodlights. Other factors such as water clarity (i.e., turbidity) and floating debris can decrease capture efficiencies.

The littoral zone habitat in the Tonto Creek Delta region was not mapped prior to sampling; however, GPS mapping of the boat survey paths was performed (Figure 2). Boat electrofishing occurred in Roosevelt Lake and Tonto Creek Delta over six reaches along the northern shoreline, to a location approximately 250 m downstream of A-Cross Road. In addition, eight reaches were surveyed along the southern shoreline near Highway 188.

July 2020

By late July, the water elevation in Roosevelt Lake had decreased by approximately five ft as compared to levels during the April sampling. On July 27, 2020, aquatic habitat conditions (i.e., hyporheic flow, riffles, and pools) were mapped in Tonto Creek, just downstream of A-Cross Road, and the lake margin identified. On July 28 and 29, boat electrofishing surveys were performed on Roosevelt Lake and the Tonto Creek Delta when the water elevation was 2,145.26 ft (Figure 2). The amount of floating woody debris and organic matter had also greatly decreased; therefore, the fish surveys were performed at night. Eleven electrofishing reaches were surveyed along the northern shoreline from near Indian Point Campground to a location approximately 150 m downstream of the lake margin. On the second night, an additional seven electrofishing reaches were surveyed along the southern shoreline near Highway 188.

Fish Sampling

October 2019

Standard backpack electrofishing techniques were used to capture fish in Tonto Creek during the daylight hours and boat electrofishing techniques were used to capture fish in the delta region and margin of Roosevelt during the night. The AGFD led the fish surveys on October 15 and 23, 2019 and GEI Consultants Inc. (GEI) participated in the survey performed on October 15, 2019. The majority of the Tonto Creek survey (nine pools) were surveyed on October 15, and the remaining four pools were surveyed the following week by AGFD. The Tonto Creek delta and Roosevelt Lake margin survey was completed the night of October 15, 2019. Two non-wadeable pools were identified between the wadeable habitat in Tonto Creek and the Roosevelt lake margin boundary which were not surveyed for fish.

Tonto Creek

Wadeable fish survey equipment included one to two Halltech Aquatic Research (HT-2000) backpack electrofishing units, and three to four dip netters to manage fish collection. Electrofishing time was recorded in seconds and output settings were 150 to 250 volts at a frequency of 40 to 60 hertz, which produced a mean current of 2.2 to 3.2 amps. Fish were collected, measured for total length (TL, mm), weighed (g), and all fish were released back to the creek, except for the larger predatory fish that were collected for stomach content analysis (see Prey Composition below). Nonnative predatory fish included species such as the Largemouth Bass, Smallmouth Bass, Green Sunfish, Channel Catfish and Yellow Bullhead that prey upon other fish or animals. When multiple non-predatory fish including Common Carp or Gizzard Shad were collected, only length ranges (i.e., min-max) and counts were determined, and when multiple Largemouth Bass less than 100 mm with small gape sizes were collected, only a count was recorded.

On the day of the survey, the upstream and downstream boundary of each pool was identified, and a single-pass electrofishing survey was completed prior to habitat measurements. The total length of each pool sampled was measured (m) and three to six cross sectional transects, depending on total length, were equally spaced throughout the reach from the downstream to upstream boundary. At each transect, wetted stream width (m) was measured and divided by six to establish five equally spaced stations where water depth (m) was measured, starting at water's edge left bank (looking upstream) and ending at water's edge right bank. Four photographs were taken at the downstream and upstream boundaries of each habitat sampled [view looking downstream, right bank (east), upstream and left bank (west), Appendix C) and GPS coordinates of the boundaries were recorded. Water quality measurements of temperature (°C), conductivity (µS/cm), and pH (su) were recorded at the pool nearest to A-Cross Road on October 23, 2019.

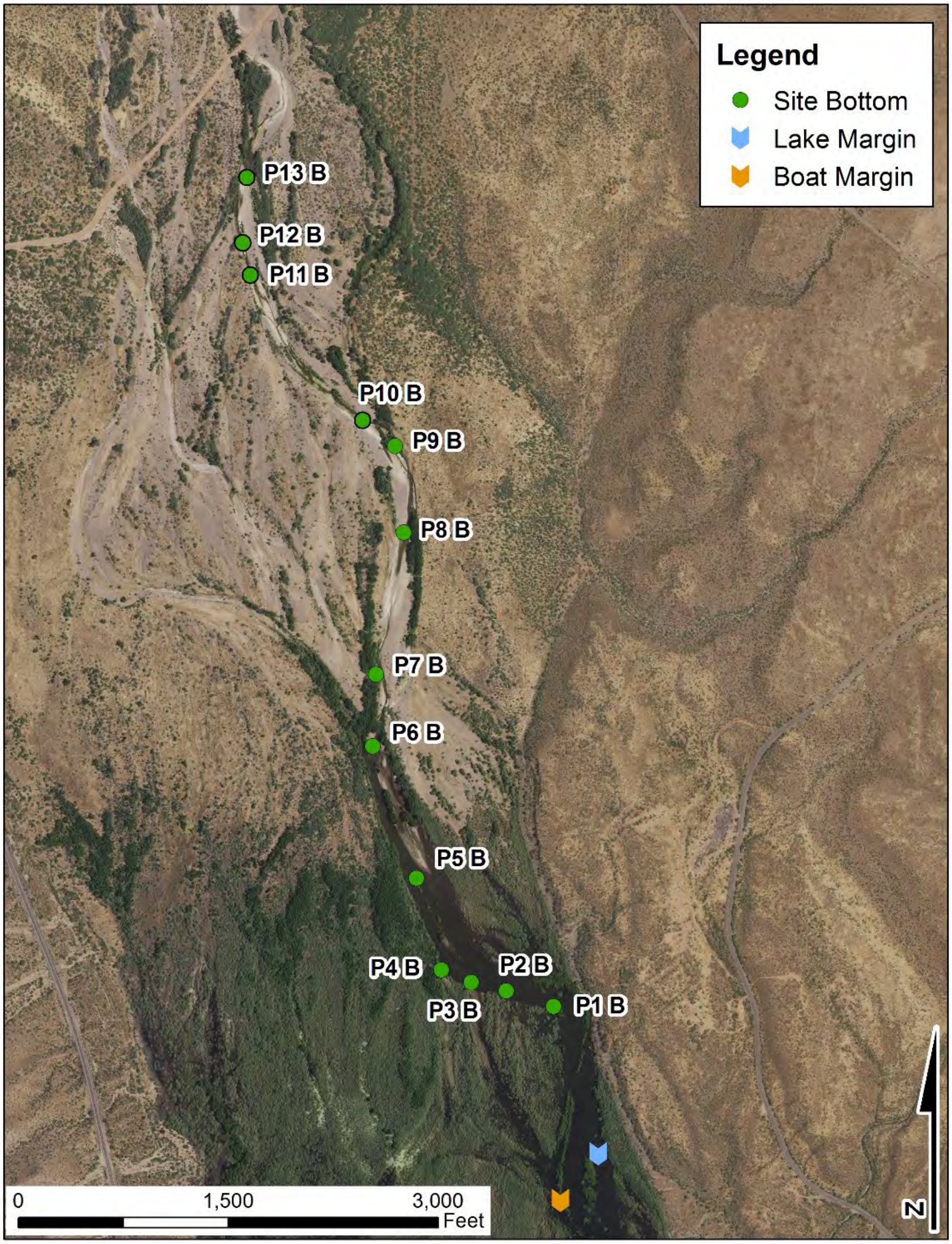

Figure 1. Map of sites sampled on Tonto Creek, with the lake margin and upstream boundary of the boat survey, October 2019.

Roosevelt Lake

The delta and lake shoreline survey consisted of six electrofishing sites where single passes were made with the AGFD Region VI electrofishing boat equipped with a Smith-Root Apex control box, Kohler generator, and two boom mounted spherical anodes. The Apex unit was set at 150 volts with a frequency of 60 Hz and 30 percent duty cycle which produced a mean current of 8 amps. The boat slowly moved through shallow littoral zone habitat targeting shoreline reaches and inundated Tamarisk and brush habitat. All predatory fish collected were measured for TL and weight, with the majority of fish being sampled for stomach contents (see Prey Composition below). Bycatch species (e.g., Common Carp and Gizzard Shad) were not measured; fish less than 100 mm TL were not weighed, and all fish not dissected were released in close proximity to their point of collection.

April 2020

Roosevelt Lake and Tonto Creek Delta

The delta and lake shoreline survey consisted of fourteen electrofishing sites where single passes of 15 minutes each were made with the AGFD Region VI electrofishing boat. The Apex unit was set at 200 volts with a frequency of 60 Hz and 40 percent duty cycle which produced a mean current of 7 amps. The boat slowly moved through shallow (i.e., < 6 ft deep) littoral zone habitat targeting shoreline reaches and inundated Tamarisk and brush habitat. All predatory fish collected were measured for TL and weight, with the majority of fish providing stomach contents for analysis. All fish not dissected were released in close proximity to their point of collection. Common Carp and Gizzard Shad were counted when stunned in the water but not collected for measurement. Numerous larval fish and juvenile Threadfin Shad were also observed during sampling but were not counted due to their abundance.

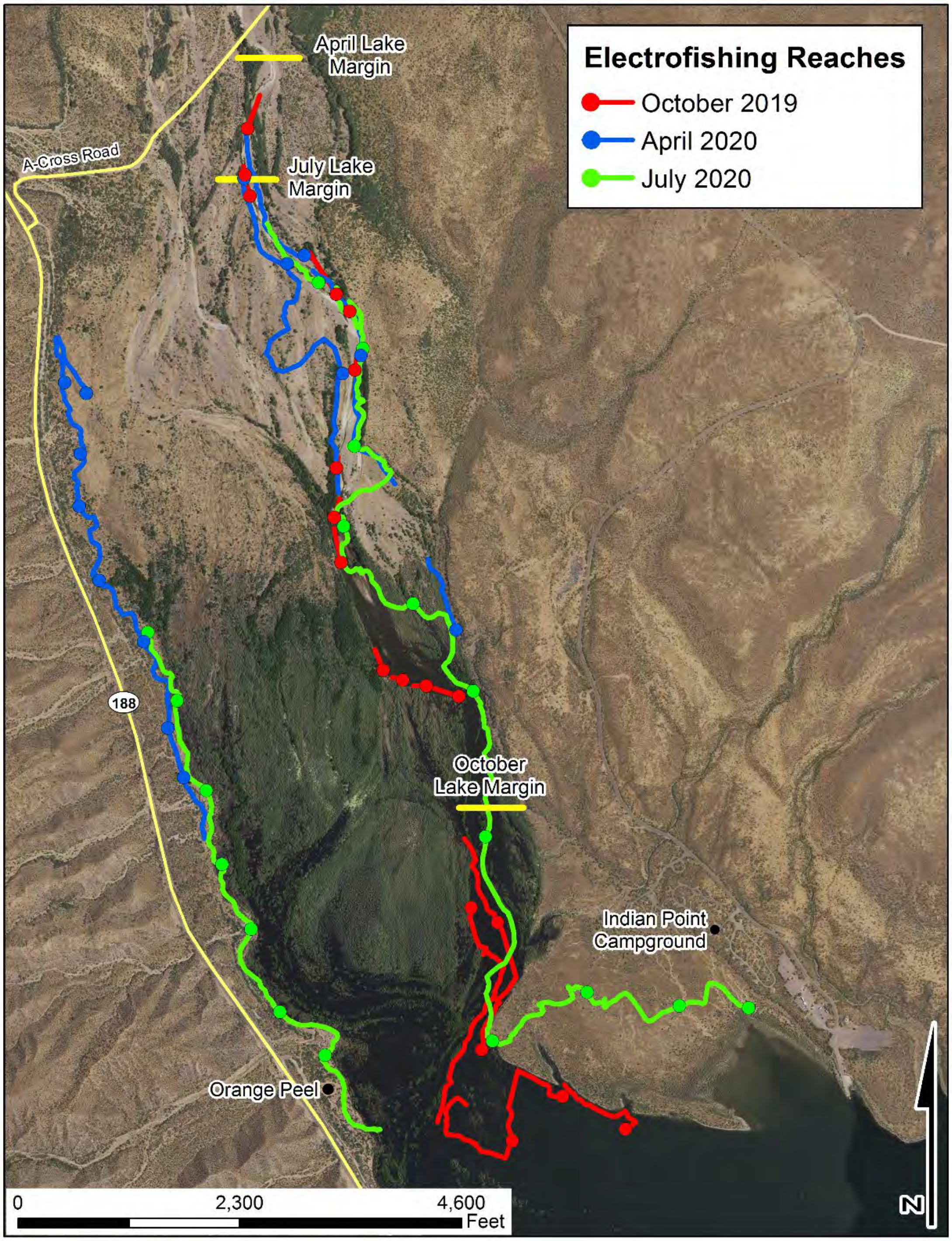

Figure 2. Map of sites sampled on Roosevelt Lake, Tonto Creek Delta, October 2019, April 2020, and July 2020.

July 2020

Roosevelt Lake and Tonto Creek Delta

The delta and lake shoreline survey consisted of eighteen electrofishing sites where single passes of 15 minutes each were made with the AGFD Region VI electrofishing boat. The Apex unit was set at 200 volts with a frequency of 60 Hz and 40 percent duty cycle which produced a mean current of 7 amps. The boat slowly moved through shallow littoral zone habitat (i.e., < 6 ft deep) targeting shoreline reaches and inundated Tamarisk and brush habitat. All predatory fish collected were measured for TL, weighed, and gastric lavage was performed on most fish while Bluegill stomachs were again dissected from the fish. Common Carp and Gizzard Shad were counted when stunned in the water, and numerous Threadfin Shad were observed during sampling but were not counted due to their abundance.

The late summer fish sampling event was influenced by a localized rainfall event that scoured the nearby Bush Fire scar the day before sampling. On July 27, 2020, three debris flows occurred in drainages along Highway 188, closing the highway, with the largest of the debris flows occurring near Orange Peel. This debris flow resulted in a large sediment deposition fan extending into Roosevelt Lake (Photo 1). The sediment/debris flow brought in scoured organic matter from the Bush Fire scar, enriching the nearby waters and attracting forage and predatory fish to the shoreline near Orange Peel. Approximately half of the fish collected over two nights of sampling were collected from two electrofishing reaches along Orange Peel, including over half of the stomach contents samples were collected from these reaches.

Photo 1. Sediment deposition fan near Orange Peel, July 28, 2020. Online photo accessed via AZfamily.com (Laura Lollman).

Prey Composition

All stomach samples collected during the surveys were analyzed by the AGFD. In the lab, stomach contents were examined using a binocular microscope to examine dietary contents and to determine prey composition based on the following dietary categories: Organic Matter, Invertebrates, Crayfish, Fish, Snakes, Empty, and Other. A count of each particle/fragment was made for each sample such that a relative percent of dietary composition could be estimated for each fish. For the purposes of data presentation and analysis, the invertebrate and crayfish categories were combined to represent "invertebrates," because only a few crayfish were observed in the samples.

October 2019

Tonto Creek

Predatory fish species [e.g., Largemouth Bass (*Micropterus salmoides*), Green Sunfish (*Lepomis cyanellus*), Yellow Bullhead (*Ameiurus natalis*)] with a gape size greater than 12.5 mm were sacrificed for stomach content analysis. The majority of samples were collected as whole-body fish, with each fish placed in a separate Whirl-Pak bag (~4.5 × 9.0 in) along with the sample identification label and preserved with isopropyl alcohol. When the fish was too large to fit inside of the Whirl-Pak, dissection occurred onsite to remove the stomach which was preserved accordingly with sample identification label inside the bag. Tissue samples were placed in a cooler with wet ice and transported to AGFD laboratory where stored in a refrigerator at 4°C.

Roosevelt Lake

A subset of the predatory fish [e.g., Largemouth Bass and Yellow Bass (*Morone mississippiensis*)] collected received gastric lavage (Foster 1977; Light et al. 1983) using a 3/8 OD silicon tubing attached to the end of a pressurized garden sprayer that was inserted through the esophageal opening to flush the stomach contents (Photo 3). The fish was gently massaged to expel any stomach contents which were collected into a wire-mesh sieve (Photo 4). A laboratory squirt bottle, filled with lake water, was used to consolidate dietary contents and a laboratory spatula was used to transfer contents to the Whirl-Pak along with sample identification label and preserved with isopropyl alcohol. In a few instances, gastric lavage did not expel an appreciable dietary amount, and in these cases, dissection occurred onsite to remove the stomach, which was preserved along with lavage contents, if any.

April and July 2020

Roosevelt Lake and Tonto Creek Delta

The majority of predatory fish (e.g., Largemouth Bass, Yellow Bass, Bluegill (*Lepomis macrochirus*) and Black Crappie (*Pomoxis nigromaculatus*)] collected were sampled for stomach content analysis by either gastric lavage or dissection. Based on the October 2019 relationship between gape size and total length for Largemouth Bass, individuals greater than 100 mm in TL were sampled for stomach contents in both April and July 2020. The lavage setup was also slightly different in that an aquarium pump and 5/16 OD silicon tubing was placed in the live well and controlled by an electric foot switch to provide pressurized water (Photo 2). The gastric lavage samples were collected (Photo 3) and preserved using the same approach as in October. Whole stomachs were dissected from Bluegill and Black Crappie rather than using gastric lavage. Lastly, there were many Largemouth Bass that revealed empty stomachs in April and July when using gastric lavage, and the decision was made not to sacrifice these bass for their stomachs. In October, laboratory analysis confirmed that the dissected Largemouth Bass stomachs were in fact empty when gastric lavage resulted in no stomach contents.

Photo 2. Left. Gastric lavage of Largemouth Bass.

Photo 3. Above. Stomach content sample, Largemouth Bass.

Fish and Prey Results

October 2019

Tonto Creek

Thirteen pools were identified for fish sampling between A-Cross Road (2,150 ft) and the existing lake inundation zone (2,120.46 ft) on October 15. Pool lengths ranged from 24 to 205 meters (m) with an average water depth of 0.27 m; although six pools contained maximum water depths ≥ 0.80 m (Table 1). The width/depth ratio ranged from 16.5 to 100.3, characterizing the wide-shallow nature of the aquatic habitat. Nine pools (P1-P9) were measured on October 15 and the remaining four pools (P10-P13) were measured on October 23, 2019. Between these sampling events, there was considerable pool size reduction observed although not quantified. There were two pools located between P1 and the lake margin that were not sampled because they were too deep for wading and not accessible by the electrofishing boat.

Downstream of P6, there was visible flow through riffle habitat connecting each pool. The nearest streamflow gage, approximately 15 river miles upstream, is the Tonto Creek above Gun Creek near Roosevelt gage which provisionally reported flow of 1.88 cubic feet per second (cfs) on October 15, 2019. The previous regional rainfall event occurred on September 23, 2019 resulting in a peak flow of 1,760 cfs at the Tonto Creek gage, after which flow slowly returned to baseflow conditions. At the time of sampling on lower Tonto Creek, surface flows were primarily driven by hyporheic flows (i.e., shallow ground water) affected by head pressure from reservoir storage.

Upstream of P6, the dry channel severed surface flow connectivity between Pools P6-P7, P7-P8, and P10-P11, creating isolated pockets of habitat. Notably, when wading through the pools, even the upstream pools, the water temperature was cooler on the upstream end of the deeper pools where hyporheic flow entered and warmer in the tail-out sections of each pool.

The dominant substrate in the pools and riffle habitat was a mix of cobble and gravel sized particles, with depositions zones containing more sand and fine-grained particles. Periphytic algae covered most of the substrate in the pools with occasional filamentous algae at the water's surface. Emergent aquatic plants were primarily limited to the stream reach from P4 to P6. Depending on the sinuosity of the stream reach, either the left or right bank habitat was limited to a dry cobble bed channel with wide, unvegetated gravel bars, while the opposite bank was covered by a mix of cottonwood, tamarisk, willow, and other shrubs (Appendix C, see Photos 10, 14, 22, 29, 38). The expanse of the dry channel often limited the direct terrestrial – aquatic habitat interface at water's edge, which may limit NMGS access to the wet portions of Tonto Creek.

Table 1. Aquatic habitat characteristics for sites sampled on Tonto Creek, October 2019.

Site	Pool Length (m)	Width (m)			Depth (m)			Width/Depth Ratio
		Min	Max	Mean Width	Min	Max	Mean Depth	
P1	98	4.4	21.5	13.6	0.01	0.52	0.14	100.3
P2	42	8.4	14.0	11.4	0.01	0.66	0.25	46.2
P3	40	4.5	8.2	6.4	0.03	0.48	0.17	36.6
P4	52	5.3	9.7	7.1	0.02	0.26	0.10	72.3
P5	110	12.2	25.1	18.2	0.01	0.89	0.38	48.4
P6	57	5.3	10.1	8.0	0.01	0.87	0.37	21.6
P7	44	4.5	8.6	7.3	0.02	0.80	0.29	25.4
P8	55	5.8	11.6	9.3	0.05	0.88	0.33	27.7
P9	85	3.6	9.6	7.8	0.02	0.85	0.43	18.3
P10	205	5.2	11.1	9.0	0.01	0.26	0.12	77.2
P11	26	3.5	7.8	5.3	0.03	0.71	0.32	16.5
P12	24	4.7	7.5	5.8	0.02	0.71	0.33	17.9
P13	113	6.0	16.5	10.5	0.05	0.81	0.25	41.6

Fish Species Composition

A total of 518 fish were collected from the pools in Tonto Creek (Table 2; Appendix A), representing nine species, one of which is native to Arizona – Sonora Sucker (*Catostomus insignis*). The nonnative fish assemblage primarily consisted of Largemouth Bass, Bluegill, and Common Carp (*Cyprinus carpio)*; although other nonnative fish were present – Gizzard Shad (*Dorosoma cepedianum)*, Yellow bullhead, Green Sunfish, Smallmouth Bass (*Micropterus dolomieu*), and Channel Catfish (*Ictalurus punctatus*). The nonnative predatory fish included Largemouth Bass, Smallmouth Bass, Green Sunfish, Bluegill, Yellow Bullhead and Channel Catfish. The catch rate per unit hour for the three dominant species collected ranged from approximately 42 to 66 fish per hour (Table 2).

Table 2. Numbers of fish caught (N), percent composition, mean catch per hour (CPUE) and CPUE standard error (SE) for pools in Tonto Creek, October 2019.

Species	N	Percent Composition	Mean CPUE ± SE
Bluegill	130	25	50.3 ± 17.7
Channel Catfish	1	<1	0.3 ± 0.3
Common Carp	127	25	42.7 ± 19.6
Gizzard Shad	46	9	14.4 ± 10.5
Green Sunfish	29	6	9.6 ± 3.6
Largemouth Bass	140	27	66.2 ± 21.1
Smallmouth Bass	1	<1	0.3 ± 0.3
Sonora Sucker	4	<1	1.4 ± 0.8
Yellow Bullhead	40	8	14.5 ± 3.6
Total	**518**	**100**	**199.7 ± 33.6**

Largemouth Bass were collected from every pool sampled and did not reveal a longitudinal pattern relative to proximity of the reservoir margin (Figure 3). However, a stepwise linear regression between Largemouth Bass abundance by site and measured habitat characteristics, including sampling effort, resulted in a significant relationship ($p = 0.003$) between abundance and maximum water depth ($R^2 = 0.56$), indicating that deeper pools contained more bass. While this relationship is not surprising, the maximum water depth of aquatic habitat likely effects water permanency and possibly prolongs the duration between terrestrial and aquatic habitat interface along Tonto Creek.

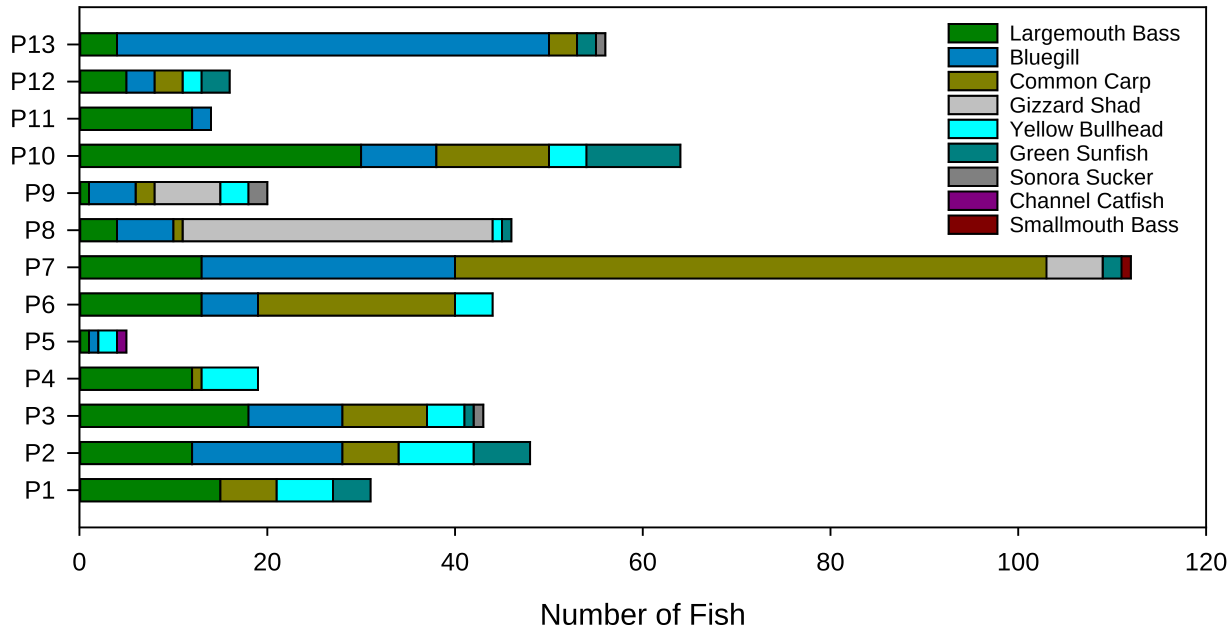

Figure 3. Number of fish collected by site in Tonto Creek, October 2019.

Fish Morphometrics

Largemouth Bass total lengths for measured fish ranged from 62 to 220 mm (Table 3), with 75 percent of the fish being less than 100 mm (Figure 4) while 25 percent of the fish were considered capable of predation on the NMGS based on their gape size. Thirty-eight Largemouth Bass were batch counted due to their small size (i.e., <60 mm). Only 24 Largemouth Bass were greater than 150 mm in total length, which has been used as a lower limit for determining relative weight (Wr) for each fish based on its length to weight relationship (Henson 1991; Blackwell et al. 2000). Relative weight is often used to evaluate energy (i.e., prey) acquisition and storage, and if the mean Wr for a subset of the population is greater than 100 (unitless metric), then the fish are heavier than the typical population for that species, and if less than 80, then the population may be prey limited (Hubert and Quist 2010). The mean Wr for the 24 Largemouth Bass was 92.2 indicating that fish were generally thinner than an average population; although prey were available.

Table 3. Minimum, maximum, and mean lengths and weights including sample size (N) of fish collected and measured from Tonto Creek, October 2019.

Species	Length (mm)				Weight (g)			
	N	Min	Max	Mean	N	Min	Max	Mean
Bluegill	117	84	140	112.4	100	15	57	26.1
Channel Catfish	1	519	519	519.0	1	1,292	1,292	1,292
Common Carp	20	68	164	123.9	17	19	68	30.9
Green Sunfish	29	43	164	95.4	11	14	70	29.7
Largemouth Bass	102	62	220	109.6	35	13	151	57.9

Species	Length (mm)				Weight (g)			
	N	Min	Max	Mean	N	Min	Max	Mean
Smallmouth Bass	1	185	185	185.0	1	72	72	72.0
Sonora Sucker	4	109	138	122.3	4	14	29	20.5
Yellow Bullhead	40	72	165	109.9	26	13	54	20.9

Vertical gape opening was measured in the field on a subset of Largemouth Bass collected from Tonto Creek. It was determined that a gape size of approximately 12.5 mm corresponded to a fish total length of approximately 100 mm, which was later confirmed by linear regression analysis (Figure 5, [(n = 32, correlation coefficient = 0.87). Based on this relationship, a lower threshold total length of 100 mm guided the selection of Largemouth Bass for stomach content analysis in subsequent sampling events of the Tonto Creek Delta and Roosevelt Lake shoreline.

Bluegill total lengths ranged from 84 to 140 mm, with 77 percent of the fish being larger than 100 mm in total length. Bluegill larger than 100 mm revealed a mean weight and mean Wr of 26.1 g and 89.8, respectively. Even though the Bluegill are considered a nonnative predator in this system, their gape size was considerably less than 12.5 mm, thus all fish were released. The mean total lengths for other nonnative predatory fish included 95 mm for Green Sunfish, 110 mm for Yellow Bullhead, and single specimens of Smallmouth Bass and Channel Catfish at 185 and 519 mm in total length, respectively.

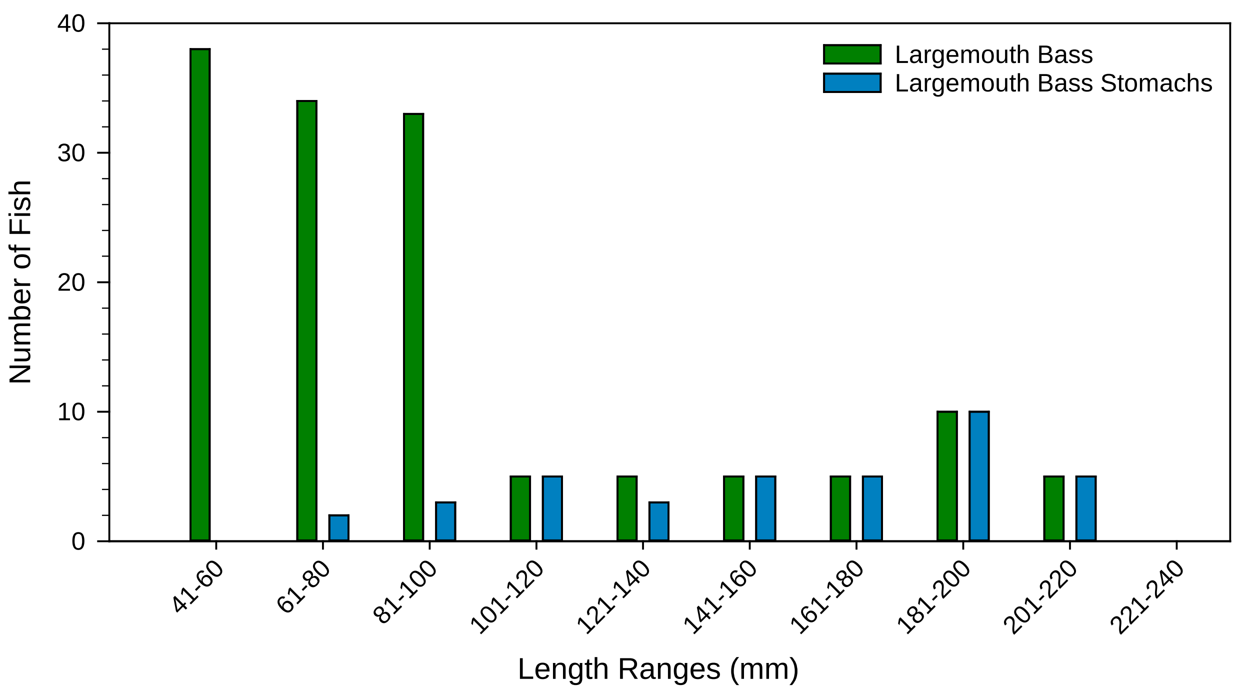

Figure 4. Size class of Largemouth Bass collected from Tonto Creek, and the size class of fish that provided stomach samples, October 2019.

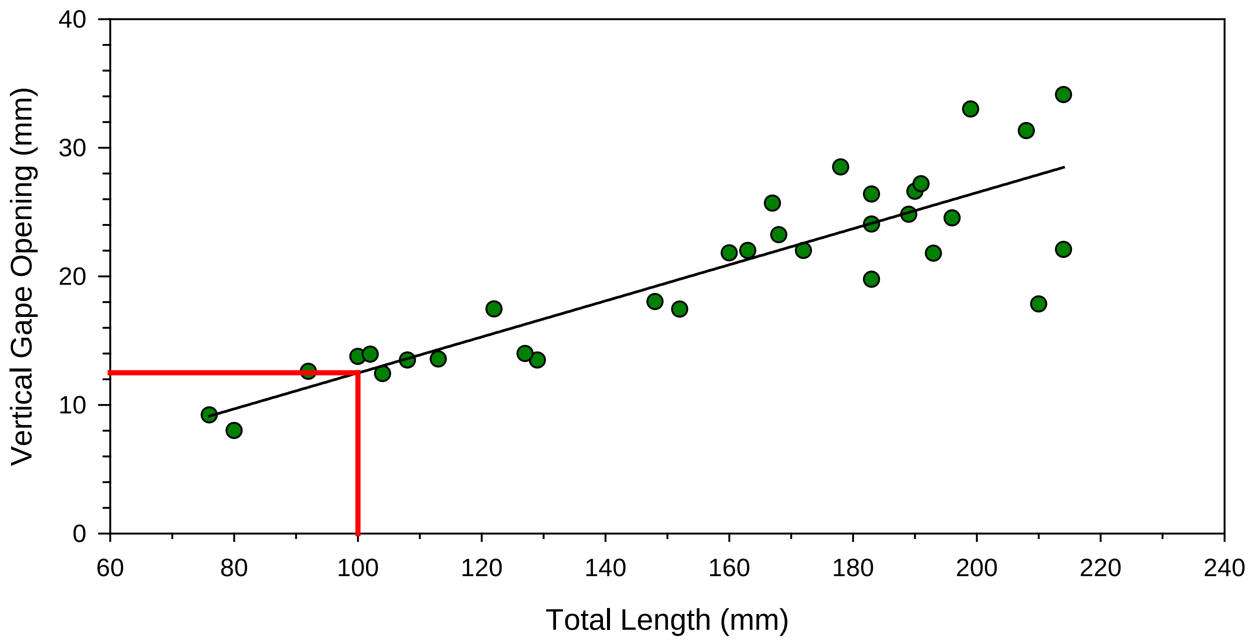

Figure 5. Relationship between gape size and total length for Largemouth Bass collected from Tonto Creek, October 2019. Red line corresponds to 12.5 mm gape and 100 mm total length based on linear regression analysis (black line).

Fish Stomach Contents

Based on the gape size threshold, a total of 56 fish stomach samples were collected from the nonnative predatory fish – Largemouth Bass (38), Green Sunfish (8), Yellow Bullhead (8), Smallmouth Bass (1), and Channel Catfish (1) – found in 11 of the 13 pools sampled in October, 2019 (Appendix B). The dominant dietary category observed in fish collected from Tonto Creek was Invertebrate, followed by Organic Matter, then Fish. For example, in the six stomach samples collected from Site P7 (Figure 6), three contained Invertebrates, two contained Organic Matter, two contained Fish, and two stomachs were Empty. Four fish stomachs were Empty, and no particles or fragments were identified as being from a Snake. Notably, a few invertebrates were more specifically identified as *Physa* sp. (snail), beetles, damselfly/dragonfly, crayfish, along with filamentous algae and gravel.

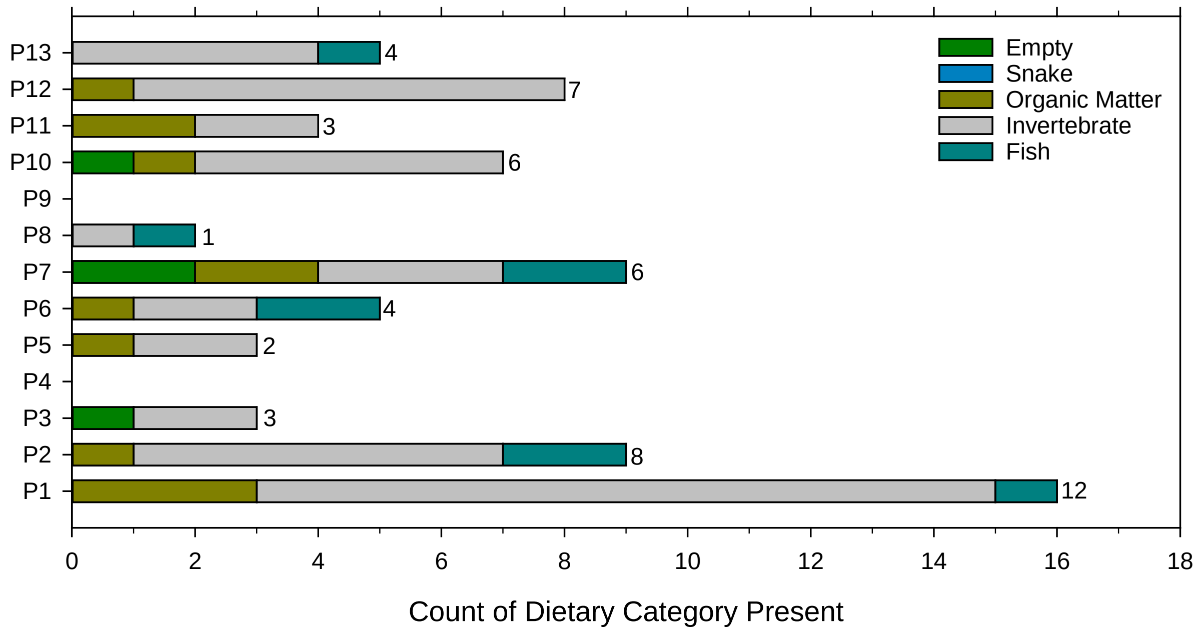

Figure 6. The number of occurrences for each dietary category observed in the stomach samples collected from each site on Tonto Creek, October 2019. Numerical values at the end of the bars represent the number of stomachs sampled at each site.

Because Largemouth Bass are the primary predatory fish in Tonto Creek, and have the potential to prey upon NMGS, these fish became the focal point of the stomach content analysis. The size of Largemouth Bass that provided stomach samples ranged from 76 to 220 mm, representing 27 percent (36 individuals) the total number of fish collected from Tonto Creek (Figure 4). Ninety-five percent of the stomach contents identified were Invertebrates (Figure 7), with the majority of the stomachs containing only Invertebrates (21 fish). Only two percent of dietary contents were identified as Fish, with only four stomachs containing only Fish. In contrast, the dietary contents of Largemouth Bass collected from Roosevelt Lake was dominated by Fish (74 Percent) while Invertebrates accounted for 13 percent of the dietary contents. Organic Matter comprised 7 percent of the Largemouth Bass dietary contents, and 6 percent were Empty (Figure 7).

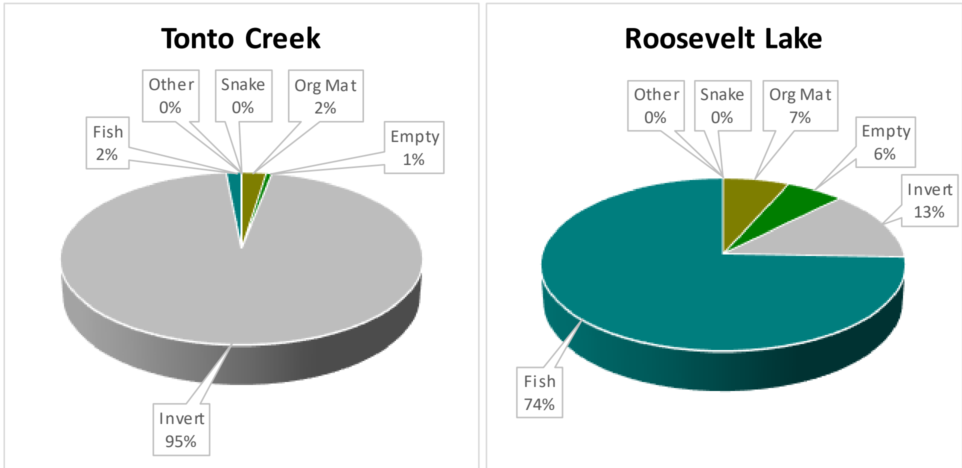

Figure 7. Percentage of dietary contents observed in Largemouth Bass stomachs collected from Tonto Creek and Roosevelt Lake, October 2019.

Prey Observations

Prey observations in the Tonto Creek pools during sampling were limited to young-of-year (YOY) size class Gizzard Shad and numerous large tadpoles that were not identified. Notably, no amphibians were observed in the dietary contents collected in October 2019.

Incidental NMGS Observations

During the October 15, 2019 sampling event, approximately 5.4 river kilometers (km) were traveled by foot, which included streambank riparian and aquatic habitat passage by seven field biologists. On October 23, 2019, approximately 1.8 river km were traveled by foot, and over the course of both sampling events, approximately 950 m of aquatic habitat was surveyed using electrofishing equipment. No incidental NMGS observations occurred during the fish surveys.

Roosevelt Lake

On the evening of October 15, boat electrofishing occurred along six pathways (i.e., EF1, EF2, etc.) in the shallow lake margin and Tonto Creek delta areas, covering approximately 2.2 km of aquatic habitat. Boat electrofishing began (1820 h) on the northwest lake margin at a point approximately 750 m west of the boat ramp at Indian Point Campground and continued through the delta region upstream to a point in Tonto Creek (end of EF5) that was approximately 100 m from the lake margin that was mapped during the Tonto Creek Survey. The sixth surveyed reach occurred along the southwest lake margin traveling in a downstream direction and ended (2230 h) in more open water adjacent to the Orange Peel Campground.

Fish Species Composition

A total of 311 fish were collected from Roosevelt Lake and the Tonto Creek delta region, representing nine nonnative fish species (Table 4, Appendix A). The three most abundant fish species collected were Gizzard Shad, Largemouth Bass, Threadfin Shad (*Dorosoma petenense*), while less abundant fish included Bluegill, Yellow Bass (*Morone mississippiensis*), and Common Carp. These other nonnative fish were present – Green Sunfish, Black Crappie (*Pomoxis nigromaculatus*), and Tilapia spp. The nonnative predatory fish included Largemouth Bass, Yellow Bass, Green Sunfish, Bluegill, and Black Crappie. The catch rate per unit hour for the three dominant species collected ranged from approximately 29 to 100 fish per hour. Notably, because nonnative predatory fish were the target species, many of the bycatch species were not collected, and only counted, once a representative assemblage was collected and identified.

Table 4. Numbers of fish caught (N), percent composition, mean catch per hour (CPUE) and CPUE standard error (SE) for Roosevelt Lake/delta, October 2019.

Species	N	Percent Composition	**Mean CPUE ± SE**
Black Crappie	2	<1	1.3 ± 1.3
Bluegill	19	6	12.2 ± 7.2
Common Carp	15	5	8.9 ± 1.9
Gizzard Shad	136	44	99.6 ± 54.1
Green Sunfish	5	2	3.3 ± 2.6
Largemouth Bass	72	23	44.1 ± 15.7
Threadfin Shad	43	14	28.8 ± 27.0
Tilapia spp.	2	<1	1.1 ± 0.7
Yellow Bass	17	5	9.7 ± 3.4
Total	311	100	208.8 ± 70.2

Largemouth bass were collected mostly along the electrofishing pathways EF1 through EF4 where the numbers ranged from 10 to 23 individuals (Figure 8), while Yellow Bass were most abundant along EF1, EF2, and EF6. Bluegill, Green Sunfish, and Black Crappie were also more abundant along EF1 – northwest lake margin than other delta areas. Closer to the upstream lake margin boundary in Tonto Creek and along the southwest stream bank/delta region, Gizzard Shad were more abundant, and a few Largemouth Bass were collected (Figure 8).

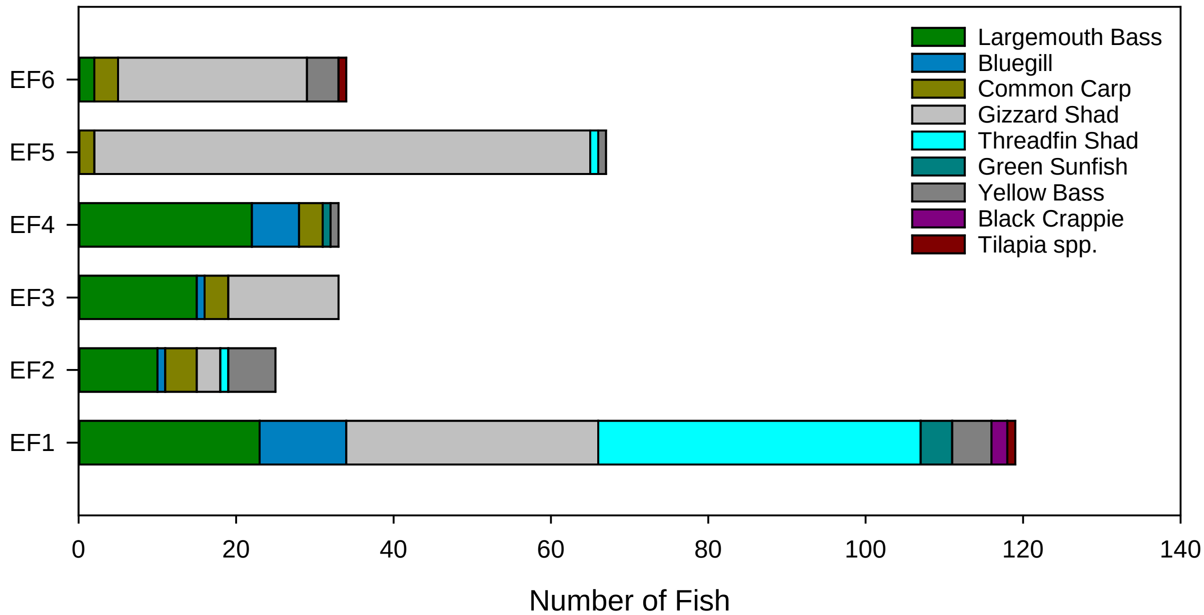

Figure 8. Number of fish collected by site in Roosevelt Lake/delta, October 2019.

Fish Morphometrics

Largemouth Bass total lengths ranged from 72 to 534 mm (Table 5), with 75 percent of the fish being greater than 150 mm TL (Figure 9) with a mean weight of 229 g. The Wr for Largemouth Bass greater than 150 mm TL (n = 53) was 104.7, indicating that fish were generally plumper than an average population. Gape size was not measured on fish collected from the reservoir, because the relative size of lavage tubing compared to the esophageal opening became the limiting factor for sampling stomach contents without sacrificing smaller fish. However, based on the gape size to total length relationship, 85 percent of the Largemouth Bass collected were considered capable of predation on NMGS. Some larger specimens were dissected onsite because lavage did not result in expulsion of dietary contents. These whole stomach samples were collected to confirm the field observations that the stomachs were empty.

Bluegill total lengths ranged from 99 to 152 mm, and Yellow Bass total lengths ranged from 76 to 258 mm, with only one Yellow Bass sufficient in size to collect stomach contents. All other nonnative predatory fish were too small to sample stomach contents using lavage and were not dissected onsite.

Largemouth Bass represented multiple size-classes with fish from each age group providing stomach samples. Of the 54 Largemouth Bass greater than 150 mm TL, 36 were sampled using gastric lavage (Figure 9).

Table 5. Minimum, maximum, and mean lengths and weights including sample size (N) of fish collected and measured from Roosevelt Lake/delta, October 2019.

Species	Length (mm)				Weight (g)			
	N	Min	Max	Mean	N	Min	Max	Mean
Black Crappie	2	80	82	81.0	--	--	--	--
Bluegill	19	99	152	124.8	18	20	70	38.9
Green Sunfish	5	76	104	93.4	2	20	20	20.0
Largemouth Bass	72	72	534	198.9	60	20	2,620	228.5
Tilapia spp.	2	138	180	159.0	2	30	50	40.0
Yellow Bass	17	76	258	101.5	2	10	270	140.0

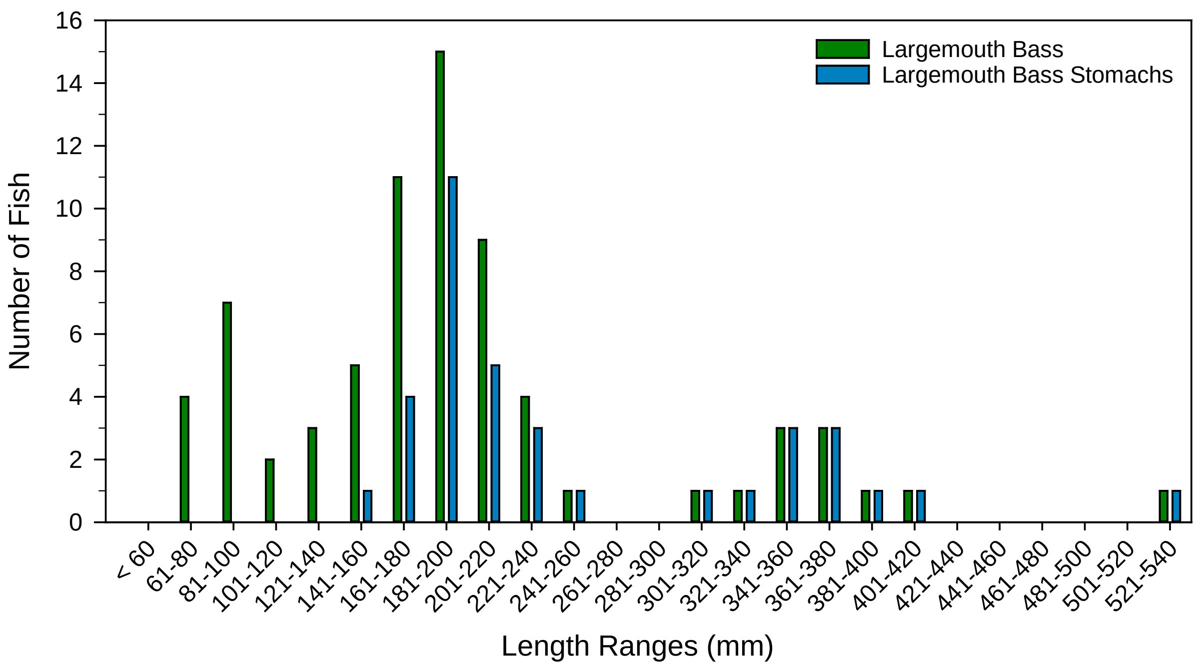

Figure 9. Size class of Largemouth Bass collected from Roosevelt Lake and the Tonto Creek delta, and the size class of fish that provided stomach samples, October 2019.

Fish Stomach Contents

A total of 37 nonnative predatory fish were sampled using gastric lavage with fish approximately 200 mm TL generally expelling all of their dietary contents. However, it was observed that lavage on some larger fish generally resulted in few or no dietary contents being expelled. As a result, a subset (n = 4) of these larger fish were dissected onsite to remove the stomach. The relative low percentage of fish with empty stomachs may be indicative of rapid digestion since last feeding, time of sampling, feeding habits of larger fish, or even sampling methodology (Pope et al. 2010; Vinson and Angradi 2011) and is not reflective of a poor success rate using lavage on larger fish.

Visual observations of the stomach contents expelled during lavage indicated that YOY shad were the dominant food source for Largemouth Bass. Many YOY fish were expelled largely intact and easily identified. No snakes, or fragments of snakes were visually observed in any of the expelled dietary samples at the time of collection nor during the microscopic examination of the stomach contents (Appendix B). In the Roosevelt Lake/delta samples, the dominant dietary category was Fish, followed by Invertebrate, and then Organic Matter. For example, in the 16 stomach samples collected from EF1, 14 contained Fish, 7 contained Invertebrates, 6 contained Organic Matter, and 1 stomach was Empty (Figure 10). A total of seven fish stomachs were Empty.

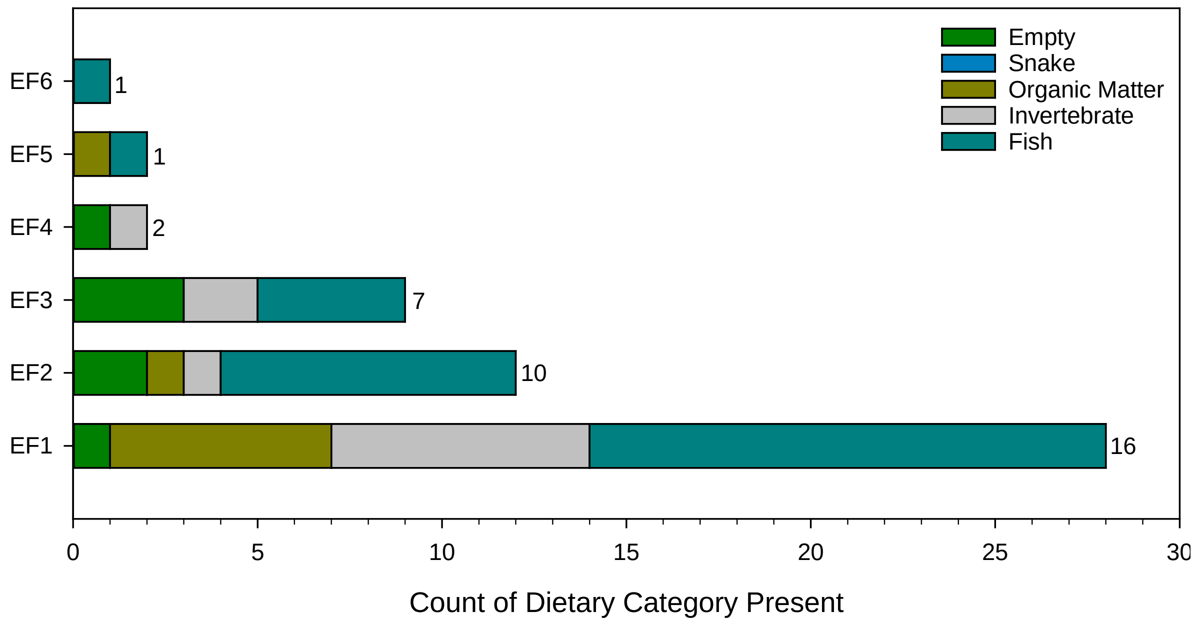

Figure 10. The number of occurrences for each dietary category observed in the stomach samples collected from each site on Roosevelt Lake/delta, October 2019. Numerical values at the end of the bars represent the number of stomachs sampled at each site.

The dominance of the Invertebrate category in Largemouth Bass stomachs collected from Tonto Creek is different from the bass stomachs collected from Roosevelt Lake and the delta region (Figure 7). This variability in diet reflects the differences in size-class, preferential feeding habit, and prey availability. In Tonto Creek, 84 percent of the Largemouth Bass assemblage were less than 150 mm in length and many of the stomach samples were collected from fish in the 80 to 120 mm range (Figure 11), with the lower end of the range truncated based on gape size. This size-class of fish contained nearly 100 percent of Invertebrates in their stomach, but this relationship may be influenced by dietary preference for invertebrates, the seasonal availability of prey and their relative size (i.e., smaller fish). The seasonal availability of prey may lead to resource competition between the smaller and larger bass in Tonto Creek. In other Arizona lakes, the 80 to 120 mm bass have made the feeding habit transition to selectively feed on both invertebrates and fish (Wilde and Paulson 1988; Wanjala et al. 1986).

Therefore, if the fish prey resource was more abundant, the fish less than 150 mm TL would likely contain a larger percentage of fish in their diet.

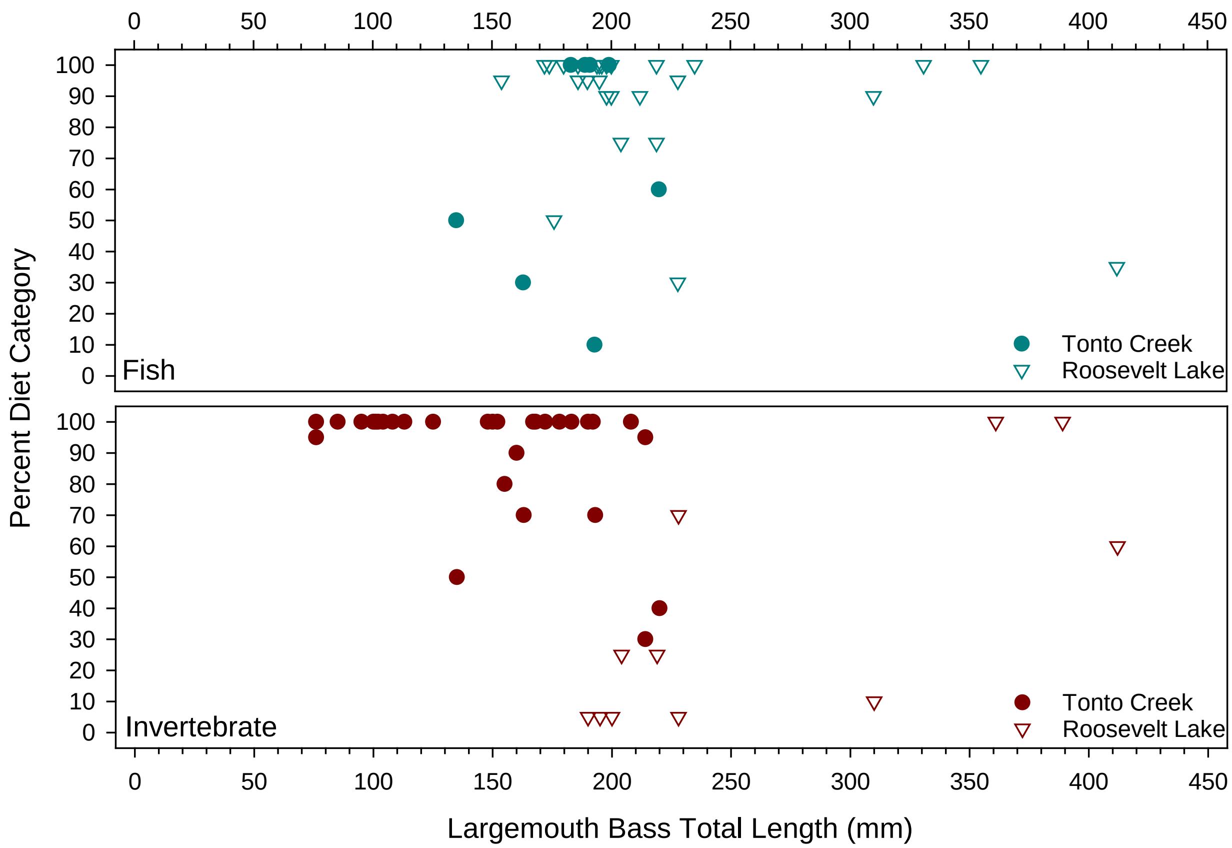

Figure 11. Relationships between the Fish (top) and Invertebrate (bottom) diet categories and size-class of Largemouth Bass in Tonto Creek and Roosevelt Lake, October 2019.

There was more overlap in the number of stomach samples collected from the bass ranging from 150 to 250 mm TL in Tonto Creek (16 samples) and Roosevelt Lake (24 samples); however, the dietary composition was different. In Tonto Creek, the majority of stomach contents from this size class of fish was dominated by Invertebrates, with only a few piscivorous bass. In contrast, the dietary contents from the 150 to 250 mm size class of bass from Roosevelt Lake/delta was dominated by Fish, with Invertebrates comprising a smaller percentage of the diet. The abundant Gizzard Shad and Threadfin Shad population in the reservoir allows for the preferential selection of fish over invertebrates, although invertebrates remained a component of their diet, including the diet of bass greater than 250 mm TL. These dietary relationships were also influenced by the different electrofishing strategies and the timing of the surveys (i.e., fall). Overall, the data indicate that Largemouth Bass primarily feed on invertebrates in Tonto Creek during late fall, while piscivory is the predominant feeding strategy for the Largemouth Bass sampled from Roosevelt Lake and the delta region.

Prey Observations

During the sampling event in October 2019, the Roosevelt Lake and the Tonto Creek delta area contained numerous YOY Gizzard Shad and Threadfin Shad which were the dominant prey for bass; although the YOY Bluegill, sunfish and crappie were also a potential food source. When the stomach content samples were processed in the AGFD laboratory, shad were confirmed as the dominant food source in Largemouth Bass (personal communication, A. Jones).

Incidental NMGS Observations

During the October 15, 2019 sampling event, approximately 2.2 km were boat electrofished for a total of 1.7 hours (i.e., Apex control box operation), which included weaving through the shallow littoral zone habitat and areas of inundated willows, tamarisk, and cottonwood. No incidental NMGS observations occurred during the boat surveys.

April 2020

Roosevelt Lake and Tonto Creek Delta

During daylight hours on April 28, 2020, boat electrofishing occurred along 14 pathways in the shallow lake margin and Tonto Creek Delta, covering approximately 5 km of aquatic habitat in length. Boat electrofishing began (0850 h) on the northwest lake margin at a point approximately 2 km northwest of the boat ramp at Indian Point Campground and continued north through the Tonto Creek delta to a location that was approximately 250 m downstream of A-Cross Road. Boat electrofishing continued back downstream along the southwestern tree lined streambank of Tonto Creek. A total of six surveys were completed (1145 h) in the Tonto Creek Delta that covered approximately 3 km of shallow (i.e., < 2 m) aquatic habitat containing a mix of inundated tamarisk, willows, and cottonwoods. The seventh electrofishing pathway began at 1220 h and reached the northwestern lake margin that was approximately 350 m south of the intersection between Highway 188 and A-Cross Road. The eight remaining surveys occurred in a southerly direction for approximately 2 km along the Roosevelt Lake shoreline near Highway 188, ending (1445 h) approximately 880 m north of Orange Peel. Electrofishing occurred in shallow aquatic habitat containing numerous standing dead trees, tamarisk, willows, and brush (Appendix C).

Fish Species Composition

A total of 221 fish were collected from Roosevelt Lake and the Tonto Creek Delta, representing six nonnative fish species (Table 6, Appendix A). The two most abundant fish species collected were Common Carp and Gizzard Shad, while Buffalo spp. (*Ictiobus spp.*), and Largemouth Bass were less abundant. Bluegill and Black Crappie were collected in small numbers from a few locations. The nonnative predatory fish included Largemouth Bass, Bluegill, and Black Crappie. The catch rate per unit hour for the most abundant species collected was approximately 21 fish per hour. Notably, because nonnative predatory fish were the target species, many of the bycatch species were not collected and brought on board the boat, and only counted in the water, once a representative assemblage was collected and identified. Numerous Threadfin Shad and larval fish were observed in the shallow lake margins but were generally unaffected by electrofishing and thus not collected or counted during the surveys.

Largemouth bass were collected mostly along the electrofishing pathways EF1 and EF2 and EF5 and EF6, which were on opposite sides of the Tonto Creek channel, accounting for 17 individuals (Figure 12). The remaining 16 Largemouth Bass were collected from each of the electrofishing reaches along Highway 188. Common Carp, Gizzard Shad, and Buffalo spp. were present in nearly all electrofishing reaches, accounting for 83 percent of the fish collected.

Table 6. Numbers of fish caught (N), percent composition, mean catch per hour (CPUE) and CPUE standard error (SE) for Roosevelt Lake Delta, April 2020. NA = not applicable based on sample size.

Species	N	Percent Composition	**Mean CPUE ± SE**
Black Crappie	2	1	0.6 ± NA
Bluegill	2	1	0.6 ± NA
Buffalo spp.	36	16	10.4 ± 2.7
Common Carp	72	33	20.9 ± 3.2
Gizzard Shad	76	34	21.7 ± 4.5
Largemouth Bass	33	15	9.8 ± 2.8
Total	221	100	64.0 ± 13.2

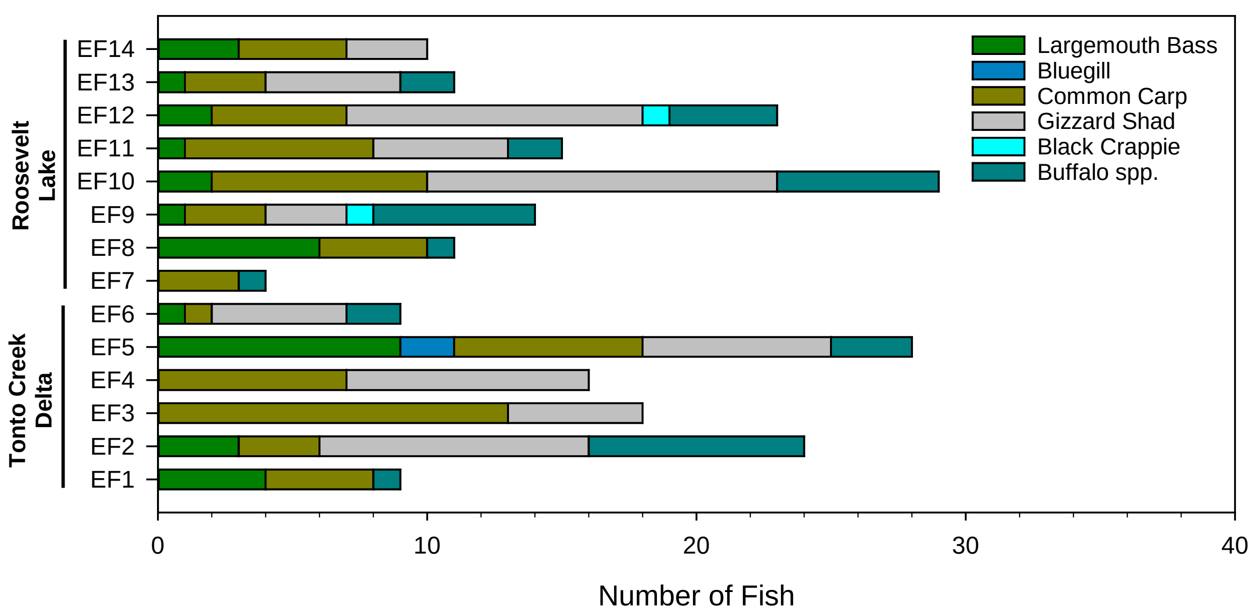

Figure 12. Number of fish collected by site in Roosevelt Lake and Tonto Creek delta, April 2020.

Fish Morphometrics

Largemouth Bass total lengths ranged from 102 to 523 mm (Table 7), with almost all of fish being greater than 150 mm TL (Figure 9). The Wr for Largemouth Bass greater than 150 mm TL (n = 32) was 88.8, indicating that fish were generally thinner than an average population. Largemouth Bass represented multiple size-classes with fish from each age group providing stomach samples. A total of 32 Largemouth Bass were sampled using gastric lavage (Figure 9) and all fish were considered capable of predation on NMGS based on the gape size to total length relationship for bass. Bluegill total lengths ranged from 192 to 206 mm and Black Crappie total lengths ranged from 275 to 328 mm, with two individuals for each species sampled for stomach contents.

Table 7. Minimum, maximum, and mean lengths and weights including sample size (N) of fish collected and measured from Roosevelt Lake/delta, April 2019.

Species	Length (mm)				Weight (g)			
	N	Min	Max	Mean	N	Min	Max	Mean
Black Crappie	2	275	328	302	2	350	440	395
Bluegill	2	192	206	199	2	200	200	200
Largemouth Bass	33	102	523	307	33	20	1,960	467

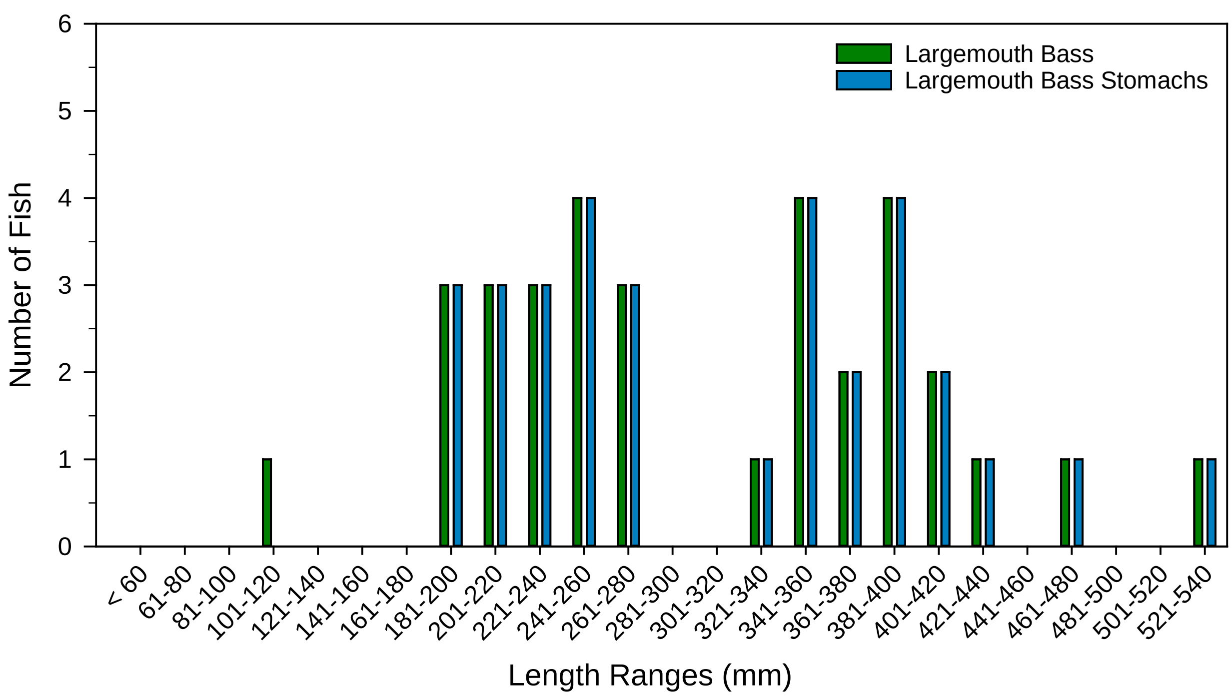

Figure 13. Size class of Largemouth Bass collected from Roosevelt Lake and the Tonto Creek delta, and the size class of fish that provided stomach samples, April 2020.

Fish Stomach Contents

A total of 36 stomach content samples were collected from nonnative predatory fish with two Largemouth Bass in the 341-360 mm and one fish in the 361-380 size class revealing empty stomachs. Visual observations of the stomach contents expelled during lavage indicated that larval fish and Threadfin Shad were the dominant food source by sample mass for Largemouth Bass. Many YOY fish were expelled largely intact and easily identified (Photo 3). Aquatic insects included water boatman, dragonflies, and other non-identifiable invertebrates. Organic matter was also abundant due to the large amount of floating debris on the lake and one plastic fluke fishing lure, absent the hook, was observed in one sample. No snakes, or fragments of snakes were visually observed in any of the expelled dietary samples at the time of collection or during the microscopic examination of the stomach contents (Appendix B). In the Roosevelt Lake – Tonto Creek delta samples, the dominant dietary category was Fish, followed by Organic Matter, and then Invertebrate (Figure 14).

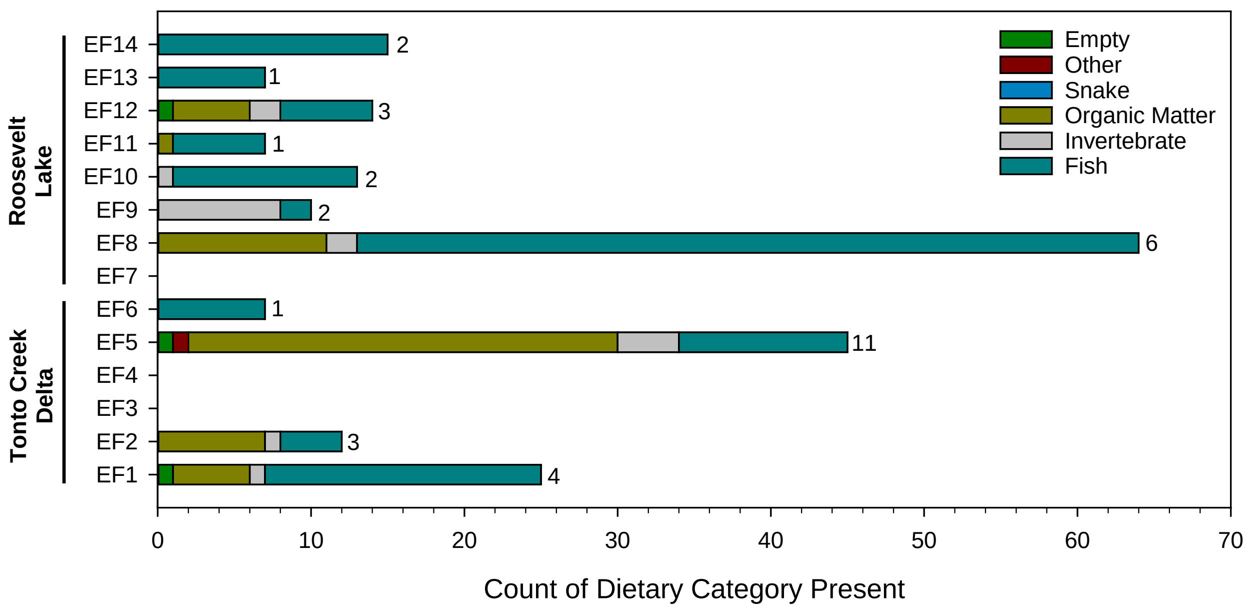

Figure 14. The number of occurrences for each dietary category observed in the stomach samples collected from each site on Roosevelt Lake and Tonto Creek delta, April 2019. Numerical values at the end of the bars represent the number of stomachs sampled at each site.

July 2020

Roosevelt Lake and Tonto Creek Delta

On the evenings of July 28 and 29, 2020, boat electrofishing occurred along 18 pathways in the shallow lake margin and Tonto Creek delta, covering approximately 7 km of aquatic habitat in length. Boat electrofishing began (2030 h) on the northwest lake margin at a point approximately 350 m northwest of the boat ramp at Indian Point Campground and continued north through the Tonto Creek delta to a location that was approximately 150 m downstream of the lake margin in Tonto Creek. A total of eleven surveys were completed (0045 h) in the Tonto Creek channel that covered approximately 4.9 km of shallow (i.e., < 2 m) aquatic habitat containing a mix of inundated tamarisk, willows, and cottonwoods. During the twilight hours on July 29, 2020, the electrofishing boat was motored through inundated standing dead trees, as far north as possible, along the Highway 188 shoreline. Electrofishing began at 2040 h and continued in a southerly direction for 2.1 km, ending (0015 h) approximately 200 m south of Orange Peel. Electrofishing occurred in shallow aquatic habitat containing numerous standing dead trees, tamarisk, willows, and brush (Appendix C).

Fish Species Composition

A total of 423 fish were collected from Roosevelt Lake and the Tonto Creek delta, representing nine nonnative and one native fish species (Table 8, Appendix A). The most abundant species was the Largemouth Bass, representing 48 percent of the individuals collected. Common Carp and Gizzard Shad accounted for 18 percent and 19 percent of the individuals, respectively, while Yellow Bass accounted for 9 percent. The remaining six fish species accounted for 6 percent of the individuals collected. The nonnative predatory fish included Largemouth Bass, Yellow Bass, Bluegill, and Green Sunfish; the native species was the Sonoran Sucker. The catch rate for Largemouth Bass was approximately 45 fish per hour. Similar to previous sampling events, many of the bycatch species were not collected, and only counted in the water when observed. Numerous Threadfin Shad were observed in the shallow lake margins despite only one individual being collected.

Table 8. Numbers of fish caught (N), percent composition, mean catch per hour (CPUE) and CPUE standard error (SE) for Roosevelt Lake/delta, April 2020.

Species	N	Percent Composition	**Mean CPUE ± SE**
Bluegill	16	4	3.6 ± 1.6
Buffalo spp.	3	1	0.7 ± 0.5
Common Carp	75	18	16.7 ± 4.8
Gizzard Shad	80	19	17.8 ± 4.5
Goldfish	1	<1	0.2 ± 0.2
Green Sunfish	1	<1	0.2 ± 0.2
Largemouth Bass	203	48	45.1 ± 23.2
Sonora Sucker	4	1	0.9 ± 0.9
Threadfin Shad	1	<1	0.2 ± 0.2
Yellow Bass	39	9	8.7 ± 7.5
Total	423	100	94.0 ± 31.2

As discussed above, the Bush Fire, a localized rainfall event, and subsequent debris flow into Roosevelt Lake greatly influenced aquatic biota. Approximately 73 percent of the Largemouth Bass collected over two nights of electrofishing was from two reaches near Orange Peel , Sites EF17 and EF18 (Figure 15). These two reaches also contained most of the Yellow Bass and Bluegill collected. Site EF10, in the Tonto Creek Delta, was the third most productive reach in terms of collecting Largemouth Bass. This reach contained a backwater habitat, such that when sampled using boat electrofishing equipment, the fish were corralled by the habitat, increasing the capture efficiency for this reach. A total of 18 Largemouth Bass—nine percent of the total number caught—were from EF10, with 15 fish providing stomach content samples.

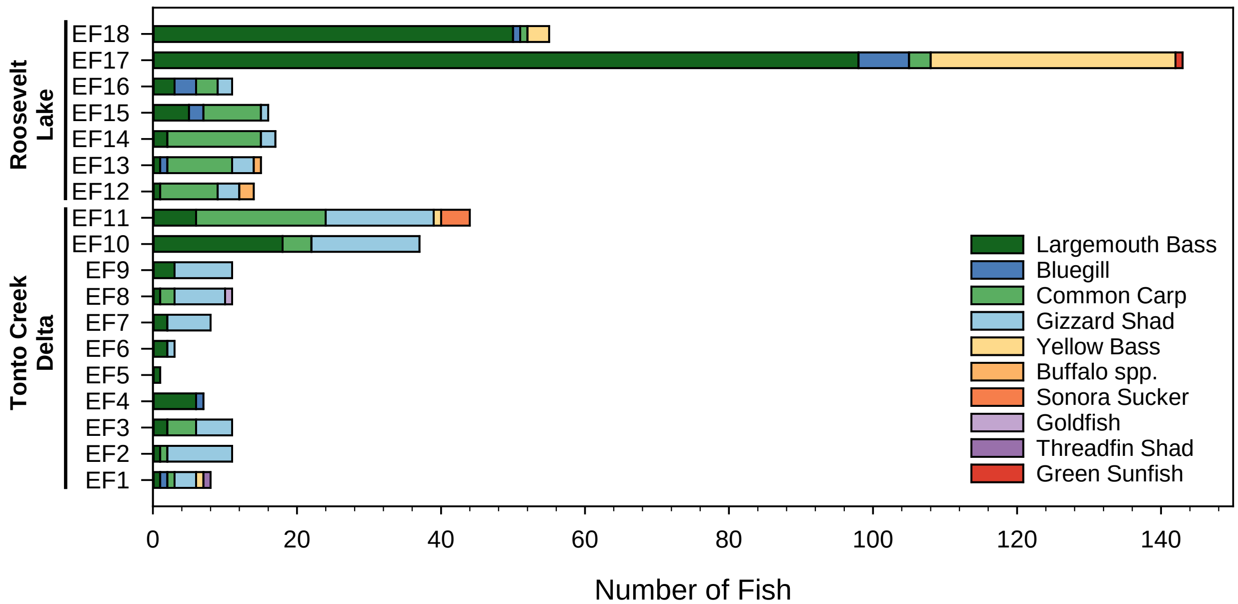

Figure 15. Number of fish collected by site in Roosevelt Lake and Tonto Creek Delta, July 2020.

Fish Morphometrics

Largemouth Bass total lengths ranged from 62 to 469 mm (Table 9), with the 64 percent of fish being less than 150 mm TL (Figure 9). The Wr for Largemouth Bass greater than 150 mm TL (n = 74) was 108.2, indicating that fish were generally plumper than an average population. Largemouth Bass represented multiple size-classes with fish from each age group providing stomach samples. Approximately 70 percent of Largemouth Bass collected were considered capable of predation on NMGS given the gape size to total length relationship, with 91 bass sampled using gastric lavage (Figure 16). Yellow Bass total lengths ranged from 50 to 292 mm and Bluegill total lengths ranged from 275 to 328 mm with each species providing two and nine stomach samples, respectively. The Yellow Bass sampled were capable of predation on the NMGS, although the Bluegill gape size likely precludes any predation on NMGS.

Table 9. Minimum, maximum, and mean lengths and weights including sample size (N) of fish collected and measured from Roosevelt Lake and Tonto Creek Delta, July 2020.

Species	Length (mm)				Weight (g)			
	N	Min	Max	Mean	N	Min	Max	Mean
Bluegill	16	101	202	150	15	20	170	85
Green Sunfish	1	86	86	86	--	--	--	--
Largemouth Bass	203	62	469	147	136	10	1,710	124
Yellow Bass	39	50	292	81	2	90	410	250

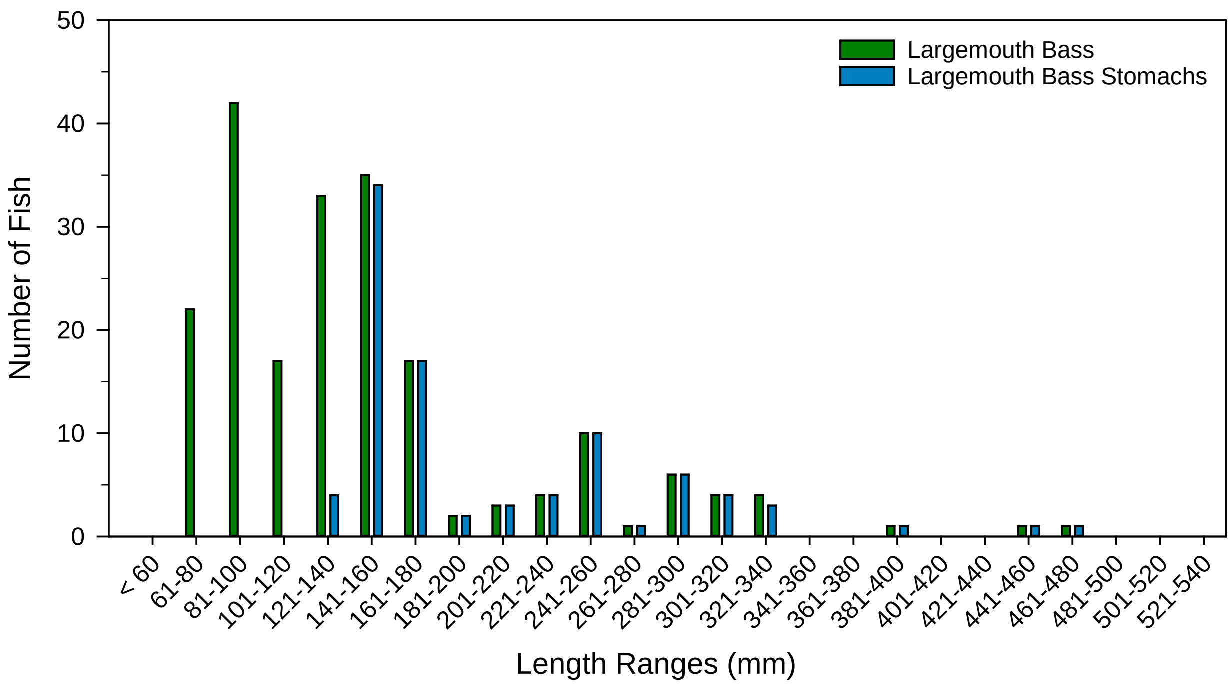

Figure 16. Size class of Largemouth Bass collected from Roosevelt Lake and the Tonto Creek delta, and the size class of fish that provided stomach samples, July 2020.

Fish Stomach Contents

A total of 102 stomach content samples were collected from nonnative predatory fish with 21 Largemouth Bass, ranging from 140 to 450 mm TL, revealing empty stomachs. Visual observations of the stomach contents expelled during lavage indicated that Threadfin Shad were again the dominant food source for Largemouth Bass. Organic matter was also abundant due to the large amount of floating debris on the lake. Stomach contents also included aquatic insects and one crayfish. No snakes, or fragments of snakes were visually observed in any of the expelled dietary samples at the time of collection or during the microscopic examination of the stomach contents (Appendix B).

Laboratory analysis of the stomach samples collected in July, enumerated 1,051 particles with the dominant dietary category being Invertebrates, followed by Organic Matter, and then Fish (Figure 17, Figure 18). However, on closer examination of the data, the nine Bluegill stomachs accounted for 68 percent of the total number of particles counted, while the 91 Largemouth Bass and two Yellow Bass accounted for 31 and 1 percent of the particles counted, respectively. The disparity in dietary categories between these species likely reflects the different dietary habits of each species, that may have been accentuated by different field techniques to sample the stomach—gastric lavage versus dissection. Bluegill are generalist feeders that primarily consume zooplankton and aquatic invertebrates whereas Largemouth Bass primarily consume small fish and aquatic invertebrates. Bluegill stomach samples were dissected whole in the field, preserved, and then further dissected in the laboratory to expose the contents; whereas the bass stomach samples were collected using gastric lavage and a mesh strainer that may allow zooplankton and small organic matter to pass through during sample collection (Photo 3). When the influence of the nine Bluegill is removed, Organic Matter was the dominant particle counted for Largemouth Bass, while Fish became the second most abundant particle counted (Figure 18). Again, the dietary analysis of Largemouth Bass was influenced by the abundance of fish collected from EF17 and EF18.

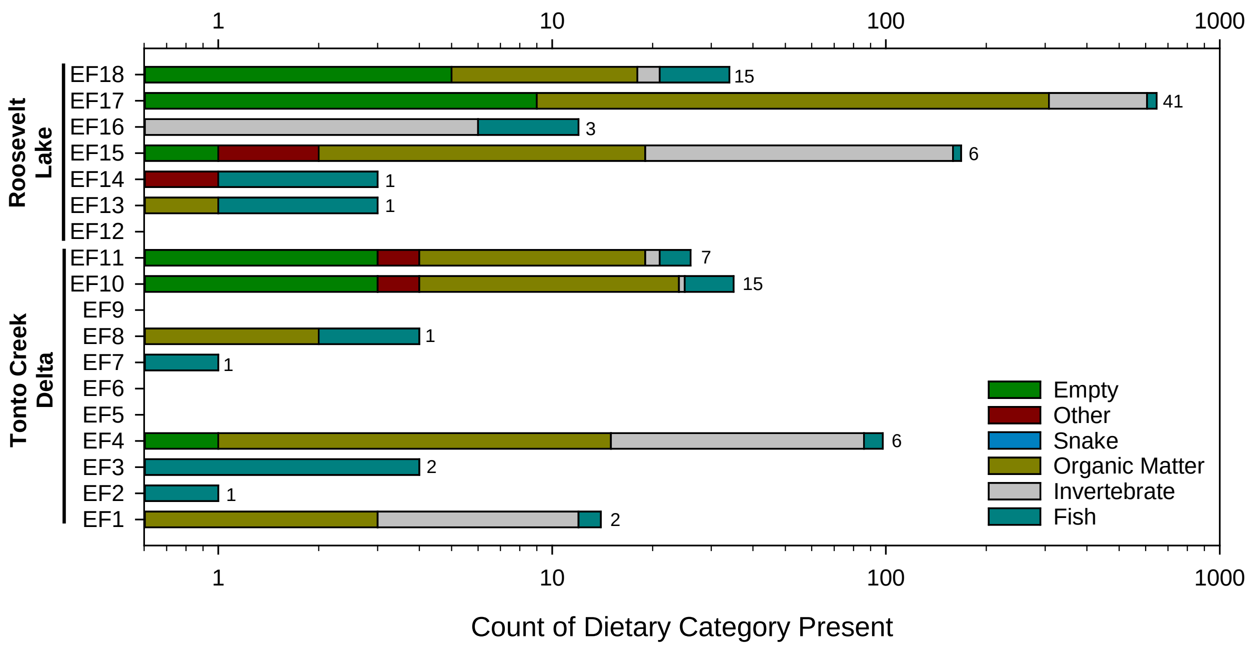

Figure 17. The number of occurrences for each dietary category observed in the stomach samples collected from each site on Roosevelt Lake and Tonto Creek Delta, July 2020. Numerical values represent the number of stomachs sampled at each site. Note logarithmic scale on x-axis.

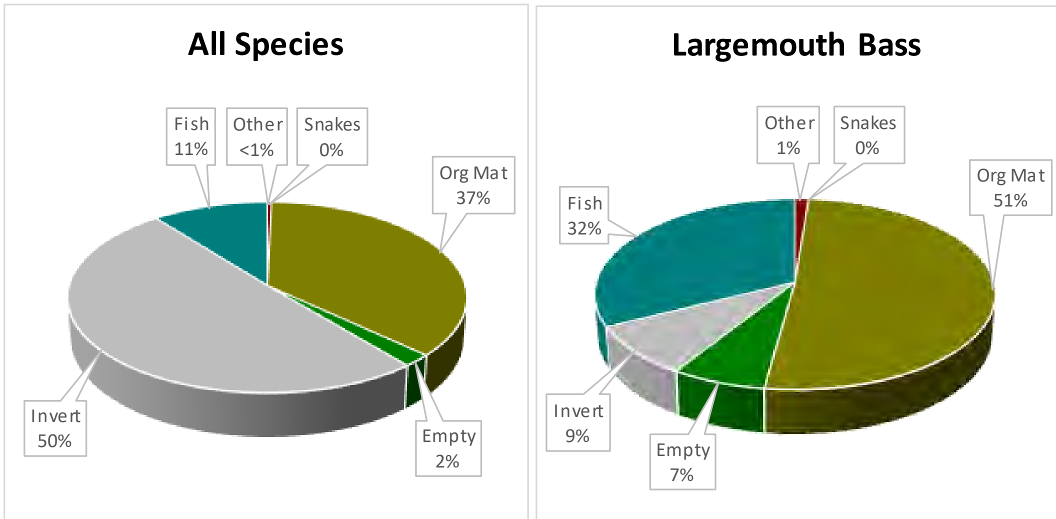

Figure 18. Percentage of dietary category observed in the stomachs of all fish species sampled and for Largemouth Bass, July 2020.

Summary of Fishery Data

October 2019

Tonto Creek

In October 2019, eight nonnative and one native fish species were sampled from 13 pools in Tonto Creek between A-Cross Road and the Reservoir margin. The three most abundant species included Largemouth Bass, Bluegill, and Common Carp which accounted for 77 percent of the 518 individuals collected. The nonnative predatory fish included Largemouth Bass, Smallmouth Bass, Green Sunfish, Bluegill, Yellow Bullhead and Channel Catfish, with 56 stomach content samples being collected from the representative predatory species, except for the Bluegill, whose gape size was too small. The vast majority of Largemouth Bass collected were less than 100 mm in length and exhibited a gape size too small for stomach content analysis. The relative weight of Largemouth Bass greater than 150 mm in total length indicated that fish were skinnier than a normal population of bass. The relative abundance of Largemouth Bass was significantly correlated with maximum water depth, such that the deeper waters contained more bass. No other measured habitat characteristics were related to the abundance of bass. The maximum water depth of aquatic habitat likely effects water permanency and possibly prolongs the duration between terrestrial and aquatic habitat interface along Tonto Creek; although there were reaches of dry cobble-bed channel that also severely limited the direct terrestrial and aquatic habitat interface. Both of these characteristics could affect NMGS access to aquatic habitat at different times of the year.

Approximately 7.2 river km were traveled by foot, which included streambank riparian and aquatic habitat passage by up to seven field biologists and approximately 950 m of aquatic habitat was surveyed using electrofishing equipment. No incidental NMGS observations occurred during the fish surveys in Tonto Creek.

Roosevelt Lake

In October 2019, nine nonnative fish species were collected from Roosevelt Lake and the Tonto Creek Delta with Gizzard Shad, Largemouth Bass, and Threadfin Shad accounting for 80 percent of the fish collected. Less abundant fish included the Bluegill, Yellow Bass, and Common Carp while a few individuals representing Green Sunfish, Black Crappie, and Tilapia spp. were also collected. Largemouth Bass accounted for 23 percent of the total number collected and their relative weight indicated that fish in the reservoir/delta region were plumper than a normal population of bass. Thirty-six stomach samples were collected from Largemouth Bass and one stomach sample from a Yellow Bass.

Approximately 2.2 km were boat electrofished for a total of 1.7 hours, which included weaving through the shallow littoral zone habitat and areas of inundated willows, tamarisk, and cottonwood. No incidental NMGS observations occurred during the boat surveys.

April 2020

Roosevelt Lake and Tonto Creek Delta

In April 2020, six nonnative fish species were collected from Roosevelt Lake and the Tonto Creek Delta with Common Carp and Gizzard Shad being the two most abundant species collected, while Buffalo spp. and Largemouth Bass were less abundant. Bluegill and Black Crappie were rare. Of the total number of fish collected (n = 221), 47 percent were from the Tonto Creek Delta and 53 percent from Roosevelt Lake. Similarly, the number of Largemouth Bass collected were nearly equally divided between the Tonto Creek Delta habitat (52 percent) and Roosevelt Lake habitat (48 percent), as well as the stomach content samples collected, 53 and 47 percent, respectively. Largemouth Bass accounted for 15 percent of the total number of fish collected, representing multiple size-classes. In general, the Largemouth Bass collected during the spring were thinner than an average population.

Approximately 5 km of shallow aquatic habitat were boat electrofished in Tonto Creek Delta and Roosevelt Lake during the daylight for total of 6 hours, which included weaving through the shallow littoral zone habitat and areas of inundated willows, tamarisk, and cottonwood. No incidental NMGS observations occurred during the daylight boat surveys.

July 2020

Roosevelt Lake and Tonto Creek Delta

In July 2020, nine nonnative and one native fish species were collected from Roosevelt Lake and the Tonto Creek Delta with Largemouth Bass representing 48 percent of the 423 fish collected over two nights of boat electrofishing. Common Carp and Gizzard Shad combined for 37 percent of the total fish collected, while Yellow Bass was the second most abundant predatory fish collected. Of the total number of fish collected, 36 percent were from the Tonto Creek Delta and 64 percent from Roosevelt Lake. The number of Largemouth Bass individuals collected differed between the Tonto Creek Delta habitat (20 percent) and Roosevelt Lake habitat (80 percent) largely due to the influence of the sediment deposition fan. The number of stomach content samples collected was more in line with the numbers of fish collected from each habitat type, with 34 percent collected from Tonto Creek Delta and 66 percent collected from Roosevelt Lake. Largemouth Bass were represented by multiple size-classes, even though the majority of the individuals collected were less than 150 mm TL. In general, the Largemouth Bass collected during the summer were plumper than an average population.

Approximately 7 km of shallow aquatic habitat were boat electrofished in Tonto Creek Delta and Roosevelt Lake during nighttime conditions for 7.8 hours, which included weaving through the shallow littoral zone habitat and areas of inundated willows, tamarisk, and cottonwood. No incidental NMGS observations occurred during the nighttime boat surveys.

Prey Composition

In October 2019, a total of 74 Largemouth Bass stomachs were analyzed, enumerating, and categorizing the dietary particles into one of five categories—Organic Matter, Invertebrate, Fish, Snake, Other, with a sixth category of Empty. Invertebrates were the most abundant dietary category observed followed by Fish (Figure 19). No snakes, or fragments of snakes were observed during gastric lavage or the microscopic examination of the stomach contents. The abundance of invertebrates in the Largemouth Bass diet was primarily attributed to the smaller size-class of fish found in Tonto Creek, combined with the limited fish prey-base in Tonto Creek. In Roosevelt Lake, piscivory was the predominant feeding strategy for the Largemouth Bass, although Invertebrates remained a dietary component of larger fish.

In April 2020, visual observations of the 32 Largemouth Bass stomachs sampled using gastric lavage indicated that larval fish and Threadfin Shad were the dominant food source for Largemouth Bass which was confirmed by the laboratory analysis (Figure 19). Organic Matter was the second most abundant particle counted followed by Invertebrate. No snakes, or fragments of snakes were observed during gastric lavage or the microscopic examination of the stomach contents. Piscivory was the predominant feeding strategy for Largemouth Bass in Roosevelt Lake and Tonto Creek Delta in the spring, and there were no apparent differences in Largemouth Bass size class or feeding preference between the two habitat areas sampled. A combination of lake level and seasonal habitat use appeared to erode the differences in habitat usage and prey availability/selection that were observed during the fall.

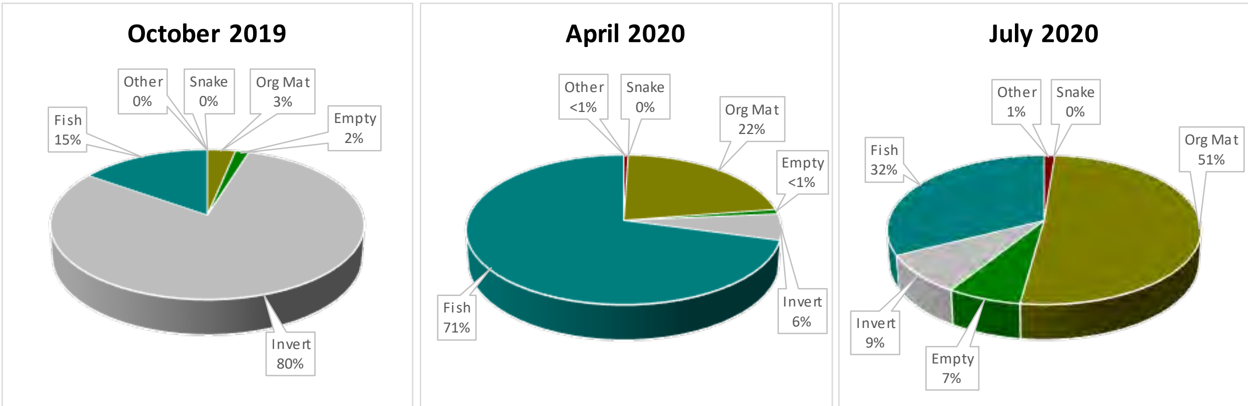

Figure 19. Percentage of dietary categories observed in Largemouth Bass stomachs collected in October 2019, April, and July 2020.

In July 2020, visual observations of the 91 Largemouth Bass stomach sampled using gastric lavage indicated that Threadfin Shad were the dominant food source in terms of mass, even though Organic Matter was numerically dominant category. Invertebrates accounted for nine percent of the particles counted while 7 percent of the stomachs were empty (Figure 19). No snakes, or fragments of snakes were observed during gastric lavage or the microscopic examination of the stomach contents. Piscivory was the predominant feeding strategy for Largemouth Bass in Roosevelt Lake and Tonto Creek Delta, with incidental consumption of organic matter which was likely influenced by debris flow entering the lake. The Bush Fire and a subsequent storm related debris flow that occurred one day prior to sampling provided a source of dissolved and particulate organic to the lake that attracted numerous forage and predatory fish.

Study 4 Findings

A primary objective of Study 4 was to characterize nonnative fish species composition and the size class structure of the Largemouth Bass population and their prey consumption habits within Tonto Creek from A-Cross Road (elevation 2,151 ft) downstream to a location above the prevailing water level of Roosevelt Lake, including the shallow lake margins of the Tonto Creek Delta. The study occurred over two consecutive years, capturing the seasonal differences in aquatic habitat, fishery use, and prey consumption during fall 2019 and spring and summer 2020. Over the course of the study, the aquatic habitat availability, structure, and its interface with terrestrial habitat in Tonto Creek greatly changed due to the change from the low water level in October 2019 (2,120 ft) to a maximum water elevation of 2,150.29 ft in mid-April 2020. The seasonally wet winter and rising lake levels changed the aquatic habitat from isolated pools in the fall 2019 to an expansive delta in the spring and summer 2020.

In October 2019, the pool habitat in Tonto Creek was supported by hyporheic flows that helped maintain surface water connectivity between the pools closer to the reservoir. However, the pools further upstream near A-Cross Road lacked the surface water connectivity and became isolated pooled habitat. Depending on the sinuosity of the braided stream channel, either the left or right bank habitat was limited to a dry cobble bed channel with wide, unvegetated gravel bars, while the opposite bank was covered by a mix of cottonwood, tamarisk, willow, and other shrubs. The expanse of the dry channel often limited the direct terrestrial–aquatic habitat interface at water's edge, which could limit Northern Mexican Gartersnake [*Thamnophis eques megalops,* (NMGS)] access to the wet portions of Tonto Creek during periods of low reservoir level and residual pool habitat.

The Inundation zone in April and July 2020, changed the terrestrial–aquatic habitat interface such that the eastern stream bank of Tonto Creek became a contiguous boundary between aquatic and terrestrial wetland/upland habitat. The terrestrial wetland habitat along the western stream bank became inundated with the aquatic habitat extending to the upland habitat corridor along Highway 188. This variability in aquatic habitat types (i.e., isolated pool vs continuous lake margin) likely influenced the amount of edge habitat available for potential NMGS use, as well as the seasonal nonnative fishery use and prey selection.

A primary goal of Study 4 was to determine whether nonnative fish with a limited gape size prey on NMGS where their habitat preferences may overlap. The Salt River Project's overarching hypothesis was *Nonnative fish species (gape size ½ to ¾ inch) capable of preying on NMGS will not persist in stream segments and isolated backwaters of Tonto Creek within the conservation space where NMGS habitat exists*.

This multi-season study collected nonnative predatory fish from Tonto Creek, the Tonto Creek delta, and the shoreline areas of Roosevelt Lake when the NMGS is expected to actively use the aquatic–wetland edge habitat to forage on anurans, fish, and aquatic invertebrates. The fall and spring sampling events occurred when the NMGS also engage in mating while the summer sampling event occurred during the birthing period (June to August). During the summer, neonate and juvenile NMGS are likely more reliant on aquatic habitat to help with thermoregulation during the seasonally high ambient air temperatures as well as to access a forage base during this sensitive life-stage. Sampling occurred during both daylight and nighttime hours to effectively sample the different aquatic habitat uses.

In October, nonnative fish, including Largemouth Bass, were collected from each pool sampled in Tonto Creek with the furthest upstream pool approximately 200 meters from A-Cross Road. A subset of Largemouth Bass was measured for vertical gape opening to ensure that fish near the lower gape limit were adequately being sampled and to evaluate the relationship between gape size and total length. The relationship showed that the two variables are highly correlated and that a vertical gape opening of 12.5 mm corresponds to a total length of 100 mm for Largemouth Bass in Tonto Creek. Based on gape size, 25 percent of the Largemouth Bass collected in Tonto Creek were considered capable of preying on NMGS, although the predominant dietary category observed in these fish was invertebrates. The majority of bass collected were less than 100 mm in total length.

In April and July, nearly all of the nonnative predatory fish, including Largemouth Bass, collected from the shoreline habitat in the Tonto Creek Delta and Roosevelt Lake were considered capable of predation on NMGS based on their gape size. The furthest upstream reaches sampled in April and July were approximately 300 and 600 meters from A-Cross Road, respectively.

A total of 231 fish stomachs were analyzed during the study, with 1,995 dietary particles being counted and classified as either Organic Matter, Invertebrate, Fish, Snake, or Other, along with 35 Empty stomachs. In nonnative predatory fish, Invertebrates accounted for 57 percent of the dietary contents, while Organic Matter and Fish accounted for 23 percent and 17 percent, respectively. Based on the stomach content analysis, there was no documented predation on NMGS by Largemouth Bass or other nonnative fish during this study. In addition, over the course of the study, field biologists logged approximately 7.2 km of foot travel through terrestrial wetland edge habitat and 15.2 km of electrofishing wadeable pool and shallow littoral zone habitat in Tonto Creek, the Delta, and Roosevelt Lake and there were no visual observations of NMGS.

While the study confirmed that nonnative fish persist in isolated pool habitat in Tonto Creek and along the shoreline in the delta, the study did not document nonnative fish predation on NMGS during their seasonally active phase. The presence of shallow groundwater between A-Cross Road and the Reservoir, maintained the residual pool habitat and influenced water temperature, creating suitable habitat for nonnative fish, including multiple predatory species, as well as supporting a forage base of young-of-year fish, anurans, and aquatic invertebrates. The persistence of the residual pool habitat is likely influenced by dry and wet year conditions as well as lake elevation, although the duration of these conditions was not evaluated. Nonnative fish, including Largemouth Bass utilized the shallow littoral zone habitat in Tonto Creek Delta and Roosevelt Lake during the variable lake elevations sampled. The littoral zone habitat supported a robust forage base of larval fish, and juvenile Threadfin Shad and Gizzard Shad which is supported by the stomach content analysis of fish collected from the delta and lake margins. The presence of nonnative fish, including Largemouth Bass, in the shallow water habitat indicate the potential for niche overlap with NMGS, although the likelihood of predation on the NMGS is low based on our field observations and fish stomach content analysis. When residual pool habitat persists in Tonto Creek, the nonnative predatory fish are more likely to have a greater influence on NMGS through competition for the same forage base rather than by direct predation on NMGS given the smaller size class of fish. These aquatic habitats become isolated, limiting fish movement, and thereby reducing the prey base over time due to predation. However, in the shallow shoreline margins of the Tonto Creek delta and Roosevelt Lake, where fish populations can easily move from shallow to open water habitat, the competition for the same forage base is negligible given that Largemouth Bass appear more reliant on the robust shad fishery in Roosevelt Lake.

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Appendix A Fish Data

Table A-1. Fish data collected for Tonto Creek, Tonto Creek Delta, and Roosevelt Lake, October 2019, April 2020, and July 2020.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Tonto Creek	Fall	10/15/2019	P1	Common Carp	Cyprinus carpio	97-138	.	6	.	.
Tonto Creek	Fall	10/15/2019	P1	Green Sunfish	Lepomis cyanellus	164	70	1	25	Yes
Tonto Creek	Fall	10/15/2019	P1	Green Sunfish	Lepomis cyanellus	128	33	1	14.54	Yes
Tonto Creek	Fall	10/15/2019	P1	Green Sunfish	Lepomis cyanellus	94	.	1	10	.
Tonto Creek	Fall	10/15/2019	P1	Green Sunfish	Lepomis cyanellus	53	.	1	.	.
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	Micropterus salmoides	155	33	1	.	Yes
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	Micropterus salmoides	150	37	1	.	Yes
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	Micropterus salmoides	125	18	1	.	Yes
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	Micropterus salmoides	101	.	1	.	Yes
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	Micropterus salmoides	95	.	1	.	Yes
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	Micropterus salmoides	85	.	1	.	Yes
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	Micropterus salmoides	80	.	1	8	.
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	Micropterus salmoides	79	.	1	.	.
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	Micropterus salmoides	79	.	1	.	.
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	Micropterus salmoides	77	.	1	.	.
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	Micropterus salmoides	76	.	1	.	Yes
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	Micropterus salmoides	76	.	1	9.21	Yes
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	Micropterus salmoides	73	.	1	.	.
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	Micropterus salmoides	66	.	1	.	.
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	Micropterus salmoides	62	.	1	.	.
Tonto Creek	Fall	10/15/2019	P1	Yellow Bullhead	Ameiurus natalis	165	54	1	15.13	Yes
Tonto Creek	Fall	10/15/2019	P1	Yellow Bullhead	Ameiurus natalis	122	.	1	12.18	.
Tonto Creek	Fall	10/15/2019	P1	Yellow Bullhead	Ameiurus natalis	121	.	1	.	.
Tonto Creek	Fall	10/15/2019	P1	Yellow Bullhead	Ameiurus natalis	121	21	1	13.03	Yes
Tonto Creek	Fall	10/15/2019	P1	Yellow Bullhead	Ameiurus natalis	114	.	1	11.51	.
Tonto Creek	Fall	10/15/2019	P1	Yellow Bullhead	Ameiurus natalis	102	.	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Bluegill	Lepomis macrochirus	136	44	1	11.21	.
Tonto Creek	Fall	10/15/2019	P2	Bluegill	Lepomis macrochirus	131	38	1	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Tonto Creek	Fall	10/15/2019	P2	Bluegill	Lepomis macrochirus	128	33	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Bluegill	Lepomis macrochirus	126	35	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Bluegill	Lepomis macrochirus	125	34	1	9.5	.
Tonto Creek	Fall	10/15/2019	P2	Bluegill	Lepomis macrochirus	122	29	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Bluegill	Lepomis macrochirus	121	31	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Bluegill	Lepomis macrochirus	114	23	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Bluegill	Lepomis macrochirus	113	25	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Bluegill	Lepomis macrochirus	113	28	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Bluegill	Lepomis macrochirus	112	24	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Bluegill	Lepomis macrochirus	112	24	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Bluegill	Lepomis macrochirus	112	23	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Bluegill	Lepomis macrochirus	111	19	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Bluegill	Lepomis macrochirus	106	20	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Bluegill	Lepomis macrochirus	104	17	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Common Carp	Cyprinus carpio	111-165	.	6	.	.
Tonto Creek	Fall	10/15/2019	P2	Green Sunfish	Lepomis cyanellus	92	.	1	12.14	.
Tonto Creek	Fall	10/15/2019	P2	Green Sunfish	Lepomis cyanellus	91	.	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Green Sunfish	Lepomis cyanellus	79	.	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Green Sunfish	Lepomis cyanellus	78	.	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Green Sunfish	Lepomis cyanellus	74	.	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Green Sunfish	Lepomis cyanellus	72	.	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Largemouth Bass	Micropterus salmoides	199	99	1	33	Yes
Tonto Creek	Fall	10/15/2019	P2	Largemouth Bass	Micropterus salmoides	178	55	1	28.5	Yes
Tonto Creek	Fall	10/15/2019	P2	Largemouth Bass	Micropterus salmoides	168	49	1	23.23	Yes
Tonto Creek	Fall	10/15/2019	P2	Largemouth Bass	Micropterus salmoides	163	43	1	22.01	Yes
Tonto Creek	Fall	10/15/2019	P2	Largemouth Bass	Micropterus salmoides	152	34	1	17.44	Yes
Tonto Creek	Fall	10/15/2019	P2	Largemouth Bass	Micropterus salmoides	80	.	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Largemouth Bass	Micropterus salmoides	78	.	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Largemouth Bass	Micropterus salmoides	75	.	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Largemouth Bass	Micropterus salmoides	70	.	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Largemouth Bass	Micropterus salmoides	70	.	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Largemouth Bass	Micropterus salmoides	69	.	1	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Tonto Creek	Fall	10/15/2019	P2	Largemouth Bass	Micropterus salmoides	68	.	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Yellow Bullhead	Ameiurus natalis	140	32	1	12.45	Yes
Tonto Creek	Fall	10/15/2019	P2	Yellow Bullhead	Ameiurus natalis	134	28	1	12.85	Yes
Tonto Creek	Fall	10/15/2019	P2	Yellow Bullhead	Ameiurus natalis	123	23	1	12.7	Yes
Tonto Creek	Fall	10/15/2019	P2	Yellow Bullhead	Ameiurus natalis	120	19	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Yellow Bullhead	Ameiurus natalis	116	21	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Yellow Bullhead	Ameiurus natalis	116	20	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Yellow Bullhead	Ameiurus natalis	111	13	1	.	.
Tonto Creek	Fall	10/15/2019	P2	Yellow Bullhead	Ameiurus natalis	83	.	1	.	.
Tonto Creek	Fall	10/15/2019	P3	Bluegill	Lepomis macrochirus	116	22	1	.	.
Tonto Creek	Fall	10/15/2019	P3	Bluegill	Lepomis macrochirus	116	27	1	.	.
Tonto Creek	Fall	10/15/2019	P3	Bluegill	Lepomis macrochirus	115	25	1	.	.
Tonto Creek	Fall	10/15/2019	P3	Bluegill	Lepomis macrochirus	115	26	1	.	.
Tonto Creek	Fall	10/15/2019	P3	Bluegill	Lepomis macrochirus	113	22	1	.	.
Tonto Creek	Fall	10/15/2019	P3	Bluegill	Lepomis macrochirus	110	23	1	.	.
Tonto Creek	Fall	10/15/2019	P3	Bluegill	Lepomis macrochirus	108	21	1	.	.
Tonto Creek	Fall	10/15/2019	P3	Bluegill	Lepomis macrochirus	102	18	1	.	.
Tonto Creek	Fall	10/15/2019	P3	Bluegill	Lepomis macrochirus	89	.	1	.	.
Tonto Creek	Fall	10/15/2019	P3	Bluegill	Lepomis macrochirus	88	.	1	.	.
Tonto Creek	Fall	10/15/2019	P3	Common Carp	Cyprinus carpio	83-131	.	9	.	.
Tonto Creek	Fall	10/15/2019	P3	Green Sunfish	Lepomis cyanellus	43	.	1	.	.
Tonto Creek	Fall	10/15/2019	P3	Largemouth Bass	Micropterus salmoides	<100	.	10	.	.
Tonto Creek	Fall	10/15/2019	P3	Largemouth Bass	Micropterus salmoides	196	62	1	24.54	Yes
Tonto Creek	Fall	10/15/2019	P3	Largemouth Bass	Micropterus salmoides	113	19	1	13.56	Yes
Tonto Creek	Fall	10/15/2019	P3	Largemouth Bass	Micropterus salmoides	104	13	1	12.42	Yes
Tonto Creek	Fall	10/15/2019	P3	Largemouth Bass	Micropterus salmoides	83	.	1	.	.
Tonto Creek	Fall	10/15/2019	P3	Largemouth Bass	Micropterus salmoides	82	.	1	.	.
Tonto Creek	Fall	10/15/2019	P3	Largemouth Bass	Micropterus salmoides	79	.	1	.	.
Tonto Creek	Fall	10/15/2019	P3	Largemouth Bass	Micropterus salmoides	72	.	1	.	.
Tonto Creek	Fall	10/15/2019	P3	Largemouth Bass	Micropterus salmoides	64	.	1	.	.
Tonto Creek	Fall	10/15/2019	P3	Sonora Sucker	Catostomus insignis	138	29	1	.	.
Tonto Creek	Fall	10/15/2019	P3	Yellow Bullhead	Ameiurus natalis	109	16	1	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Tonto Creek	Fall	10/15/2019	P3	Yellow Bullhead	Ameiurus natalis	107	18	1	.	.
Tonto Creek	Fall	10/15/2019	P3	Yellow Bullhead	Ameiurus natalis	106	16	1	10.68	.
Tonto Creek	Fall	10/15/2019	P3	Yellow Bullhead	Ameiurus natalis	106	13	1	.	.
Tonto Creek	Fall	10/15/2019	P4	Common Carp	Cyprinus carpio	90	.	1	.	.
Tonto Creek	Fall	10/15/2019	P4	Largemouth Bass	Micropterus salmoides	<100	.	12	.	.
Tonto Creek	Fall	10/15/2019	P4	Yellow Bullhead	Ameiurus natalis	110	18	1	.	.
Tonto Creek	Fall	10/15/2019	P4	Yellow Bullhead	Ameiurus natalis	109	16	1	.	.
Tonto Creek	Fall	10/15/2019	P4	Yellow Bullhead	Ameiurus natalis	109	16	1	.	.
Tonto Creek	Fall	10/15/2019	P4	Yellow Bullhead	Ameiurus natalis	104	16	1	.	.
Tonto Creek	Fall	10/15/2019	P4	Yellow Bullhead	Ameiurus natalis	95	.	1	.	.
Tonto Creek	Fall	10/15/2019	P4	Yellow Bullhead	Ameiurus natalis	83	.	1	.	.
Tonto Creek	Fall	10/15/2019	P5	Bluegill	Lepomis macrochirus	110	24	1	.	.
Tonto Creek	Fall	10/15/2019	P5	Channel Catfish	Ictalurus punctatus	519	1292	1	.	Yes
Tonto Creek	Fall	10/15/2019	P5	Largemouth Bass	Micropterus salmoides	<100	.	1	.	.
Tonto Creek	Fall	10/15/2019	P5	Yellow Bullhead	Ameiurus natalis	130	28	1	12.32	Yes
Tonto Creek	Fall	10/15/2019	P5	Yellow Bullhead	Ameiurus natalis	122	23	1	.	.
Tonto Creek	Fall	10/15/2019	P6	Bluegill	Lepomis macrochirus	120	29	1	.	.
Tonto Creek	Fall	10/15/2019	P6	Bluegill	Lepomis macrochirus	113	25	1	.	.
Tonto Creek	Fall	10/15/2019	P6	Bluegill	Lepomis macrochirus	110	21	1	.	.
Tonto Creek	Fall	10/15/2019	P6	Bluegill	Lepomis macrochirus	109	20	1	.	.
Tonto Creek	Fall	10/15/2019	P6	Bluegill	Lepomis macrochirus	108	20	1	.	.
Tonto Creek	Fall	10/15/2019	P6	Bluegill	Lepomis macrochirus	105	19	1	.	.
Tonto Creek	Fall	10/15/2019	P6	Common Carp	Cyprinus carpio	98-148	.	21	.	.
Tonto Creek	Fall	10/15/2019	P6	Largemouth Bass	Micropterus salmoides	<100	.	9	.	.
Tonto Creek	Fall	10/15/2019	P6	Largemouth Bass	Micropterus salmoides	191	87	1	27.19	Yes
Tonto Creek	Fall	10/15/2019	P6	Largemouth Bass	Micropterus salmoides	183	73	1	24.06	Yes
Tonto Creek	Fall	10/15/2019	P6	Largemouth Bass	Micropterus salmoides	160	47	1	21.82	Yes
Tonto Creek	Fall	10/15/2019	P6	Largemouth Bass	Micropterus salmoides	148	33	1	18.04	Yes
Tonto Creek	Fall	10/15/2019	P6	Yellow Bullhead	Ameiurus natalis	113	16	1	.	.
Tonto Creek	Fall	10/15/2019	P6	Yellow Bullhead	Ameiurus natalis	104	13	1	.	.
Tonto Creek	Fall	10/15/2019	P6	Yellow Bullhead	Ameiurus natalis	84	.	1	.	.
Tonto Creek	Fall	10/15/2019	P6	Yellow Bullhead	Ameiurus natalis	82	.	1	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	124	32	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	123	33	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	122	30	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	116	25	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	115	19	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	115	23	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	112	24	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	112	23	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	112	24	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	111	18	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	109	21	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	107	19	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	106	17	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	106	21	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	104	20	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	104	15	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	104	17	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	103	17	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	103	17	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	102	19	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	102	16	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	101	15	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	100	15	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	97	.	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	96	.	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	94	.	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Bluegill	Lepomis macrochirus	93	.	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Common Carp	Cyprinus carpio	96-141	.	63	.	.
Tonto Creek	Fall	10/15/2019	P7	Gizzard Shad	Dorosoma cepedianum	108-129	.	6	.	.
Tonto Creek	Fall	10/15/2019	P7	Green Sunfish	Lepomis cyanellus	104	19	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Green Sunfish	Lepomis cyanellus	96	.	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Largemouth Bass	Micropterus salmoides	<100	.	3	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Tonto Creek	Fall	10/15/2019	P7	Largemouth Bass	Micropterus salmoides	214	131	1	22.09	Yes
Tonto Creek	Fall	10/15/2019	P7	Largemouth Bass	Micropterus salmoides	210	119	1	17.85	Yes
Tonto Creek	Fall	10/15/2019	P7	Largemouth Bass	Micropterus salmoides	193	83	1	21.79	Yes
Tonto Creek	Fall	10/15/2019	P7	Largemouth Bass	Micropterus salmoides	189	83	1	24.82	Yes
Tonto Creek	Fall	10/15/2019	P7	Largemouth Bass	Micropterus salmoides	183	70	1	19.77	Yes
Tonto Creek	Fall	10/15/2019	P7	Largemouth Bass	Micropterus salmoides	129	18	1	13.48	.
Tonto Creek	Fall	10/15/2019	P7	Largemouth Bass	Micropterus salmoides	127	19	1	13.99	.
Tonto Creek	Fall	10/15/2019	P7	Largemouth Bass	Micropterus salmoides	98	.	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Largemouth Bass	Micropterus salmoides	96	.	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Largemouth Bass	Micropterus salmoides	95	.	1	.	.
Tonto Creek	Fall	10/15/2019	P7	Smallmouth Bass	Micropterus dolomieu	185	72	1	20.38	Yes
Tonto Creek	Fall	10/15/2019	P8	Bluegill	Lepomis macrochirus	116	.	1	.	.
Tonto Creek	Fall	10/15/2019	P8	Bluegill	Lepomis macrochirus	115	.	1	.	.
Tonto Creek	Fall	10/15/2019	P8	Bluegill	Lepomis macrochirus	112	.	1	.	.
Tonto Creek	Fall	10/15/2019	P8	Bluegill	Lepomis macrochirus	111	.	1	.	.
Tonto Creek	Fall	10/15/2019	P8	Bluegill	Lepomis macrochirus	109	.	1	.	.
Tonto Creek	Fall	10/15/2019	P8	Bluegill	Lepomis macrochirus	84	.	1	.	.
Tonto Creek	Fall	10/15/2019	P8	Common Carp	Cyprinus carpio	114	.	1	.	.
Tonto Creek	Fall	10/15/2019	P8	Gizzard Shad	Dorosoma cepedianum	65-374	.	33	.	.
Tonto Creek	Fall	10/15/2019	P8	Green Sunfish	Lepomis cyanellus	87	.	1	.	.
Tonto Creek	Fall	10/15/2019	P8	Largemouth Bass	Micropterus salmoides	<100	.	3	.	.
Tonto Creek	Fall	10/15/2019	P8	Largemouth Bass	Micropterus salmoides	135	31	1	.	Yes
Tonto Creek	Fall	10/15/2019	P8	Yellow Bullhead	Ameiurus natalis	72	.	1	.	.
Tonto Creek	Fall	10/15/2019	P9	Bluegill	Lepomis macrochirus	115	25	1	.	.
Tonto Creek	Fall	10/15/2019	P9	Bluegill	Lepomis macrochirus	114	.	1	.	.
Tonto Creek	Fall	10/15/2019	P9	Bluegill	Lepomis macrochirus	108	23	1	.	.
Tonto Creek	Fall	10/15/2019	P9	Bluegill	Lepomis macrochirus	104	19	1	.	.
Tonto Creek	Fall	10/15/2019	P9	Bluegill	Lepomis macrochirus	95	.	1	.	.
Tonto Creek	Fall	10/15/2019	P9	Common Carp	Cyprinus carpio	114-139	.	2	.	.
Tonto Creek	Fall	10/15/2019	P9	Gizzard Shad	Dorosoma cepedianum	84-94	.	7	.	.
Tonto Creek	Fall	10/15/2019	P9	Largemouth Bass	Micropterus salmoides	84	.	1	.	.
Tonto Creek	Fall	10/15/2019	P9	Sonora Sucker	Catostomus insignis	110	14	1	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Tonto Creek	Fall	10/15/2019	P9	Sonora Sucker	Catostomus insignis	109	14	1	.	.
Tonto Creek	Fall	10/15/2019	P9	Yellow Bullhead	Ameiurus natalis	132	29	1	.	.
Tonto Creek	Fall	10/15/2019	P9	Yellow Bullhead	Ameiurus natalis	102	13	1	.	.
Tonto Creek	Fall	10/15/2019	P9	Yellow Bullhead	Ameiurus natalis	87	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Bluegill	Lepomis macrochirus	122	30	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Bluegill	Lepomis macrochirus	119	28	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Bluegill	Lepomis macrochirus	118	29	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Bluegill	Lepomis macrochirus	116	27	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Bluegill	Lepomis macrochirus	115	27	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Bluegill	Lepomis macrochirus	111	23	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Bluegill	Lepomis macrochirus	108	21	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Bluegill	Lepomis macrochirus	95	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Common Carp	Cyprinus carpio	154	30	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Common Carp	Cyprinus carpio	140	27	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Common Carp	Cyprinus carpio	140	39	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Common Carp	Cyprinus carpio	137	41	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Common Carp	Cyprinus carpio	126	31	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Common Carp	Cyprinus carpio	115	20	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Common Carp	Cyprinus carpio	114	24	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Common Carp	Cyprinus carpio	112	19	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Common Carp	Cyprinus carpio	112	21	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Common Carp	Cyprinus carpio	111	23	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Common Carp	Cyprinus carpio	110	19	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Common Carp	Cyprinus carpio	68	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Green Sunfish	Lepomis cyanellus	143	48	1	16.95	Yes
Tonto Creek	Fall	10/23/2019	P10	Green Sunfish	Lepomis cyanellus	112	23	1	14.6	Yes
Tonto Creek	Fall	10/23/2019	P10	Green Sunfish	Lepomis cyanellus	101	18	1	13.5	Yes
Tonto Creek	Fall	10/23/2019	P10	Green Sunfish	Lepomis cyanellus	99	17	1	12	.
Tonto Creek	Fall	10/23/2019	P10	Green Sunfish	Lepomis cyanellus	98	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Green Sunfish	Lepomis cyanellus	98	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Green Sunfish	Lepomis cyanellus	98	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Green Sunfish	Lepomis cyanellus	94	14	1	10.8	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Tonto Creek	Fall	10/23/2019	P10	Green Sunfish	Lepomis cyanellus	90	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Green Sunfish	Lepomis cyanellus	57	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	183	65	1	26.4	Yes
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	172	61	1	22.01	Yes
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	102	13	1	13.94	Yes
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	96	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	92	.	1	12.6	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	92	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	91	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	88	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	88	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	86	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	85	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	85	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	83	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	83	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	83	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	83	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	82	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	82	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	82	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	82	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	80	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	79	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	78	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	78	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	77	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	75	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	74	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	73	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	72	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	Micropterus salmoides	69	.	1	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Tonto Creek	Fall	10/23/2019	P10	Yellow Bullhead	Ameiurus natalis	103	15	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Yellow Bullhead	Ameiurus natalis	97	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Yellow Bullhead	Ameiurus natalis	94	.	1	.	.
Tonto Creek	Fall	10/23/2019	P10	Yellow Bullhead	Ameiurus natalis	93	.	1	.	.
Tonto Creek	Fall	10/23/2019	P11	Bluegill	Lepomis macrochirus	132	41	1	.	.
Tonto Creek	Fall	10/23/2019	P11	Bluegill	Lepomis macrochirus	117	31	1	.	.
Tonto Creek	Fall	10/23/2019	P11	Largemouth Bass	Micropterus salmoides	214	104	1	34.13	Yes
Tonto Creek	Fall	10/23/2019	P11	Largemouth Bass	Micropterus salmoides	208	98	1	31.33	Yes
Tonto Creek	Fall	10/23/2019	P11	Largemouth Bass	Micropterus salmoides	122	19	1	17.46	Yes
Tonto Creek	Fall	10/23/2019	P11	Largemouth Bass	Micropterus salmoides	96	.	1	.	.
Tonto Creek	Fall	10/23/2019	P11	Largemouth Bass	Micropterus salmoides	94	.	1	.	.
Tonto Creek	Fall	10/23/2019	P11	Largemouth Bass	Micropterus salmoides	89	.	1	.	.
Tonto Creek	Fall	10/23/2019	P11	Largemouth Bass	Micropterus salmoides	83	.	1	.	.
Tonto Creek	Fall	10/23/2019	P11	Largemouth Bass	Micropterus salmoides	81	.	1	.	.
Tonto Creek	Fall	10/23/2019	P11	Largemouth Bass	Micropterus salmoides	80	.	1	.	.
Tonto Creek	Fall	10/23/2019	P11	Largemouth Bass	Micropterus salmoides	79	.	1	.	.
Tonto Creek	Fall	10/23/2019	P11	Largemouth Bass	Micropterus salmoides	78	.	1	.	.
Tonto Creek	Fall	10/23/2019	P11	Largemouth Bass	Micropterus salmoides	75	.	1	.	.
Tonto Creek	Fall	10/23/2019	P12	Bluegill	Lepomis macrochirus	115	24	1	.	.
Tonto Creek	Fall	10/23/2019	P12	Bluegill	Lepomis macrochirus	108	21	1	.	.
Tonto Creek	Fall	10/23/2019	P12	Bluegill	Lepomis macrochirus	98	.	1	.	.
Tonto Creek	Fall	10/23/2019	P12	Common Carp	Cyprinus carpio	121	25	1	.	.
Tonto Creek	Fall	10/23/2019	P12	Common Carp	Cyprinus carpio	114	21	1	.	.
Tonto Creek	Fall	10/23/2019	P12	Common Carp	Cyprinus carpio	111	19	1	.	.
Tonto Creek	Fall	10/23/2019	P12	Green Sunfish	Lepomis cyanellus	107	21	1	14.65	Yes
Tonto Creek	Fall	10/23/2019	P12	Green Sunfish	Lepomis cyanellus	105	18	1	13.58	Yes
Tonto Creek	Fall	10/23/2019	P12	Green Sunfish	Lepomis cyanellus	80	.	1	.	.
Tonto Creek	Fall	10/23/2019	P12	Largemouth Bass	Micropterus salmoides	190	87	1	26.6	Yes
Tonto Creek	Fall	10/23/2019	P12	Largemouth Bass	Micropterus salmoides	167	47	1	25.68	Yes
Tonto Creek	Fall	10/23/2019	P12	Largemouth Bass	Micropterus salmoides	108	13	1	13.48	Yes
Tonto Creek	Fall	10/23/2019	P12	Largemouth Bass	Micropterus salmoides	92	.	1	.	.
Tonto Creek	Fall	10/23/2019	P12	Largemouth Bass	Micropterus salmoides	70	.	1	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Tonto Creek	Fall	10/23/2019	P12	Yellow Bullhead	Ameiurus natalis	132	25	1	14.68	Yes
Tonto Creek	Fall	10/23/2019	P12	Yellow Bullhead	Ameiurus natalis	122	22	1	13.43	Yes
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	140	57	1	11.19	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	131	43	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	131	43	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	130	38	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	129	38	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	128	42	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	123	38	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	122	35	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	121	30	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	120	28	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	118	31	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	118	27	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	118	27	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	118	32	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	118	32	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	117	31	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	117	29	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	116	30	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	116	25	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	115	27	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	115	27	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	113	22	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	113	27	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	112	27	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	112	27	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	111	22	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	111	24	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	111	24	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	110	27	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	109	20	1	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	105	20	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	100	18	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	94	.	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Bluegill	Lepomis macrochirus	.	.	13	.	.
Tonto Creek	Fall	10/23/2019	P13	Common Carp	Cyprinus carpio	164	68	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Common Carp	Cyprinus carpio	163	36	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Common Carp	Cyprinus carpio	162	63	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Green Sunfish	Lepomis cyanellus	138	46	1	17.16	Yes
Tonto Creek	Fall	10/23/2019	P13	Green Sunfish	Lepomis cyanellus	91	.	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Largemouth Bass	Micropterus salmoides	220	151	1	.	Yes
Tonto Creek	Fall	10/23/2019	P13	Largemouth Bass	Micropterus salmoides	192	99	1	.	Yes
Tonto Creek	Fall	10/23/2019	P13	Largemouth Bass	Micropterus salmoides	100	15	1	13.76	Yes
Tonto Creek	Fall	10/23/2019	P13	Largemouth Bass	Micropterus salmoides	93	.	1	.	.
Tonto Creek	Fall	10/23/2019	P13	Sonora Sucker	Catostomus insignis	132	25	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Black Crappie	Pomoxis nigromaculatus	82	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Black Crappie	Pomoxis nigromaculatus	80	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Bluegill	Lepomis macrochirus	140	50	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Bluegill	Lepomis macrochirus	134	40	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Bluegill	Lepomis macrochirus	132	50	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Bluegill	Lepomis macrochirus	128	40	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Bluegill	Lepomis macrochirus	127	40	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Bluegill	Lepomis macrochirus	126	30	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Bluegill	Lepomis macrochirus	124	40	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Bluegill	Lepomis macrochirus	118	30	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Bluegill	Lepomis macrochirus	115	30	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Bluegill	Lepomis macrochirus	111	30	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Bluegill	Lepomis macrochirus	99	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Gizzard Shad	Dorosoma cepedianum	.	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Gizzard Shad	Dorosoma cepedianum	.	.	31	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Green Sunfish	Lepomis cyanellus	104	20	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Green Sunfish	Lepomis cyanellus	101	20	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Green Sunfish	Lepomis cyanellus	98	.	1	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Roosevelt Lake	Fall	10/15/2019	EF1	Green Sunfish	Lepomis cyanellus	88	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	412	1130	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	361	630	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	310	410	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	219	130	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	214	150	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	212	130	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	209	110	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	200	120	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	198	120	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	195	90	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	186	80	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	186	80	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	180	70	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	176	90	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	174	60	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	172	60	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	172	60	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	164	60	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	154	40	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	93	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	80	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	75	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	Micropterus salmoides	72	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Threadfin Shad	Dorosoma petenense	.	.	41	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Tilapia spp.	Tilapia spp.	180	30	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Yellow Bass	Morone mississippiensis	99	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Yellow Bass	Morone mississippiensis	99	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Yellow Bass	Morone mississippiensis	98	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Yellow Bass	Morone mississippiensis	95	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Yellow Bass	Morone mississippiensis	90	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF2	Bluegill	Lepomis macrochirus	143	60	1	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Roosevelt Lake	Fall	10/15/2019	EF2	Common Carp	Cyprinus carpio	.	.	4	.	.
Roosevelt Lake	Fall	10/15/2019	EF2	Gizzard Shad	Dorosoma cepedianum	.	.	3	.	.
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	Micropterus salmoides	359	580	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	Micropterus salmoides	355	610	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	Micropterus salmoides	331	500	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	Micropterus salmoides	255	220	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	Micropterus salmoides	235	160	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	Micropterus salmoides	200	90	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	Micropterus salmoides	196	90	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	Micropterus salmoides	194	100	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	Micropterus salmoides	190	90	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	Micropterus salmoides	154	50	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF2	Threadfin Shad	Dorosoma petenense	.	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF2	Yellow Bass	Morone mississippiensis	98	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF2	Yellow Bass	Morone mississippiensis	95	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF2	Yellow Bass	Morone mississippiensis	92	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF2	Yellow Bass	Morone mississippiensis	91	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF2	Yellow Bass	Morone mississippiensis	90	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF2	Yellow Bass	Morone mississippiensis	76	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF3	Bluegill	Lepomis macrochirus	152	70	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF3	Common Carp	Cyprinus carpio	.	.	3	.	.
Roosevelt Lake	Fall	10/15/2019	EF3	Gizzard Shad	Dorosoma cepedianum	.	.	14	.	.
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	Micropterus salmoides	534	2620	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	Micropterus salmoides	370	650	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	Micropterus salmoides	358	590	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	Micropterus salmoides	236	200	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	Micropterus salmoides	228	160	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	Micropterus salmoides	228	180	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	Micropterus salmoides	220	140	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	Micropterus salmoides	219	130	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	Micropterus salmoides	211	120	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	Micropterus salmoides	204	130	1	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	Micropterus salmoides	195	100	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	Micropterus salmoides	191	100	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	Micropterus salmoides	182	110	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	Micropterus salmoides	164	70	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	Micropterus salmoides	158	60	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Bluegill	Lepomis macrochirus	134	40	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Bluegill	Lepomis macrochirus	130	30	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Bluegill	Lepomis macrochirus	124	40	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Bluegill	Lepomis macrochirus	118	30	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Bluegill	Lepomis macrochirus	112	30	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Bluegill	Lepomis macrochirus	104	20	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Common Carp	Cyprinus carpio	.	.	3	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Green Sunfish	Lepomis cyanellus	76	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	389	830	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	375	620	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	208	110	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	200	100	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	194	90	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	164	60	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	163	60	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	163	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	161	60	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	148	40	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	147	40	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	133	30	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	122	30	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	116	20	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	107	20	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	98	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	96	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	92	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	88	.	1	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	86	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	86	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	Micropterus salmoides	72	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Yellow Bass	Morone mississippiensis	91	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF5	Common Carp	Cyprinus carpio	.	.	2	.	.
Roosevelt Lake	Fall	10/15/2019	EF5	Gizzard Shad	Dorosoma cepedianum	.	.	63	.	.
Roosevelt Lake	Fall	10/15/2019	EF5	Threadfin Shad	Dorosoma petenense	.	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF5	Yellow Bass	Morone mississippiensis	258	270	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF6	Common Carp	Cyprinus carpio	.	.	3	.	.
Roosevelt Lake	Fall	10/15/2019	EF6	Gizzard Shad	Dorosoma cepedianum	.	.	24	.	.
Roosevelt Lake	Fall	10/15/2019	EF6	Largemouth Bass	Micropterus salmoides	198	100	1	.	Yes
Roosevelt Lake	Fall	10/15/2019	EF6	Largemouth Bass	Micropterus salmoides	135	30	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF6	Tilapia spp.	Tilapia spp.	138	50	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF6	Yellow Bass	Morone mississippiensis	104	10	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF6	Yellow Bass	Morone mississippiensis	91	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF6	Yellow Bass	Morone mississippiensis	82	.	1	.	.
Roosevelt Lake	Fall	10/15/2019	EF6	Yellow Bass	Morone mississippiensis	76	.	1	.	.
Tonto Creek Delta	Spring	4/28/2020	EF1	Buffalo spp.	Ictiobus spp.	.	.	1	.	.
Tonto Creek Delta	Spring	4/28/2020	EF1	Common Carp	Cyprinus carpio	.	.	4	.	.
Tonto Creek Delta	Spring	4/28/2020	EF1	Largemouth Bass	Micropterus salmoides	191	90	1	.	Yes
Tonto Creek Delta	Spring	4/28/2020	EF1	Largemouth Bass	Micropterus salmoides	351	520	1	.	Yes
Tonto Creek Delta	Spring	4/28/2020	EF1	Largemouth Bass	Micropterus salmoides	212	110	1	.	Yes
Tonto Creek Delta	Spring	4/28/2020	EF1	Largemouth Bass	Micropterus salmoides	360	550	1	.	Yes
Tonto Creek Delta	Spring	4/28/2020	EF2	Buffalo spp.	Ictiobus spp.	.	.	8	.	.
Tonto Creek Delta	Spring	4/28/2020	EF2	Common Carp	Cyprinus carpio	.	.	3	.	.
Tonto Creek Delta	Spring	4/28/2020	EF2	Gizzard Shad	Dorosoma cepedianum	.	.	10	.	.
Tonto Creek Delta	Spring	4/28/2020	EF2	Largemouth Bass	Micropterus salmoides	197	90	1	.	Yes
Tonto Creek Delta	Spring	4/28/2020	EF2	Largemouth Bass	Micropterus salmoides	396	640	1	.	Yes
Tonto Creek Delta	Spring	4/28/2020	EF2	Largemouth Bass	Micropterus salmoides	407	880	1	.	Yes
Tonto Creek Delta	Spring	4/28/2020	EF3	Common Carp	Cyprinus carpio	.	.	13	.	.
Tonto Creek Delta	Spring	4/28/2020	EF3	Gizzard Shad	Dorosoma cepedianum	.	.	5	.	.
Tonto Creek Delta	Spring	4/28/2020	EF4	Common Carp	Cyprinus carpio	.	.	7	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Tonto Creek Delta	Spring	4/28/2020	EF4	Gizzard Shad	Dorosoma cepedianum	.	.	9	.	.
Tonto Creek Delta	Spring	4/28/2020	EF5	Bluegill	Lepomis macrochirus	206	200	1	.	Yes
Tonto Creek Delta	Spring	4/28/2020	EF5	Bluegill	Lepomis macrochirus	192	200	1	.	Yes
Tonto Creek Delta	Spring	4/28/2020	EF5	Buffalo spp.	Ictiobus spp.	.	.	3	.	.
Tonto Creek Delta	Spring	4/28/2020	EF5	Common Carp	Cyprinus carpio	.	.	7	.	.
Tonto Creek Delta	Spring	4/28/2020	EF5	Gizzard Shad	Dorosoma cepedianum	.	.	7	.	.
Tonto Creek Delta	Spring	4/28/2020	EF5	Largemouth Bass	Micropterus salmoides	358	520	1	.	Yes
Tonto Creek Delta	Spring	4/28/2020	EF5	Largemouth Bass	Micropterus salmoides	245	230	1	.	Yes
Tonto Creek Delta	Spring	4/28/2020	EF5	Largemouth Bass	Micropterus salmoides	523	1960	1	.	Yes
Tonto Creek Delta	Spring	4/28/2020	EF5	Largemouth Bass	Micropterus salmoides	359	520	1	.	Yes
Tonto Creek Delta	Spring	4/28/2020	EF5	Largemouth Bass	Micropterus salmoides	390	650	1	.	Yes
Tonto Creek Delta	Spring	4/28/2020	EF5	Largemouth Bass	Micropterus salmoides	475	1530	1	.	Yes
Tonto Creek Delta	Spring	4/28/2020	EF5	Largemouth Bass	Micropterus salmoides	390	700	1	.	Yes
Tonto Creek Delta	Spring	4/28/2020	EF5	Largemouth Bass	Micropterus salmoides	440	1070	1	.	Yes
Tonto Creek Delta	Spring	4/28/2020	EF5	Largemouth Bass	Micropterus salmoides	405	860	1	.	Yes
Tonto Creek Delta	Spring	4/28/2020	EF6	Buffalo spp.	Ictiobus spp.	.	.	2	.	.
Tonto Creek Delta	Spring	4/28/2020	EF6	Common Carp	Cyprinus carpio	.	.	1	.	.
Tonto Creek Delta	Spring	4/28/2020	EF6	Gizzard Shad	Dorosoma cepedianum	.	.	5	.	.
Tonto Creek Delta	Spring	4/28/2020	EF6	Largemouth Bass	Micropterus salmoides	255	230	1	.	Yes
Roosevelt Lake	Spring	4/28/2020	EF7	Buffalo spp.	Ictiobus spp.	.	.	1	.	.
Roosevelt Lake	Spring	4/28/2020	EF7	Common Carp	Cyprinus carpio	.	.	3	.	.
Roosevelt Lake	Spring	4/28/2020	EF8	Buffalo spp.	Ictiobus spp.	.	.	1	.	.
Roosevelt Lake	Spring	4/28/2020	EF8	Common Carp	Cyprinus carpio	.	.	4	.	.
Roosevelt Lake	Spring	4/28/2020	EF8	Largemouth Bass	Micropterus salmoides	251	180	1	.	Yes
Roosevelt Lake	Spring	4/28/2020	EF8	Largemouth Bass	Micropterus salmoides	270	230	1	.	Yes
Roosevelt Lake	Spring	4/28/2020	EF8	Largemouth Bass	Micropterus salmoides	263	210	1	.	Yes
Roosevelt Lake	Spring	4/28/2020	EF8	Largemouth Bass	Micropterus salmoides	231	160	1	.	Yes
Roosevelt Lake	Spring	4/28/2020	EF8	Largemouth Bass	Micropterus salmoides	215	130	1	.	Yes
Roosevelt Lake	Spring	4/28/2020	EF8	Largemouth Bass	Micropterus salmoides	327	350	1	.	Yes
Roosevelt Lake	Spring	4/28/2020	EF9	Black Crappie	Pomoxis nigromaculatus	275	350	1	.	Yes
Roosevelt Lake	Spring	4/28/2020	EF9	Buffalo spp.	Ictiobus spp.	.	.	6	.	.
Roosevelt Lake	Spring	4/28/2020	EF9	Common Carp	Cyprinus carpio	.	.	3	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Roosevelt Lake	Spring	4/28/2020	EF9	Gizzard Shad	Dorosoma cepedianum	.	.	3	.	.
Roosevelt Lake	Spring	4/28/2020	EF9	Largemouth Bass	Micropterus salmoides	371	610	1	.	Yes
Roosevelt Lake	Spring	4/28/2020	EF10	Buffalo spp.	Ictiobus spp.	.	.	6	.	.
Roosevelt Lake	Spring	4/28/2020	EF10	Common Carp	Cyprinus carpio	.	.	8	.	.
Roosevelt Lake	Spring	4/28/2020	EF10	Gizzard Shad	Dorosoma cepedianum	.	.	13	.	.
Roosevelt Lake	Spring	4/28/2020	EF10	Largemouth Bass	Micropterus salmoides	266	200	1	.	Yes
Roosevelt Lake	Spring	4/28/2020	EF10	Largemouth Bass	Micropterus salmoides	186	100	1	.	Yes
Roosevelt Lake	Spring	4/28/2020	EF11	Buffalo spp.	Ictiobus spp.	.	.	2	.	.
Roosevelt Lake	Spring	4/28/2020	EF11	Common Carp	Cyprinus carpio	.	.	7	.	.
Roosevelt Lake	Spring	4/28/2020	EF11	Gizzard Shad	Dorosoma cepedianum	.	.	5	.	.
Roosevelt Lake	Spring	4/28/2020	EF11	Largemouth Bass	Micropterus salmoides	210	130	1	.	Yes
Roosevelt Lake	Spring	4/28/2020	EF12	Black Crappie	Pomoxis nigromaculatus	328	440	1	.	Yes
Roosevelt Lake	Spring	4/28/2020	EF12	Buffalo spp.	Ictiobus spp.	.	.	4	.	.
Roosevelt Lake	Spring	4/28/2020	EF12	Common Carp	Cyprinus carpio	.	.	5	.	.
Roosevelt Lake	Spring	4/28/2020	EF12	Gizzard Shad	Dorosoma cepedianum	.	.	11	.	.
Roosevelt Lake	Spring	4/28/2020	EF12	Largemouth Bass	Micropterus salmoides	385	820	1	.	Yes
Roosevelt Lake	Spring	4/28/2020	EF12	Largemouth Bass	Micropterus salmoides	372	590	1	.	Yes
Roosevelt Lake	Spring	4/28/2020	EF13	Buffalo spp.	Ictiobus spp.	.	.	2	.	.
Roosevelt Lake	Spring	4/28/2020	EF13	Common Carp	Cyprinus carpio	.	.	3	.	.
Roosevelt Lake	Spring	4/28/2020	EF13	Gizzard Shad	Dorosoma cepedianum	.	.	5	.	.
Roosevelt Lake	Spring	4/28/2020	EF13	Largemouth Bass	Micropterus salmoides	240	180	1	.	Yes
Roosevelt Lake	Spring	4/28/2020	EF14	Common Carp	Cyprinus carpio	.	.	4	.	.
Roosevelt Lake	Spring	4/28/2020	EF14	Gizzard Shad	Dorosoma cepedianum	.	.	3	.	.
Roosevelt Lake	Spring	4/28/2020	EF14	Largemouth Bass	Micropterus salmoides	255	200	1	.	Yes
Roosevelt Lake	Spring	4/28/2020	EF14	Largemouth Bass	Micropterus salmoides	228	150	1	.	Yes
Roosevelt Lake	Spring	4/28/2020	EF14	Largemouth Bass	Micropterus salmoides	102	20	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF1	Bluegill	Lepomis macrochirus	159	80	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF1	Common Carp	Cyprinus carpio	.	.	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF1	Gizzard Shad	Dorosoma cepedianum	.	.	3	.	.
Tonto Creek Delta	Summer	7/28/2020	EF1	Largemouth Bass	Micropterus salmoides	133	30	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF1	Threadfin Shad	Dorosoma petenense	.	.	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF1	Yellow Bass	Morone mississippiensis	70	.	1	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Tonto Creek Delta	Summer	7/28/2020	EF2	Common Carp	Cyprinus carpio	.	.	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF2	Gizzard Shad	Dorosoma cepedianum	.	.	9	.	.
Tonto Creek Delta	Summer	7/28/2020	EF2	Largemouth Bass	Micropterus salmoides	124	30	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF3	Common Carp	Cyprinus carpio	.	.	4	.	.
Tonto Creek Delta	Summer	7/28/2020	EF3	Gizzard Shad	Dorosoma cepedianum	.	.	5	.	.
Tonto Creek Delta	Summer	7/28/2020	EF3	Largemouth Bass	Micropterus salmoides	241	240	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF3	Largemouth Bass	Micropterus salmoides	304	400	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF4	Bluegill	Lepomis macrochirus	170	90	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF4	Largemouth Bass	Micropterus salmoides	79	.	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF4	Largemouth Bass	Micropterus salmoides	159	30	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF4	Largemouth Bass	Micropterus salmoides	164	40	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF4	Largemouth Bass	Micropterus salmoides	234	170	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF4	Largemouth Bass	Micropterus salmoides	245	150	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF4	Largemouth Bass	Micropterus salmoides	327	510	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF5	Largemouth Bass	Micropterus salmoides	76	.	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF6	Gizzard Shad	Dorosoma cepedianum	.	.	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF6	Largemouth Bass	Micropterus salmoides	89	.	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF6	Largemouth Bass	Micropterus salmoides	91	.	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF7	Gizzard Shad	Dorosoma cepedianum	.	.	6	.	.
Tonto Creek Delta	Summer	7/28/2020	EF7	Largemouth Bass	Micropterus salmoides	97	.	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF7	Largemouth Bass	Micropterus salmoides	384	840	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF8	Common Carp	Cyprinus carpio	.	.	2	.	.
Tonto Creek Delta	Summer	7/28/2020	EF8	Gizzard Shad	Dorosoma cepedianum	.	.	7	.	.
Tonto Creek Delta	Summer	7/28/2020	EF8	Goldfish	Carassius auratus	.	.	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF8	Largemouth Bass	Micropterus salmoides	469	1710	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF9	Gizzard Shad	Dorosoma cepedianum	.	.	8	.	.
Tonto Creek Delta	Summer	7/28/2020	EF9	Largemouth Bass	Micropterus salmoides	64	.	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF9	Largemouth Bass	Micropterus salmoides	85	.	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF9	Largemouth Bass	Micropterus salmoides	116	.	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF10	Common Carp	Cyprinus carpio	.	.	4	.	.
Tonto Creek Delta	Summer	7/28/2020	EF10	Gizzard Shad	Dorosoma cepedianum	.	.	15	.	.
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	Micropterus salmoides	108	10	1	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	Micropterus salmoides	129	20	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	Micropterus salmoides	140	40	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	Micropterus salmoides	142	40	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	Micropterus salmoides	143	20	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	Micropterus salmoides	147	40	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	Micropterus salmoides	148	40	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	Micropterus salmoides	150	50	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	Micropterus salmoides	155	40	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	Micropterus salmoides	155	50	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	Micropterus salmoides	161	50	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	Micropterus salmoides	161	50	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	Micropterus salmoides	164	50	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	Micropterus salmoides	166	60	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	Micropterus salmoides	172	70	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	Micropterus salmoides	174	60	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	Micropterus salmoides	273	300	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	Micropterus salmoides	310	430	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF11	Common Carp	Cyprinus carpio	.	.	18	.	.
Tonto Creek Delta	Summer	7/28/2020	EF11	Gizzard Shad	Dorosoma cepedianum	.	.	15	.	.
Tonto Creek Delta	Summer	7/28/2020	EF11	Largemouth Bass	Micropterus salmoides	248	210	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF11	Largemouth Bass	Micropterus salmoides	285	310	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF11	Largemouth Bass	Micropterus salmoides	299	330	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF11	Largemouth Bass	Micropterus salmoides	306	410	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF11	Largemouth Bass	Micropterus salmoides	306	400	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF11	Largemouth Bass	Micropterus salmoides	327	420	1	.	Yes
Tonto Creek Delta	Summer	7/28/2020	EF11	Sonora Sucker	Catostomus insignis	291	250	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF11	Sonora Sucker	Catostomus insignis	277	230	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF11	Sonora Sucker	Catostomus insignis	287	270	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF11	Sonora Sucker	Catostomus insignis	272	230	1	.	.
Tonto Creek Delta	Summer	7/28/2020	EF11	Yellow Bass	Morone mississippiensis	292	410	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF12	Buffalo spp.	Ictiobus spp.	.	.	2	.	.
Roosevelt Lake	Summer	7/29/2020	EF12	Common Carp	Cyprinus carpio	.	.	8	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Roosevelt Lake	Summer	7/29/2020	EF12	Gizzard Shad	Dorosoma cepedianum	.	.	3	.	.
Roosevelt Lake	Summer	7/29/2020	EF12	Largemouth Bass	Micropterus salmoides	70	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF13	Bluegill	Lepomis macrochirus	130	50	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF13	Buffalo spp.	Ictiobus spp.	.	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF13	Common Carp	Cyprinus carpio	.	.	9	.	.
Roosevelt Lake	Summer	7/29/2020	EF13	Gizzard Shad	Dorosoma cepedianum	.	.	3	.	.
Roosevelt Lake	Summer	7/29/2020	EF13	Largemouth Bass	Micropterus salmoides	245	200	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF14	Common Carp	Cyprinus carpio	.	.	13	.	.
Roosevelt Lake	Summer	7/29/2020	EF14	Gizzard Shad	Dorosoma cepedianum	.	.	2	.	.
Roosevelt Lake	Summer	7/29/2020	EF14	Largemouth Bass	Micropterus salmoides	122	30	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF14	Largemouth Bass	Micropterus salmoides	157	90	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF15	Bluegill	Lepomis macrochirus	185	140	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF15	Bluegill	Lepomis macrochirus	122	30	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF15	Common Carp	Cyprinus carpio	.	.	8	.	.
Roosevelt Lake	Summer	7/29/2020	EF15	Gizzard Shad	Dorosoma cepedianum	.	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF15	Largemouth Bass	Micropterus salmoides	141	30	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF15	Largemouth Bass	Micropterus salmoides	184	80	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF15	Largemouth Bass	Micropterus salmoides	246	230	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF15	Largemouth Bass	Micropterus salmoides	250	180	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF15	Largemouth Bass	Micropterus salmoides	292	340	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF16	Bluegill	Lepomis macrochirus	202	170	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF16	Bluegill	Lepomis macrochirus	131	50	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF16	Bluegill	Lepomis macrochirus	101	20	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF16	Common Carp	Cyprinus carpio	.	.	3	.	.
Roosevelt Lake	Summer	7/29/2020	EF16	Gizzard Shad	Dorosoma cepedianum	.	.	2	.	.
Roosevelt Lake	Summer	7/29/2020	EF16	Largemouth Bass	Micropterus salmoides	154	50	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF16	Largemouth Bass	Micropterus salmoides	241	180	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF16	Largemouth Bass	Micropterus salmoides	332	620	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Bluegill	Lepomis macrochirus	156	80	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Bluegill	Lepomis macrochirus	112	30	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Bluegill	Lepomis macrochirus	190	150	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Bluegill	Lepomis macrochirus	174	120	1	.	Yes

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Roosevelt Lake	Summer	7/29/2020	EF17	Bluegill	Lepomis macrochirus	167	100	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Bluegill	Lepomis macrochirus	170	120	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Bluegill	Lepomis macrochirus	120	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Common Carp	Cyprinus carpio	.	.	3	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Green Sunfish	Lepomis cyanellus	86	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	70	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	73	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	73	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	75	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	76	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	76	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	76	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	78	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	78	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	80	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	81	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	81	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	81	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	81	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	81	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	82	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	82	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	83	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	85	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	85	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	86	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	87	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	87	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	88	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	88	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	89	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	90	.	1	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	91	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	92	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	93	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	95	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	100	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	101	20	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	101	10	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	105	10	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	109	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	116	30	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	118	10	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	119	30	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	120	20	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	123	20	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	123	40	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	124	20	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	125	20	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	125	30	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	125	30	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	126	20	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	127	30	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	129	20	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	129	20	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	130	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	130	30	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	130	30	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	131	40	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	132	40	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	133	30	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	134	30	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	134	30	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	136	30	1	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	137	30	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	139	40	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	140	20	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	141	40	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	144	60	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	145	40	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	146	50	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	149	50	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	150	40	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	150	60	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	151	50	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	151	40	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	153	60	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	153	50	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	155	70	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	155	70	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	156	50	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	158	60	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	159	60	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	166	60	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	166	60	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	166	70	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	169	70	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	171	60	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	175	80	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	180	80	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	180	90	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	201	90	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	219	130	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	224	160	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	225	160	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	239	200	1	.	Yes

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	241	180	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	241	180	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	243	180	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	282	380	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	285	320	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	292	340	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	Micropterus salmoides	324	450	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	74	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	91	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	82	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	70	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	68	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	75	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	69	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	68	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	60	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	74	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	66	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	55	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	71	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	73	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	85	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	74	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	68	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	79	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	57	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	77	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	50	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	72	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	75	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	64	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	71	.	1	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	75	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	69	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	74	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	55	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	83	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	83	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	75	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	89	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Yellow Bass	Morone mississippiensis	85	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Bluegill	Lepomis macrochirus	115	40	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Common Carp	Cyprinus carpio	.	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	62	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	69	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	75	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	75	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	75	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	76	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	77	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	80	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	81	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	82	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	84	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	85	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	86	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	86	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	91	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	93	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	94	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	95	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	95	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	97	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	98	.	1	.	.

Waterbody	Season	Collection Date	Site	Common Name	Species	Length (mm)	Weight (g)	Count	Gape Size (mm)	Stomach Sample
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	98	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	98	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	99	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	101	10	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	106	20	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	111	10	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	114	20	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	115	20	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	115	20	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	120	20	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	122	20	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	123	30	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	125	20	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	130	20	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	136	40	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	139	40	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	141	30	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	144	50	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	144	30	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	144	40	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	145	40	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	151	40	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	156	50	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	159	50	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	165	60	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	171	60	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	200	110	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	218	130	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	Micropterus salmoides	450	1340	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF18	Yellow Bass	Morone mississippiensis	70	.	1	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Yellow Bass	Morone mississippiensis	185	90	1	.	Yes
Roosevelt Lake	Summer	7/29/2020	EF18	Yellow Bass	Morone mississippiensis	71	.	1	.	.

Appendix B Stomach Content Data

Table B-1. Stomach content analysis for samples collected from Tonto Creek and Roosevelt Lake in October 2019.

Waterbody	Season	Collection Date	Site	Common Name	Length (mm)	Weight (g)	No. Particles Counted	% Fish	% Invertebrate	% Snake	% Organic Matter	% Other	% Empty
Tonto Creek	Fall	10/15/2019	P1	Green Sunfish	164	70	9	.	100%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P1	Green Sunfish	128		26	.	100%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	155	33	31	.	84%	.	16%	.	.
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	150	32	112	.	100%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	125	18	36	.	100%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	101		53	.	100%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	95		21	.	100%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	85		27	.	100%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	76		8	.	88%	.	13%	.	.
Tonto Creek	Fall	10/15/2019	P1	Largemouth Bass	76	0	13	.	100%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P1	Yellow Bullhead	165	54	6	17%	83%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P1	Yellow Bullhead	121	21	7	.	86%	.	14%	.	.
Tonto Creek	Fall	10/15/2019	P2	Largemouth Bass	199	99	1	100%	0%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P2	Largemouth Bass	178	55	22	.	100%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P2	Largemouth Bass	168	49	2	.	100%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P2	Largemouth Bass	163	43	9	11%	89%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P2	Largemouth Bass	152	34	3	.	100%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P2	Yellow Bullhead	140	32	3	.	100%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P2	Yellow Bullhead	134	28	1	.	0%	.	100%	.	.
Tonto Creek	Fall	10/15/2019	P2	Yellow Bullhead	123	23	5	.	100%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P3	Largemouth Bass	196	62	.	.	0%	.	.	.	100%
Tonto Creek	Fall	10/15/2019	P3	Largemouth Bass	113	19	14	.	100%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P3	Largemouth Bass	104	13	15	.	100%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P5	Channel Catfish	519		3	.	67%	.	33%	.	.
Tonto Creek	Fall	10/15/2019	P5	Yellow Bullhead	130	23	1	.	100%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P6	Largemouth Bass	191	87	1	100%	0%	.	.	.	.

Waterbody	Season	Collection Date	Site	Common Name	Length (mm)	Weight (g)	No. Particles Counted	% Fish	% Invertebrate	% Snake	% Organic Matter	% Other	% Empty
Tonto Creek	Fall	10/15/2019	P6	Largemouth Bass	183	73	1	100%	0%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P6	Largemouth Bass	160	47	17	.	94%	.	6%	.	.
Tonto Creek	Fall	10/15/2019	P6	Largemouth Bass	148	33	8	.	100%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P7	Largemouth Bass	214	104	4	.	75%	.	25%	.	.
Tonto Creek	Fall	10/15/2019	P7	Largemouth Bass	210	119	.	.	0%	.	.	.	100%
Tonto Creek	Fall	10/15/2019	P7	Largemouth Bass	193	83	5	20%	40%	.	40%	.	.
Tonto Creek	Fall	10/15/2019	P7	Largemouth Bass	189	83	1	100%	0%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P7	Largemouth Bass	183	70	5	.	100%	.	.	.	.
Tonto Creek	Fall	10/15/2019	P7	Smallmouth Bass	185	72	.	.	0%	.	.	.	100%
Tonto Creek	Fall	10/15/2019	P8	Largemouth Bass	135	31	2	50%	50%	.	.	.	.
Tonto Creek	Fall	10/23/2019	P10	Green Sunfish	143	48	8	.	87%	.	13%	.	.
Tonto Creek	Fall	10/23/2019	P10	Green Sunfish	112	23	1	.	100%	.	.	.	.
Tonto Creek	Fall	10/23/2019	P10	Green Sunfish	101	18	8	.	100%	.	.	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	183	65	.	.	.	.	.	.	100%
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	172	61	5	.	100%	.	.	.	.
Tonto Creek	Fall	10/23/2019	P10	Largemouth Bass	102	13	30	.	100%	.	.	.	.
Tonto Creek	Fall	10/23/2019	P11	Largemouth Bass	214	131	5	.	60%	.	40%	.	.
Tonto Creek	Fall	10/23/2019	P11	Largemouth Bass	208	98	7	.	100%	.	.	.	.
Tonto Creek	Fall	10/23/2019	P11	Largemouth Bass	122	19	1	.	.	.	100%	.	.
Tonto Creek	Fall	10/23/2019	P12	Green Sunfish	107	21	7	.	100%	.	.	.	.
Tonto Creek	Fall	10/23/2019	P12	Green Sunfish	105	18	1	.	100%	.	.	.	.
Tonto Creek	Fall	10/23/2019	P12	Largemouth Bass	190	87	1	.	100%	.	.	.	.
Tonto Creek	Fall	10/23/2019	P12	Largemouth Bass	167	47	13	.	100%	.	.	.	.
Tonto Creek	Fall	10/23/2019	P12	Largemouth Bass	108	13	25	.	100%	.	.	.	.
Tonto Creek	Fall	10/23/2019	P12	Yellow Bullhead	132	25	3	.	100%	.	.	.	.
Tonto Creek	Fall	10/23/2019	P12	Yellow Bullhead	122	22	5	.	80%	.	20%	.	.
Tonto Creek	Fall	10/23/2019	P13	Green Sunfish	138	46	16	.	100%	.	.	.	.
Tonto Creek	Fall	10/23/2019	P13	Largemouth Bass	220	151	15	7%	93%	.	.	.	.
Tonto Creek	Fall	10/23/2019	P13	Largemouth Bass	192	99	1	.	100%	.	.	.	.
Tonto Creek	Fall	10/23/2019	P13	Largemouth Bass	100	15	5	.	100%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	412	1130	6	33%	50%	.	17%	.	.

Waterbody	Season	Collection Date	Site	Common Name	Length (mm)	Weight (g)	No. Particles Counted	% Fish	% Invertebrate	% Snake	% Organic Matter	% Other	% Empty
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	361	630	2	.	100%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	310	410	5	80%	20%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	219	130	5	60%	40%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	214	150	.	.	0%	.	.	.	100%
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	212	130	3	67%	0%	.	33%	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	204	110	3	67%	33%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	200	120	5	60%	20%	.	20%	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	198	120	11	91%	0%	.	9%	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	195	90	3	67%	33%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	186	80	5	80%	0%	.	20%	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	186	80	1	100%	0%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	180	70	7	100%	0%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	176	90	4	50%	0%	.	50%	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	174	60	2	100%	0%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF1	Largemouth Bass	172	60	3	100%	0%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	359	580	.	.	0%	.	.	.	100%
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	355	610	2	100%	0%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	331	500	1	100%	0%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	235	160	1	100%	0%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	225	220	.	.	0%	.	.	.	100%
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	200	90	2	100%	0%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	196	90	4	100%	0%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	194	100	9	100%	0%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	190	90	6	83%	17%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF2	Largemouth Bass	154	50	3	67%	0%	.	33%	.	.
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	534	2620	.	.	0%	.	.	.	100%
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	370	650	.	.	0%	.	.	.	100%
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	358	590	.	.	0%	.	.	.	100%
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	228	180	3	33%	67%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	228	160	8	88%	13%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	219	130	4	100%	0%	.	.	.	.

Waterbody	Season	Collection Date	Site	Common Name	Length (mm)	Weight (g)	No. Particles Counted	% Fish	% Invertebrate	% Snake	% Organic Matter	% Other	% Empty
Roosevelt Lake	Fall	10/15/2019	EF3	Largemouth Bass	195	100	3	100%	0%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	389	830	1	.	100%	.	.	.	.
Roosevelt Lake	Fall	10/15/2019	EF4	Largemouth Bass	375	620	.	.	0%	.	.	.	100%
Roosevelt Lake	Fall	10/15/2019	EF5	Yellow Bass	258	270	7	71%	0%	.	29%	.	.
Roosevelt Lake	Fall	10/15/2019	EF6	Largemouth Bass	198	100	2	100%	0%	.	.	.	.
Tonto Creek Delta	Spring	4/28/2020	EF1	Largemouth Bass	360	550	3	33%	33%	.	33%	.	.
Tonto Creek Delta	Spring	4/28/2020	EF1	Largemouth Bass	351	520	.	.	0%	.	.	.	100%
Tonto Creek Delta	Spring	4/28/2020	EF1	Largemouth Bass	212	110	5	100%	0%	.	.	.	.
Tonto Creek Delta	Spring	4/28/2020	EF1	Largemouth Bass	191	90	16	75%	0%	.	25%	.	.
Tonto Creek Delta	Spring	4/28/2020	EF2	Largemouth Bass	407	880	2	.	0%	.	100%	.	.
Tonto Creek Delta	Spring	4/28/2020	EF2	Largemouth Bass	396	640	7	14%	14%	.	71%	.	.
Tonto Creek Delta	Spring	4/28/2020	EF2	Largemouth Bass	197	90	3	100%	0%	.	.	.	.
Tonto Creek Delta	Spring	4/28/2020	EF5	Bluegill	206	200	3	.	0%	.	100%	.	.
Tonto Creek Delta	Spring	4/28/2020	EF5	Bluegill	192	200	6	.	0%	.	100%	.	.
Tonto Creek Delta	Spring	4/28/2020	EF5	Largemouth Bass	523	1960	9	33%	0%	.	56%	11%	.
Tonto Creek Delta	Spring	4/28/2020	EF5	Largemouth Bass	475	1530	3	33%	33%	.	33%	.	.
Tonto Creek Delta	Spring	4/28/2020	EF5	Largemouth Bass	440	1070	6	17%	0%	.	83%	.	.
Tonto Creek Delta	Spring	4/28/2020	EF5	Largemouth Bass	405	860	2	50%	0%	.	50%	.	.
Tonto Creek Delta	Spring	4/28/2020	EF5	Largemouth Bass	390	650	2	100%	0%	.	.	.	.
Tonto Creek Delta	Spring	4/28/2020	EF5	Largemouth Bass	390	700	3	33%	0%	.	67%	.	.
Tonto Creek Delta	Spring	4/28/2020	EF5	Largemouth Bass	359	520	.	.	0%	.	.	.	100%
Tonto Creek Delta	Spring	4/28/2020	EF5	Largemouth Bass	358	520	5	.	60%	.	40%	.	.
Tonto Creek Delta	Spring	4/28/2020	EF5	Largemouth Bass	245	230	5	40%	0%	.	60%	.	.
Tonto Creek Delta	Spring	4/28/2020	EF6	Largemouth Bass	255	230	7	100%	0%	.	.	.	.
Roosevelt Lake	Spring	4/28/2020	EF8	Largemouth Bass	327	350	21	100%	0%	.	.	.	.
Roosevelt Lake	Spring	4/28/2020	EF8	Largemouth Bass	270	230	5	20%	0%	.	80%	.	.
Roosevelt Lake	Spring	4/28/2020	EF8	Largemouth Bass	263	210	13	85%	8%	.	8%	.	.
Roosevelt Lake	Spring	4/28/2020	EF8	Largemouth Bass	251	180	12	100%	0%	.	.	.	.
Roosevelt Lake	Spring	4/28/2020	EF8	Largemouth Bass	231	160	9	56%	11%	.	33%	.	.
Roosevelt Lake	Spring	4/28/2020	EF8	Largemouth Bass	215	130	4	25%	0%	.	75%	.	.
Roosevelt Lake	Spring	4/28/2020	EF9	Black Crappie	275	350	7	14%	86%	.	.	.	.

Waterbody	Season	Collection Date	Site	Common Name	Length (mm)	Weight (g)	No. Particles Counted	% Fish	% Invertebrate	% Snake	% Organic Matter	% Other	% Empty
Roosevelt Lake	Spring	4/28/2020	EF9	Largemouth Bass	371	610	3	33%	67%	.	.	.	.
Roosevelt Lake	Spring	4/28/2020	EF10	Largemouth Bass	266	200	7	100%	0%	.	.	.	.
Roosevelt Lake	Spring	4/28/2020	EF10	Largemouth Bass	186	100	6	83%	17%	.	.	.	.
Roosevelt Lake	Spring	4/28/2020	EF11	Largemouth Bass	210	130	7	86%	0%	.	14%	.	.
Roosevelt Lake	Spring	4/28/2020	EF12	Black Crappie	328	440	7	.	29%	.	71%	.	.
Roosevelt Lake	Spring	4/28/2020	EF12	Largemouth Bass	385	820	6	100%	0%	.	.	.	.
Roosevelt Lake	Spring	4/28/2020	EF12	Largemouth Bass	372	590	.	.	0%	.	.	.	.
Roosevelt Lake	Spring	4/28/2020	EF13	Largemouth Bass	240	180	7	100%	0%	.	.	.	.
Roosevelt Lake	Spring	4/28/2020	EF14	Largemouth Bass	255	200	9	100%	0%	.	.	.	.
Roosevelt Lake	Spring	4/28/2020	EF14	Largemouth Bass	228	150	6	100%	0%	.	.	.	.
Tonto Creek Delta	Summer	7/28/2020	EF1	Bluegill	159	80	12	.	75%	.	25%	.	.
Tonto Creek Delta	Summer	7/28/2020	EF1	Largemouth Bass	133	30	2	100%	0%	.	.	.	.
Tonto Creek Delta	Summer	7/28/2020	EF2	Largemouth Bass	124	30	1	100%	0%	.	.	.	.
Tonto Creek Delta	Summer	7/28/2020	EF3	Largemouth Bass	304	400	3	100%	0%	.	.	.	.
Tonto Creek Delta	Summer	7/28/2020	EF3	Largemouth Bass	241	240	1	100%	0%	.	.	.	.
Tonto Creek Delta	Summer	7/28/2020	EF4	Bluegill	170	90	71	.	99%	.	1%	.	.
Tonto Creek Delta	Summer	7/28/2020	EF4	Largemouth Bass	327	510	13	46%	0%	.	54%	.	.
Tonto Creek Delta	Summer	7/28/2020	EF4	Largemouth Bass	245	150	3	33%	0%	.	67%	.	.
Tonto Creek Delta	Summer	7/28/2020	EF4	Largemouth Bass	234	170	5	80%	0%	.	20%	.	.
Tonto Creek Delta	Summer	7/28/2020	EF4	Largemouth Bass	164	40	.	.	0%	.	.	.	100%
Tonto Creek Delta	Summer	7/28/2020	EF4	Largemouth Bass	159	30	5	20%	20%	.	60%	.	.
Tonto Creek Delta	Summer	7/28/2020	EF7	Largemouth Bass	384	840	1	100%	0%	.	.	.	.
Tonto Creek Delta	Summer	7/28/2020	EF8	Largemouth Bass	469	1710	4	50%	0%	.	50%	.	.
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	310	430	1	100%	0%	.	.	.	.
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	273	300	2	.	0%	.	100%	.	.
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	174	60	.	.	0%	.	.	.	100%
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	172	70	2	50%	0%	.	50%	.	.
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	166	60	2	50%	0%	.	50%	.	.
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	164	50	4	25%	0%	.	50%	25%	.
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	161	50	2	50%	50%	.	.	.	.
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	161	50	4	.	0%	.	100%	.	.

Waterbody	Season	Collection Date	Site	Common Name	Length (mm)	Weight (g)	No. Particles Counted	% Fish	% Invertebrate	% Snake	% Organic Matter	% Other	% Empty
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	155	50	7	29%	0%	.	71%	.	.
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	155	40	4	.	0%	.	100%	.	.
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	150	50	1	100%	0%	.	.	.	.
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	148	40	2	50%	0%	.	50%	.	.
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	147	40	1	100%	0%	.	.	.	.
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	142	40	.	.	0%	.	.	.	100%
Tonto Creek Delta	Summer	7/28/2020	EF10	Largemouth Bass	140	40	.	.	0%	.	.	.	100%
Tonto Creek Delta	Summer	7/28/2020	EF11	Largemouth Bass	327	420	.	.	0%	.	.	.	100%
Tonto Creek Delta	Summer	7/28/2020	EF11	Largemouth Bass	306	410	.	.	0%	.	.	.	100%
Tonto Creek Delta	Summer	7/28/2020	EF11	Largemouth Bass	306	400	7	43%	0%	.	57%	.	.
Tonto Creek Delta	Summer	7/28/2020	EF11	Largemouth Bass	299	330	.	.	0%	.	.	.	100%
Tonto Creek Delta	Summer	7/28/2020	EF11	Largemouth Bass	285	310	2	.	50%	.	.	50%	.
Tonto Creek Delta	Summer	7/28/2020	EF11	Largemouth Bass	248	210	4	25%	25%	.	50%	.	.
Tonto Creek Delta	Summer	7/28/2020	EF11	Yellow Bass	292	410	10	10%	0%	.	90%	.	.
Roosevelt Lake	Summer	7/29/2020	EF13	Largemouth Bass	245	200	3	67%	0%	.	33%	.	.
Roosevelt Lake	Summer	7/29/2020	EF14	Largemouth Bass	157	90	3	67%	0%	.	.	33%	.
Roosevelt Lake	Summer	7/29/2020	EF15	Bluegill	185	140	150	.	93%	.	7%	.	.
Roosevelt Lake	Summer	7/29/2020	EF15	Largemouth Bass	292	340	.	.	0%	.	.	.	100%
Roosevelt Lake	Summer	7/29/2020	EF15	Largemouth Bass	250	180	5	20%	0%	.	80%	.	.
Roosevelt Lake	Summer	7/29/2020	EF15	Largemouth Bass	246	230	3	67%	0%	.	.	33%	.
Roosevelt Lake	Summer	7/29/2020	EF15	Largemouth Bass	184	80	7	71%	0%	.	29%	.	.
Roosevelt Lake	Summer	7/29/2020	EF15	Largemouth Bass	141	30	2	50%	0%	.	50%	.	.
Roosevelt Lake	Summer	7/29/2020	EF16	Bluegill	202	170	2	50%	50%	.	.	.	.
Roosevelt Lake	Summer	7/29/2020	EF16	Largemouth Bass	241	180	2	100%	0%	.	.	.	.
Roosevelt Lake	Summer	7/29/2020	EF16	Largemouth Bass	154	50	8	38%	63%	.	.	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Bluegill	190	150	21	5%	0%	.	95%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Bluegill	174	120	40	.	0%	.	100%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Bluegill	170	120	180	.	78%	.	22%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Bluegill	167	100	180	.	67%	.	33%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Bluegill	156	80	57	.	39%	.	61%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	324	450	.	.	0%	.	.	.	100%

Waterbody	Season	Collection Date	Site	Common Name	Length (mm)	Weight (g)	No. Particles Counted	% Fish	% Invertebrate	% Snake	% Organic Matter	% Other	% Empty
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	292	340	11	27%	0%	.	73%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	285	320	.	.	0%	.	.	.	100%
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	282	380	8	38%	0%	.	63%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	243	180	.	.	0%	.	.	.	100%
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	241	180	.	.	0%	.	.	.	100%
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	241	180	2	50%	0%	.	50%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	239	200	.	.	0%	.	.	.	100%
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	225	160	.	.	0%	.	.	.	100%
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	224	160	8	25%	0%	.	75%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	219	130	16	6%	0%	.	94%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	201	90	4	25%	0%	.	75%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	180	80	4	25%	0%	.	75%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	180	90	8	13%	25%	.	63%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	175	80	8	38%	0%	.	63%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	171	60	4	100%	0%	.	.	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	169	70	.	.	0%	.	.	.	100%
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	166	60	.	.	0%	.	.	.	100%
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	166	60	2	50%	0%	.	50%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	166	70	4	50%	25%	.	25%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	159	60	5	20%	20%	.	60%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	158	60	13	8%	0%	.	92%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	156	50	3	33%	67%	.	.	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	155	70	1	100%	0%	.	.	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	155	70	4	50%	0%	.	50%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	153	60	6	17%	33%	.	50%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	153	50	7	14%	14%	.	71%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	151	50	3	33%	0%	.	67%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	151	40	3	33%	0%	.	67%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	150	40	5	40%	0%	.	60%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	150	60	3	33%	0%	.	67%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	149	50	6	33%	0%	.	67%	.	.

Waterbody	Season	Collection Date	Site	Common Name	Length (mm)	Weight (g)	No. Particles Counted	% Fish	% Invertebrate	% Snake	% Organic Matter	% Other	% Empty
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	146	50	8	13%	0%	.	88%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	145	40	.	.	0%	.	.	.	100%
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	144	60	11	9%	45%	.	45%	.	.
Roosevelt Lake	Summer	7/29/2020	EF17	Largemouth Bass	141	40	4	25%	50%	.	25%	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	450	1340	.	.	0%	.	.	.	100%
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	218	130	.	.	0%	.	.	.	100%
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	200	110	3	67%	0%	.	33%	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	171	60	.	.	0%	.	.	.	100%
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	165	60	.	.	0%	.	.	.	100%
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	159	50	3	33%	33%	.	33%	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	156	50	3	33%	67%	.	.	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	151	40	1	100%	0%	.	.	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	145	40	1	100%	0%	.	.	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	144	50	.	.	0%	.	.	.	100%
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	144	30	5	20%	0%	.	80%	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	144	40	4	25%	0%	.	75%	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	141	30	3	33%	0%	.	67%	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Largemouth Bass	139	40	2	50%	0%	.	50%	.	.
Roosevelt Lake	Summer	7/29/2020	EF18	Yellow Bass	185	90	4	75%	0%	.	25%	.	.

Appendix C-1, Photo Log, October 2019

Photo 1. P1 B downstream.

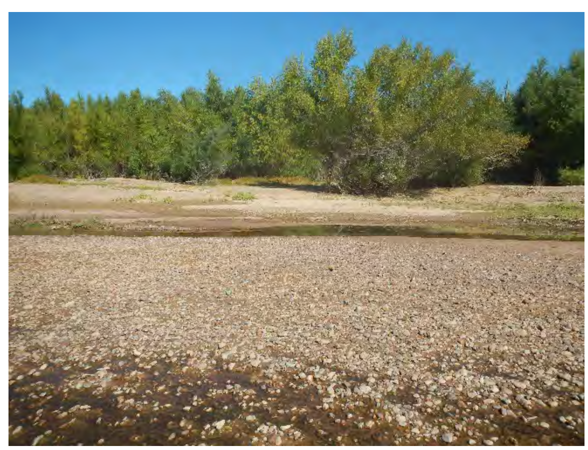

Photo 2. P1 B right bank (east).

Photo 3. P1 B upstream.

Photo 4. P1 B left bank (west).

Photo 5. P1 midpoint downstream.

Photo 6. P1 midpoint right bank.

Photo 7. P1 midpoint upstream.

Photo 8. P1 midpoint left bank.

Photo 9. P2 B downstream.

Photo 10. P2 B right bank.

Photo 11. P2 B upstream.

Photo 12. P2 B left bank.

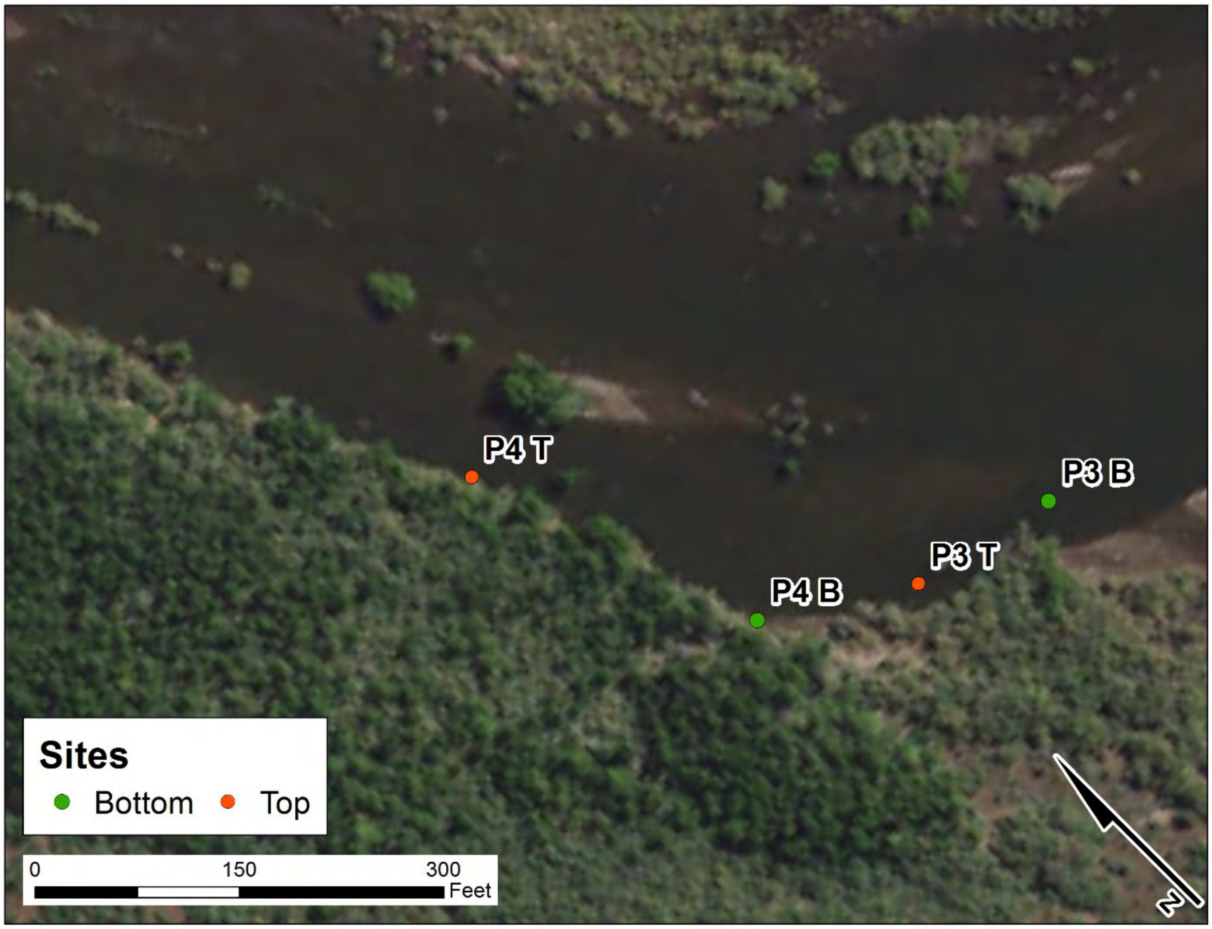

Photo 13. P3 B downstream.

Photo 14. P3 B right bank.

Photo 15. P3 B upstream.

Photo 16. P3 B left bank.

Photo 17. P3 T downstream.

Photo 18. P3 T right bank.

Photo 19. P3 T upstream.

Photo 20. P3 T left bank.

Photo 21. P4 T downstream.

Photo 22. P4 T right bank.

Photo 23. P4 T upstream.

Photo 24. P4 T left bank.

Photo 25. Shallow channel connecting P4 and P5, upstream.

Photo 26. Shallow channel connecting P4 and P5, downstream.

Photo 27. P5 downstream too shallow to efish.

Photo 28. P5 right bank too shallow to efish.

Photo 29. P5 upstream to shallow to efish.

Photo 30. P5 right bank too shallow to efish.

Photo 31. P5 B downstream.

Photo 32. P5 B right bank.

Photo 33. P5 B upstream.

Photo 34. P5 B right bank.

Photo 35. P5 T downstream.

Photo 36. P5 T right bank.

Photo 37. P5 T upstream.

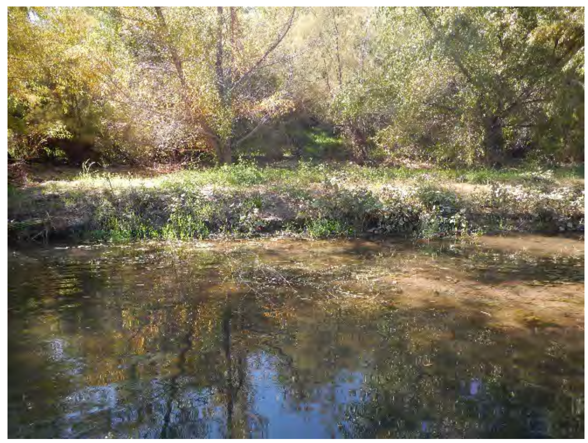

Photo 38. P5 T left bank.

Photo 39. P6 B downstream.

Photo 40. P6 B right bank.

Photo 41. P6 B upstream.

Photo 42. P6 B left bank.

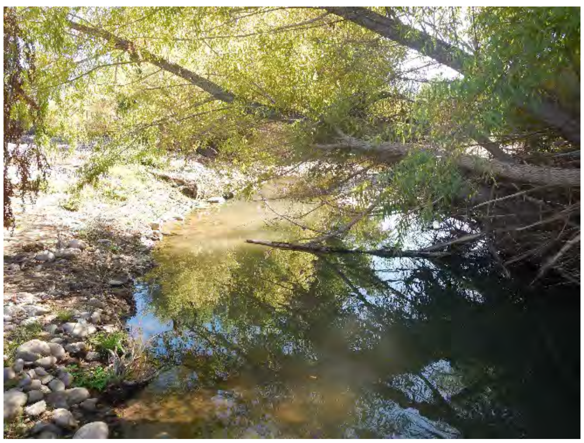

Photo 43. P6 T downstream.

Photo 44. P6 T right bank.

Photo 45. P6 T upstream.

Photo 46. P6 T right bank.

Photo 47. Dry channel between P6 and P7, downstream.

Photo 48. Dry channel between P6 and P7, right bank.

Photo 49. Dry channel between P6 and P7, upstream.

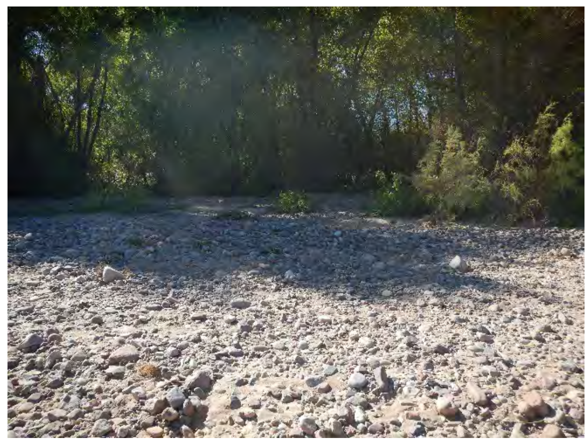

Photo 50. Dry channel between P6 and P7, left bank.

Photo 51. P6 T upstream.

Photo 52. P6 T right bank.

Photo 53. P7 B downstream.

Photo 54. P7 B right bank.

Photo 55. P7 B upstream.

Photo 56. P7 B left bank.

Photo 57. P7 T downstream.

Photo 58. P7 T right bank.

Photo 59. P7 T upstream.

Photo 60. P7 T left bank.

Photo 61. P8 B downstream.

Photo 62. P8 B right bank.

Photo 63. P8 B upstream.

Photo 64. P8 B left bank.

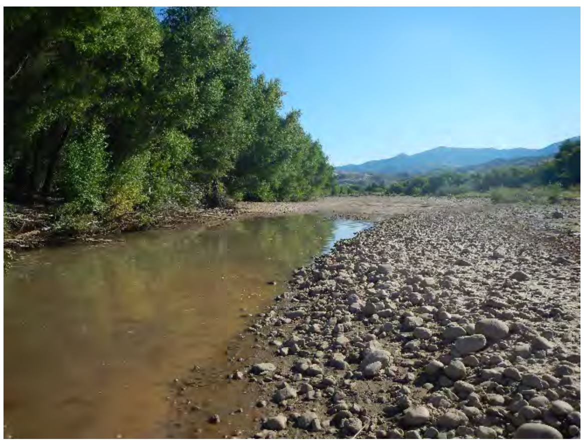

Photo 65. P8 T downstream.

Photo 66. P8 T right bank.

Photo 67. P8 T upstream.

Photo 68. P8 T right bank.

Photo 69. P9 B downstream.

Photo 70. P9 B right bank.

Photo 71. P9 B upstream.

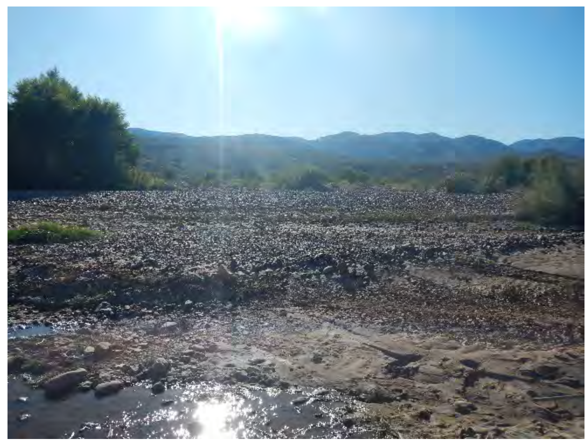

Photo 72. P9 B left bank.

Photo 73. P9 T downstream.

Photo 74. P9 T right bank.

Photo 75. P9 T upstream.

Photo 76. P9 T left bank.

Appendix D-2, Photo Log, April 2020

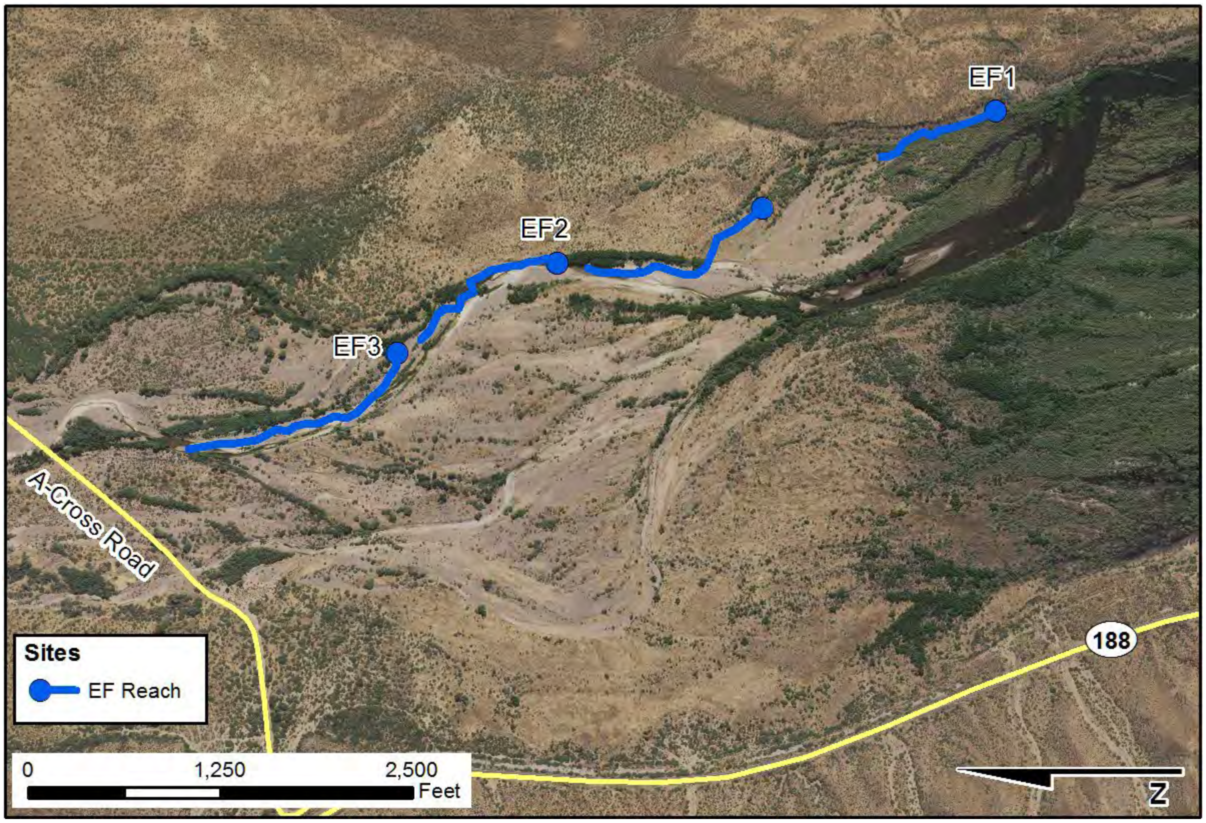

Photo 77. EF2 view across channel.

Photo 78. EF2 right bank (north).

Photo 79. EF2 upstream.

Photo 80. EF3 upstream.

Photo 81. EF3 view across channel.

Photo 82. EF3 downstream, right bank.

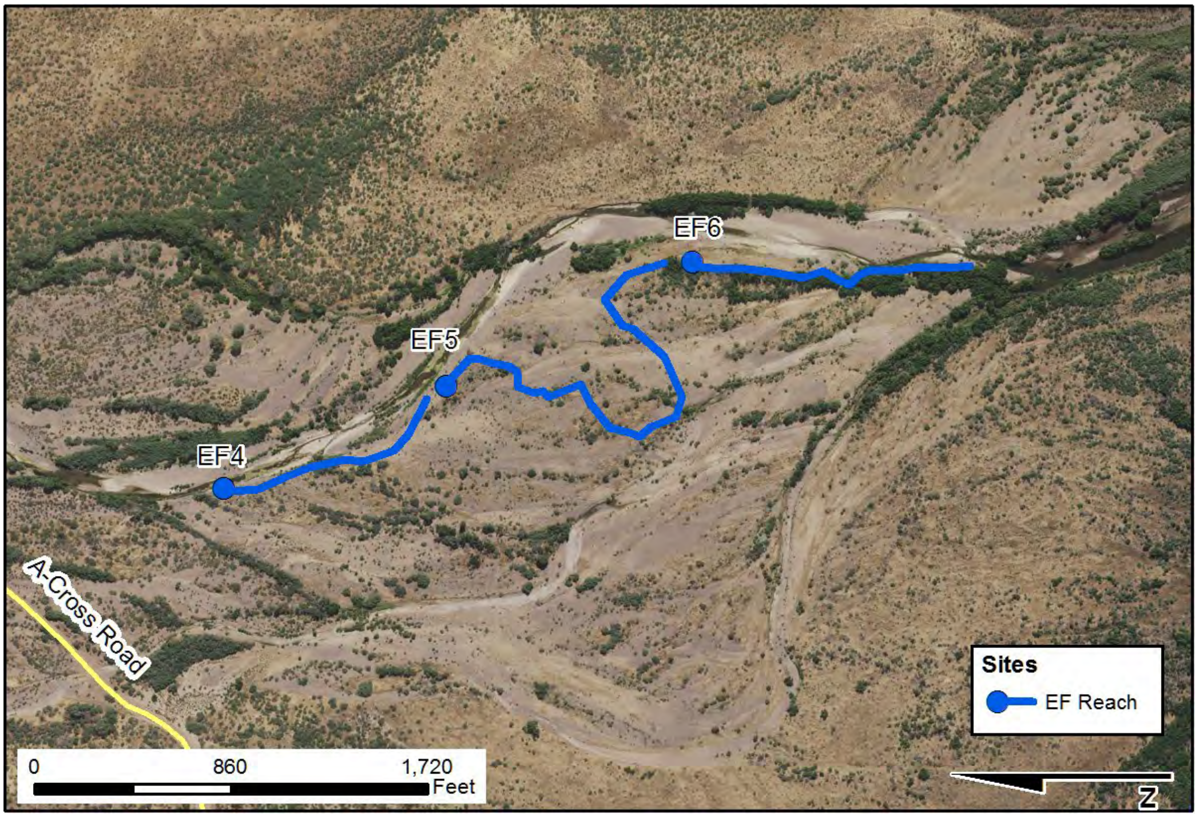

Photo 83. EF4 left bank (west).

Photo 84. EF4 left bank (west).

Photo 85. EF4 view south.

Photo 86. EF5 inundated habitat beyond left bank.

Photo 87. EF5 inundated habitat beyond left bank.

Photo 88. EF6 inundated habitat.

Photo 89. EF6 view towards reservoir.

Photo 90. EF6 inundated habitat beyond left bank.

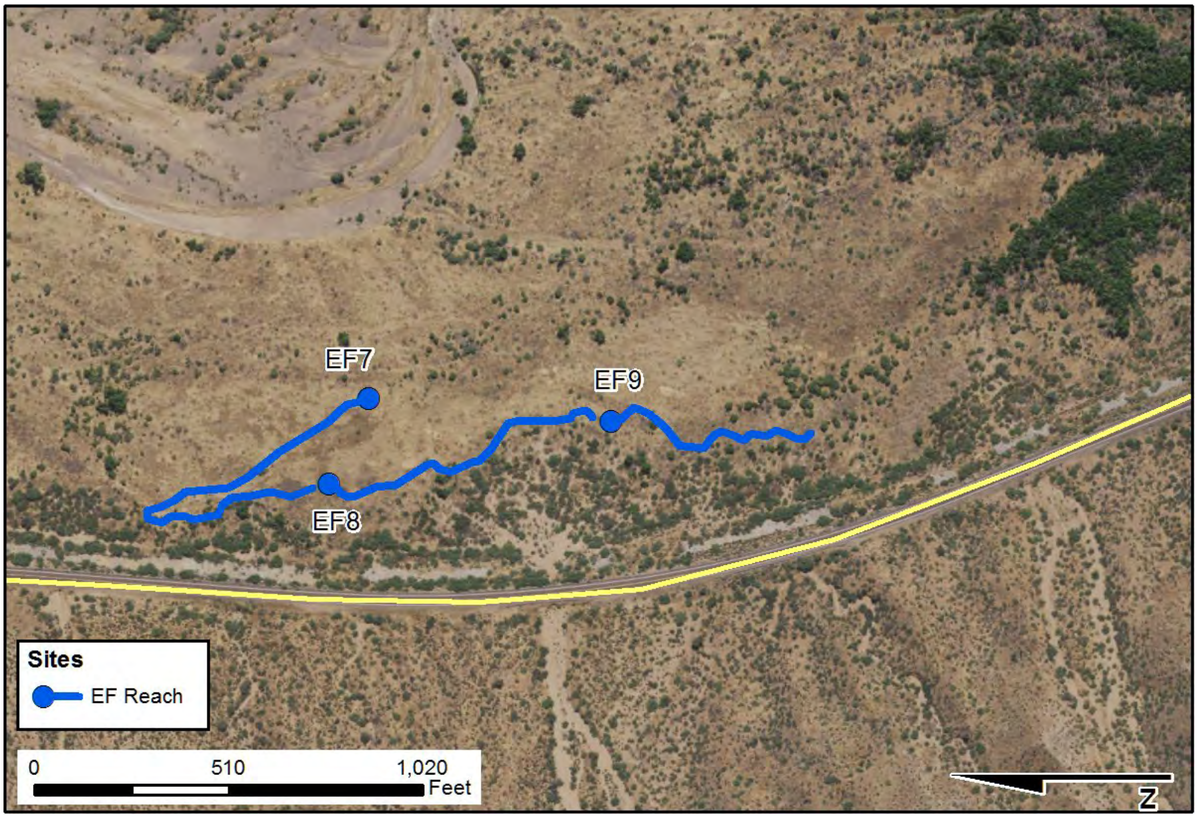

Photo 91. Open water between EF6 and EF7.

Photo 92. Open water between EF6 and EF7.

Photo 93. Open water between EF6 and EF7.

Photo 94. EF7 northern end of reservoir.

Photo 95. EF7 west shoreline.

Photo 96. EF7 west shoreline.

Photo 97. EF8 west shoreline.

Photo 98. EF8 Largemouth Bass diet contents.

Photo 99. EF8 Largemouth Bass diet contents.

Photo 100. EF9 west shoreline.

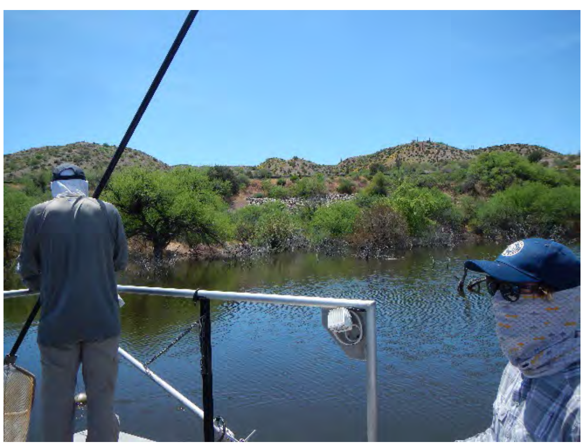

Photo 101. EF10 west shoreline.

Photo 102. EF10 view south.

Photo 103. EF10 west shoreline.

Photo 104. EF10 view south.

Photo 105. EF10 west shoreline.

Photo 106. EF11 view east towards open water.

Photo 107. EF11 west shoreline.

Photo 108. EF11 west shoreline.

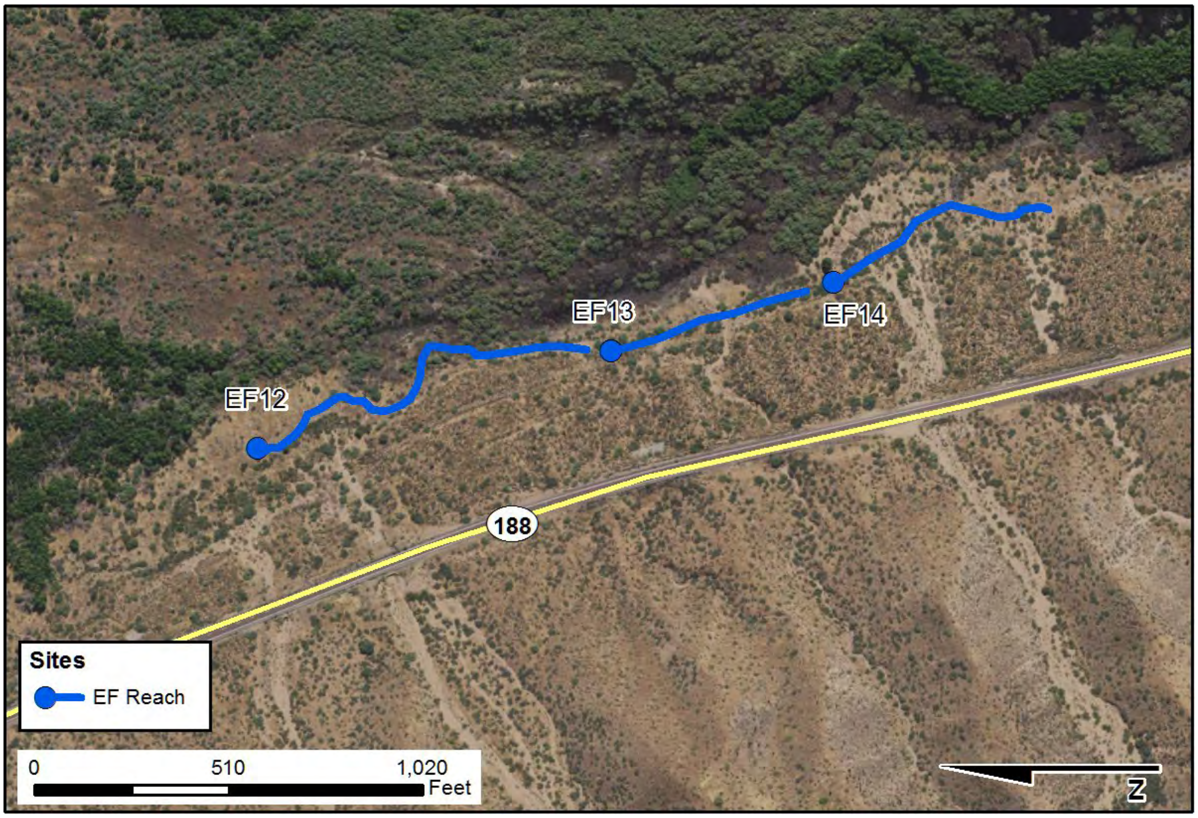

Photo 109. EF12 west shoreline.

Photo 110. EF12 west shoreline.

Photo 111. EF12 west shoreline.

Photo 112. EF12 view east towards open water.

Photo 113. EF13 west shoreline.

Photo 114. EF13 west shoreline.

Photo 115. EF13 west shoreline.

Appendix E-3, Photo Log, July 2020

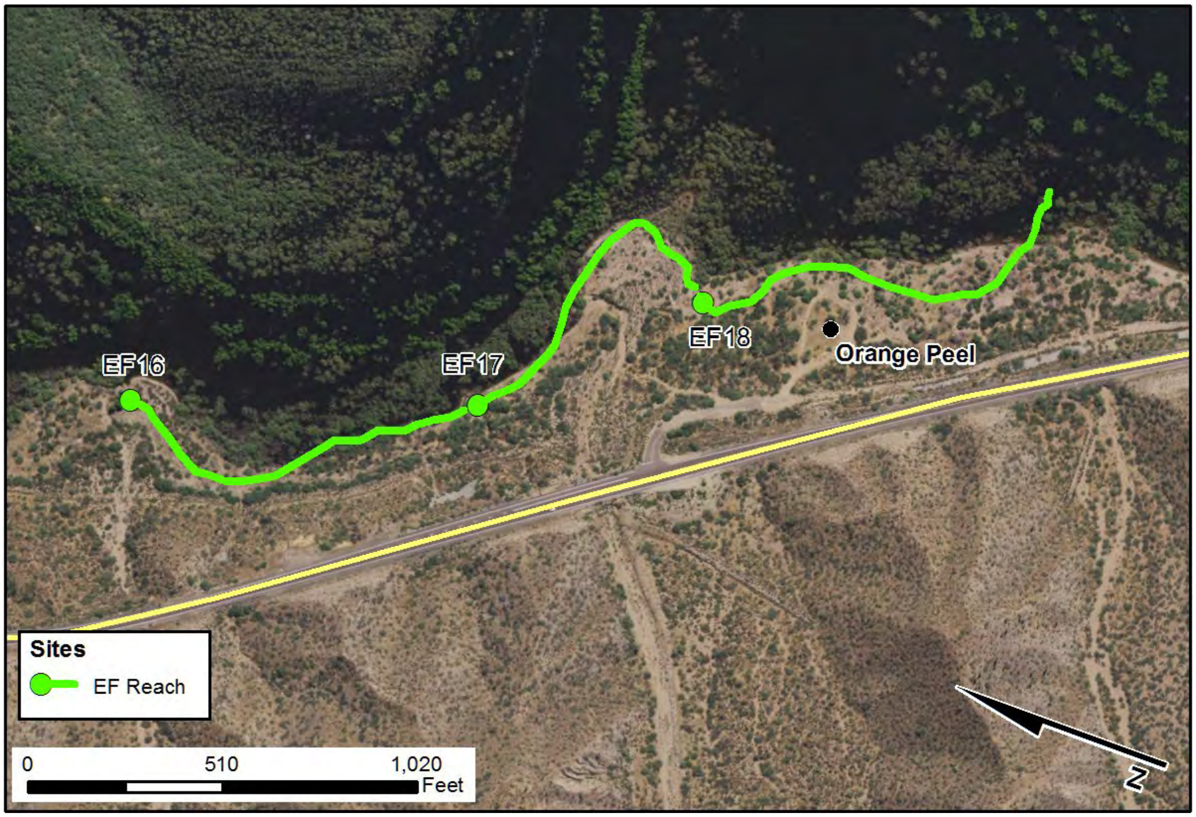

Photo 116. View of lake, 0.8 mi north Orange Peel.

Photo 117. View of sediment deposition at Orange Peel.

Photo 118. View of lake at Orange Peel.

Photo 119. EF4 Largemouth Bass stomach contents.

Photo 120. Night electrofishing.

Photo 121. EF8 Largemouth Bass.

Photo 122. EF8 Largemouth Bass stomach contents.

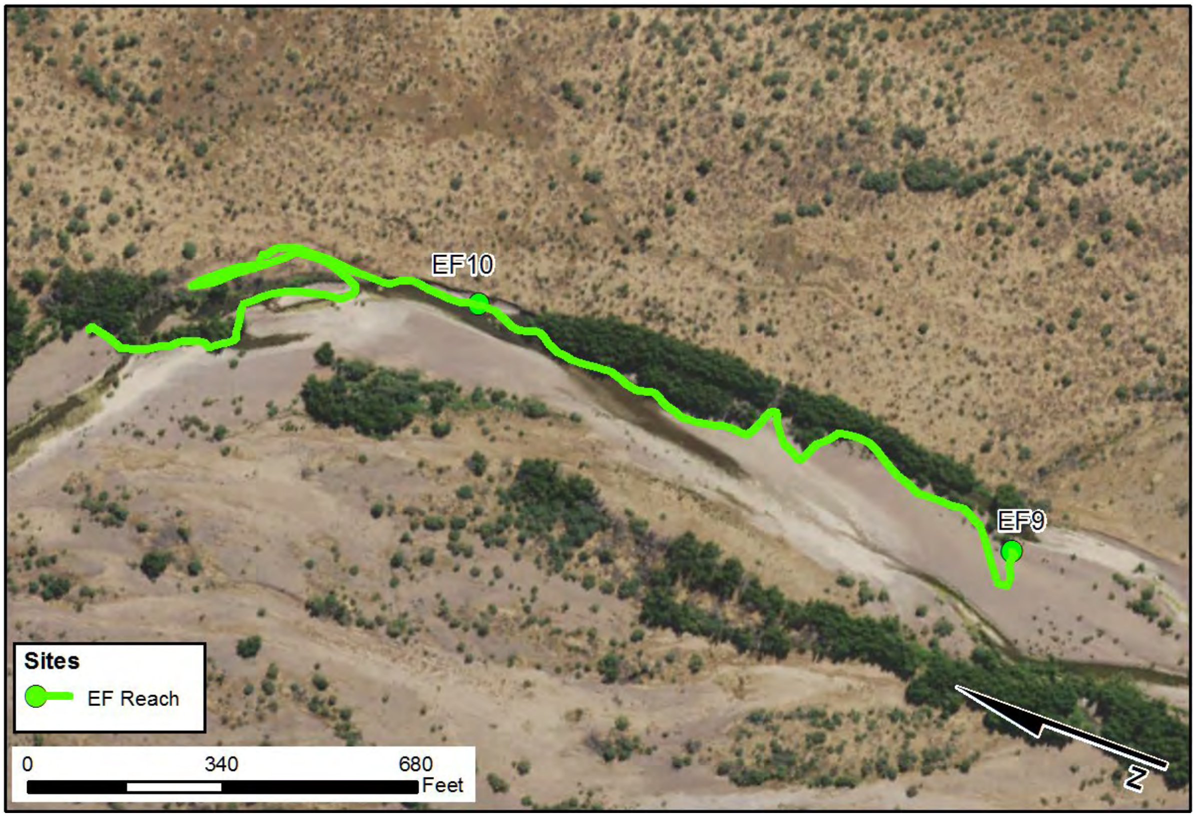

Photo 123. EF9 right bank (north).

Photo 124. EF9 right bank (north).

APPENDIX G

Assessment of Northern Mexican Gartersnake Occupancy and Habitat within the Roosevelt Lake Permit Area

ASSESSMENT OF NORTHERN MEXICAN GARTERSNAKE OCCUPANCY AND HABITAT WITHIN THE ROOSEVELT LAKE PERMIT AREA

JANUARY 2022

PREPARED FOR

Salt River Project Agricultural Improvement and Power District

PREPARED BY

SWCA Environmental Consultants

ASSESSMENT OF NORTHERN MEXICAN GARTERSNAKE OCCUPANCY AND HABITAT WITHIN THE ROOSEVELT LAKE PERMIT AREA

Prepared for

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January 2022

CONTENTS

Appendices

Figures

Tables

INTRODUCTION AND BACKGROUND

Salt River Project Agricultural Improvement and Power District (SRP) is seeking to amend its existing Roosevelt Lake Habitat Conservation Plan (RHCP) to include the northern Mexican gartersnake (*Thamnophis eques megalops*; gartersnake). The gartersnake became listed under the Endangered Species Act (ESA) as a threatened species in 2014 and is known to occur along lower Tonto Creek, including the Roosevelt Lake permit area (U.S. Fish and Wildlife Service [USFWS] 2014). The RHCP amendment is also seeking to expand the original permit area, i.e., Conservation Space (CS; elevation < 2,151 feet above mean sea level [amsl]) to also include the Flood Control Space (FCS; elevation 2,151–2,175 feet amsl) and a corridor along lower Tonto Creek from the top of the FCS upstream to the crossing of East Del Chi Drive (Figure 1). As part of amending the RHCP, an assessment of gartersnake occupancy and habitat suitability within the permit area was needed to adequately address potential impacts of conservation storage operations on the gartersnake and gartersnake likely occupied habitat. For the purposes of this report, the assessment efforts will focus on the CS and FCS of Roosevelt Lake.

The gartersnake is considered a riparian obligate, and although the species is considered highly aquatic, it also requires terrestrial habitat (USFWS 2014). The USFWS defined several physical and/or biological features necessary for gartersnakes as part of their determination of critical habitat (USFWS 2021). Based on the habitat features identified by the USFWS, SWCA Environmental Consultants (SWCA) has summarized gartersnake habitat requirements into three main components: 1) presence of perennial aquatic habitat, 2) suitability of terrestrial riparian habitat for essential behaviors (breeding, feeding, and sheltering), and 3) suitability of the ecological community (predators, competitors, and prey) that will be used to evaluate potential habitat suitability for gartersnakes. In this report, SWCA assesses which areas of the Roosevelt Lake permit area should be considered likely occupied habitat based on the cumulative results of presence/absence surveys and evaluating the three habitat components that are necessary to support gartersnake populations.

Presence/Absence Surveys

The gartersnake is a cryptic species, and low detection rates make presence difficult to determine for populations occurring at low densities (Nowak et al. 2020). Recent presence/absence surveys for gartersnake along the Tonto Creek and Salt River arms of Roosevelt Lake began in 2014 (Nowak et al. 2015). From 2015 to 2018, surveys focused on the Tonto Creek arm (Nowak et al. 2020). Additional surveys along the Salt River were conducted by Arizona Game and Fish Department (AGFD) biologists in 2019 and 2020 (Baker et al. 2019; Grimsley-Padron et al. 2020). Additional surveys in the Tonto Creek arm were conducted in 2020 by EcoPlan Associates, Inc. (EcoPlan) (2020). Collectively, the results of these surveys are summarized in this report.

Habitat Suitability

As part of SRP's Recovery Permit,[1] SRP was required to undertake several studies evaluating and quantifying gartersnake habitat, as summarized below.

The goal of Study 1 (Habitat Model) was to model likely occupied habitat based on the abundance and distribution of water within the Tonto Creek arm, which is affected by the elevation level of Roosevelt Lake (SWCA 2022a). The purpose of this habitat model was to map the amount and distribution of likely occupied gartersnake habitat, as well as changes to habitat based on reservoir elevation.

[1] Section 10(a)(1)(A) Recovery Permit for the Northern Mexican Gartersnake for the Proposed Scientific and/or Enhancement of Propagation or Survival Activities (Number: TE62371D-0; Effective: 12/03/2019; Expires: 1/31/2024, Roosevelt).

The goal of Study 2 (Vegetation Model) was to model how rising and falling reservoir elevation levels impact the distribution and extent of aquatic and emergent wetland plants, which are known to be an important habitat component for gartersnake by providing shelter and cover (SWCA 2022b).

The goal of this study was to evaluate the occupancy and potential habitat suitability for gartersnakes within the Roosevelt Lake permit area, specifically within the CS and FCS. To facilitate this evaluation comparing occupancy and habitat of the Tonto Creek and Salt River arms of the permit area, SWCA reviewed existing literature on gartersnake habitat use and identified key habitat components as described below.

Telemetry Study Review

As part of this report, SWCA reviewed existing literature on gartersnake habitat selection to identify the structural features of riparian habitats required for gartersnake essential behaviors. Three main telemetry studies on gartersnake habitat selection in Arizona have been reported or published. The first occurred at the Bubbling Ponds State Fish Hatchery (Sprague and Bateman 2018); the second in the Verde Valley at Dead Horse Ranch State Park and Camp Verde Riparian Preserve (Emmons 2017; Emmons and Nowak 2016); and the third at Tonto Creek within the HCP permit area (Myrand 2019; Nowak et al. 2020).
All three studies used similar methods to document macrohabitat and microhabitat at each location where an individual gartersnake was located. All gartersnake locations were paired with a randomly selected reference location where similar macrohabitat and microhabitat data were collected. The goal of these telemetry studies was to determine the macrohabitat and microhabitat variables selected by gartersnake, compared with available habitat within the overall landscape. Based on these macrohabitat and microhabitat variables, a vegetation transect survey design was developed by ERO Resources (ERO) (2020) to compare habitat structure within the Roosevelt Lake permit area along Tonto Creek (where gartersnake are known to occur) and Salt River (where gartersnake have not been detected).
The appropriate macrohabitat and microhabitat variables were incorporated into the analysis and characterization of perennial aquatic habitat and terrestrial riparian habitat for comparison between the Tonto Creek and Salt River arms of the permit area.

MACROHABITAT

Despite differences in general habitats recorded in previous studies, gartersnake consistently selected for aquatic edge macrohabitat. At the Bubbling Ponds State Fish Hatchery, during the active season, snakes were primarily located along banks or edges of ponds (both active and fallow) or in marshy areas of fallow ponds; these two macrohabitat types accounted for 80.8% of female and 64.5% of male observations (Sprague and Bateman 2018). For gartersnake in the Verde Valley, Emmons (2017) found that macrohabitat types were selectively ranked as follows (letters in parentheses indicate significant differences between groups): aquatic edge (A) > wetland (AB) > open land (AB) > dry edge (B) > forest land (BC) > open water (C). Aquatic edge was significantly preferred over all other macrohabitat types except for wetlands, and open water was used significantly less often, compared with all other types except for forest land.

Although gartersnake were not documented frequently in open-water macrohabitat types, gartersnake are known to cross open water and the presence of water is an important requirement of gartersnake habitat (USFWS 2014).

MICROHABITAT

Based on the results of habitat selection studies using radio telemetry, several conclusions can be drawn regarding the microhabitat variables selected by gartersnake at several different sites. At the Bubbling

Ponds State Fish Hatchery, Sprague and Bateman (2018) studied differences in microhabitat selection for males during the active season as well as for females during the active season and during gestation. Both male and female gartersnake selected locations that were closer to water and had more cover less than 1 m above the ground, greater percent cover of forbs, and higher slopes, and avoided areas with greater percent cover of sedges and rushes (Table 1). Female gartersnake at Bubbling Ponds State Fish Hatchery also selected for areas with greater percent shrub cover; however, this variable was not statistically significant for active season males. Male gartersnake at Bubbling Ponds State Fish Hatchery avoided areas with greater percent cover of tree species; however, this variable was not statistically significant for active-season females. For all telemetry studies, variables that are not reported were not statistically significant.

Table 1. Coefficients for Microhabitat Variables Included in Top-Ranked Habitat Selection Models for Gartersnake at Bubbling Ponds State Fish Hatchery, Arizona

Variable	Coefficient (Indicates Selection [+] or Avoidance [−])	
	Female (Active Season)	Male (Active Season)
Percent canopy cover < 1 m	0.026	0.039
Distance to water	−0.068	−0.064
Percent cover forb	0.022	0.007
Percent cover shrub	0.043	NA
Percent cover tree	NA	−0.009
Slope	0.028	0.034
Percent cover sedge/rush	−0.009	−0.026
Water depth	−0.003	−0.005

Source: Reproduced from Sprague and Bateman (2018).

A second telemetry study of gartersnake in the Verde Valley, Arizona, found similar results but was only able to analyze females because of low sample size of males (Table 2). As was the case at Bubbling Ponds State Fish Hatchery, gartersnake in the Verde Valley selected locations closer to water, with greater slope, and with greater cover of debris/litter and live vegetation. Snakes in the Verde Valley avoided locations with deeper water and greater cover of bare ground and open water.

Table 2. Coefficients for Microhabitat Variables Included in Top-Ranked Habitat Selection Models for Gartersnake at Sites in the Verde Valley, Arizona

Variable	Coefficient (Indicates Selection [+] or Avoidance [−])
	Female (Active Season)
Distance to water	−0.03
Water depth	−1.37
Slope	0.03
Percent cover bare ground	−0.03
Percent cover debris/litter	0.02
Percent cover open water	−0.02
Percent cover live vegetation	0.02

Source: Reproduced from Emmons (2017).

A third telemetry study within the Tonto Creek arm of Roosevelt Lake compared habitat selection of female gartersnake prior to and during a period of inundation (Table 3) (Myrand 2019). Myrand (2019) found that female gartersnake selected for sites closer to water and with greater percent ground cover less than 1 m above the ground during both the non-inundated and inundated periods. During the non-inundated period, snakes avoided areas with greater slopes and selected areas with greater edge water depth, but these variables were not important during the inundation period. Female gartersnake also avoided locations with greater percent canopy cover greater than 1 m above the ground during the non-inundated period but selected for this variable during the inundated period. This change in selection against and then for greater percent canopy cover greater than 1 m above the ground may reflect changes in available habitat caused by flooding of riparian woodland habitat during the inundation period. Myrand (2019) found that mean percent canopy cover decreased from 36% ± 2% during the non-inundated period to 21% ± 3% during inundation.

Table 3. Coefficients for Microhabitat Variables Included in Top-Ranked Habitat Selection Models for Gartersnake during Periods of Non-inundation and Inundation at Sites along Tonto Creek, Arizona

Variable	Coefficient (Indicates Selection [+] or Avoidance [−])	
	Female (Active Season; Non-inundated)	*Female (Active Season; Inundated)*
Slope	−0.025	NA
Percent canopy cover < 1 m	0.041	0.043
Distance to water	−0.04	−0.017
Water depth	2.165	NA
Percent canopy cover > 1 m	−0.00007	0.029

Source: Reproduced from Myrand (2019).

These three studies demonstrate that while there may be differences in the microhabitat variables that gartersnake select at different sites, during the active season gartersnake consistently select for areas that are closer to water and have greater ground cover.

Habitat Components

SWCA established three habitat components that are necessary to support gartersnake populations: 1) presence of perennial aquatic habitat, 2) suitability of terrestrial riparian habitat for essential behaviors (breeding, feeding, and sheltering), and 3) suitability of the ecological community (predators, competitors, and prey). These three habitat components were established based on summarizing the physical and biological features of critical habitat as defined by the USFWS (2021). Determination of the extent of likely occupied gartersnake habitat within the RHCP permit area is based on the cumulative results of presence/absence surveys and evaluating the three habitat components that are necessary to support gartersnake populations.

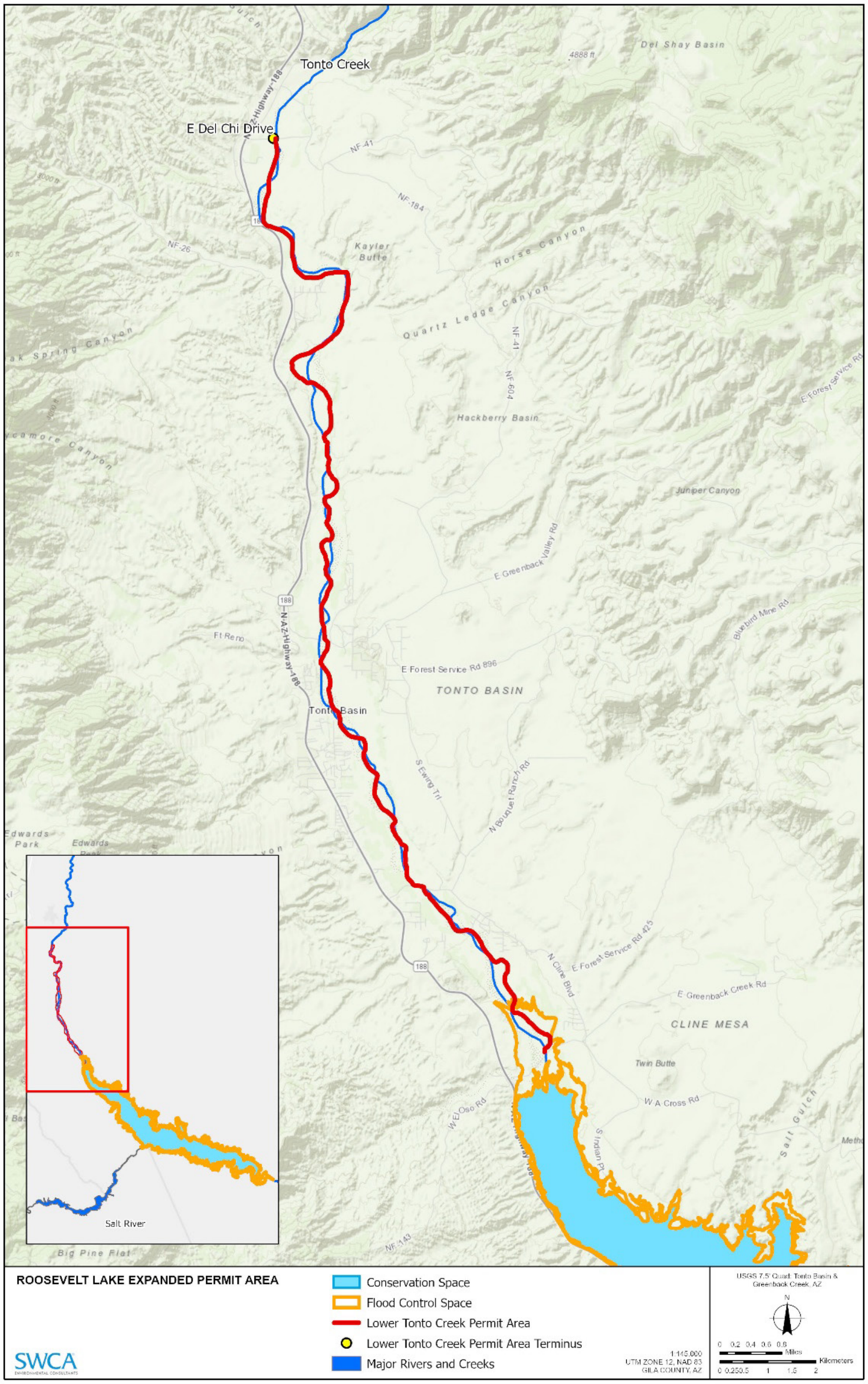

Figure 1. Roosevelt Lake Permit Area and Conservation Space.

PERENNIAL AQUATIC HABITAT

As a riparian obligate, gartersnakes require a persistent water source, which may include perennial or spatially intermittent streams or lentic wetlands such as off-channel springs, cienegas, and natural and constructed ponds (USFWS 2014). Persistent water sources are an important feature of gartersnake habitat because most of the gartersnakes' preferred prey items (amphibians and fish) require persistent water. Ephemeral wetlands and streams are not generally considered suitable habitat unless they are in proximity to persistent water sources, because ephemeral wetlands are not likely to support a reliable prey base for gartersnakes. Although the gartersnake is a highly aquatic species (USFWS 2014), previous telemetry studies have shown gartersnakes are primarily located along the margins of aquatic habitat and do not tend to occupy open-water habitats, though they will move through them (Emmons and Nowak 2016; Nowak et al. 2020; Sprague and Bateman 2018).

TERRESTRIAL RIPARIAN HABITAT

In addition to perennial aquatic habitat, gartersnakes also require suitable terrestrial habitat structure that may include riparian vegetation, small mammal burrows, boulder fields, rock crevices, and/or downed woody debris. These organic and inorganic structural features are necessary to provide the complex microhabitats needed for essential behaviors (breeding, feeding, and sheltering). The review of existing literature on gartersnake habitat selection described above was used to identify the structural features of terrestrial riparian habitats required for gartersnake essential behaviors (SWCA 2021c). ERO Resources (ERO) used the methods and results of these studies to develop a vegetation transect survey design to compare habitat structure within the Roosevelt Lake permit area along the Tonto Creek arm (where gartersnakes are known to occur) and the Salt River arm (where gartersnakes have not been detected), as described in the Methods section below (ERO 2020).

ECOLOGICAL COMMUNITY

The gartersnake also requires an ecological community that provides ample foraging opportunities of prey species while minimizing the negative impacts of nonnative predator and competitor species such that recruitment of gartersnake is not inhibited and viable prey populations are maintained. The interaction of nonnative anuran and fish species as it relates to the ecological community's suitability for gartersnake is complex and somewhat poorly understood, but in general, ecological communities with greater abundance and diversity of native anurans and fish species and lower numbers of nonnative anurans (bullfrogs) and fish (particularly of the Centrarchidae and Ictaluridae families) would be more suitable for gartersnake than communities dominated by nonnative anuran and fish species (USFWS 2014). Incidental captures and observations of potential predator, competitor, and prey species from surveys are also summarized in this report. The composition of the ecological community may provide additional insight into differences in habitat suitability of the Tonto Creek and Salt River arms for gartersnake.

Site Descriptions

The Tonto Creek arm of Roosevelt Lake lies at the northwestern end of the reservoir and consists of a spatially intermittent braided stream with a mosaic of riparian woody vegetation, including velvet mesquite (*Prosopis velutina*), desertbroom (*Baccharis sarothroides*), Goodding's willow (*Salix gooddingii*), Fremont cottonwood (*Populus fremontii*), and patches of dense stands of nonnative saltcedar (*Tamarix ramosissima*) (ERO 2020). Marshes within the Tonto Creek arm are dominated by cattail (*Typha* sp.), rushes (*Juncus* sp.), and sedges (*Carex* sp. and *Scirpus* sp.). While the Tonto Creek arm is characterized as a spatially intermittent stream, it includes persistent pools of water within the stream channel as well as along the margins of Roosevelt Lake that provide the perennial aquatic habitat necessary to sustain a known population of gartersnake.

The Salt River arm of Roosevelt Lake lies at the southeastern end of the reservoir and consists of a single, wide, perennial stream channel dominated by a dense monoculture of saltcedar with intermittent patches of giant reed (*Arundo donax*), cattail (*Typha* sp.), Goodding's willow, and Fremont cottonwood (ERO 2020). The Rock House Demonstration Site is an SRP conservation property that lies just upstream of Roosevelt Lake on the Salt River. The Rock House Demonstration Site is approximately 20 acres in size, and suitable gartersnake habitat at the site consists of an irrigation canal lined with abundant grasses (Baker et al. 2019). Existing upland vegetation at the Rock House Demonstration Site is composed of scattered velvet mesquite with a sparse understory of annual plants.

The Tonto Creek and Salt River arms of Roosevelt Lake are separated by approximately 20 linear miles. Unlike the Tonto Creek and Salt River arms, the intervening habitat consists of deep open water of Roosevelt Lake and lake margins with steep and rocky slopes. This intervening habitat is unlikely to be suitable for gartersnakes, although SRP recognizes that it is not impossible that gartersnakes could move through this area.

METHODS

Presence/Absence

Field surveys for gartersnake presence/absence were classified as either trapping surveys or visual encounter surveys (VES). Trapping surveys consisted of using partially submerged minnow traps (up to 110 in 2019 and 200 in 2020), with effort recorded as the total number of active trap hours. VES typically consisted of one or more field surveyors walking along suitable stream banks and sometimes included placement and checking of coverboards as a means of facilitating gartersnake detection (EcoPlan 2020).

Habitat Suitability

Perennial Aquatic Habitat

Both the Tonto Creek and Salt River arms are known to have persistent water sources (Arizona Department of Environmental Quality 2020; The Nature Conservancy 2020). The presence and extent of water was confirmed using field surveys. The locations of 15 transects along Tonto Creek and seven transects along the Salt River were randomly selected. Each transect was centered on a stream channel and extended 60 meters (m) perpendicular to the channel on each side, for a total transect length of 120 m. Visual estimates of aquatic macrohabitats were collected in 5-m-radius plots centered at 15-m intervals along the length of each transect for a total of nine plots per transect. Representative photographs were taken in each plot. The following aquatic macrohabitat variables, if present, were identified within each plot: aquatic edge, wetland, and open water. The percentage of plots with each aquatic macrohabitat type was calculated for each transect. The percentage of aquatic macrohabitats present for each transect was then averaged by site (i.e., averaged for either the Tonto Creek or Salt River arm).

Terrestrial Riparian Habitat

Data collected during transect plots were also used to characterize terrestrial riparian habitat. At each plot, the dominant tree species, if present, were recorded: saltcedar, willow, mixed, or mesquite. The following terrestrial macrohabitat variables, if present, were identified within each plot: dry edge, riparian woodland, herbaceous meadow, and shrubland. The percentage of plots with each dominant tree species and terrestrial macrohabitat type was calculated for each transect. The percentage of dominant tree species and terrestrial macrohabitat presence for each transect was then averaged by site.

Within each plot, microhabitat variables were estimated to characterize terrestrial habitat structure. Microhabitat variables were percent canopy cover more than 1 m above the ground surface and canopy cover less than 1 m above the ground surface. The following structure categories were ranked based on their percent cover in the plots: live vegetation, debris/litter, sand, dead material, and rock/cobble. Ranks were classified as being less than 10%, 10% to 29%, 30% to 49%, 50% to 79%, or greater than 80% cover. The percent cover of each microhabitat variable was averaged across each transect and then summarized by site. For ranked microhabitat variables, the middle value of each percentage range was used for calculations.

Ecological Community

During gartersnake presence/absence surveys using trapping and VES methods, incidental captures/observations of non-target species were also recorded. However, non-target species captured during trapping surveys were not directly removed from traps between trap checks. Potential prey species were left in traps as a means of “baiting” traps to facilitate gartersnake captures because that was the primary goal of surveys. The results of these incidental captures can be used to document presence/absence of potential predator, competitor, and prey species. However, interpretations of abundance of non-target species is somewhat limited because traps were not emptied between trap checks. Amphibian captures were identified to species; nonnative fish species were grouped into soft-rayed and spiny (Centrarchidae and Ictaluridae families) categories.

RESULTS

Presence/Absence

In 2014, a total of 23,263 trap hours and 39 hours of VES resulted in captures of at least nine gartersnake individuals within the Tonto Creek arm of Roosevelt Lake (Nowak et al. 2015). Further surveys along Tonto Creek from 2015 through 2017 resulted in a total of 81 gartersnake individuals with a total survey effort of 212,593 trap hours and 2,919 hours of VES (Nowak et al. 2020). The most recent surveys in 2020 detected seven gartersnake individuals with a total survey effort of 551.5 hours of VES.

Despite survey effort totaling 96,312 trap hours and 24.2 hours of VES, there have been no gartersnake individuals detected in the Salt River arm of Roosevelt Lake to date (Table 4). Annual trap hours within the Salt River arm in 2019 and 2020 were similar to or greater than annual trap hours within the Tonto Creek arm in 2014 when gartersnakes were detected, but were lower than annual trap hours during the 2015 to 2017 surveys.

Table 4. Presence/Absence Survey Effort for Tonto Creek and Salt River Arms of Roosevelt Lake

Site Name	Funnel Trapping (trap hours)	Visual Encounter Surveys (survey hours)	Gartersnake (individuals)
Tonto Creek Arm			
Tonto Creek Arm (2014)	23,263	39	9
Tonto Creek Arm (2015–2017)	212,593	2,919	81
Tonto Creek (2020)	–	551.5	7
Salt River Arm			
Salt River Arm (2014)	–	24.2	0
Salt River Arm (2019)	34,728	–	0
Salt River Arm (2020)	61,584	–	0

Habitat Suitability

Perennial Aquatic Habitat

MACROHABITAT

The results of macrohabitat analysis show that aquatic macrohabitats (open water, aquatic edge, and wetland) were present at both the Salt River and Tonto Creek arms (Table 5, Figure 2). Although both the Tonto Creek and Salt River arms have persistent aquatic habitat, there are differences in stream channel morphology and consequently water flow and turbidity between the two arms. The Tonto Creek arm is generally characterized as a spatially intermittent stream where flow rates and turbidity tend to be low (Figure 3) except during periods of high runoff, particularly during rain events and periods of high snowmelt. In contrast, the Salt River is far more “channelized” compared to the Tonto Creek arm (Figure 4). This channelization results in steeper banks, faster water flow, and increased water turbidity. A comparison of water turbidity and velocity data from the U.S. Geological Survey (USGS) National Water Information System (NWIS) for two stream gage locations, one in Tonto Creek and one in Salt River, shows that the Salt River has consistently higher turbidity and velocity in comparison to Tonto Creek (Appendix A). Although Tonto Creek certainly experiences increased turbidity and velocity during and immediately following rain events and snowmelt, these events are expected to be temporary and of short duration. For the Salt River, these conditions of increased turbidity and velocity are more persistent conditions.

Table 5. Mean and Standard Error of Percent Aquatic Macrohabitat Types Observed by Site

Macrohabitat Type Mean (Standard Error)*	Salt River Arm	Tonto Creek Arm
Number of transects	7	15
Aquatic edge	22.2% (1.92)	15.6% (3.03)
Open water	20.6% (2.49)	13.3% (3.29)
Wetland	8.1% (3.07)	1.5% (1.48)

*Standard error provides an estimate of variance among samples and accounts for the sample size.

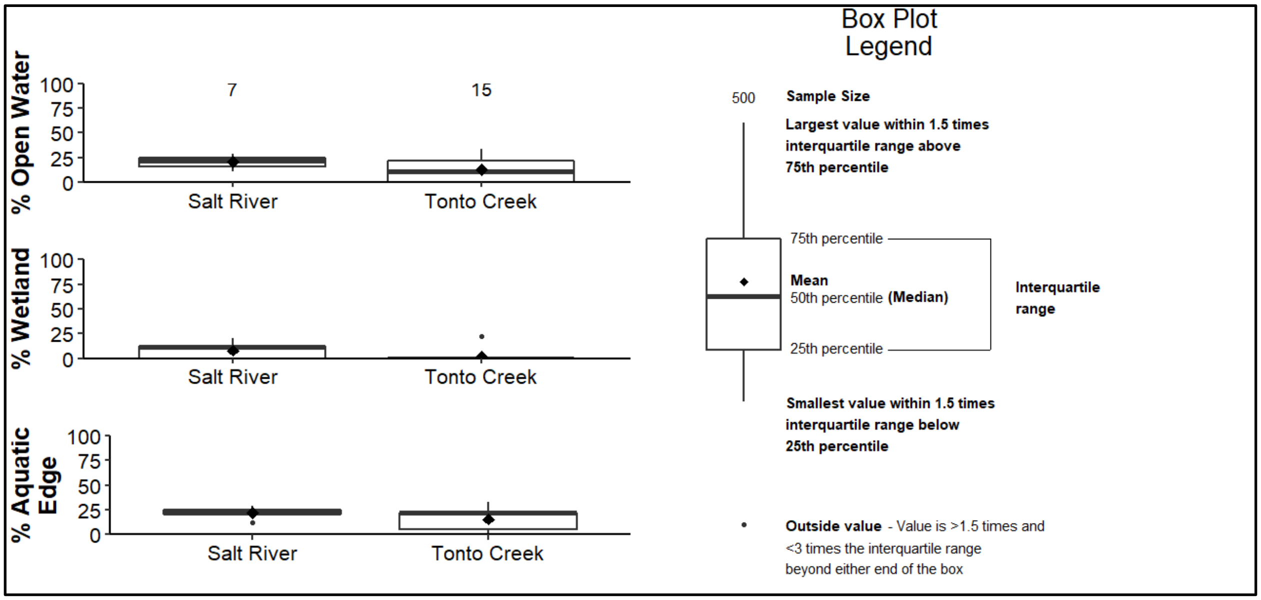

Figure 2. Box plots of aquatic macrohabitat types.

Figure 3. Example of aquatic habitat in the Tonto Creek arm of Roosevelt Lake.

Figure 4. Example of aquatic habitat in the Salt River arm of Roosevelt Lake.

Terrestrial Riparian Habitat

MACROHABITAT

Saltcedar was common in both river arms, but it was far more dominant in the Salt River arm than the Tonto Creek arm (Table 6). Plots where native species were dominant were relatively uncommon at both sites and most of the mixed communities were a mix of native species and saltcedar. For terrestrial macrohabitats, Tonto Creek had higher amounts of dry edge macrohabitat and lower amounts of riparian woodland habitats (Table 7, Figure 5). Overall, there seems to be more dry edge macrohabitat at Tonto Creek compared to the Salt River, which suggests that there may be more habitat heterogeneity at Tonto Creek because, by definition, edge habitat would consist of at least two macrohabitat types.

Table 6. Mean and Standard Error of Percent Dominant Tree Species Observed by Site

Dominant Tree Species Mean (Standard Error)*	Salt River Arm	Tonto Creek Arm
Number of transects	7	15
Saltcedar	88.9% (5.87)	38.4% (7.77)
Willow	3.6% (3.57)	11.9% (3.51)
Mesquite	3.2% (3.17)	4.4% (3.03)
Mixed	9.2% (3.62)	27.5% (5.17)

*Standard error provides an estimate of variance among samples and accounts for the sample size.

Table 7. Mean and Standard Error of Percent Terrestrial Macrohabitat Types Observed by Site

Macrohabitat Type Mean (Standard Error)*	Salt River Arm	Tonto Creek Arm
Number of transects	7	15
Dry edge	5.4% (2.58)	17.0% (4.95)
Herbaceous meadow	19.0% (8.33)	17.1% (7.09)
Shrubland	81.6% (3.36)	63.0% (7.56)
Riparian woodland	72.5% (11.2)	20.8% (5.92)

*Standard error provides an estimate of variance among samples and accounts for the sample size.

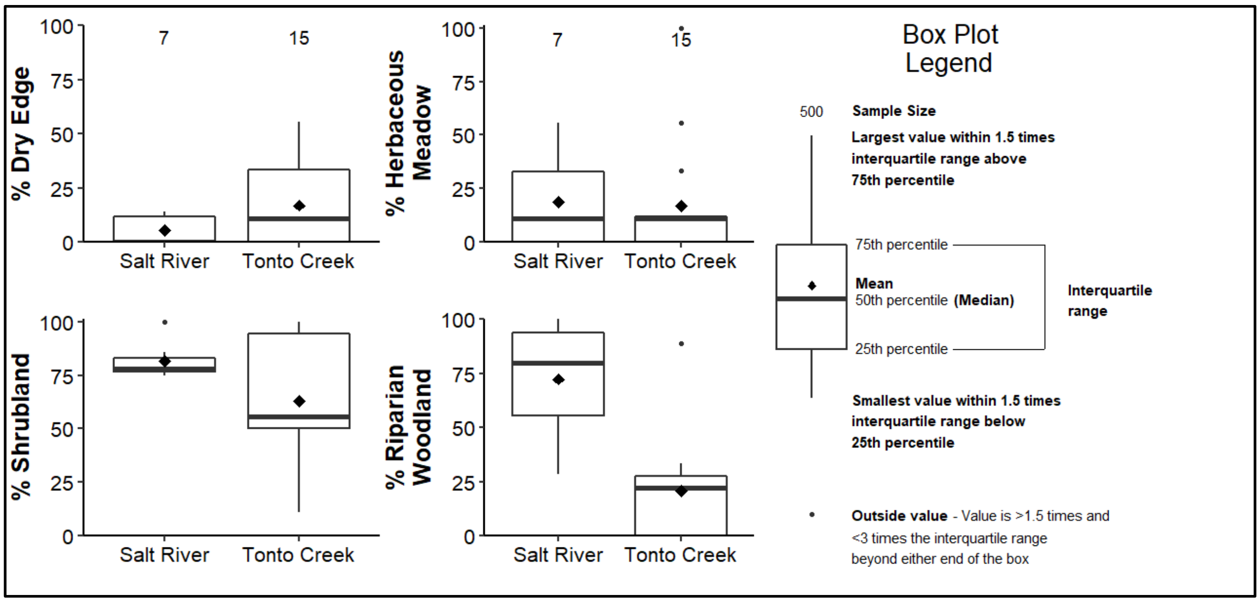

Figure 5. Box plots of upland macrohabitat types.

MICROHABITAT

Overall, the amount of live vegetation, debris/litter, and dead material surface cover types were similar along both the Salt River and Tonto Creek arms (Table 8, Figure 6). The amount of bare ground microhabitat was also greater for Tonto Creek compared with that of the Salt River (Figure 7), indicating greater availability of open spaces that may be important as basking sites for gartersnake (Sprague and Bateman 2018). For canopy cover, the amount of cover higher than 1 m was greater at Salt River compared with that at Tonto Creek, whereas cover lower than 1 m was greater at Tonto Creek than Salt River (see Table 8, see Figure 7).

Table 8. Mean and Standard Error of Percent Microhabitat Types Observed by Site

Microhabitat Variable Mean (Standard Error)*	Salt River Arm	Tonto Creek Arm
Number of transects	7	15
Live vegetation	43.2% (4.62)	38.6% (4.80)
Debris/litter	16.8% (3.98)	16.3% (2.23)
Dead material	10.8% (2.40)	14.5% (2.63)
Rock/cobble	0.4% (0.18)	14.3% (4.01)
Bare ground	17.3% (6.33)	30.2% (4.59)
Open water	0.2% (0.02)	0.1% (0.03)
Canopy cover >1 m	70.0% (5.91)	35.3% (4.65)
Canopy cover <1 m	6.8% (3.50)	22.4% (4.01)

*Standard error provides an estimate of variance among samples and accounts for the sample size.

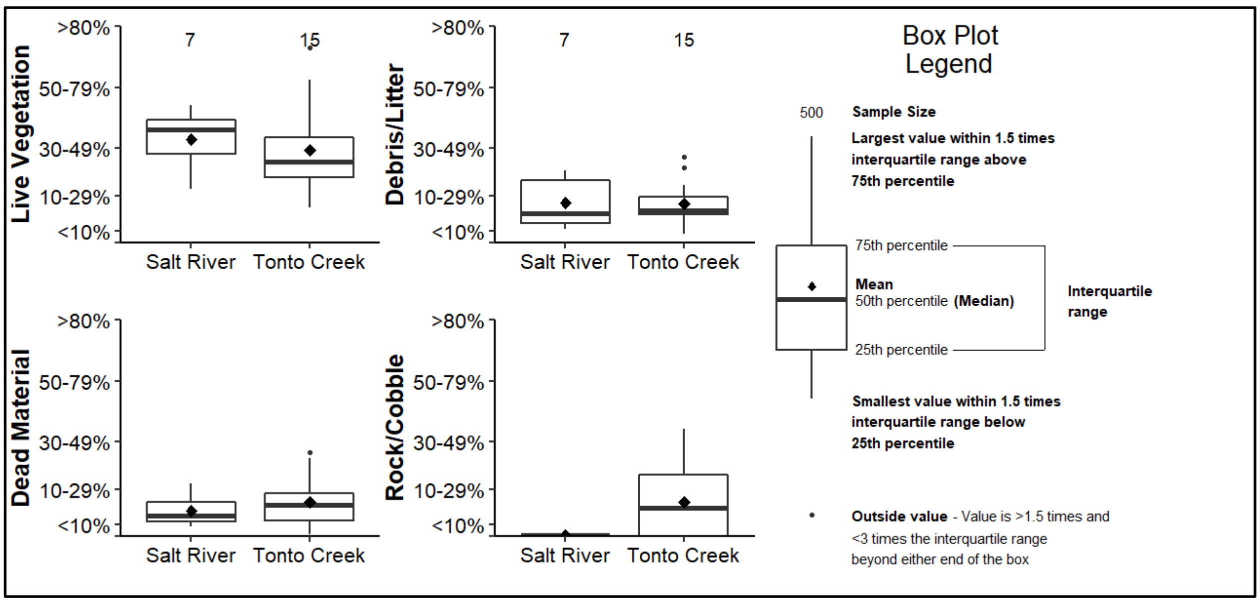

Figure 6. Box plots of percent cover of live vegetation, debris/litter, dead material, and rock/cobble.

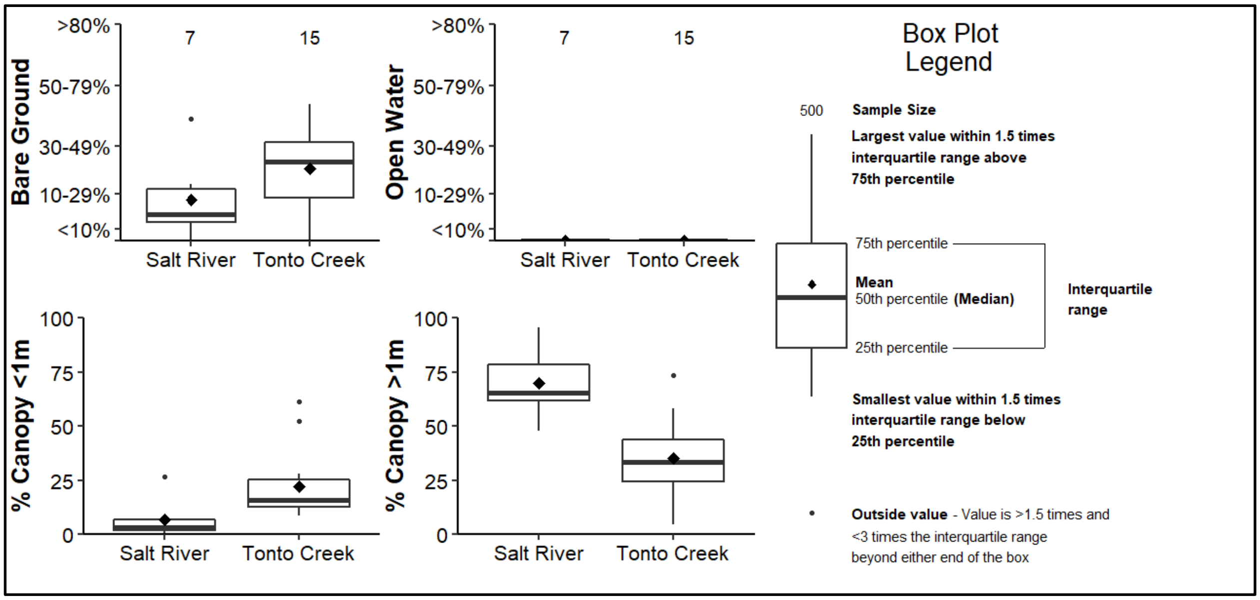

Figure 7. Box plots of percent canopy cover of bare ground, open water, canopy cover less than 1 m, and canopy cover greater than 1 m.

Ecological Community

Incidental captures of non-target species were also recorded during each of the survey periods. Anurans (adults and larva), particularly native species, are important prey for gartersnake, although nonnative fish and bullfrogs are also consumed (USFWS 2014). Incidental trap captures indicate that both native and nonnative anurans (including adults and larva) are far more abundant at Tonto Creek and were found in low numbers in the Salt River (Table 9). The only native fish species captured was the longfin dace (*Agosia chrysogaster*), which was found exclusively at the Bar X and A Cross sites of Tonto Creek. Nonnative fish were found in abundance at both Tonto Creek and Salt River (see Table 6). Nonnative fish captured at both sites were composed primarily of soft-rayed species, particularly western mosquitofish (*Gambusia affinis*), which was the most abundant species at both sites. Nonnative spiny fish species included members of both the Centrarchidae and Ictaluridae families. The most commonly captured Centrarchidae species included green sunfish (*Lepomis cyanellus*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), and smallmouth bass (*Micropterus dolomieu*). Incidental captures of Ictaluridae species included black bullhead (*Ameiurus melas*), yellow bullhead (*Ameiurus natalis*), and flathead catfish (*Pylodictis olivaris*). Channel catfish (*Ictalurus punctatus*) were also captured from Tonto Creek during electroshocking surveys in October 2019 (Jones 2020). Both Tonto Creek (periodically) and Salt River are connected to Roosevelt Lake, so nonnative fish species assemblages are expected to be similar at both sites. Incidental encounters also documented the presence of potential predators at both the Tonto Creek and Salt River arms of Roosevelt Lake and included other snake species, mammals, birds, bullfrogs, nonnative fish, and crayfish (Nowak et al. 2015; Nowak et al. 2020).

Table 9. Incidental Species Observations

Species	Tonto Creek (2014 trapping)	Tonto Creek (2014 VES)	Tonto Creek (2015–2017 trapping)	Salt River (2014 VES)	Salt River (2019 trapping)	Salt River (2020 trapping)
Lowland leopard frog	1	0	88	0	3	0
Bullfrog*	1,763	119	5,307	0	2	5
Woodhouse's toad*	223	27	9,768	2	0	3
Native fish	201	–	351	–	0	0
Nonnative fish (soft-rayed)	4,419	–	22,565	–	3,024	2,054
Nonnative fish (spiny†)	41	–	782	–	114	243
Crayfish	374	–	–	–	267	298

*Majority of trap captures consisted of larva, i.e., tadpoles.

†Spiny fish species include all members of the Centrarchidae and Ictaluridae families.

DISCUSSION

Within the Roosevelt Lake permit area, gartersnake individuals have only been detected in the Tonto Creek arm. Habitat selection studies using radio telemetry were conducted at this site from 2015 to 2018, and results from these studies can be found in Nowak et al. (2020) and Myrand (2019). A vegetation transect study was implemented in 2019 using data collection methods similar to those used by Nowak et al. (2020) and Myrand (2019) to better quantitatively describe differences and similarities in vegetation cover at the Tonto Creek and Salt River arms of the reservoir. The known presence of gartersnake along Tonto Creek allows for a comparison of habitat characteristics at a known gartersnake occupied site with those of a site like the Salt River arm where gartersnake have not been detected.

Both the Tonto Creek and Salt River arms provide perennial aquatic habitat, which is an important component for gartersnake habitat suitability (Table 10). However, there do appear to be notable differences in water conditions between the two reservoir arms. Conditions of high velocity and turbidity may not preclude habitat from being suitable for gartersnake, as evident by their presence in the Tonto Creek arm, which does experience periods of high velocity and turbidity. However, if these conditions are persistent, it may have a negative impact on gartersnake foraging success. Gartersnakes are assumed to be visual predators and higher turbidity may limit their ability to locate aquatic prey. This may present a particular problem in the Salt River arm because of the apparent low numbers of anurans, and available prey species are generally restricted to aquatic fish. Nonnative fish species that are consumed by gartersnake were abundant at both the Salt River and Tonto Creek arms. However, the relative lack of anurans, particularly native species in the Salt River, suggests that important prey species and forage opportunities may be lacking in the Salt River arm of Roosevelt Lake and may contribute to the unsuitability of this portion of the permit area as gartersnake habitat. The steep banks and faster water flows may also limit gartersnake foraging by making prey captures more difficult.

These differences in the stream channel morphologies of the two arms also impact the terrestrial riparian habitat, as observed in the generally more diverse and heterogeneous habitat observed in the Tonto Creek arm compared to the abundance and dominance of saltcedar in the Salt River arm (see Table 6; see Figures 3 and 4).

A study of riparian habitats and reptile/amphibian diversity at sites along the San Pedro and Gila Rivers showed that monotypic nonnative stands (i.e., saltcedar) had low habitat index scores (low heterogeneity) compared with sites dominated by native trees, which had more heterogeneous habitats and higher habitat index scores, with both of the two native stand types (cottonwood/willow and mesquite) having similar habitat indices (Bateman and Merritt 2020). This study found significant positive relationships between high habitat index scores (high heterogeneity) and reptile/amphibian communities, particularly for species richness (Bateman and Merritt 2020). Another study by Bailey et al. (2001) found that saltcedar leaf litter had a negative impact on aquatic macroinvertebrate diversity, resulting in a two-fold decrease in species richness and a four-fold decrease in overall abundance when compared to native cottonwood leaf litter. This reduction in aquatic macroinvertebrates could contribute to the low numbers of observed anurans in the Salt River arm. Although gartersnakes do not typically rely on lizards or macroinvertebrates as prey items, their absence and/or reduced presence could limit alternative prey items, given the documented reduced presence of anurans.

Another mechanism that Bateman and Merritt (2020) proposed may be responsible for the lower suitability of saltcedar monocultures for lizard species was that saltcedar monocultures are characterized by high levels of canopy cover and low variability, which could limit basking and ability to thermoregulate. Although data from transects showed that Salt River and Tonto Creek did have comparable amounts of live vegetation and debris/litter, Salt River had a much lower percentage of canopy cover less than 1 m and a much higher percentage of canopy cover greater than 1 m. This may be an important distinction between habitat structure between the two areas, because several previous studies of gartersnake microhabitat selection in Arizona showed that gartersnakes select areas with percent canopy cover less than 1 m, and generally avoid areas with canopy cover greater than 1 m (Emmons and Nowak 2016; Nowak et al. 2020; Sprague and Bateman 2018). This difference in observed canopy cover may be a result of the dominance of saltcedar in the Salt River arm, which may negatively impact the thermoregulatory environment for gartersnakes by limiting habitat heterogeneity. This lack of heterogeneity could limit gartersnakes' ability to locate suitable basking and cover sites. The lower percentage of canopy cover less than 1 m in the Salt River arm may also limit the amount of cover that gartersnakes have available as refuge from predators, both terrestrial and including nonnative fish, when gartersnakes are foraging along streambanks.

Table 10. Evaluation of Habitat Suitability for Gartersnake at Roosevelt Lake Permit Area

Site	Presence/ Absence	Perennial Aquatic Habitat	Terrestrial Riparian Habitat	Ecological Community	Determination
Roosevelt Lake					
Tonto Creek Arm	Occupied	Suitable: Spatially Intermittent Stream and Reservoir	Suitable: Presence of gartersnake and habitat selection studies demonstrate that riparian habitat is suitable for gartersnake.	Suitable: Presence of native anurans and fish (prey). Nonnative anurans (bullfrogs), fish (spiny), and crayfish are present, but gartersnake population appears resilient.	Gartersnakes are known to occupy this site. Habitat suitability will be used as the standard for evaluating other sites/properties.

Site	Presence/ Absence	Perennial Aquatic Habitat	Terrestrial Riparian Habitat	Ecological Community	Determination
Salt River arm	Not Detected	Potentially unsuitable: Perennial stream; however, water turbidity and flow rates are substantially higher at the Salt River compared to Tonto Creek, which may negatively impact habitat suitability.	Potentially unsuitable: Adjacent riparian habitat does not appear to provide sufficient habitat structure for gartersnake. This is likely because the dense monoculture of saltcedar is unlikely to provide sufficient habitat heterogeneity for thermoregulation, shelter, foraging opportunities, and protection from predators.	Potentially unsuitable: Native anurans and fish are absent or in low numbers. Nonnative anurans are also mostly absent. Nonnative fish (spiny) and crayfish are abundant. While nonnative fish may provide some foraging opportunities, the lack of prey may negatively impact habitat suitability.	Potentially unsuitable: No gartersnake detections despite substantial effort. Habitat is suspected to be unsuitable because of poor water conditions combined with exclusively aquatic prey, which may provide insufficient forage, and the lack of suitable terrestrial riparian habitat structure for essential behaviors (breeding, feeding, and sheltering).

Despite several surveys along the Salt River within the Roosevelt Lake permit area, no gartersnake were detected. Annual trap effort along the Salt River in 2019 (34,728 trap hours) and 2020 (61,584 trap hours) was slightly lower than the average annual trap effort within the Tonto Creek arm from 2015 through 2017 (approximately 70,864.3 trap hours per year). However, both years of trapping in the Salt River arm (2019 and 2020) were higher than the Tonto Creek trapping effort in 2014 (23,263 trap hours). This suggests that trap effort between the two arms of Roosevelt Lake have been comparable, although VES effort along the Salt River has been substantially lower than in Tonto Creek. The inherent low detectability of gartersnakes means that the failure to detect gartersnakes does not definitively prove their absence. However, the combined results of our studies along the Salt River—i.e., lack of gartersnake detections, differences in aquatic habitat conditions, potentially unsuitable terrestrial habitat structure, and potentially unsuitable ecological community—suggest that it is unlikely that the Salt River arm of Roosevelt Lake currently provides likely occupied gartersnake habitat. Based on these results it should not be necessary for SRP to include the Salt River arm of Roosevelt Lake in habitat mitigation efforts for gartersnake, as it is not likely to be occupied by gartersnakes under current conditions.

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APPENDIX A

White Paper –
Comparison of Select Flow Conditions on Tonto Creek and Salt River

PURPOSE

The purpose of this white paper is to compare select flow or water conditions that are of importance to northern Mexican gartersnake (gartersnake) habitat and use. Comparisons are made between Tonto Creek, an intermittent stream which feeds Roosevelt Lake from the west, and the Salt River, a largely perennial stream which feeds Roosevelt Lake from the east.

The two parameters explored here are turbidity and flow velocity.

TURBIDITY

Turbidity data were obtained from the U.S. Geological Survey (USGS) National Water Information System (NWIS) for two stream gage locations:

- Gage #09499000, TONTO CREEK ABOVE GUN CREEK, NEAR ROOSEVELT, AZ
- Gage #09498500 SALT RIVER NEAR ROOSEVELT, AZ

Available turbidity data are summarized in Table A-1. Note that while most values were reported in nephelometric turbidity units (NTU), some were reported in Jackson turbidity units. For the purposes of this summary, these were assumed to be similar enough to use as a single data set.

Table A-1. Turbidity Data from USGS NWIS for Tonto Creek and Salt River

Location	Period of Record	Number of Measurements	Average (NTU)	Median (NTU)	Minimum (NTU)	Maximum (NTU)
Tonto Creek	1976–1992	42	9	2	0	120
Salt River	2004–2019	75	235	19	2	5,370

Note: Specific water quality codes used were P00070 and P00076 for Tonto Creek, and P63676 for Salt River. Some data were flagged as estimated; these are included in the summary statistics as well.

Overall, based on the available period of record from this data source, turbidity appears to be consistently and substantially lower on Tonto Creek than on the Salt River.

VELOCITY

Velocity is a factor of both flow rate and channel geometry, and therefore is highly specific to single locations and flow conditions. The USGS NWIS contains field measurements taken at the location of the gages during various flow events. Available velocity data are summarized in Table A-2.

Table A-2. Channel Velocity Data from USGS NWIS for Tonto Creek and Salt River

Location	Period of Record	Number of Measurements	Average Channel Velocity (ft/sec)	Median Channel Velocity (ft/sec)	Minimum Channel Velocity (ft/sec)	Maximum Channel Velocity (ft/sec)
Tonto Creek	2002–2021	762	1.0	0.7	0.01	11.1
Salt River	1978–2021	830	1.7	1.3	0	12.6

Overall, based on the available period of record from this data source, velocity appears to be consistently lower on Tonto Creek than on the Salt River.

APPENDIX H

Northern Mexican Gartersnake Habitat Modeling at Roosevelt Lake

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NORTHERN MEXICAN GARTERSNAKE HABITAT MODELING AT ROOSEVELT LAKE, ARIZONA[1]

EXECUTIVE SUMMARY

Salt River Project Agricultural Improvement and Power District (SRP) is seeking to amend its existing Roosevelt Lake Habitat Conservation Plan (RHCP) to include the northern Mexican gartersnake (*Thamnophis eques megalops*; gartersnake). The gartersnake became listed under the Endangered Species Act (ESA) as a threatened species in 2014 and is known to occur along lower Tonto Creek, including the Roosevelt Lake permit area (U.S. Fish and Wildlife Service [USFWS] 2014). The RHCP amendment is also seeking to expand the original permit area, i.e., Conservation Space (CS; elevation < 2,151 feet above mean sea level [amsl]) to also include the Flood Control Space (FCS; elevation 2,151 to 2,175 feet amsl) and a corridor along lower Tonto Creek from the top of the FCS upstream to the crossing of East Del Chi Drive. For the purposes of this report, the habitat modeling efforts will focus on the Tonto Creek arm of the CS and the FCS of Roosevelt Lake.

We used Normalized Difference Vegetation Index (NDVI) and photo interpretation methods to identify and map water features on a series of aerial images. We matched National Agriculture Imagery Program (NAIP) imagery collected in 2015 and 2017 to gartersnake locations recorded during the Nowak et al. (2019) study period, and we measured the distance from each gartersnake location to the nearest mapped water. Buffering the mapped water by 94 m encompassed 95% of the 674 gartersnake telemetry locations and encompassed an average of 84% of the minimum convex polygons (MCPs) for each individual gartersnake. Buffering water features by 94 m thus provides a good approximation of gartersnake likely occupied habitat. We modeled available gartersnake likely occupied habitat by applying the 94-m buffer to all the channel water features identified from an aerial time series and adding this channel habitat to reservoir edge habitat modeled at 2-foot intervals in lake elevation. Available gartersnake likely occupied habitat within the CS decreased from approximately 600 acres at lake elevation 2,036 feet amsl, to 100 acres at full pool elevation 2,151 feet amsl.

For the FCS, we followed similar methods to map and buffer water, but only included channel habitat and did not include any calculations of reservoir edge habitat because of the brief periods of time that the lake inundates the FCS. Likely occupied gartersnake habitat within the FCS under current operations ranges from a maximum of 195.8 acres when Roosevelt Lake elevation is less than 2,151 feet amsl to 0 acres when fully inundated at elevation 2,175 feet amsl.

Under the planned deviation, habitat loss in the first 5 vertical feet would total up to 37.7 acres at reservoir elevation 2,156 feet amsl and would leave at least 158.1 acres of available gartersnake habitat within the FCS during the 120-day period. This temporary habitat loss of 37.7 acres during the 120-day period represents the most substantial difference between likely occupied gartersnake habitat available in the FCS under current operations and the planned deviation. Outside of the planned deviation, management of water levels in the FCS would operate under the current operations as described above.

[1] This report is subject to change through continued development.

This mapping approach to model likely occupied gartersnake habitat can be repeated as new imagery becomes available to document changes in reservoir level and consequently gartersnake habitat. This will allow a repeatable method of documenting “take” of gartersnake habitat from SRP operations of Roosevelt Lake. The model can also be refined as remote sensing technology and water detection capabilities advance.

INTRODUCTION

Salt River Project Agricultural Improvement and Power District (SRP) is seeking to amend its existing Roosevelt Lake Habitat Conservation Plan (RHCP) to include the northern Mexican gartersnake (*Thamnophis eques megalops*; gartersnake). The gartersnake became listed under the Endangered Species Act (ESA) as a threatened species in 2014 and is known to occur along lower Tonto Creek, including the Roosevelt Lake permit area (U.S. Fish and Wildlife Service [USFWS] 2014). The RHCP amendment is also seeking to expand the original permit area, i.e., Conservation Space (CS; elevation < 2,151 feet above mean sea level [amsl]) to also include the Flood Control Space (FCS; elevation 2,151 to 2,175 feet amsl) and a corridor along lower Tonto Creek from the top of the FCS upstream to the crossing of East Del Chi Drive. For the purposes of this report, the habitat modeling efforts will focus on the Tonto Creek arm of the CS and the FCS of Roosevelt Lake.

The gartersnake is a cryptic subspecies with low detection rates, and quantitative population estimates are difficult to calculate (Nowak et al. 2019). Consequently, SRP anticipates using habitat impacts as a surrogate for population estimates to assess and track incidental take of gartersnakes in the permit area for the RHCP Amendment, as well as to address Study 1 of SRP’s permit.[2] The goal of the habitat modeling study described herein is to model likely occupied habitat for gartersnakes within the permit area of Roosevelt Lake now and in the future. While SRP understands that the entire permit area could be potentially occupied by gartersnakes at any time, the focus of this modeling effort was to determine a reliable method of quantifying likely occupied gartersnake habitat over time as a way of determining habitat take.

The gartersnake is a riparian-obligate within a generally xeric landscape, and its persistence within the permit area depends on the quantity and quality of suitable habitat. Dam operations and the rise and fall of reservoir levels affect the presence and distribution of water within the permit area, which in turn affects the amount of available habitat for gartersnakes. Generally, SRP actions that store water cause the lake elevation level to rise, which inundates portions of the CS or FCS and reduces available habitat. Conversely, SRP actions that release water cause the lake elevation level to decline, which exposes portions of the CS and FCS and expands available habitat. Thus, the availability of gartersnake habitat is a direct consequence, at least in part, of changing lake elevation levels. This habitat impact occurs within the CS and occasionally within the FCS. In the CS, changes in habitat availability can persist for months or years. In the FCS, changes in habitat availability can persist for days (under current operations) or months (under the planned deviation).

SRP looked at a variety of different habitat variables, such as vegetation, soils, topography, etc.; however, water was identified as the variable most associated with gartersnake locations and was mappable for past, present, and future.

[2] Section 10(a)(1)(A) Recovery Permit for the Northern Mexican Gartersnake for the Proposed Scientific and/or Enhancement of Propagation or Survival Activities (Number: TE62371D-0; Effective: 12/03/2019; Expires: 1/31/2024, Roosevelt).

The objectives of this study include the following:

1. Determine a consistent, reproducible, and defensible method to map the location of water within the permit area.
2. Determine an appropriate distance-to-water buffer to define the extent of habitat likely to be occupied by gartersnakes within the permit area.
3. Use the distance-to-water buffer and mapped water within the permit area to model likely occupied habitat within the permit area across the range of possible reservoir pool elevations.

CONSERVATION SPACE

1. Mapping Water

Previous studies of gartersnake habitat selection have clearly linked gartersnakes with aquatic edge habitats during the active season (Emmons and Nowak 2016; Nowak et al. 2019; Sprague and Bateman 2018) and mapping the location of water pools within the CS is therefore critical to understanding where gartersnakes are likely to occur. Tonto Creek is a spatially intermittent creek that flows primarily during spring runoff and after large precipitation events during the monsoon season. Tonto Creek contains persistent backwaters and marshy areas that vary in size and location from year to year.

Several approaches were considered for mapping the location and extent of water:

- Field-based mapping
- Topographic and hydrologic modeling
- Feature mapping from aerial imagery

Using GPS equipment to map water locations is a challenging undertaking that is not a practical and replicable approach. The area's rough terrain and dense vegetation, along with the time investment required, were prohibitive, and this approach was removed as an option for this study.

We tested topographic and hydrologic modeling for mapping channel conditions of Tonto Creek. The model was based on 2015 LiDAR terrain data and readily identified channel and flowlines, but this approach was too simplistic. The model assumed that water was always present within the creek channel but did not identify backwaters or intermittent waters that were visible on aerial imagery.

Mapping water from aerial imagery proved to be the best approach. National Agriculture Imagery Program (NAIP) imagery is a standard, high-quality product administered by the U.S. Department of Agriculture Farm Service Agency. High-resolution NAIP data are readily available through public data servers such as Earth Explorer. Water features are clearly visible in the imagery if they are not obscured by vegetation, and standard image processing workflows, such as spectral indices, provide an unbiased and practical method of making repeated delineations. These workflows are described below.

NAIP acquisition coincides with local leaf-on conditions, and data are available as three-band natural color (Red, Green, Blue [RGB]) or four-band color near-infrared (NIR) images with a spatial resolution of 1 m or less. These images are well suited for mapping a variety of land cover types, including water. NAIP imagery from 2005, 2007, 2010, 2013, 2015, and 2017 is available for the CS. SRP provided additional imagery collected by the U.S. Bureau of Reclamation in 2000 and 2002 for use in the analysis. The Bureau of Reclamation imagery is natural color (i.e., RGB) with a spatial resolution of less than 0.25 m and was collected at historically low reservoir conditions in September 2000 and November 2002.

NDVI is a spectral index commonly used to map vegetation and other landcover types. NDVI is effective in identifying water bodies from multispectral imagery (Jensen 2016) and exploits the spectral response of different landcovers in the red (R) and NIR portion of the spectrum. NDVI is calculated as NIR−R/NIR+R. The resulting NDVI values range from −1 to +1; high positive values correlate to vegetation, and water typically has an NDVI value less than 0 (Albarakat and Lakshmi 2019).

We processed five NIR NAIP scenes (2007, 2010, 2013, 2015, and 2017) using the NDVI algorithm to enhance, identify, and map water bodies within the CS. This included lake water, channel water, backwaters, marshy areas, and other discernible surface water. Deep shadows often have negative NDVI values and were removed from the dataset by a geographic information system (GIS) analyst through photo interpretation and digitizing. Three RGB datasets (2000, 2002, and 2005) lacked an NIR channel and could not be processed with NVDI. Water features were mapped in these datasets by a GIS analyst using photo interpretation and digitizing. Although we did not complete an accuracy assessment, we systematically reviewed the data throughout the mapping process to minimize commission and omission errors. Representative images used in this study demonstrate how the amount and distribution of water within the CS changes over time (Figures 1a through 1h).

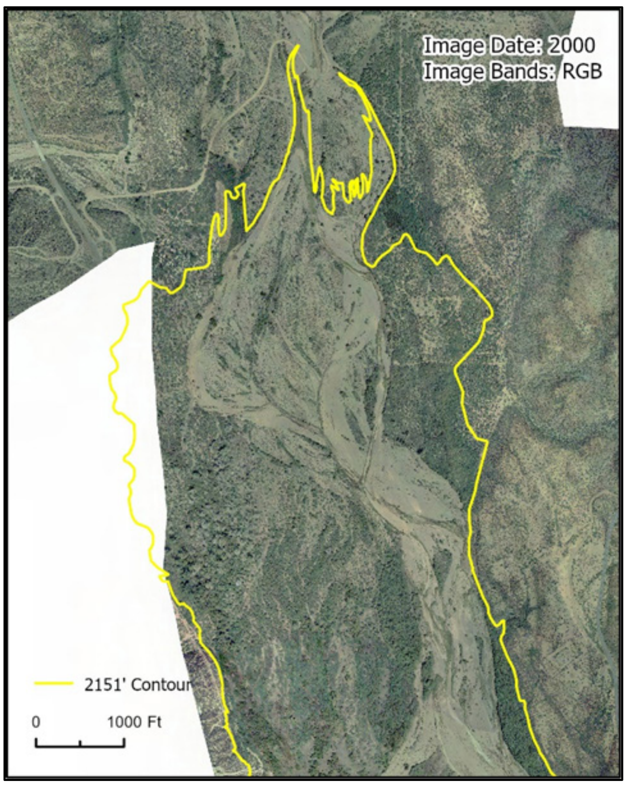

Figure 1a. Image date 2000.

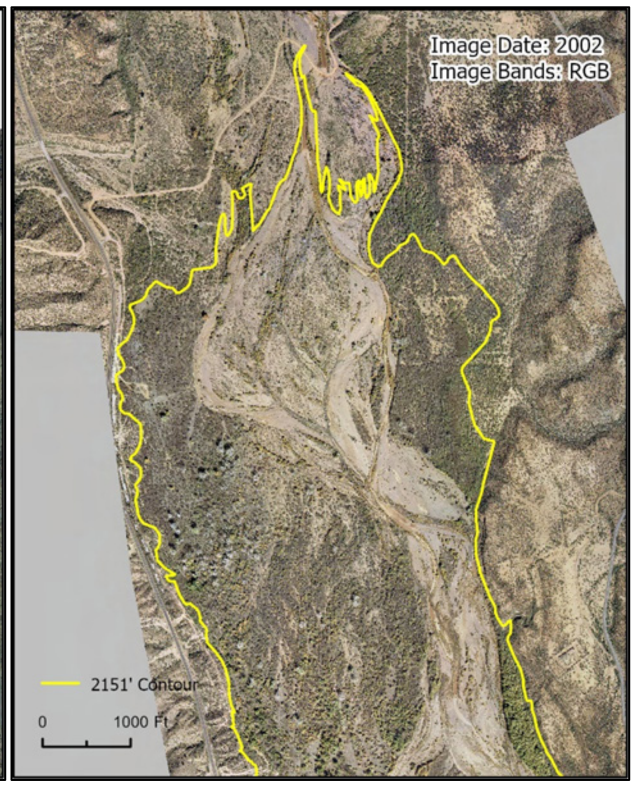

Figure 1b. Image date 2002.

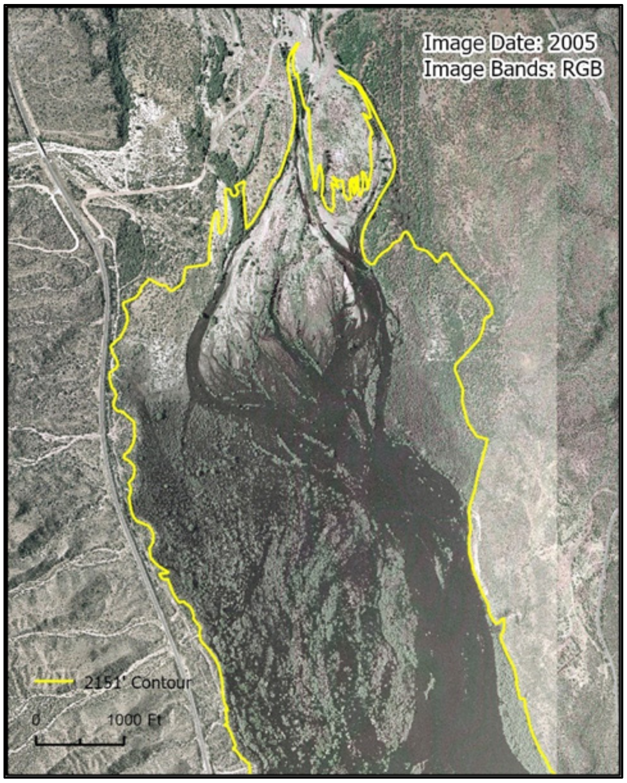

Figure 1c. Image date 2005.

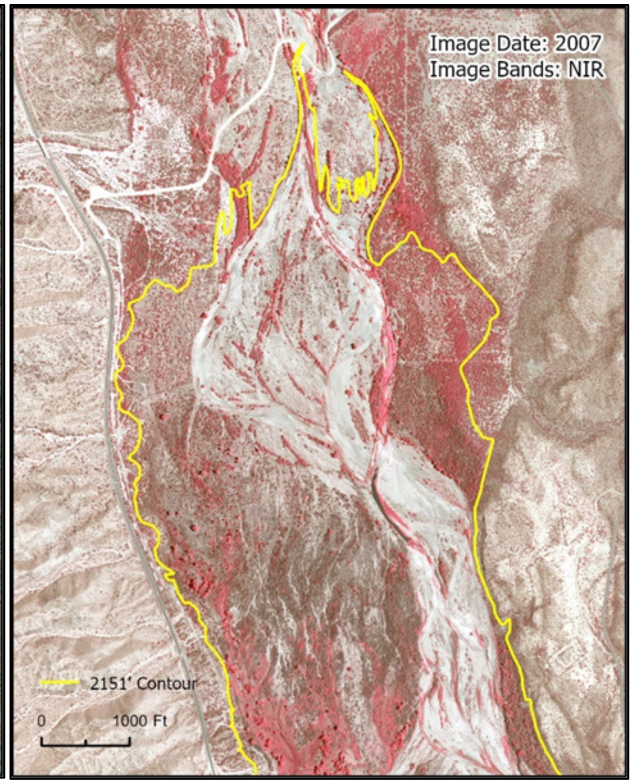

Figure 1d. Image date 2007.

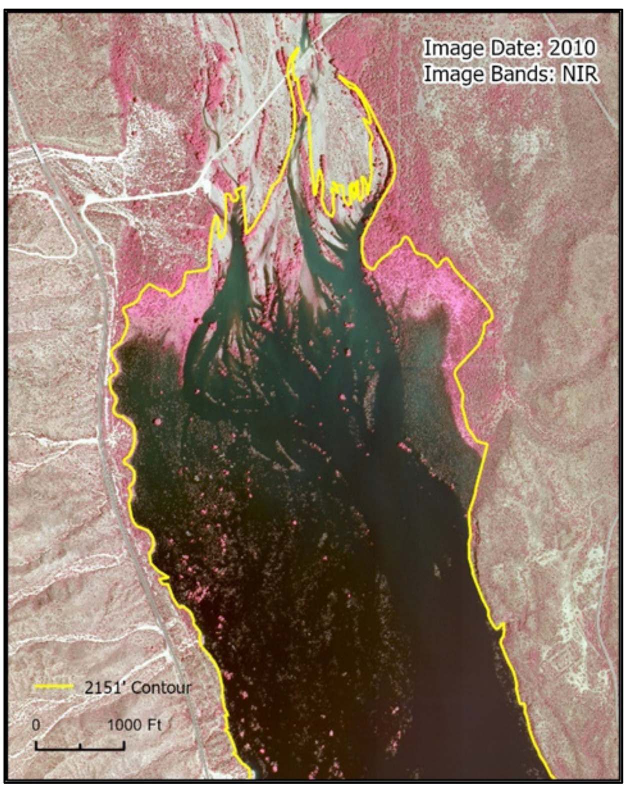

Figure 1e. Image date 2010.

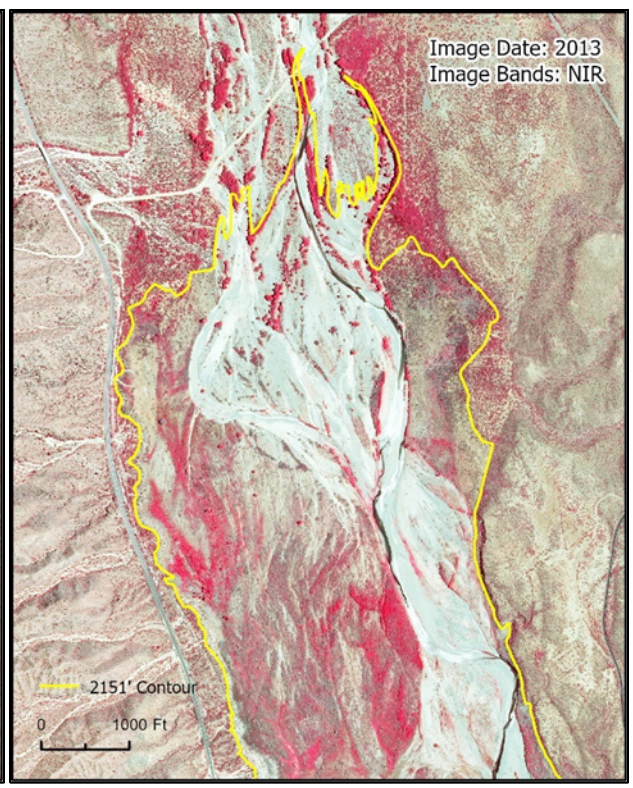

Figure 1f. Image date 2013.

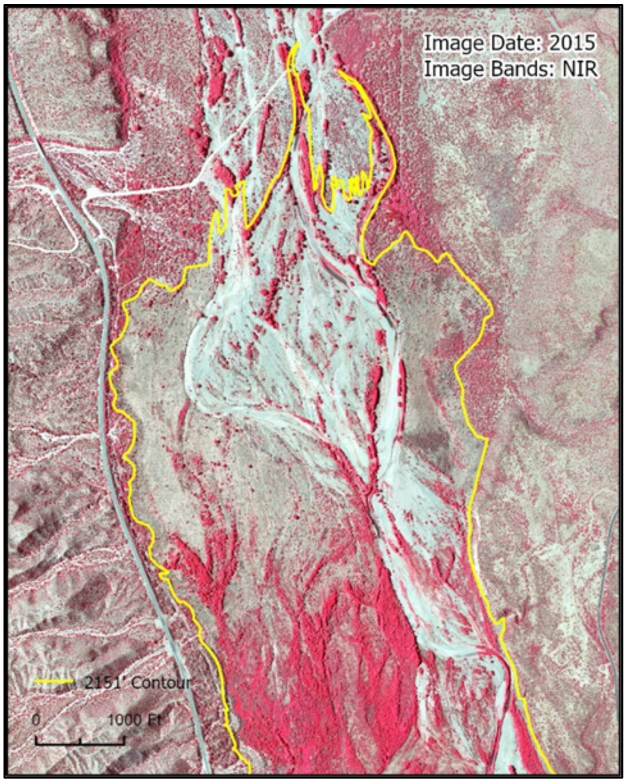

Figure 1g. Image date 2015.

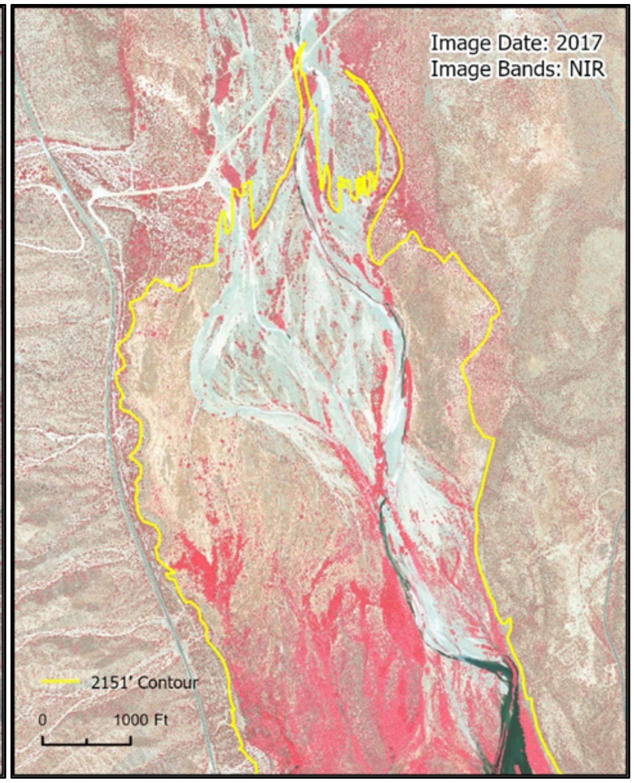

Figure 1h. Image date 2017.

2. Determining Distance-to-Water Buffer

As demonstrated by numerous studies, distance to water is a critical factor in gartersnake habitat selection, and the species is closely associated with aquatic edge habitats (Emmons and Nowak 2016; Nowak et al. 2019; Sprague and Bateman 2018). The species is associated with riparian areas and uses wetlands, adjacent uplands, and shallow aquatic habitats. Based on this previous research, a key indicator of likely occupied habitat for gartersnakes is the distance to water. A distance-to-water buffer could, thus, be applied to mapped water bodies to identify gartersnake likely occupied habitat.

The distance to water value is dependent on how waters are mapped and may not represent the actual distance to water on the date the gartersnake was detected. If waters are overpredicted, then the calculated distance to water would be smaller than the real distance. Conversely, if waters are underpredicted, then the calculated distance to water would be greater than the actual distance. Modeling must balance both types of error. Objectivity, replicability, and practicability are important considerations in selecting a model for calculating the distance to water. We calculated distance to water as the distance from observed locations of gartersnake detections (Nowak et al. 2019) to the limits of waters identified on the landscape at a particular time based on NAIP imagery, as described in greater detail below.

From 2015 through 2018, Nowak et al. (2019) used radio telemetry to study the movements and habitat use of 30 gartersnakes within and near the Tonto Creek arm of the CS. Of these 30 snakes, 25 inhabited the CS considered in this study. The difference in sample size and individuals accounts for differences between distance to water metrics reported in Nowak et al. (2019) and those reported in this study. Nowak et al. (2019) measured the distance to the nearest water for each gartersnake location directly in the field. During the active seasons of 2015–2018, adult female gartersnakes were found at a mean distance to water of 33.45 m (standard error [SE] = 3.89 m; range = 0–393 m), and male gartersnakes had a mean distance to water of 30.59 m (SE = 11.09 m; range = 1–98 m) (Nowak et al. 2019). We considered using these distance-to-water measurements to calculate the distance-to-water buffer, but a proximity analysis using GIS software and the NAIP data identified several water bodies that were closer to the gartersnake locations than those recorded in the field.

Reservoir elevation increased dramatically during the 2017 active season (Nowak et al. 2019), and we used two NAIP images (2015 and 2017) to account for the different reservoir elevation levels during the period of telemetry observations. In total, 674 gartersnake telemetry locations were matched with the associated NAIP image (Table 1), and the distance to mapped water was calculated for each location.

Table 1. Matching of NAIP Imagery with Gartersnake Field Observations

NAIP Image	Date Range of Field Observations	Number of Field Observations
June 2015	October 2015 through December 2016	298
June 2017	January 2017 through March 2018	376
Total		**674**

Overall, the distance-to-water measurements as calculated from the mapped water had a smaller mean, median, and standard error than those obtained in the field (Table 2). However, a paired comparison of the field and model measurements showed that 61% were within 10 m and 85% were within 50 m (Figure 2).

Table 2. Statistical Values of Field Observations vs. Model Estimates

Statistic	Field Observations	Model Estimates	Paired Difference
Sample size	674	674	674
Mean (m)	38.1	21.3	18.9
Standard deviation (m)	69.2	41.7	47.9
Standard error (m)	2.7	1.6	1.9
Median (m)	12.0	6.0	0
Minimum (m)	0	0	−129.0
Maximum (m)	393.0	269.2	358.8
95% quantile (m)	178.6	94.0	N/A

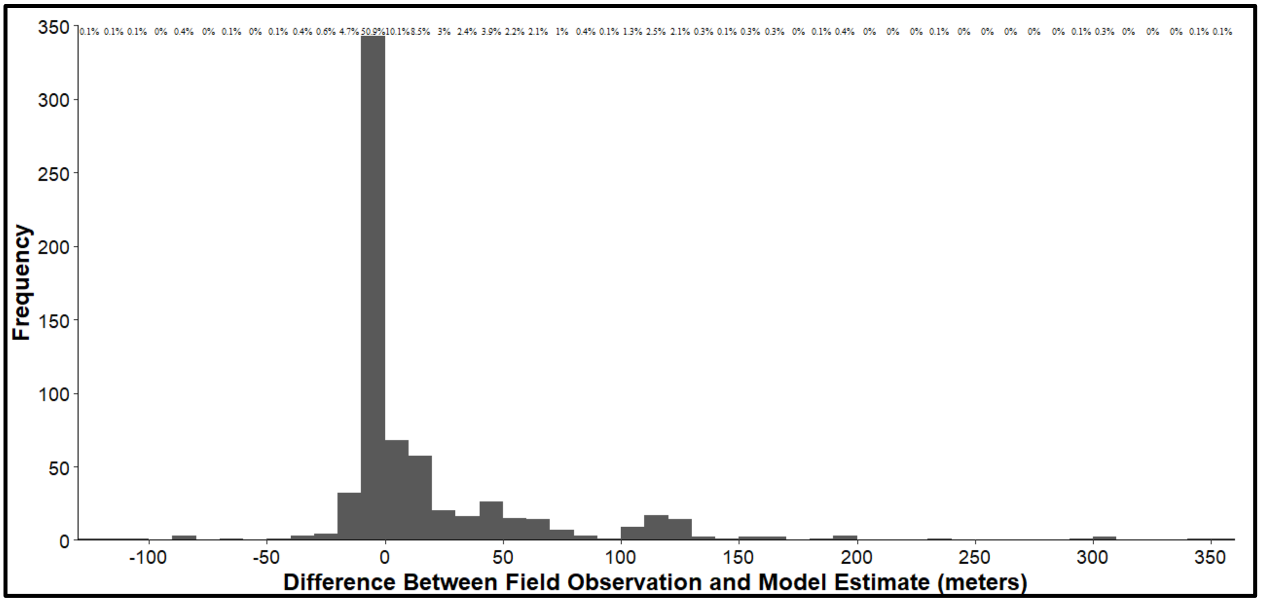

Figure 2. Histogram comparing distance to water obtained from field observations with model estimates.

Monthly scatter plots of field observations vs. model estimates show that the correlation between the two sets of measurements varied over time (Figures 3 and 4). In Figures 3 and 4, the red line is set to a slope of 1 (i.e., perfect correlation). Points above the line demonstrate where the model estimated that distance to water was greater than the distance observed in the field, whereas points below the line indicate the reverse. Field data collected in October 2015 and from April through June 2016 correlated well with measurements obtained from the June 2015 NAIP image (see Figure 3). However, correlations for March 2016 and July through October 2016 had greater variation. Field data collected from May through August 2017 correlated well with measurements obtained from the model based on the June 2017 NAIP imagery (see Figure 4).

Overall, the comparison of the two methods suggests a good correlation between the field observations and the model estimates of distance to water. This further supports the decision to use the NAIP imagery to map the amount and distribution of water within the Tonto Creek arm of the CS.

The next step in developing the distance-to-water buffer was to determine a suitable threshold of modeled distance to water within which gartersnakes would likely occur. This threshold was used to determine the extent of likely occupied habitat within the Tonto Creek arm of the CS at a given reservoir elevation. Our goal was to establish a threshold distance that would encompass the majority of the gartersnake telemetry locations recorded by Nowak et al. (2019). SWCA and SRP recognize that gartersnakes may occur anywhere within the permit area. However, the goal of this study was to develop a reliable and replicable means of assessing changes in the amount and distribution of likely occupied gartersnake habitat over time in relation to the rise and fall of Roosevelt Lake resulting from SRP dam operations.

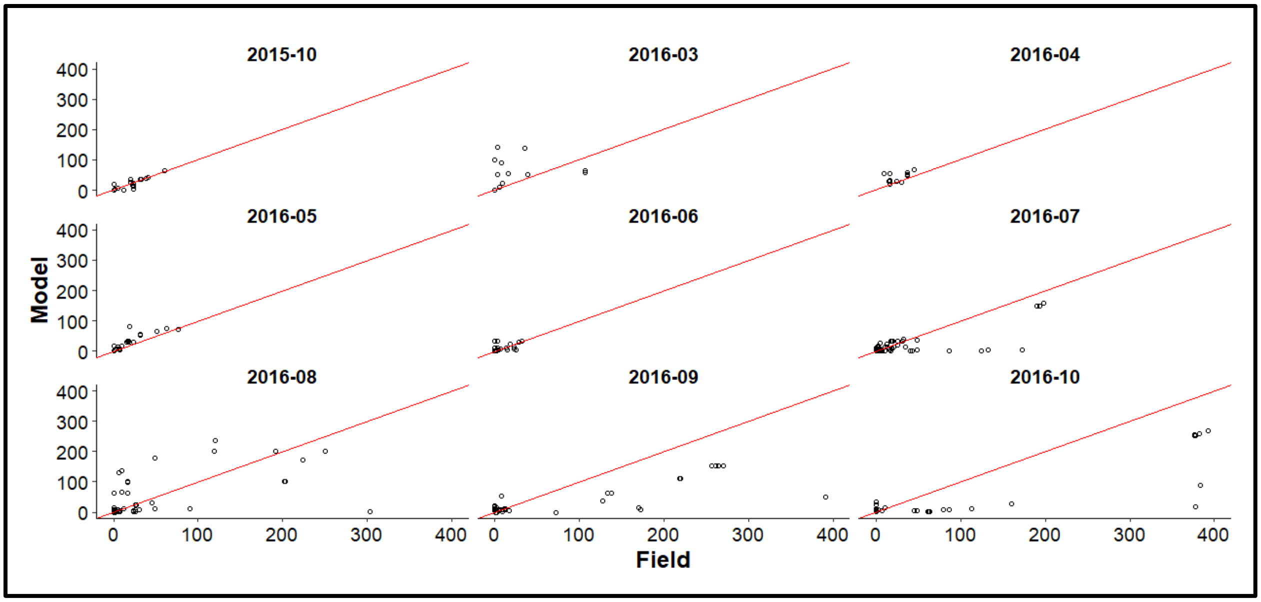

Figure 3. Monthly scatter plots showing distance from active season gartersnake telemetry locations to water as obtained from field observations vs. model estimates from October 2015 through October 2016. Red line indicates a 1:1 slope. Suffix after year indicates month.

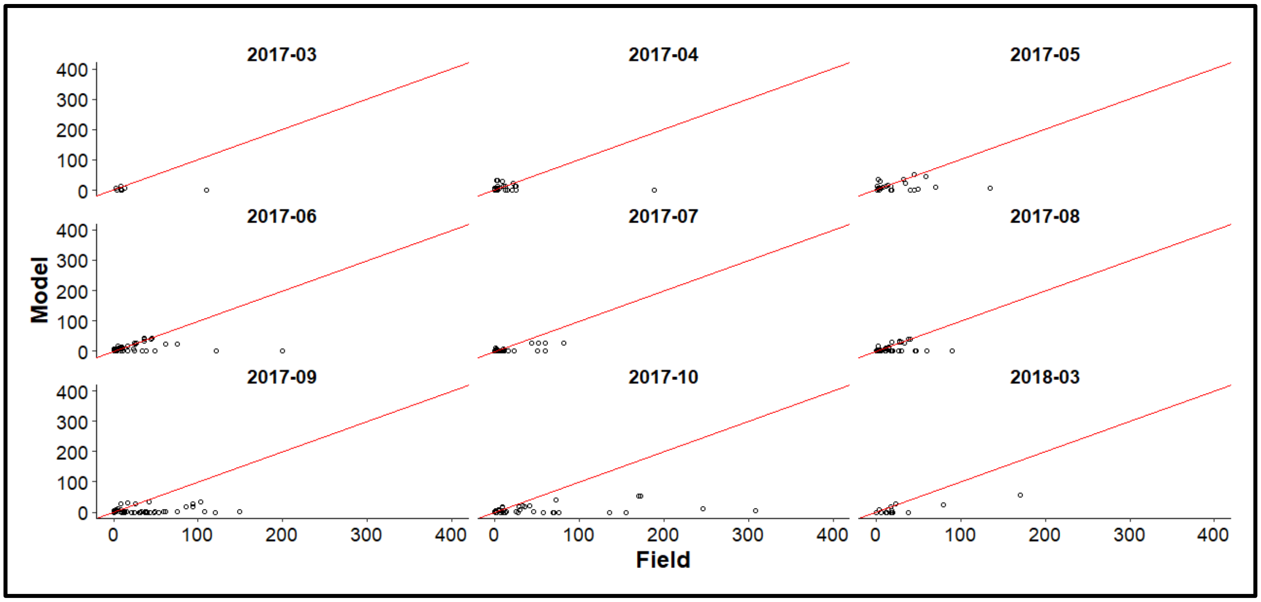

Figure 4. Monthly scatter plots showing distance from active season gartersnake telemetry locations to water as obtained from field observations vs. model estimates from March 2017 through March 2018. Red line indicates a 1:1 slope. Suffix after year indicates month.

Using the 95% quantile provides a suitable trade-off between including most observations while also excluding outlier observations that could be indicative of snakes moving to brumation sites or dispersing between habitats. A distance to water of 94 m encompassed 95% of the 674 gartersnake telemetry locations (Figure 5), and this was chosen as the distance-to-water buffer.

We buffered the mapped water in the NAIP images from 2015 and 2017 by 94 m. This buffered area represents the model of gartersnake likely occupied habitat within the CS for those 2 years.

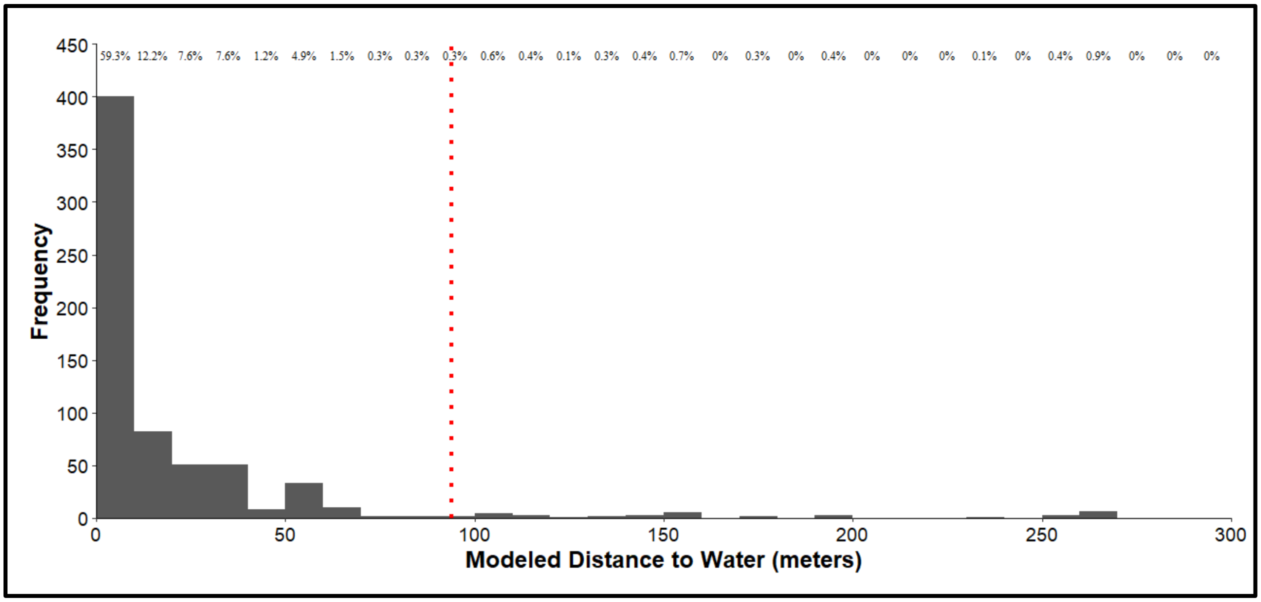

Figure 5. Histogram of modeled estimates of distance to water. Red line indicates 94-m threshold used to estimate likely occupied habitat.

To test the spatial efficacy of the habitat model, we generated minimum convex polygons (MCPs) for each individual gartersnake (active- and winter-season telemetry combined) to estimate the acreage of habitat used by gartersnakes. Of the 30 gartersnakes studied by Nowak et al. (2019), six individuals had sufficient observations to estimate home range size accurately using the MCP method, resulting in home range estimates of 13.2–55.2 acres (mean = 29.5 acres, SE = 7.1). However, we calculated an MCP for each of the 25 individuals found within the CS, even those with only a few locations, to assess the entire spatial distribution of known gartersnakes with the habitat model. We intersected each MCP with either the 2015 or 2017 modeled habitat (as appropriate) and calculated the overlap. The area of overlap between gartersnake home range MCPs and modeled habitat ranged from 46% to 100%, with a mean of 84%, suggesting that the model accurately represents gartersnake use areas within the CS (Table 3).

Table 3. Overlap of MCP Home Range for Individual Gartersnake with Modeled Likely Occupied Habitat

Snake ID	MCP Home Range (acres)	Area of MCP Home Range within Modeled Habitat (acres)	Percent of Overlap MCP/Modeled Habitat (%)
ID1*	13.24	11.74	89%
ID2	2.63	2.53	96%
ID3	69.10	50.65	73%
ID4	0.17	0.17	100%
ID5	3.16	2.88	91%
ID6*	16.27	14.43	89%
ID7	1.12	1.07	95%
ID8	2.45	1.97	81%
ID9*	21.59	19.29	89%
ID10	7.80	4.99	64%
ID12*	55.15	36.90	67%

Snake ID	MCP Home Range (acres)	Area of MCP Home Range within Modeled Habitat (acres)	Percent of Overlap MCP/Modeled Habitat (%)
ID15	1.12	0.83	74%
ID16	34.67	25.82	74%
ID17	0.96	0.94	98%
ID18	28.97	21.74	75%
ID19	0.77	0.75	98%
ID20*	23.73	16.99	72%
ID22	0.92	0.87	95%
ID23	0.01	0.01	100%
ID24	17.95	15.67	87%
ID25	4.29	4.08	95%
ID26	0.27	0.27	100%
ID28	49.09	30.00	61%
ID29	0.51	0.51	100%
ID30	40.92	18.71	46%
			Mean: 84%

* Snake was considered to have sufficient locations to accurately estimate a home range (Nowak et al. 2019).

3. Modeling Likely Occupied Habitat within the Conservation Space Across the Range of Possible Reservoir Pool Elevations

The gartersnake habitat model includes the Tonto Creek arm of Roosevelt Lake, ranging from elevation 2,151 feet amsl down to approximately elevation 2,036 feet amsl, and reflects the full range of reservoir conditions since 2002, when the reservoir was at the lowest elevation observed in recent history. Elevation data from a 2013 study were used to calculate a high-resolution terrain model of 2-foot elevational contours of the CS from elevation 2,036 feet amsl (historic low) to 2,151 feet amsl (full pool) to map the possible perimeter of the lake at a given reservoir elevation (Bureau of Reclamation 2014). We identified areas of consistent non-habitat landcover (e.g., steep slopes, bare rocky ground, unsuitable vegetation communities, and incompatible land uses such as all-terrain vehicle trails) and excluded these from the habitat model (Figure 6).

We modeled the maximum available habitat for the CS by combining the mapped channel waters from all the years of available aerial imagery with a reservoir edge habitat dataset (Appendix A; see Figure 6). The reservoir edge is the perimeter of the lake at any given reservoir elevation. We buffered each 2-foot elevation contour by 94 m to create a reservoir edge habitat layer. We also buffered the mapped channel waters by 94 m and added this to the reservoir edge habitat layer to create a maximum available habitat model at each 2-foot elevational contour of the lake. Shallow water habitat (≤ 3 feet deep) was calculated from the terrain data and added to the model at full pool levels. The shallow water habitat was added to show that habitat is still available, even at full pool elevation. This final dataset modeled estimated change in the availability of gartersnake likely occupied habitat within the full range of reservoir levels observed since 2002.

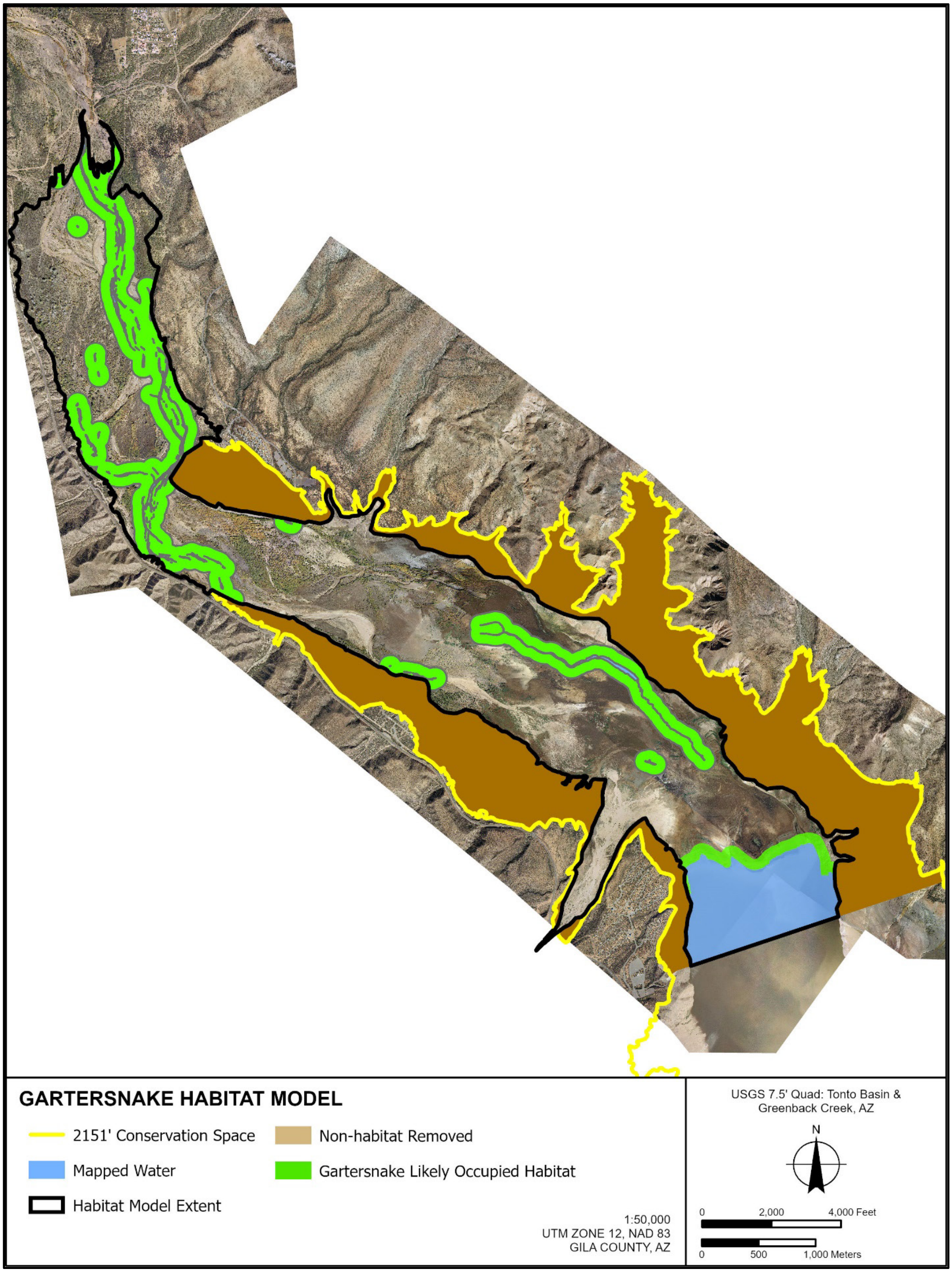

Figure 6. Gartersnake habitat model within the Conservation Space.

The greatest amount of modeled gartersnake habitat (613.3 acres) occurs when the reservoir elevation is near its lowest, at elevation 2,044 feet amsl (Figure 7). The smallest amount of modeled gartersnake habitat, 100.5 acres, occurs when the reservoir is near peak elevation, at 2,148 feet amsl (see Figure 7).

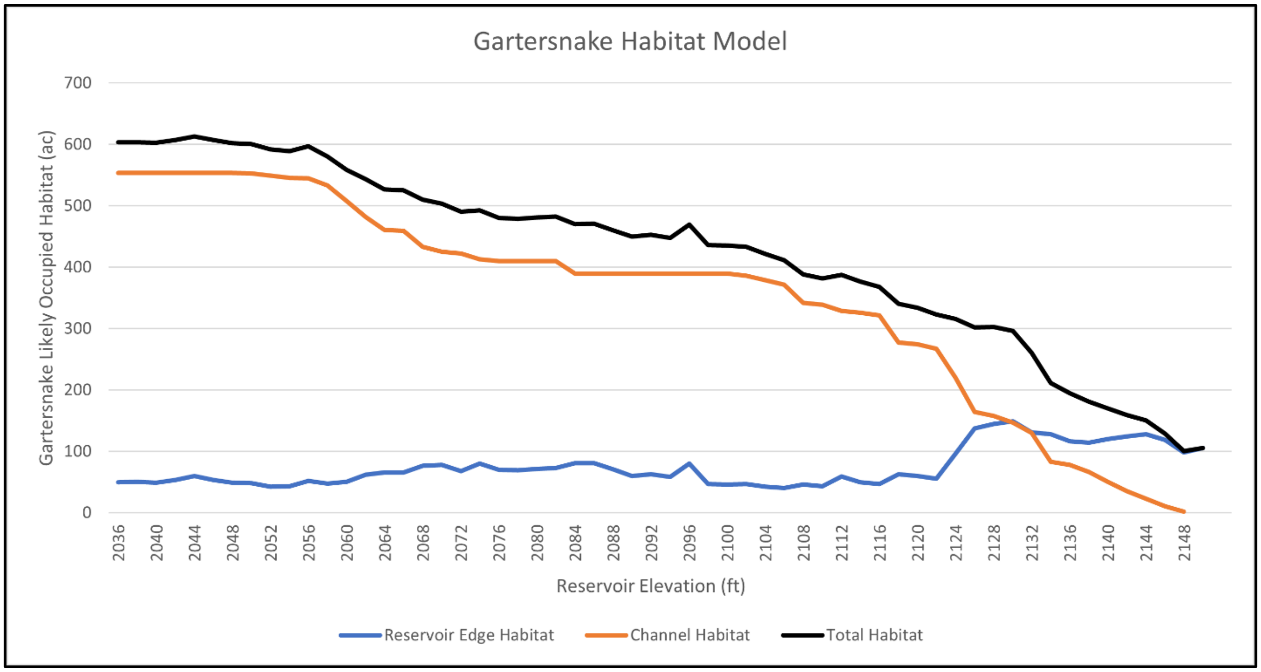

Figure 7. Line plot of modeled gartersnake habitat vs. reservoir elevations of 2,036 feet through 2,151 feet amsl.

FLOOD CONTROL SPACE

1. Mapping Water

Water in the FCS was mapped and digitized using the same methods used for mapping channel habitat within the CS. Unlike the CS, where the reservoir edge provides suitable habitat for gartersnakes, in the FCS the reservoir edge is unlikely to contribute substantially to gartersnake habitat. This is because the lake has rarely entered the FCS in the past and is estimated to do so only occasionally in the future, and then for relatively brief periods. For these reasons we did not include reservoir edge habitat in habitat calculations for the FCS.

2. Determining Distance-to-Water Buffer

The combined extent of channel habitat within the FCS was buffered by the 94-m distance to water used for the CS (Figure 8). We chose to use the same distance towater buffer as used for the CS because of the low sample size of snakes that only occurred in the FCS (n = 5). Only using data from those five snakes would have limited both statistical analysis and our ability to apply consistent methods between the CS and the FCS.

3. Modeling Likely Occupied Habitat within the Flood Control Space Across the Range of Possible Reservoir Pool Elevations

FCS Current Operations

Flood control operations occur when Roosevelt Lake exceeds the elevation of the CS and enters the FCS. Under current operations of the FCS, SRP is required to manage releases such that the reservoir elevation is returned to the limits of the CS within 20 days of first entering the FCS. Possible reservoir elevation contours within the FCS were mapped based on an updated 2018 elevation dataset at 1-foot intervals (SRP 2018). Based on the FCS habitat model, likely occupied gartersnake habitat within the FCS under current operations ranges from a maximum of 195.8 acres when Roosevelt Lake elevation is less than 2,151 feet amsl to 0 acres when fully inundated at elevation 2,175 feet amsl (Figure 9).

FCS Planned Deviation

SRP is also requesting and proposes to implement a planned deviation of current flood control operations, pending approval from the U.S. Army Corps of Engineers and the Bureau of Reclamation. The planned deviation would allow SRP to extend the duration in which it must evacuate the FCS from 20 days to 120 days. This planned deviation would only apply to the first 5 vertical feet of the FCS (between reservoir elevation 2,151 feet amsl and 2,156 feet amsl) and only in 3 years within a defined 5-year period. SRP is requesting approval for the planned deviation that would allow for use starting in January 2023 and ending in December 2028. Current operations of the FCS would apply when the lake is above the 2,156-foot elevation contour, when the planned deviation period has expired, or when SRP has implemented these alternate flood control measures in 3 of the 5 years.

Under this planned deviation, habitat loss in the first 5 vertical feet would total up to 37.7 acres at reservoir elevation 2,156 feet amsl and would leave at least 158.1 acres of available gartersnake habitat within the FCS during the 120-day period. This temporary habitat loss of 37.7 acres during the 120-day period represents the most substantial difference between likely occupied gartersnake habitat available in the FCS under current operations and the planned deviation. Outside of the planned deviation, management of water levels in the FCS would operate under the current operations as described above.

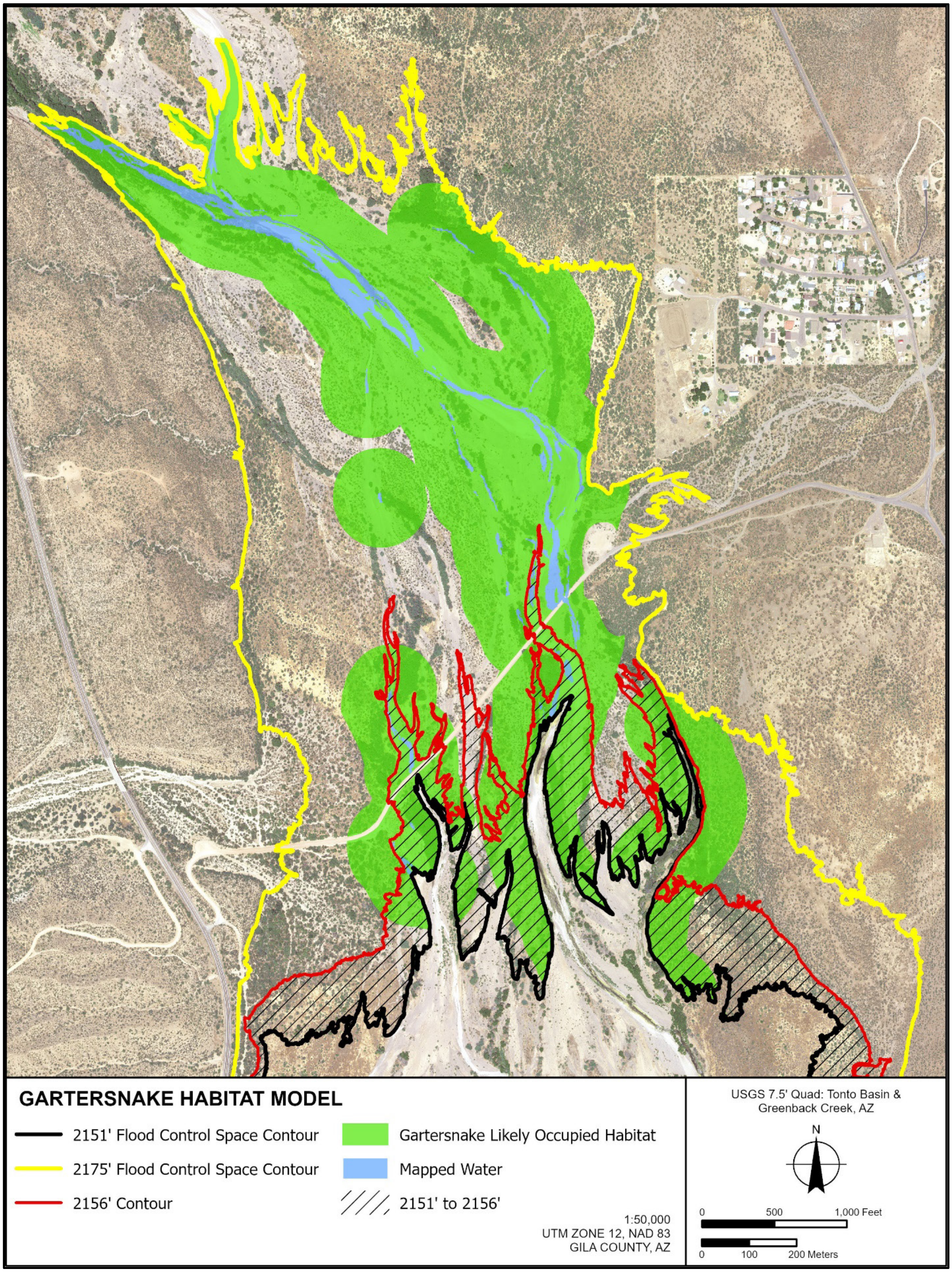

Figure 8. Gartersnake habitat model within the Flood Control Space.

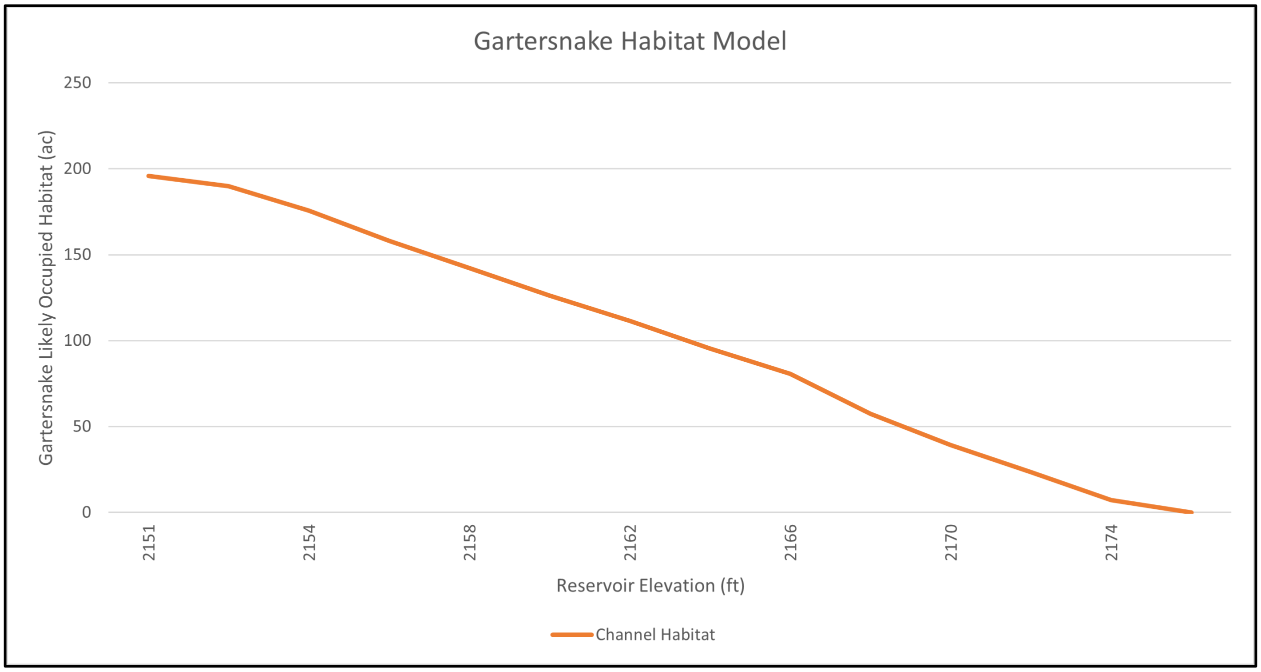

Figure 9. Modeled gartersnake habitat vs. reservoir elevations of 2,151 feet amsl through 2,175 feet amsl.

CONCLUSIONS

We used NDVI and photo interpretation methods to identify and map water features on a series of aerial images. We matched NAIP imagery collected in 2015 and 2017 to gartersnake locations recorded during the Nowak et al. (2019) study period, and we measured the distance from each gartersnake location to the nearest mapped water. Buffering the mapped water by 94 m encompassed 95% of the 674 gartersnake telemetry locations and encompassed an average of 84% of the MCPs for each individual gartersnake. Buffering water features by 94 m thus provides a good approximation of gartersnake likely occupied habitat. We modeled available gartersnake likely occupied habitat by applying the 94-m buffer to all the channel water features identified from an aerial time series and adding this channel habitat to reservoir edge habitat modeled at 2-foot intervals in lake elevation. Available gartersnake likely occupied habitat within the CS decreased from approximately 600 acres at lake elevation 2,036 feet amsl to 100 acres at full pool elevation 2,151 feet amsl.

For the FCS, we followed similar methods to map and buffer water, but only included channel habitat and did not include any calculations of reservoir edge habitat because of the brief periods of time that the lake inundates the FCS. Likely occupied gartersnake habitat within the FCS under current operations ranges from a maximum of 195.8 acres when Roosevelt Lake elevation is less than 2,151 feet amsl to 0 acres when fully inundated at elevation 2,175 feet amsl.

Under this planned deviation, habitat loss in the first 5 vertical feet would total up to 37.7 acres at reservoir elevation 2,156 feet amsl and would leave at least 158.1 acres of available gartersnake habitat within the FCS during the 120-day period. This temporary habitat loss of 37.7 acres during the 120-day period represents the most substantial difference between likely occupied gartersnake habitat available in the FCS under current operations and the planned deviation. Outside of the planned deviation, management of water levels in the FCS would operate under the current operations as described above.

This mapping approach to model likely occupied gartersnake habitat can be repeated as new imagery becomes available to document changes in reservoir level and consequently gartersnake habitat. This will allow a repeatable method of documenting “take” of gartersnake habitat from SRP operations of Roosevelt Lake. The habitat model can also be refined as remote sensing technology and water detection capabilities advance.

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APPENDIX A

Northern Mexican Gartersnake Likely Occupied Habitat

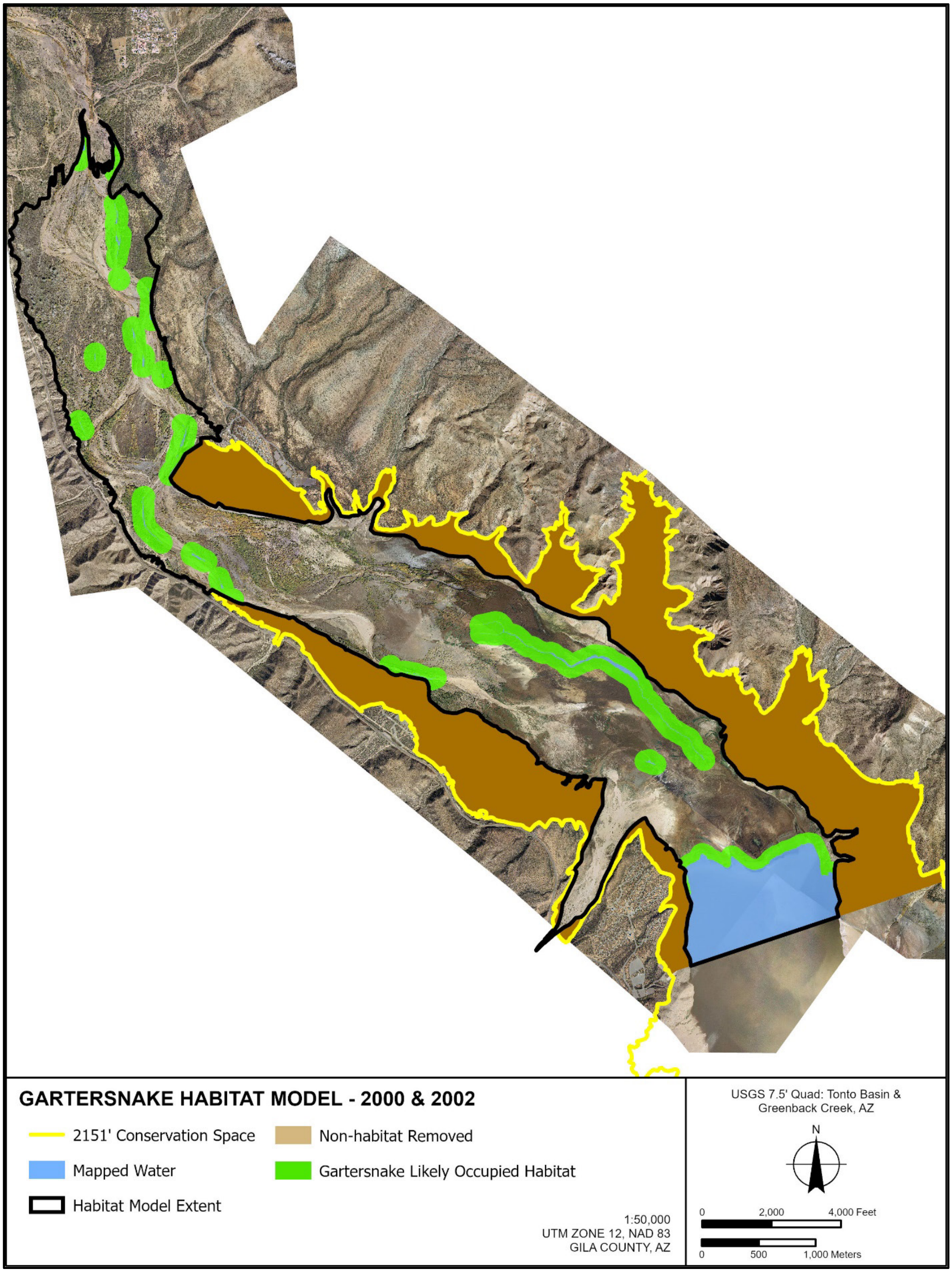

Figure A-1. Mapped water with 94-m buffer identifying likely occupied habitat, 2000 and 2002.

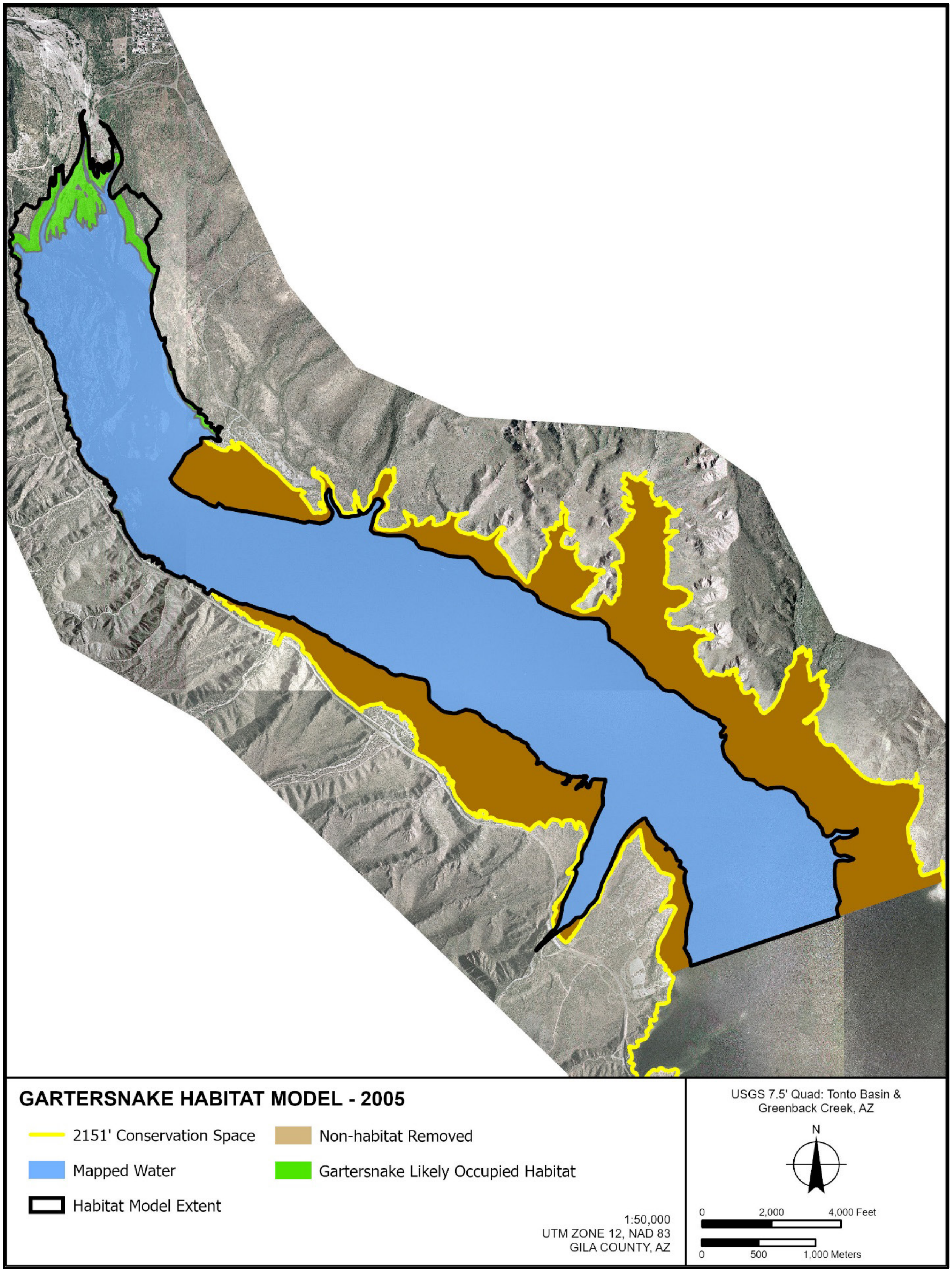

Figure A-2. Mapped water with 94-m buffer identifying likely occupied habitat, 2005.

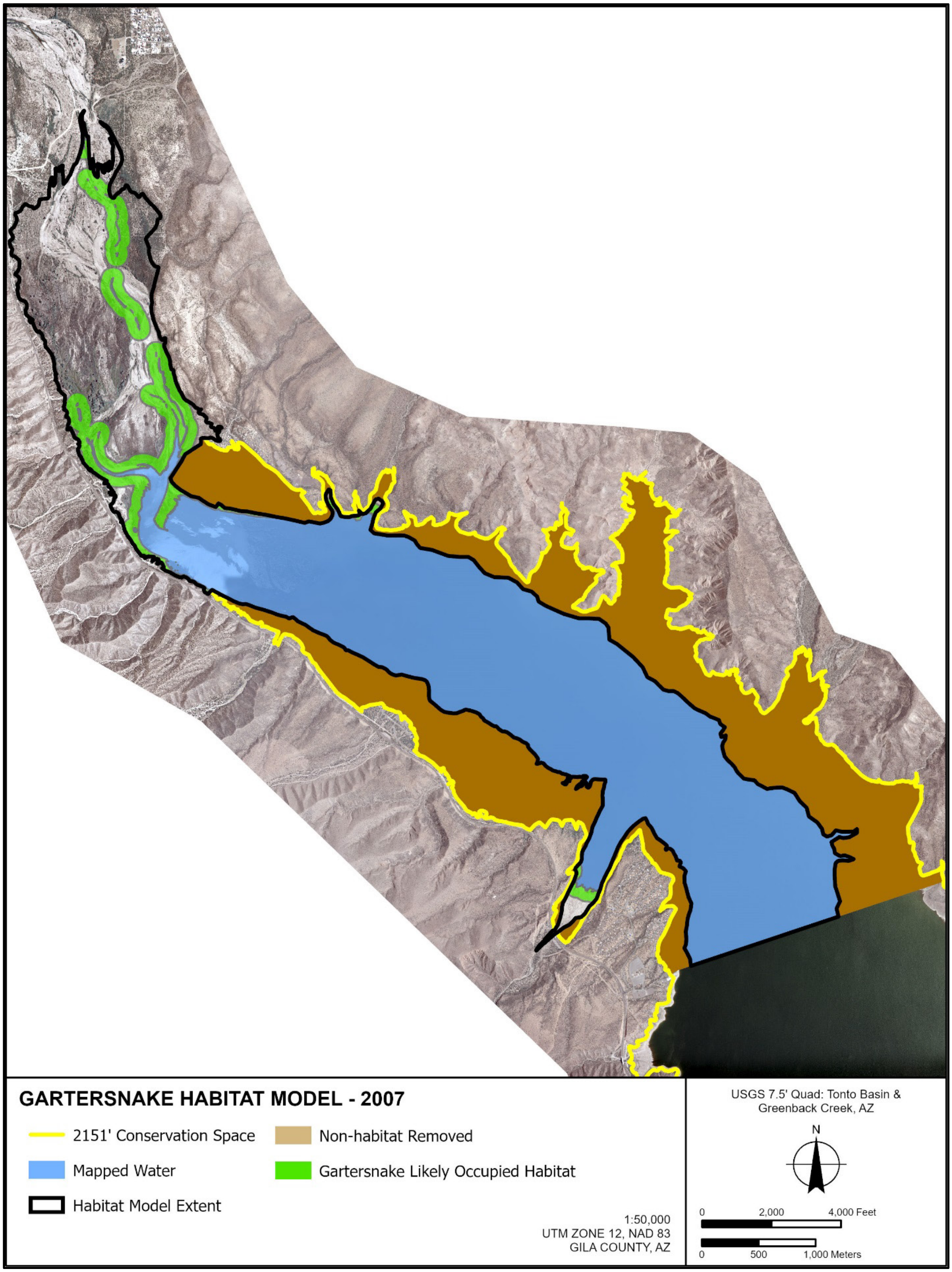

Figure A-3. Mapped water with 94-m buffer identifying likely occupied habitat, 2007.

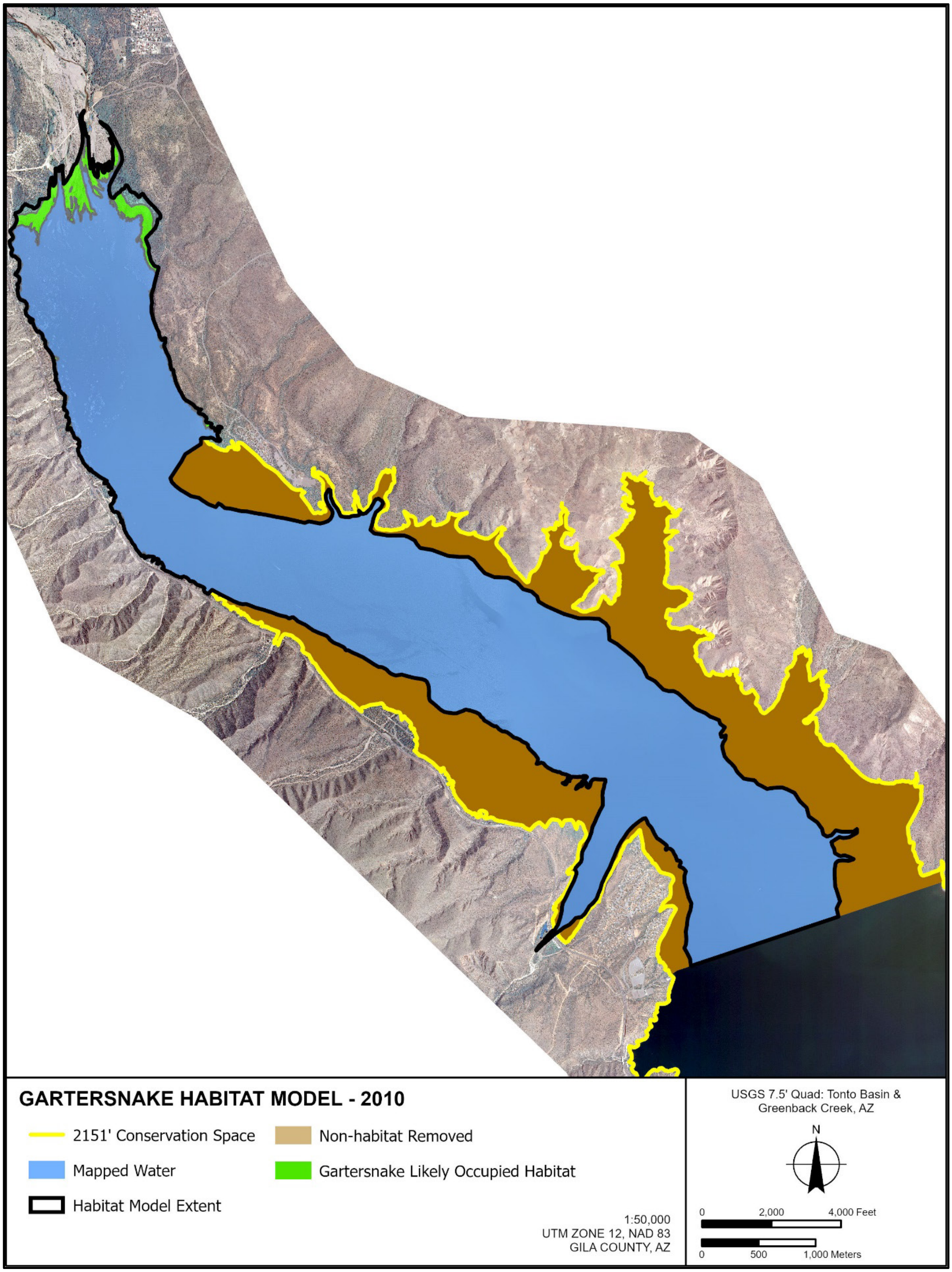

Figure A-4. Mapped water with 94-m buffer identifying likely occupied habitat, 2010.

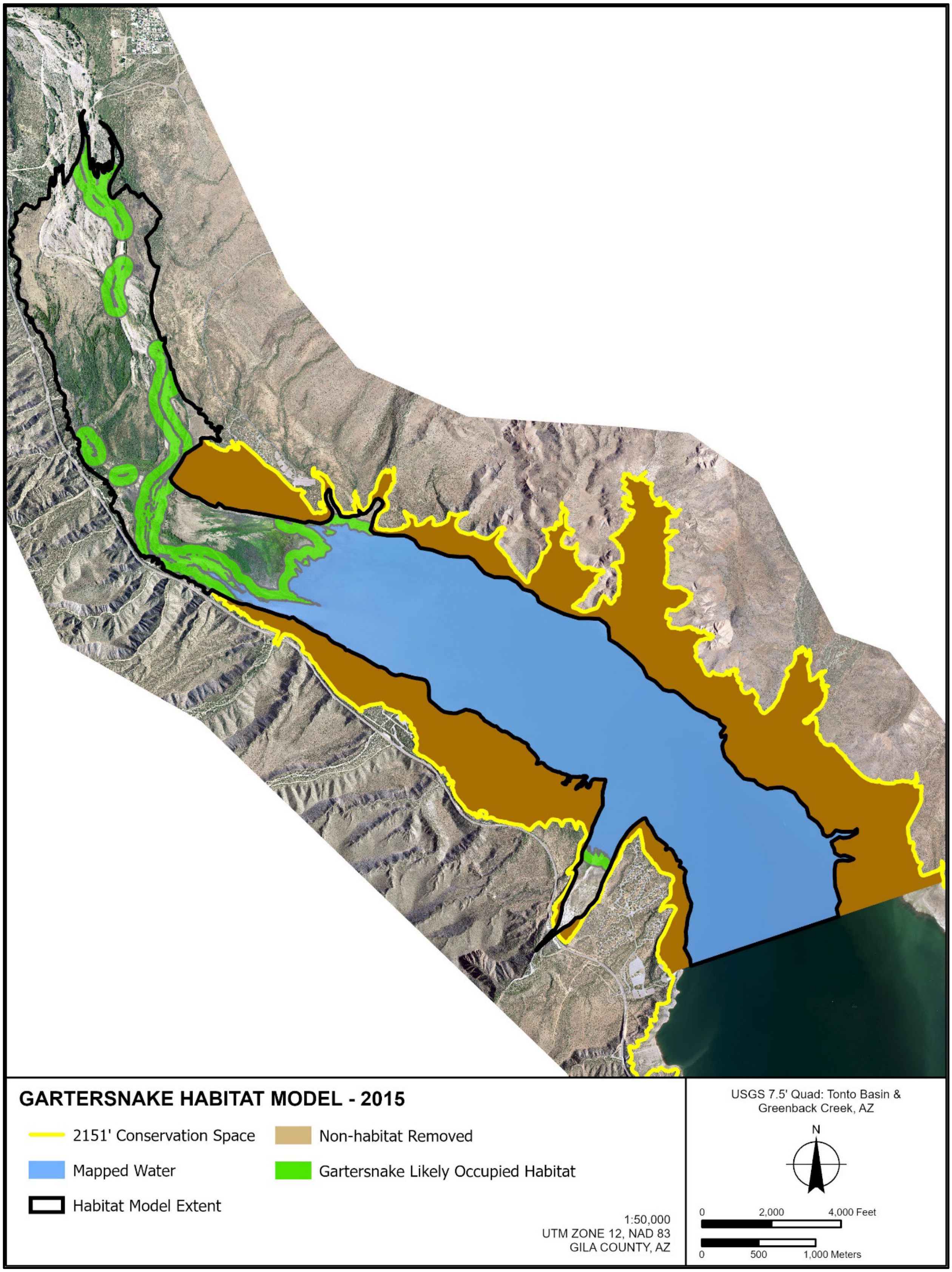

Figure A-5. Mapped water with 94-m buffer identifying likely occupied habitat, 2015.

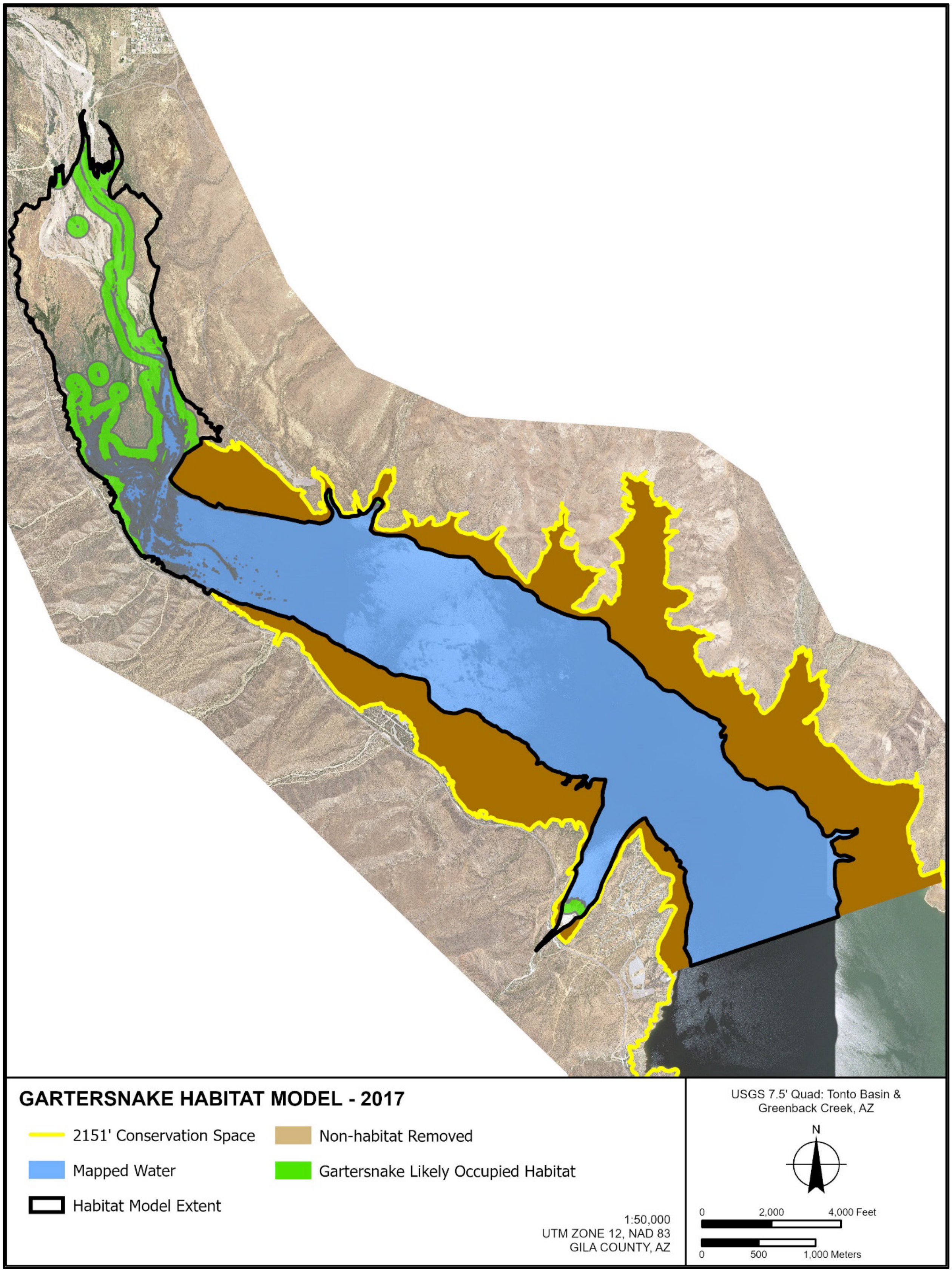

Figure A-6. Mapped water with 94-m buffer identifying likely occupied habitat, 2017.

APPENDIX I

Exploration of the Magnitude, Frequency, and Duration of Lake Elevation Changes

1 INTRODUCTION

1.1 Purpose

Reservoir operations affect the overall quantity of likely occupied terrestrial habitat for northern Mexican gartersnake (gartersnake) on the Tonto Creek arm of Roosevelt Lake. As the reservoir inundates portions of the Tonto Creek arm and then recedes, there are changes in the overall available acreage of likely occupied terrestrial habitat as well as changes in vegetation cover within that available space. This was explored in the Study 2 report.

In addition to the overall amount or acreage of likely occupied terrestrial habitat, changes in water levels also can affect the quality of likely occupied terrestrial habitat by disrupting gartersnake activities and behavior. Herein, we define quality of habitat as the presence and density of vegetation, based on literature indicating gartersnake preference for areas with dense vegetative herbaceous cover, and the role that cover may serve to support feeding, sheltering, and foraging activities (Boyarski et al. 2019; Emmons and Nowak 2016; Myrand 2019; Nowak et al. 2019). Availability and complexity of cover is hypothesized to be a mechanism for gartersnake to avoid depredation (Boyarksi et al. 2019).

These effects can be informed by exploring the magnitude, frequency, and duration of reservoir water level changes. These terms are defined as follows:

- Magnitude—The change in water level elevation, in feet, measured between two specific points in time. A positive magnitude reflects an increase in reservoir water level over time. A negative magnitude reflects a decrease in reservoir water level over time. Magnitudes are explored both in absolute terms (feet of rise) and rates of rise (feet per day or feet per hour).
- Frequency—How often, as a percentage of time, a change of any given magnitude would be anticipated to occur.
- Duration—How long trends in changes (either increasing or decreasing water levels) tend to continue before reversing. A special case considered in this whitepaper is how often the reservoir fills completely (defined as a reservoir elevation of 2,151 feet above mean sea level [amsl]) and remains full. A second special case considered in this whitepaper is how often the reservoir fills close to full (defined as a reservoir elevation of 2,141 feet amsl) and remains greater than that level.

The goal of this whitepaper is to describe the dynamic nature of the reservoir, including both typical changes and extreme changes. To identify the spectrum of normal and extreme conditions of rises and falls in water elevation caused by the reservoir operations, we explore the magnitude, frequency, and duration of changes on multiple time scales:

- year-to-year changes (Section 2),
- seasonal changes within a given year (Section 3), and
- day-to-day changes (Section 4).

1.2 Background on Typical Reservoir Operations and Historic Examples

As described by the Salt River Project Agricultural Improvement and Power District (SRP), SRP water deliveries are typically made from the Verde system in the winter to create available space and manage inflows in the smaller Verde reservoir during winter runoff season, and made from the larger Salt system during warmer summer months when demand is high and inflows are low. As a result, Roosevelt Lake levels typically rise in the winter months and decline during summer months. The timing of when Roosevelt Lake levels switch from increasing to decreasing in the spring depends on winter inflows into both systems and typically ranges between March and May. Roosevelt Lake level declines during the summer can range from about 7 feet following wet winters (e.g., 2010), up to 34 feet following dry winters (e.g., 2002), due to lesser inflows and early timing of the spring swap to using water from the Salt system. Rates of declining water levels during the summer are typically slow and consistent at only up to a few tenths of a foot per day during peak summer demand.

Roosevelt Lake level increases and rate of rise during the winter runoff season can vary depending on the timing/type of winter storms, total amount of inflow, and starting winter elevation of Roosevelt Lake. Since modification (1996), overall winter rise in Roosevelt Lake has ranged from only 3 feet in dry winters (i.e., 2002 and 2018) up to 73 feet in wet winters that start with lower Roosevelt Lake levels (i.e., 2005). Roosevelt Lake elevation rate of rise tends to occur faster with inflows at lower elevations (less storage per foot) as in 2005, and in response to higher inflows, as in 2010. Maximum daily Roosevelt Lake elevation rise during these years was about 8 feet per day, averaging about a one-third foot rise per hour.

Additionally, during fill events, flashy flows from Tonto Creek can increase stream flow from several hundred cubic feet per second (cfs) up 72,000 cfs within one day (2010). This can naturally inundate areas along the Tonto arm of Roosevelt Lake (and upstream) that are above current Roosevelt Lake level as high flows can expand across the wide wash/floodplain of Tonto Creek. Table 1 shows changes in Roosevelt Lake and maximum Tonto Creek flows during wet years since Roosevelt modifications. It should also be noted that the table includes two wet years prior to modification that observed higher rates of rise due to lower starting lake levels (1978) and higher maximum inflows (1993).

Table 1. Examples of Rates of Change during Historically Wet Years

Historically Wet Years	Starting Winter Low Elevation (feet amsl)	Total Winter Water Level Change (feet)	Max Daily Roosevelt Rise (feet)	Max Average Hourly Rate of Roosevelt Rise (feet)	Max Tonto Creek Flow (cfs)
1978*	2,016.09	116.94	22.00	0.92	~65,000
1993*	2,117.25	32.14	13.38	0.56	72,500
2005	2,074.15	73.84	8.14	0.34	34,600
2008	2,098.73	51.35	7.30	0.30	59,900
2010	2,130.61	21.47	7.83	0.32	72,200
2017	2,083.66	42.49	2.16	0.09	21,700
2019	2,089.18	43.74	2.77	0.12	14,300
2020	2,120.30	29.98	1.89	0.08	15,800

* years prior to Roosevelt modifications

2 YEAR-TO-YEAR RESERVOIR WATER LEVEL CHANGES

2.1 Magnitude and Frequency of Year-to-Year Changes

The data set available to explore anticipated year-to-year reservoir water level changes is the 106-year hydrologic model provided by SRP.[1] The probability distribution of year-to-year reservoir changes is shown in Figure 1; a negative value indicates the reservoir levels declined during the previous year, and a positive value indicates the reservoir levels increased during the previous year.[2] Key statistics are shown in Table 2.

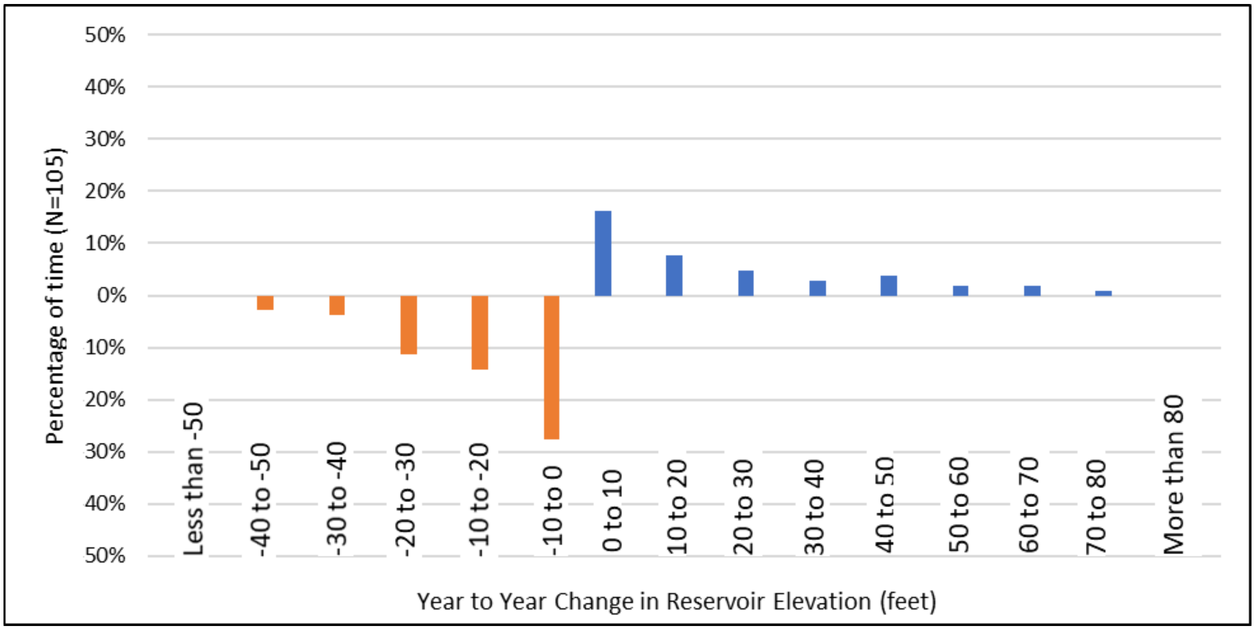

Figure 1. Magnitude and frequency of year-to-year changes in reservoir elevation.

Table 2. Key Statistics for Year-to-Year Changes in Reservoir Elevation

Statistic	All Years	Increasing Years Only	Decreasing Years Only
Number of data points (N)	105	42	63
Range of year-to-year changes	−45.6 to 73.9	0.1 to 73.9	−45.6 to −0.3
Median year-to-year change	−4.9	15.8	−12.9
Average (arithmetic) year-to-year change	−0.2	22.1	−15.0
Percentage positive (increasing years)	40%	100%	0%
Percentage negative (decreasing years)	60%	0%	100%
~25th percentile year-to-year change (feet)	+/- 6.7	5.8	−7.6

[1] For the year-to-year statistics, the water year was used for all calculations (October 1 to September 30). Other choices were also assessed (December 31 to December 31; June 30 to June 30), but made no substantial difference in the overall description of reservoir changes.

[2] For shorthand in this whitepaper, we'll use the terms "increasing year" to define a year when the reservoir elevation increases (a positive year-to-year change), and "decreasing year" to define a year when the reservoir elevation decreases (a negative year-to-year change).

Statistic	All Years	Increasing Years Only	Decreasing Years Only
~50th percentile year-to-year change (feet)	+/- 13.4	15.8	−12.9
~75th percentile year-to-year change (feet)	+/- 24.3	33.8	−21.5
~90th percentile year-to-year change (feet)	+/- 41.8	50.0	−30.0
~99th percentile year-to-year change (feet)	+/- 64.6	72.0	−45.1

* The way to interpret the percentile categories is that X percent of the time, the fluctuation is anticipated to be less than the magnitude shown. For example, 90 percent of the time the fluctuations are less than about 41.8 feet in magnitude, and 10 percent of the time the fluctuations would be more than 41.8 feet in magnitude.

The year-to-year magnitude/frequency statistics support the following general conclusions:

- Normal operation of the reservoir results in year-to-year changes in water level, either up or down. The reservoir never stays at the same level year-to-year—this is explored more in Section 2.3 below.
- These year-to-year fluctuations are typically within about 20–30 feet.[3]
- Atypical[4] increasing years can occur that range from about 50–70 feet of year-to-year rise.
- Atypical decreasing years can occur that range from about 30–45 feet of year-to-year fall.
- Extreme[5] increasing years can occur that are greater than 70 feet of year-to-year rise.
- Extreme decreasing years can occur that range greater than 45 feet of year-to-year fall.
- Decreasing years when the reservoir goes down are somewhat more frequent (60%) than increasing years when the reservoir goes up (40%).

2.2 Duration of Year-to-Year Changes

The quality and quantity of likely occupied terrestrial habitat can also be affected not just by single year-to-year changes, but by consecutive increasing years or consecutive decreasing years. To analyze these trends, we can look at how frequently multiple-year trends of increasing or decreasing water levels occur.

Table 3. Duration and Frequency of Multi-Year Increasing or Decreasing Trends

Length of Trend	Increasing Years: Number	Increasing Years: Frequency	Decreasing Years: Number	Decreasing Years: Frequency
Single increasing or decreasing years	24	73%	14	44%
2 increasing or decreasing years back-to-back	9	27%	11	35%
3 increasing or decreasing years back-to-back	0	0%	3	9%
4 increasing or decreasing years back-to-back	0	0%	3	9%

[3] For our purposes, "typical" is roughly defined by magnitudes less than the 75th percentile.

[4] For our purposes, "atypical" is roughly defined by magnitudes greater than the 90th percentile.

[5] For our purposes, "extreme" is roughly defined by magnitudes greater than the 99th percentile.

Length of Trend	Increasing Years: Number	Increasing Years: Frequency	Decreasing Years: Number	Decreasing Years: Frequency
5 increasing or decreasing years back-to-back	0	0%	0	0%
6 increasing or decreasing years back-to-back	0	0%	1	3%

These year-to-year duration statistics support the following general conclusions:

- Increasing years never occur more than twice in a row, and most of the time (73%) increasing years occur individually and are separated by decreasing years.
- In contrast, more often than not, there are consecutive decreasing years (56% of the time). When multi-year decreasing trends occur, most often they consist of 2 consecutive years of back-to-back decreases, and only infrequently consist of 3 or more consecutive years of back-to-back decreases.

2.3 Frequency and Duration of a Completely Full Reservoir

A special case to consider is how often the reservoir completely fills to an elevation of greater than 2,150.77 feet amsl and then remains completely full.

The 106-year data set shows that occasionally a completely full reservoir occurs (about 7.4% of the time), but never stays full for multiple years. The longest period in the data set for which the reservoir remains completely full is 10 months, as shown in Table 4.

The criteria can be loosened somewhat to consider not only a full reservoir, but also a nearly full reservoir. The condition of “nearly full” is defined as 2,141 feet amsl, which generally represents water levels higher than the median peak water level during the year.

Table 4. Frequency and Duration of a Completely Full or Nearly Full Reservoir

Duration of Being Completely or Nearly Full	Completely Full Reservoir (elevation >2,150.77 feet amsl)		Completely or Nearly Full Reservoir (elevation 2,141 feet amsl)	
	Number of Water Years Occurring in 106-Year Data Set	Percentage of Time*	Number of Water Years Occurring in 106-Year Data Set	Percentage of Time*
Water years with no months full or nearly full	73	69%	49	46%
Single month full	8	22%	2	4%
2 consecutive months full	15	41%	7	14%
3 consecutive months full	4	11%	3	6%
4 consecutive months full	4	11%	7	14%
5 consecutive months full	2	4%	7	14%
6 consecutive months full	4	11%	6	12%
7 consecutive months full	0	0%	5	9%
8 consecutive months full	0	0%	5	9%
9 consecutive months full	0	0%	1	2%

Duration of Being Completely or Nearly Full	Completely Full Reservoir (elevation >2,150.77 feet amsl)		Completely or Nearly Full Reservoir (elevation 2,141 feet amsl)	
	Number of Water Years Occurring in 106-Year Data Set	Percentage of Time*	Number of Water Years Occurring in 106-Year Data Set	Percentage of Time*
10 consecutive months full	0	0%	3	6%
11 to 20 months full	0	0%	4	8%
21 to 30 months full	0	0%	0	0%
More than 30 months full (max = 32)	0	0%	1	2%

* For water years with no months full or nearly full, this column represents the percentage out of the 106-year data set; for the remainder of the table, this column represents the percentage of the total number of "runs" that occurred during the 106-year data set, some of which span multiple water years.

3 SEASONAL RESERVOIR WATER LEVEL CHANGES

The year-over-year changes do not fully describe the dynamics of the reservoir operations. Even if the reservoir water level increases year-to-year, during that year water levels still fluctuate substantially as water is stored during the winter months and then delivered during the summer months.

To understand the dynamics of the reservoir operations over the course of a given year, specific parts of the year can be looked at for the magnitude, frequency, and duration of impacts. The key parts of the year examined here are:

- Storage season, November through April (11/1 through 4/30)
- Delivery season, May through October (5/1 through 10/31)
- Gartersnake active season, March through November (3/1 through 11/30). Within the active season, the following seasons specific to gartersnake life cycle activities are also considered:
  - Gartersnake spring mating season, April through May (4/1 through 5/31)
  - Gartersnake gestation season, April through May (4/1 through 5/31)
  - Gartersnake fall mating season, September through October (9/1 through 10/31)
  - Gartersnake birthing season, June through July (6/1 through 7/31)
- Gartersnake inactive season, December through February (12/1 through 2/28)

As mentioned in the background section, note that while the spring transition from storage season to delivery season on average occurs in April, it can vary considerably by several months (March to May) dependent on winter inflows into the SRP reservoir system.

3.1 Magnitude and Frequency of Seasonal Changes

The data set available to explore anticipated seasonal reservoir water level changes is the 106-year hydrologic model provided by SRP. Key statistics for the operational seasons (storage, delivery) and gartersnake seasons (active, inactive) are shown in Table 5. The probability distributions of seasonal reservoir changes are shown in Figures 2 through 5.

Table 5. Key Statistics for Seasonal Changes in Reservoir Elevation (feet change)

Statistic	Storage Season (Nov–Apr)	Delivery Season (May–Oct)	Gartersnake Active Season (Mar–Nov)	Gartersnake Inactive Season (Dec–Feb)
Number of data points (N)	106	105	105	106
Range of changes over time period	−8.5 to 95.8	−37.7 to 4.6	−45.6 to 41.8	−1.0 to 77.8
Median change over time period	14.1	−18.8	−12.9	6.5
Average (arithmetic) change over time period	18.5	−18.8	−11.6	11.0
Percentage of time positive change	86%	2%	17%	97%
Percentage of time negative change	14%	98%	83%	3%
~25th percentile change over time period (feet)	6.3	14.8	8.2	2.6
~50th percentile change over time period (feet)	14.1	18.6	14.5	6.5
~75th percentile change over time period (feet)	23.4	22.6	22.8	15.1
~90th percentile change over time period (feet)	44.8	28.2	31.1	25.8
~99th percentile change over time period (feet)	83.5	35.7	41.7	58.0

Note: For this and similar tables, the percentile ranges are based on the absolute value of the changes.

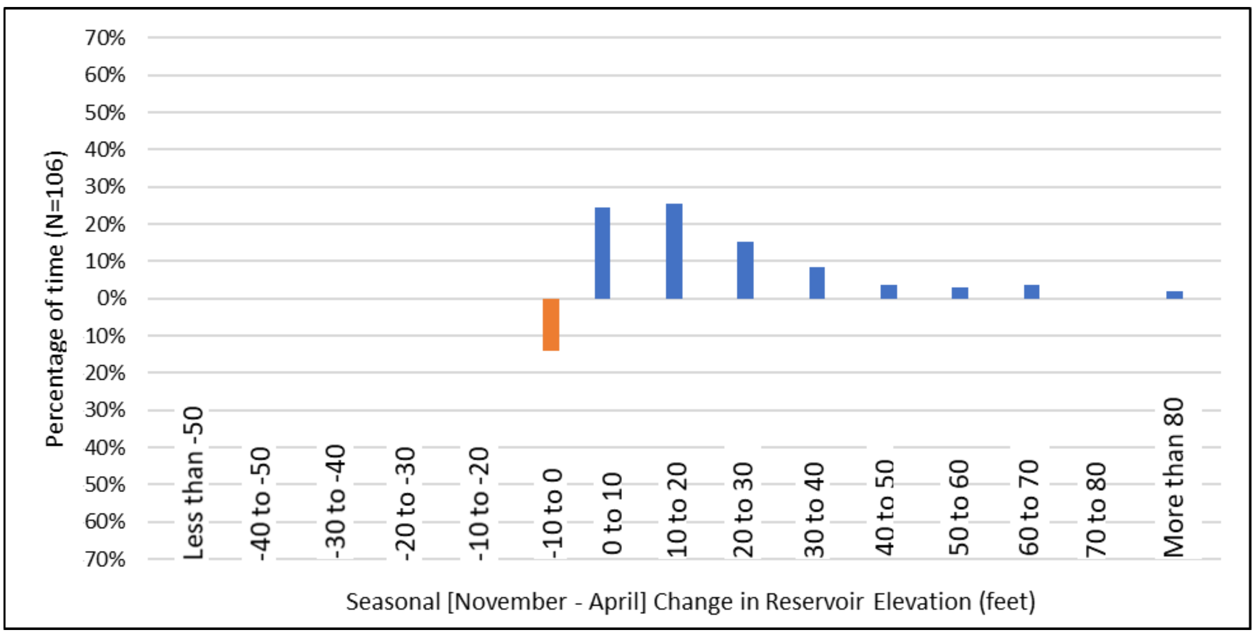

Figure 2. Magnitude and frequency of changes in reservoir elevation during storage season (November–April).

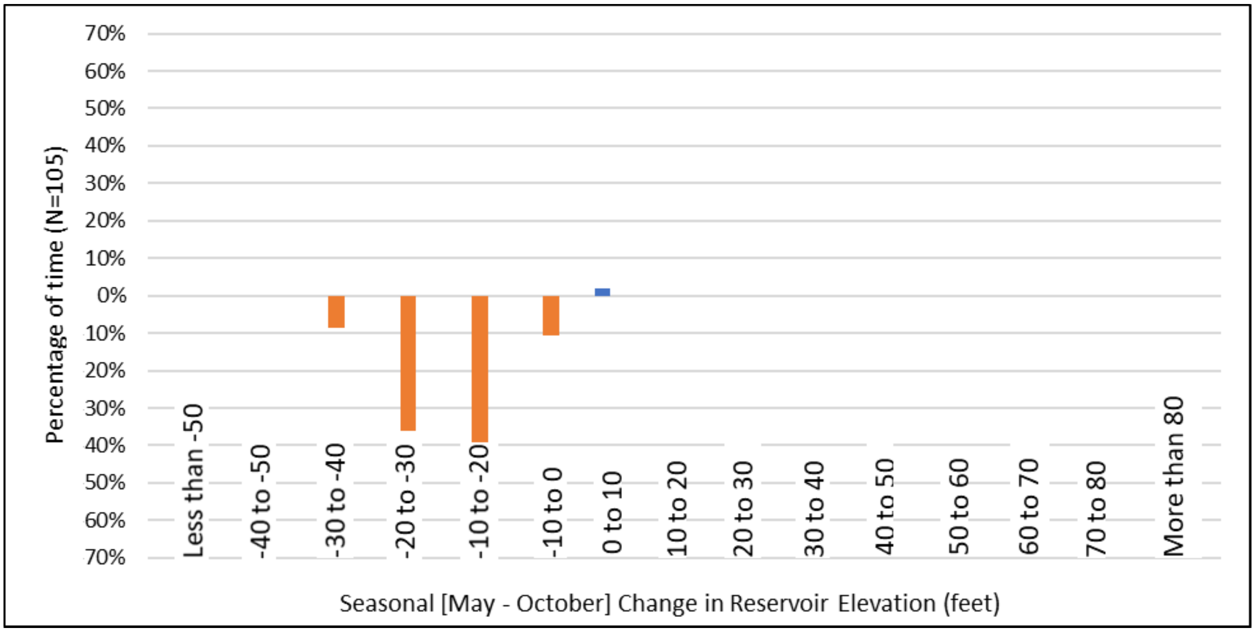

Figure 3. Magnitude and frequency of changes in reservoir elevation during delivery season (May–October).

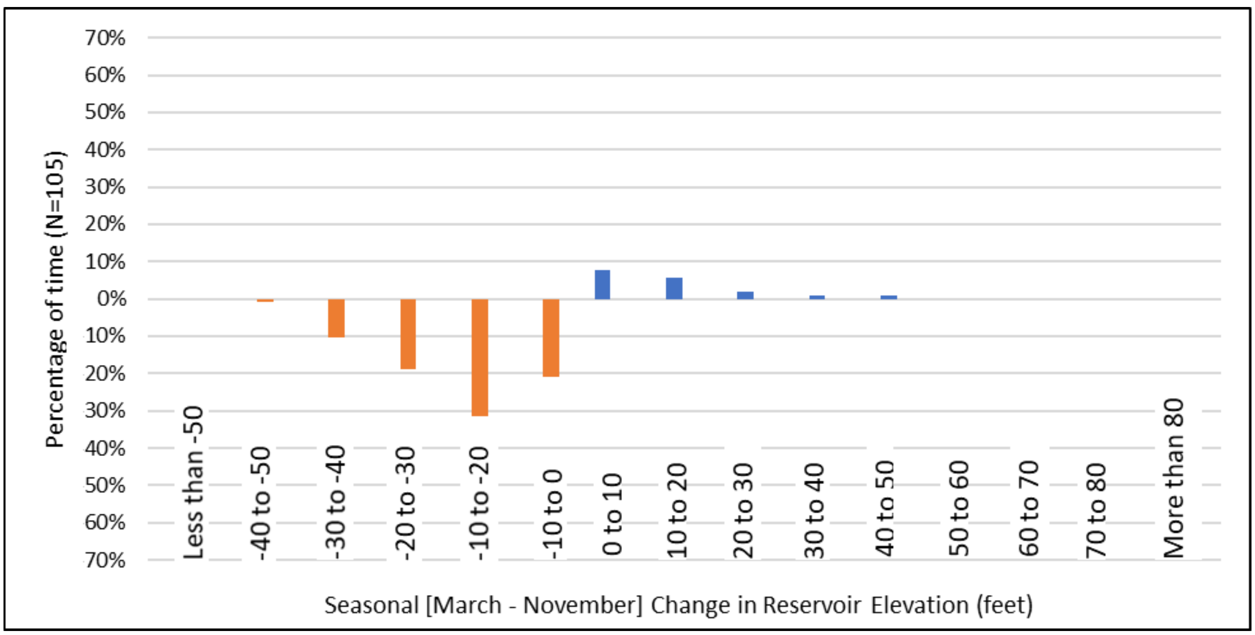

Figure 4. Magnitude and frequency of changes in reservoir elevation during gartersnake active season (March–November).

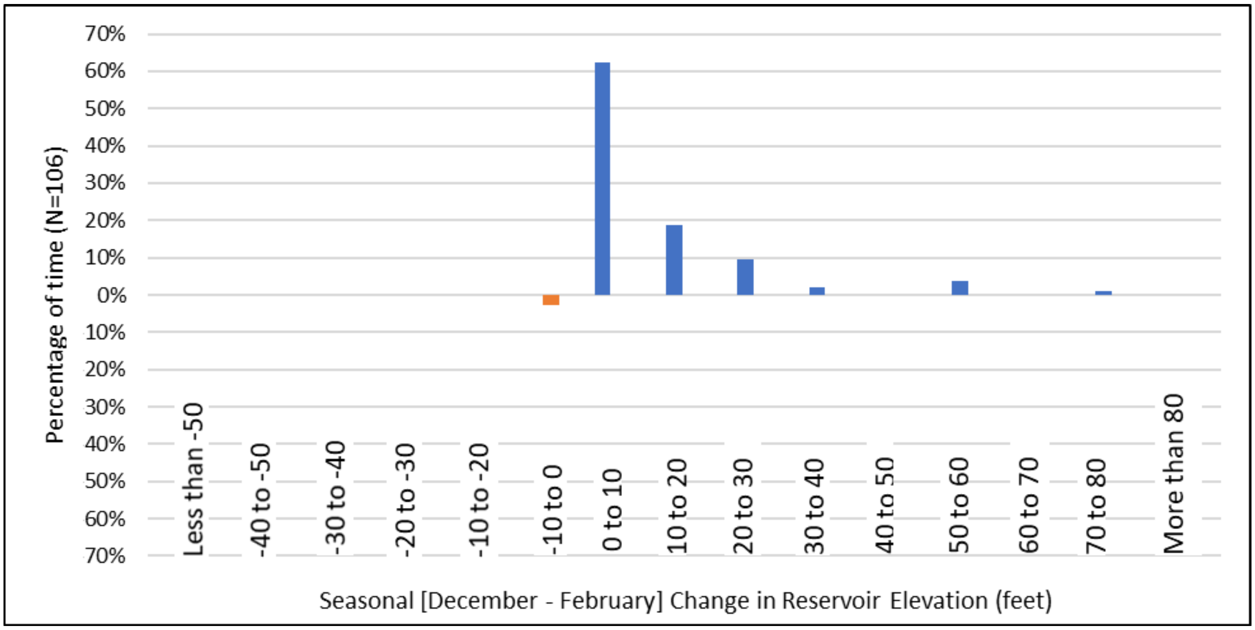

Figure 5. Magnitude and frequency of changes in reservoir elevation during gartersnake inactive season (December–February).

The seasonal changes shown above are relative changes. To give a more complete picture of the dynamics of the reservoir, we can also consider the typical reservoir water level elevations during each season, as shown in Table 6, as well as shown as a typical hydrograph in Figure 6.

Under most conditions, the reservoir is not completely full and the relative seasonal changes described above do not result in complete inundation of the Tonto Creek arm up to 2,151 feet amsl. However, about 34% of the time the reservoir completely fills during the storage season.

Table 6. Typical Reservoir Operating Levels

Statistic	Storage Season (Nov–Apr)	Delivery Season (May–Oct)	Gartersnake Active Season (Mar–Nov)	Gartersnake Inactive Season (Dec–Feb)
Number of data points (N)	106	106	106	106
Water level elevation at start of season (feet amsl); 25th percentile	2,100	2,120	2,111	2,100
Water level elevation at start of season (feet amsl); 50th percentile	2,123	2,143	2,133	2,124
Water level elevation at start of season (feet amsl); 75th percentile	2,135	2,152*	2,145	2,137
Water level elevation at start of season (feet amsl); 90th percentile	2,140	2,155*	2,154†	2,142

* At the beginning of the delivery season (May 1), the reservoir is 100% full 34% of the time. Water is only in the flood control space (above 2,150.77 feet amsl) temporarily while it is being evacuated.

† At the beginning of the gartersnake active season (March 1), the reservoir is 100% full 19% of the time. Water is only in the flood control space (above 2,150.77 feet amsl) temporarily while it is being evacuated.

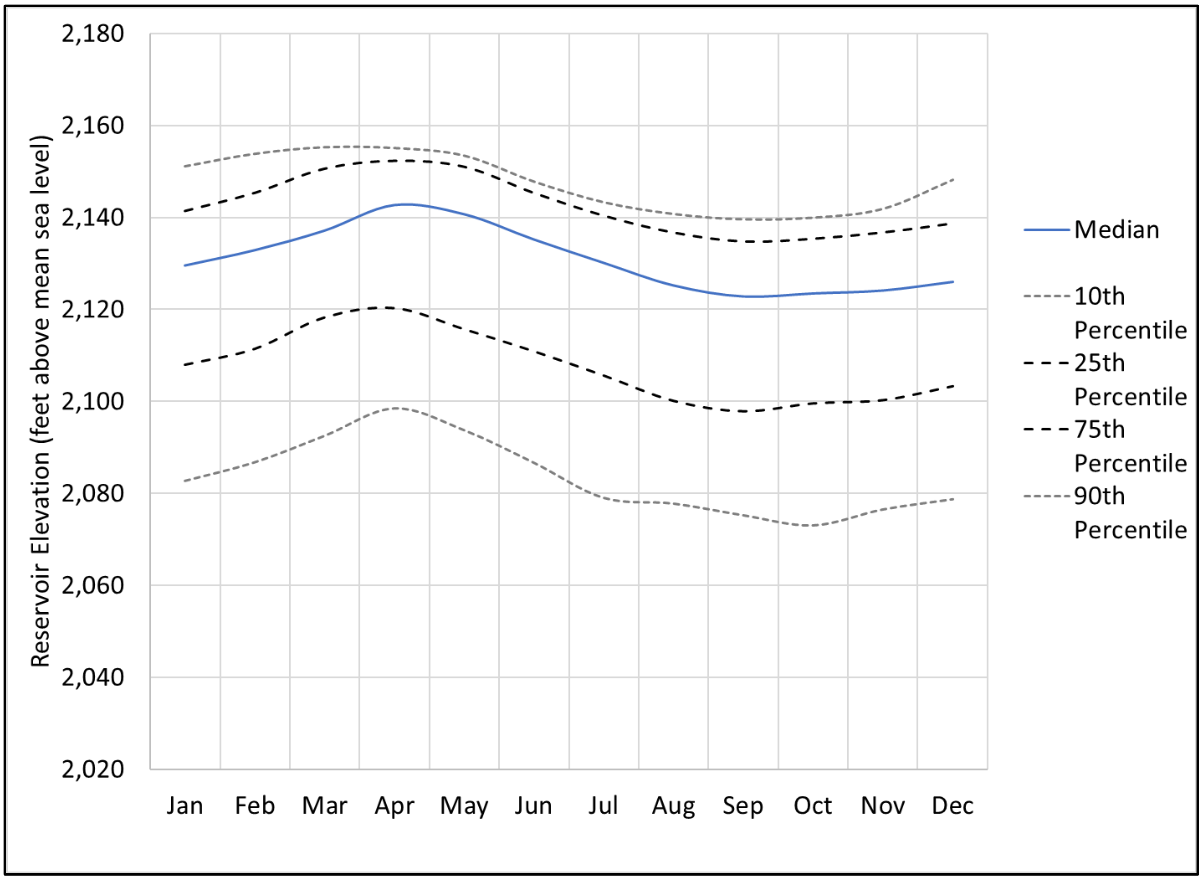

Figure 6. Typical operational hydrograph.

The seasonal changes can also be considered in the context of how rapid changes occur within the likely occupied terrestrial habitat, where they would be experienced by gartersnake individuals (Table 7).

Table 7. Daily and Hourly Rates of Change in Reservoir Elevation

Statistic	Storage Season (Nov–Apr)	Delivery Season (May–Oct)	Gartersnake Active Season (Mar–Nov)	Gartersnake Inactive Season (Dec–Feb)
Primary direction of change	Rising	Falling	Falling	Rising
Vertical Rate of Change (feet per day)				
Maximum daily rate of change over time period	0.5	0.2	0.2	0.9
Median daily rate of change over time period	0.1	0.1	0.1	0.1
Average (arithmetic) daily rate of change over time period	0.1	0.1	0.1	0.1
~25th percentile change over time period	0.0	0.1	0.0	0.0
~50th percentile change over time period	0.1	0.1	0.1	0.1

Statistic	Storage Season (Nov–Apr)	Delivery Season (May–Oct)	Gartersnake Active Season (Mar–Nov)	Gartersnake Inactive Season (Dec–Feb)
~75th percentile change over time period	0.1	0.1	0.1	0.2
~90th percentile change over time period	0.2	0.2	0.1	0.3
~99th percentile change over time period	0.5	0.2	0.2	0.6
Horizontal Rate of Change (feet per hour)*				
Maximum hourly rate of change over time period	3.3	1.3	1.0	5.4
Median hourly rate of change over time period	0.5	0.6	0.3	0.5
Average (arithmetic) hourly rate of change over time period	0.7	0.6	0.4	0.8
~25th percentile change over time period	0.2	0.5	0.2	0.2
~50th percentile change over time period	0.5	0.6	0.3	0.5
~75th percentile change over time period	0.8	0.8	0.5	1.0
~90th percentile change over time period	1.5	1.0	0.7	1.8
~99th percentile change over time period	2.9	1.2	0.9	4.0

Note: The daily and hourly rates of change shown in this table are derived from the monthly time steps of the 106-year hydrologic model. Similar information based on daily time steps is shown in Section 4 of this whitepaper.

* Given the average slope of the Tonto Creek arm, 1 foot of vertical change is equal to 150 feet of horizontal change. Therefore a rate of 0.1 foot per day vertical rise or fall in the reservoir corresponds to the edge of the reservoir moving horizontally 15 feet per day, or about 0.6 foot per hour.

These frequency/magnitude statistics support the following general conclusions:

- Storage/delivery seasons:
  - The storage season and delivery season have great consistency between years. In other words, most of time (86%) water levels rise during the storage season (180 days in length), and most of the time (98%) water levels fall during the delivery season (183 days in length).
  - The typical magnitudes of rise or fall over each season are similar, around 23 feet or less. This corresponds to a typical daily vertical change of 0.1 foot per day, or a typical horizontal change of about 0.8 foot per hour.
  - Atypical increases (up to 45 feet of rise over the season) are of higher magnitude than atypical decreases (up to 28 feet of fall over the season).
  - Extreme increases (up to 84 feet of rise over the season) are of higher magnitude than extreme decreases (up to 36 feet of fall over the season). The daily rates of change seen during these extreme events during a storage or delivery season are up to 0.5 foot per day vertically, or a horizontal change of 3.3 foot per hour.
  - A typical storage season starts with a reservoir water level of 2,135 feet amsl; the reservoir completely fills during the storage season about one-third of the time (34%).

- Gartersnake active/inactive seasons:
  - The gartersnake active and inactive seasons also have great consistency between years. Most of the time (83%) water levels fall during the gartersnake active season (274 days in length), and most of the time (97%) water levels rise during the gartersnake inactive season (89 days in length).
  - A typical gartersnake active season starts with a reservoir water level of 2,145 feet amsl, and then generally declines. Typical decreases over the active season are about 20 feet, corresponding to a daily vertical change of 0.1 foot per day, or a horizontal change of 0.5 foot per hour.
  - A typical gartersnake inactive season starts with a reservoir water level of 2,141 feet amsl, and then generally rises. Typical increases over the inactive season are about 15 feet, corresponding to a daily vertical change of 0.1 foot per day, or a horizontal change of 1.0 foot per hour.
  - More extreme daily rates of change seen during the inactive season are around 0.6 vertical foot per day, or a horizontal change of 4.0 feet per hour.
  - About 19% of the time the reservoir will completely fill over the course of the gartersnake inactive season.

3.2 Magnitude and Duration of Water Level Changes during Gartersnake Life Cycle Seasons

Key statistics for the life-cycle seasons for gartersnake are summarized in Table 8 and Figures 7 through 9.

Table 8. Key Statistics for Gartersnake Life-Cycle Seasonal Changes in Reservoir Elevation (feet change)

Statistic	Gartersnake Spring Mating/ Gestation (Apr–May)	Gartersnake Fall Mating (Sep–Oct)	Gartersnake Birthing (Jun–Jul)
Number of data points (N)	106	105	106
Range of change over time period	−10.1 to 22.9	−7.7 to 30.9	−18.6 to −1.1
Median change over time period	−1.9	−2.0	−11.1
Average (arithmetic) change over time period	0.4	−1.5	−11.2
Percentage of time positive change	35%	20%	0%
Percentage of time negative change	65%	80%	100%
~25th percentile change over time period (feet)	1.9	1.5	9.8
~50th percentile change over time period (feet)	3.8	2.7	11.1
~75th percentile change over time period (feet)	7.4	4.3	12.7
~90th percentile change over time period (feet)	9.8	5.8	14.2
~99th percentile change over time period (feet)	20.8	10.6	18.0

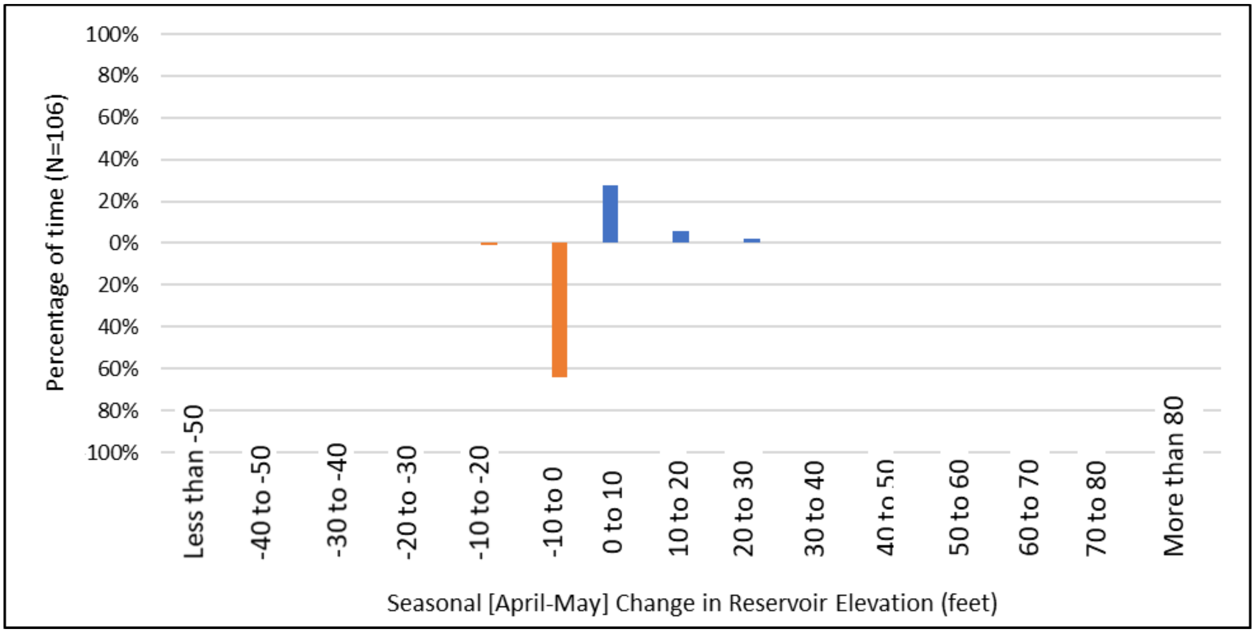

Figure 7. Magnitude and frequency of changes in reservoir elevation during gartersnake spring mating/gestation season (April–May).

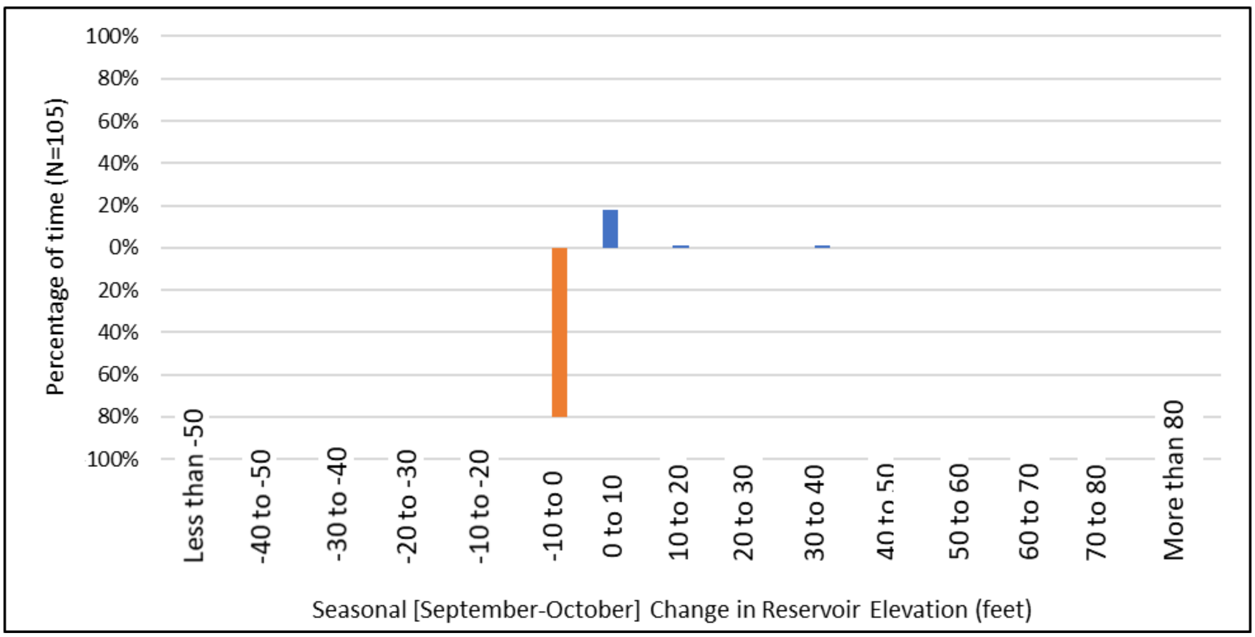

Figure 8. Magnitude and frequency of changes in reservoir elevation during gartersnake fall mating season (September–October).

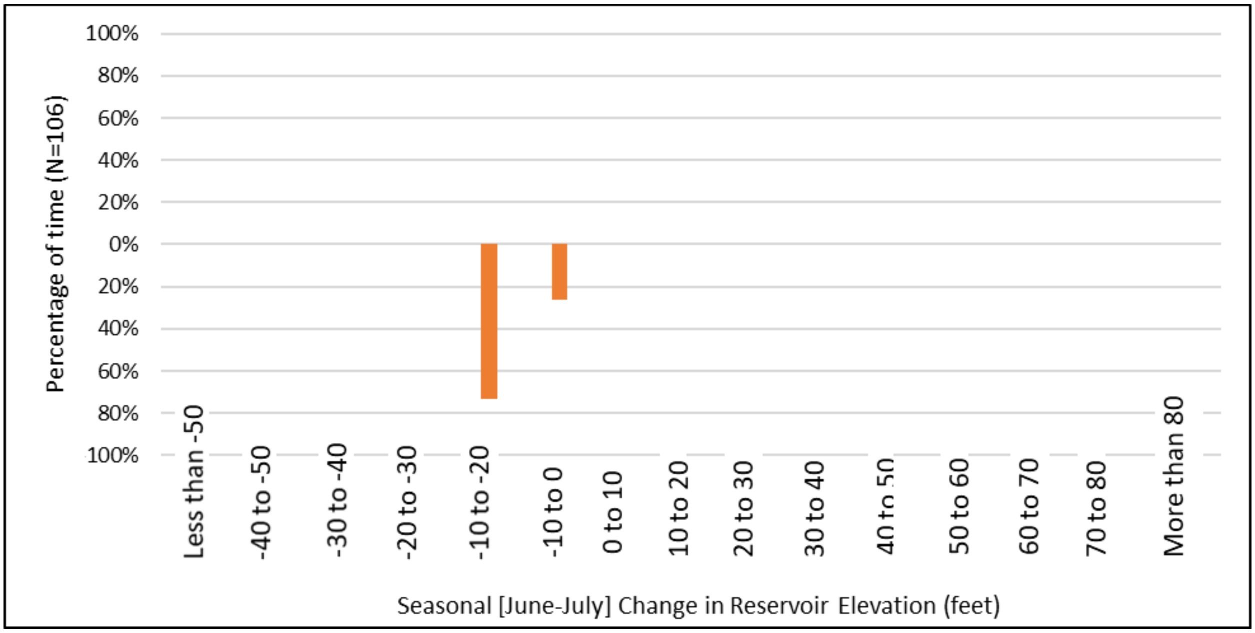

Figure 9. Magnitude and frequency of changes in reservoir elevation during gartersnake birthing season (June–July).

The daily and hourly rates of change during the gartersnake life-cycle seasons are shown in Table 9.

Table 9. Daily and Hourly Rates of Change in Reservoir Elevation for Gartersnake Life-Cycle Seasons

Statistic	Gartersnake Spring Mating/ Gestation (Apr–May)	Gartersnake Fall Mating (Sep–Oct)	Gartersnake Birthing (Jun–Aug)
Primary direction of change	Mixed	Mixed	Falling
Vertical Rate of Change (feet per day)			
Maximum daily rate of change over time period	0.4	0.5	0.3
Median daily rate of change over time period	0.0	0.0	0.2
Average (arithmetic) daily rate of change over time period	0.0	0.0	0.2
~25th percentile change over time period	0.0	0.0	0.2
~50th percentile change over time period	0.1	0.0	0.2
~75th percentile change over time period	0.1	0.1	0.2
~90th percentile change over time period	0.2	0.1	0.2
~99th percentile change over time period	0.3	0.2	0.3
Horizontal Rate of Change (feet per hour)*			
Maximum hourly rate of change over time period	2.3	3.2	1.9
Median hourly rate of change over time period	0.2	0.2	1.1

Statistic	Gartersnake Spring Mating/ Gestation (Apr–May)	Gartersnake Fall Mating (Sep–Oct)	Gartersnake Birthing (Jun–Aug)
Average (arithmetic) hourly rate of change over time period	0.1	0.2	1.1
~25th percentile change over time period	0.2	0.2	1.0
~50th percentile change over time period	0.4	0.3	1.1
~75th percentile change over time period	0.8	0.4	1.3
~90th percentile change over time period	1.0	0.6	1.5
~99th percentile change over time period	2.1	1.1	1.8

* Given the average slope of the Tonto Creek arm, 1 foot of vertical change is equal to 150 feet of horizontal change. Therefore a rate of 0.1 foot per day vertical rise or fall in the reservoir corresponds to the edge of the reservoir moving horizontally 15 feet per day, or about 0.6 foot per hour.

These frequency/magnitude statistics support the following general conclusions:

- Spring mating/gestation season:
    - There are no clear operational patterns during the spring mating/gestation season (April through May). Roughly one-third of the time the reservoir rises over this period, and roughly two-thirds of the time the reservoir falls over this period.
    - Regardless, the magnitudes of change during the spring mating/gestation season are relatively low, typically 7 feet or less. The maximum vertical rate of change seen during the spring mating/gestation season is 0.4 foot per day, or a horizontal rate of change of 2.3 feet per hour.
- Fall mating season:
    - The operational patterns during the fall mating season (September through October) tends most of the time to show falling reservoir levels (80%).
    - As with the spring mating season, the magnitudes of change during the fall mating season are relatively low, typically 4 feet or less. The maximum vertical rate of change seen during the fall mating season is 0.5 foot per day, or a horizontal rate of change of 3.2 feet per hour.
- Birthing season:
    - The birthing season consistently takes place during a time of falling reservoir levels (100%).
    - Magnitudes of change during the birthing season are about 13 feet. The maximum vertical rate of change seen during the birthing season is 0.3 foot per day, or a horizontal rate of change of 1.9 feet per hour.

3.3 Duration of Seasonal Changes

We can also assess trends of month-to-month changes that occur within these different seasons, to show how often consistent back-to-back increasing or decreasing months occur. The durations of increasing trends are shown in Table 10 for the operational storage season and the gartersnake inactive season. The durations of decreasing trends are shown in Table 11 for the operational delivery season and the gartersnake active season. Durations of trends are also shown in Table 12 for the gartersnake mating, gestation, and birthing seasons.

Table 10. Frequency and Duration of Multi-Month Increasing Trends (Storage Season, Gartersnake Inactive Season)

Back-to-Back Months of Increasing Water Levels or Completely Full Reservoir	Storage Season (Nov–Apr)	Gartersnake Inactive Season (Dec–Feb)
Single month – no trend	4%	8%
2 months of back-to-back increases	10%	13%
3 months of back-to-back increases	8%	78%
4 months of back-to-back increases	11%	–
5 months of back-to-back increases	25%	–
6 months of back-to-back increases	41%	–

Table 11. Frequency and Duration of Multi-Month Decreasing Trends (Delivery Season, Gartersnake Active Season)

Back-to-Back Months of Decreasing Water Levels	Delivery Season (May–Oct)	Gartersnake Active Season (Mar–Nov)
Single month – no trend	0%	0%
2 months of back-to-back decreases	2%	2%
3 months of back-to-back decreases	8%	3%
4 months of back-to-back decreases	23%	21%
5 months of back-to-back decreases	45%	35%
6 months of back-to-back decreases	22%	15%
7 months of back-to-back decreases	–	13%
8 months of back-to-back decreases	–	7%
9 months of back-to-back decreases	–	4%

Table 12. Frequency and Duration of Multi-Month Increasing or Decreasing Trends during Gartersnake Mating, Gestation, and Birthing Seasons

Duration of Trend	Gartersnake Spring Mating: Frequency	Gartersnake Fall Mating: Frequency	Gartersnake Birthing: Frequency
Period has 1 increasing month and 1 decreasing month	57%	66%	1%
2 increasing months back-to-back	32%	8%	0%
2 decreasing months back-to-back	11%	26%	99%

These duration statistics support the following general conclusions:

- Storage/delivery seasons:
  - More often than not (77% of years), the storage season is characterized by persistent water level rise, with consecutive month-to-month increases of 4 or more months.
  - Similarly, more often than not (90% of years), the delivery season is characterized by persistent water level fall, with consecutive month-to-month decreases of 4 or more months.

- Spring mating/gestation season:
    - There is no consistent pattern with respect to the spring mating and gestation seasons. More often than not (57% of years), the period from April to May is characterized by an even split of monthly increases and decreases. This reflects the fact that this season is at the transition between the operational storage and delivery seasons.
- Fall mating season:
    - Similarly, there is no consistent pattern with respect to the fall mating season. More often than not (66% of years) the period from September to October is characterized by an even split of monthly increases and decreases. This likely reflects a mix of decreases due to deliveries, and increases due to monsoon runoff.
- Birthing season:
    - The birthing season from June to August is characterized by persistent decreasing reservoir water levels. The large majority of the time (99% of years), this period will exhibit two month-to-month decreases in water levels. Decreasing water levels reflect an increase in likely occupied terrestrial habitat, both in quantity (total acreage) and in quality (increasing vegetation density and cover). Note that as described in detail in Study 2, there is a lag time of about 60 days for herbaceous vegetation to reestablish in previously inundated areas.

4 DAY-TO-DAY RESERVOIR WATER LEVEL CHANGES

4.1 Magnitude and Frequency of Day-to-Day Changes

The data set available to explore anticipated day-to-day reservoir water level changes is the 18-year historic operations data from 2002 through 2020. Key statistics for day-to-day reservoir changes are shown in Tables 13 and 14.

Table 13. Key Statistics for Day-to-Day Changes in Reservoir Elevation (feet change)

Statistic	Full Year	Storage Season (Nov–Apr)	Delivery Season (May–Oct)	Gartersnake Active Season (Mar–Nov)	Gartersnake Inactive Season (Dec–Feb)
Number of data points (N)	6,791	3,382	3,409	5,108	1,683
Range of change over time period	−0.68 to 8.14	−0.48 to 8.14	−0.68 to 1.03	−0.68 to 2.77	−0.38 to 8.14
Median change over time period	0.00	0.03	−0.09	−0.04	0.04
Average (arithmetic) change over time period	0.01	0.10	−0.08	−0.03	0.13
Percentage of time positive day-to-day change	51%	80%	22%	40%	85%
Percentage of time negative day-to-day change	49%	20%	78%	60%	15%
~25th percentile change over time period (feet)	0.02	0.01	0.04	0.03	0.01
~50th percentile change over time period (feet)	0.07	0.05	0.09	0.08	0.05
~75th percentile change over time period (feet)	0.14	0.12	0.15	0.15	0.11

Statistic	Full Year	Storage Season (Nov–Apr)	Delivery Season (May–Oct)	Gartersnake Active Season (Mar–Nov)	Gartersnake Inactive Season (Dec–Feb)
~90th percentile change over time period (feet)	0.23	0.28	0.21	0.21	0.31
~99th percentile change over time period (feet)	0.82	1.30	0.41	0.58	1.91

Table 14. Key Statistics for Day-to-Day Changes in Reservoir Elevation, for Gartersnake Life-Cycle Seasons (feet change)

Statistic	Gartersnake Spring Mating/ Gestation (Apr–May)	Gartersnake Fall Mating (Sep–Oct)	Gartersnake Birthing (Jun–Jul)
Number of data points (N)	1,159	1,098	1,159
Range of change over time period	−0.57 to 0.74	−0.35 to 1.03	−0.68 to 0.71
Median change over time period	−0.02	−0.04	−0.13
Average (arithmetic) change over time period	−0.02	−0.04	−0.13
Percentage of time positive day-to-day change	46%	38%	5%
Percentage of time negative day-to-day change	54%	62%	95%
~25th percentile change over time period (feet)	0.03	0.02	0.07
~50th percentile change over time period (feet)	0.07	0.06	0.12
~75th percentile change over time period (feet)	0.12	0.12	0.18
~90th percentile change over time period (feet)	0.17	0.17	0.23
~99th percentile change over time period (feet)	0.35	0.33	0.42

These frequency/magnitude statistics for day-to-day changes support the following general conclusions:

- Storage/delivery seasons:
  - The storage and delivery seasons, while showing consistency on a month-to-month basis, are still characterized by a mix of positive and negative daily changes. The storage season has positive days most of the time (80%) and the delivery season has negative days most of them time (78%).
  - The typical magnitudes of day-to-day rise or fall over each season are similar, up to a vertical change of 0.15 foot per day or less.
  - Extreme events can range from 0.24 to over 8 vertical feet per day. In reality, the number of day-to-day changes over 1 foot in magnitude happened only 43 times over the 18-year period (a frequency of 1.1%) and almost always occur in December, January, February, or March.

- Spring mating/gestation season and fall mating season:
  - The spring and fall mating seasons are both characterized by a mix of positive and negative day-to-day changes, and while negative day-to-day changes are slightly more common, it is not a substantial difference.
  - The magnitudes of day-to-day change during the spring and fall seasons are usually less than 0.12 vertical foot per day, which corresponds to a horizontal change of 0.75 foot per hour.
  - Even extreme events are relatively low in magnitude, ranging from 0.17 to 1 vertical foot per day (1.1 to 6.3 horizontal feet per hour).
- Birthing season:
  - The birthing season consistently takes place during a time of negative day-to-day changes in reservoir levels (95%).
  - The magnitudes of day-to-day change during the birthing season are usually less than 0.18 vertical foot per day, which corresponds to a horizontal change of 1.1 feet per hour.
  - Even extreme events are relatively low in magnitude, ranging from 0.23 to 0.9 vertical foot per day (1.4 to 5.6 feet per hour).

4.2 Duration of Seasonal Changes

We can also assess the trends of day-to-day changes that occur within the different seasons, to show how often consistent back-to-back increasing or decreasing months occur. The durations of increasing or decreasing trends are shown in Table 15 for the storage and delivery seasons.

Table 15. Frequency of Multi-Day Increasing Trends (Storage Season) and Decreasing Trends (Delivery Season)

Length of Trend	Storage Season: Number	Storage Season: Frequency	Delivery Season: Number	Delivery Season: Frequency
Single increasing or decreasing days	135	40%	52	28%
Up to 5 increasing or decreasing days back-to-back	238	71%	103	56%
Up to 10 increasing or decreasing days back-to-back	274	82%	132	72%
Up to 15 increasing or decreasing days back-to-back	283	85%	144	79%
Up to 20 increasing or decreasing days back-to-back	289	87%	153	84%
Maximum number of increasing or decreasing days back-to-back	113		147	

These duration statistics illustrate that multi-day stretches of rising or falling water levels are fairly common, and these periods can be quite lengthy. The delivery season exhibits multi-day decreasing trends somewhat more frequently than the storage season (72% of delivery season trends are multi-day, compared to 60% of storage season trends). In either case, trends have been seen to last up to 4 to 5 months of continual, progressive day-to-day changes.

5 DISCUSSION AND CONCLUSIONS

The operations of the Roosevelt Lake reservoir are dynamic, resulting in continual changes in water levels. A number of metrics are used in this whitepaper to describe these changes, based on the 106-year hydrologic model (monthly and yearly changes) or the 18-year historic period of record from 2002 to 2020 (daily changes). Overall, the reservoir operations can be summarized as follows:

1. While the magnitude of annual water level changes can vary dependent on reservoir inflows, seasonal water level trends are often regular and predictable. Operationally, water levels drop during the delivery season (May to October) and water levels rise during the storage season (November to April).
2. Water level rises are generally slow, less than 0.5 vertical foot per day (horizontally, about 3.2 feet per hour), except in a small (~1%) handful of extreme events.
3. In about 34% of years, the reservoir will rise high enough during the storage season to be completely full (2,151 feet amsl).
4. The amount of time the reservoir stays continually full ranges from 1 to 6 months, but most often extends 1 to 2 months, as water above the conservation space is not stored but is only temporarily there while being evacuated. The reservoir is completely full about 7.4% of the time.
5. The gartersnake active season is largely characterized by falling water levels in the reservoir, especially during the summer birthing season (June to August). However, the early and late parts of the gartersnake active season overlap with the storage season and water level increases occur during these periods as well as water level decreases. Decreasing water levels reflect an increase in likely occupied terrestrial habitat, both in quantity (total acreage) and in quality (increasing vegetation density and cover). Note that as described in detail in Study 2, there is a lag time of about 60 days for herbaceous vegetation to reestablish in previously inundated areas.
6. The gartersnake inactive season is largely characterized by rising water levels in the reservoir. Increasing water levels reflect a decrease in likely occupied terrestrial habitat, both in quantity (total acreage) and in quality due to temporary loss of herbaceous vegetation and cover.
7. The normal seasonal fluctuations contribute to cumulative year-over-year changes. Year-to-year changes generally are less than 20–30 feet overall. Year-to-year water level increases in the reservoir can extend 1 or 2 years, but no longer than that. Year-over-year water level decreases also tend to last 1 to 2 years, but can last up to 6 years.

6 LITERATURE CITED

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APPENDIX J

Overview of Flood Control Space Hydrology

PURPOSE

SRP has provided modeled monthly Roosevelt Lake water levels for the 106-year period based on historical gaged records (1913-2019) along the Salt River, Tonto Creek, and Verde River into SRP reservoirs (inflow record) adjusted for potential future climate change using the SRP Reservoir Planning Model (RPM). These data include daily modeled maximum monthly water levels above the conservation space (CS) (2,150.78 feet above mean sea level [amsl]), into the flood control space (FCS) under current operating procedures, and into the FCS under a proposed temporary deviation from current Water Control Manual (WCM). The proposed temporary deviation will be known in this whitepaper as the "FCS-D" dataset. The FCS-D dataset considers a situation in which SRP, in three out of five years, is allowed up to 120 days to evacuate water from the first 5 feet of the FCS (up to elevation 2155.78 feet amsl). Currently, operational release within the FCS aims to draw down the reservoir within 20 days of initial inundation.

Typical reservoir operations for Roosevelt Dam will be impacted by reservoir inflows, water demand, and overall system storage on a year-to-year basis. The reservoir operations of Roosevelt Lake and water elevation levels can fluctuate yearly (e.g., increase during winter runoff season and decrease during summer use season) and over multiyear periods, dependent on seasonal inflow into the SRP reservoir system. The hydrology has previously been described for the CS, including exploration of the frequency, magnitude, and duration of water level changes. The purpose of this whitepaper is to summarize the FCS and FCS-D hydrology, and compare it to that of the CS.

It is important to recognize a fundamental difference between water levels estimated in the CS and water levels modeled in the FCS. Water levels modeled for a given month in the CS are anticipated to slowly rise or fall over the course of the month but remain largely similar to the modeled value in most instances. By contrast, the modeled values within the FCS represent individual flood events. The water levels shown in the FCS dataset reflect the maximum water level reached during any flood events during each month. This has been modeled on a daily timestep incorporating the current Water Control Manual and corresponding releases within FCS and proposed deviation for the FCS-D dataset. Some examples of different types or sequences of flood events that could lead to the same result in the FCS dataset are shown in Attachment 1.

As with the exploration of the CS hydrology, the purpose of examining water level changes is because, in addition to the overall amount or acreage of likely occupied terrestrial habitat, changes in water levels also can affect the quality of likely occupied terrestrial habitat by disrupting northern Mexican gartersnake (gartersnake) activities and behavior. Similar to previous explorations, herein we define quality of habitat as the presence and density of vegetation, based on literature indicating gartersnake preference for areas with dense vegetative herbaceous cover, and the role that cover may serve to support feeding, sheltering, and foraging activities.

These effects can be informed by exploring the magnitude, frequency, and duration of reservoir water level changes due to the variability in natural inflows and corresponding reservoir operations. These terms are defined as follows:

- Magnitude—The change in water level elevation, in feet, measured between two specific points in time. A positive magnitude reflects an increase in reservoir water level over time. A negative magnitude reflects a decrease in reservoir water level over time. Magnitudes are explored both in absolute terms (feet of rise), as well as rates of change. For the CS, rates of rise were also estimated (in feet per day or feet per hour) based on average monthly water level changes. Given the episodic nature of the FCS events, this type of rate estimation is nonsensical, as there is no real connection between the water levels shown in the FCS dataset between one month and the next.

- Frequency—How often, as a percentage of time, a change of any given magnitude would be anticipated to occur.
- Duration—The FCS dataset often shows water in the FCS during consecutive months. However, given the episodic nature of the FCS dataset, this should not be construed to reflect water staying in the FCS month after month. With respect to duration, as per the WCM, water from any given event is likely removed from the FCS within 20 days.

This whitepaper explores:

- the magnitude and frequency of water level changes that enter the FCS (and FCS-D), and
- the typical seasonal timing of these events.

Number and Frequency of Events

FCS

Water levels rise above 2,150.77 feet amsl and into the FCS during 39 years over the 106-year model period, or about 37% of years (based on calendar years). Overall, reservoir water levels enter the FCS about 11% of the months (143 out of 1,272 months).

FCS-D

Under the proposed deviation from the WCM, water levels rise above 2,150.77 feet amsl and into the FCS during the same 39 years over the 106-year model period, or about 37% of years (based on calendar years). Overall, under the proposed deviation reservoir water levels enter the FCS about 13% of the months (164 out of 1,272 months).

Magnitude of Events

The typical magnitude of events reaching into the FCS is summarized in Table 1. These represent the maximum estimated monthly elevation into FCS. The values shown represent the vertical height above 2,150.77 feet amsl.

Table 1. Magnitude and frequency of events entering flood control space

Depth of Water above 2,150.77 feet amsl	Current FCS Operations under WCM (FCS)		Proposed FCS Temporary Deviation from WCM (FCS-D)	
	Number of Months Entering FCS	Percent of Months Entering FCS	Number of Months Entering FCS	Percent of Months Entering FCS
0–5 feet	110	77%	95	58%
5–10 feet	23	16%	59	36%
10–15 feet	7	5%	7	4%
15–20 feet	2	1%	2	1%
20–25 feet	1	1%	1	1%
	143	**100%**	**164**	**100%**

Seasonal Timing of Events

The months in which water is present in the FCS space is shown in Table 2. Typical reservoir operations for Roosevelt Lake exhibit increasing water levels during from November through April, which can continue into the spring and early summer during wet inflow years. Seasonal timing is also shown in Table 3, based on the magnitude of the event.

Table 2. Seasonal timing of events entering FCS

Month	Current FCS Operations under WCM (FCS)		Proposed FCS Temporary Deviation from WCM (FCS-D)	
	Number of Months Entering FCS	Percent of Months Entering FCS	Number of Months Entering FCS	Percent of Months Entering FCS
January	13	9%	13	8%
February	20	14%	20	12%
March	25	17%	27	16%
April	36	25%	36	22%
May	29	20%	35	21%
June	7	5%	20	12%
July	1	1%	1	1%
August	1	1%	1	1%
September	0	0%	0	0%
October	2	1%	2	1%
November	2	1%	2	1%
December	7	5%	7	4%
	143	**100%**	**164**	**100%**

Table 3. Seasonal timing of events entering FCS, based on magnitude

Depth of Water above 2,150.77 feet amsl	Current FCS Operations under WCM (FCS)			Proposed FCS Temporary Deviation from WCM (FCS-D)		
	Month	Number of Months Entering FCS	Percent of Months Entering FCS	Month	Number of Months Entering FCS	Percent of Months Entering FCS
0–10 feet	January	11	8%	January	11	7%
	February	15	11%	February	15	10%
	March	24	18%	March	25	16%
	April	36	27%	April	36	23%
	May	29	22%	May	35	23%
	June	7	5%	June	20	13%
	July	1	1%	July	1	1%
	August	1	1%	August	1	1%
	September	0	0%	September	0	0%
	October	2	2%	October	2	1%
	November	2	2%	November	2	1%
	December	5	4%	December	6	4%

Depth of Water above 2,150.77 feet amsl	Current FCS Operations under WCM (FCS)			Proposed FCS Temporary Deviation from WCM (FCS-D)		
	Month	**Number of Months Entering FCS**	**Percent of Months Entering FCS**	**Month**	**Number of Months Entering FCS**	**Percent of Months Entering FCS**
10–20 feet	January	1	11%	January	1	11%
	February	5	56%	February	5	56%
	March	1	11%	March	2	22%
	April	0	0%	April	0	0%
	May	0	0%	May	0	0%
	June	0	0%	June	0	0%
	July	0	0%	July	0	0%
	August	0	0%	August	0	0%
	September	0	0%	September	0	0%
	October	0	0%	October	0	0%
	November	0	0%	November	0	0%
	December	2	22%	December	1	11%
>20 feet	January	1	100%	January	1	100%
	February	0	0%	February	0	0%
	March	0	0%	March	0	0%
	April	0	0%	April	0	0%
	May	0	0%	May	0	0%
	June	0	0%	June	0	0%
	July	0	0%	July	0	0%
	August	0	0%	August	0	0%
	September	0	0%	September	0	0%
	October	0	0%	October	0	0%
	November	0	0%	November	0	0%
	December	0	0%	December	0	0%
Total		**143**			**164**	

ATTACHMENT 1

Example Hydrograph Depicting Activity in Flood Control Space, Under Current Operations and Under Proposed Deviation

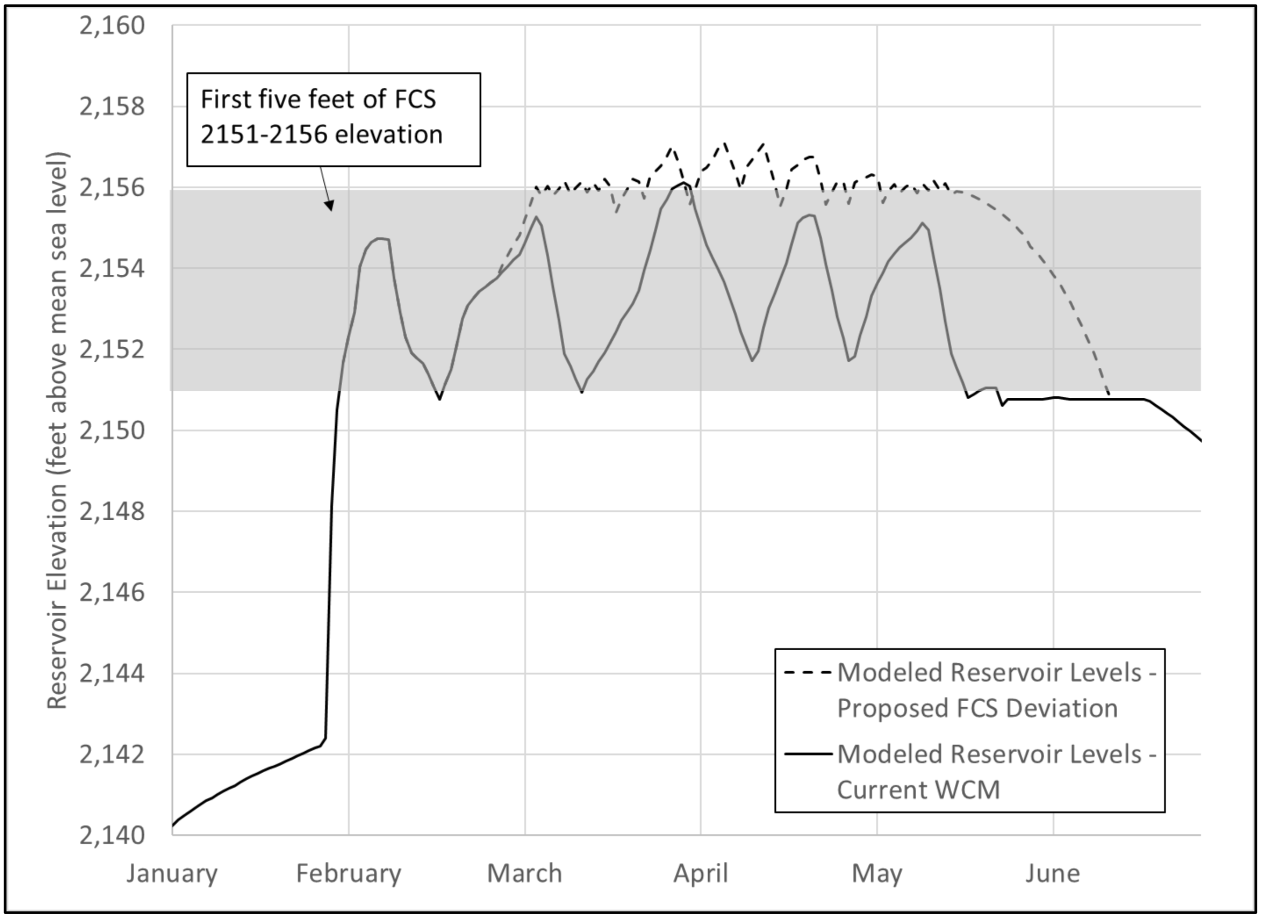

Figure 1. Illustration of estimated reservoir levels under current Water Control Manual and planned deviation for first 5 feet of FCS.

APPENDIX K

Supporting Analysis for Tonto Creek Take Metric Approach

PURPOSE

The estimate of take for northern Mexican gartersnake (NMGS) includes that associated with the habitat of the reservoir conservation space and flood control space, as well as that associated with the potential movement of non-native fish upstream in Tonto Creek. The purpose of this whitepaper is to provide supporting analysis for the surrogate take metric approach on Tonto Creek, which is based on measurement of “migration days”.

A “migration day” refers to those days that Tonto Creek is flowing at a rate between 200 and 1,100 cubic feet per second (cfs) between the dates of February 1 and May 31. These are conditions under which nonnative fish are most likely to move from the lake upstream into Tonto Creek. These specific bounding parameters were explored and defined in the Study 6 report[1] and are based on non-native fish spawning seasons as well as physical properties of the Tonto Creek channel.

Available Data Set

Flow measurements have been continuously collected on Tonto Creek for roughly 81 years, beginning in December 1940 and continuing to the present (USGS gage 09499000 Tonto Creek above Gun Creek, near Roosevelt, AZ). The USGS flow record consistently provides the average daily flow at the gage (in cfs).

Calculation of Migration Days

The data set contains a total of 81 years with average daily flow measurements between February 1 and May 31. Flow values during this window were evaluated statistically, as shown in Table 1. Distributions are shown graphically in Figures 1 through 3.

Table 1. Statistical assessment of migration days on USGS flow gage 09499000 (1941–2021)

Parameter	All Years (1941–2021)*	30-Year Rolling Average (Days per Year)	30-Year Rolling Average (Total Days)
Total number of data points	81	52	52
Number of data points with zero migration days	25	0	0
Number of data points with migration days	56	52	52
Total number of migration days, all years	1,713	-	-
Minimum total migration days during year	0	17.8**	533.0
Maximum total migration days during year	75	27.1**	812.0
Average total migration days during year	21.1	22.7	682.2
Standard deviation of total migration days during year	22.4	3.1	94.0

[1] GEI (GEI Consultants, Inc.). 2021. Potential for nonnative fish impacts to NMGS in Tonto Creek above 2,151 ft. Presentation to U.S. Fish and Wildlife Service, May 2021.

Parameter	All Years (1941–2021)*	30-Year Rolling Average (Days per Year)	30-Year Rolling Average (Total Days)
30th Percentile of total migration days during year	0.0	20.0	599.1
60th Percentile of total migration days during year	25.6	24.8	744.0
90th Percentile of total migration days during year	57.0	26.4	791.9
99th Percentile of total migration days during year	71.0	26.9	805.9

* All statistics are based on all 81 years, including those with zero migration days.

** The 30-year period with the most migration days was 1969-1998. The 30-year period with the least migration days was 1987-2016.

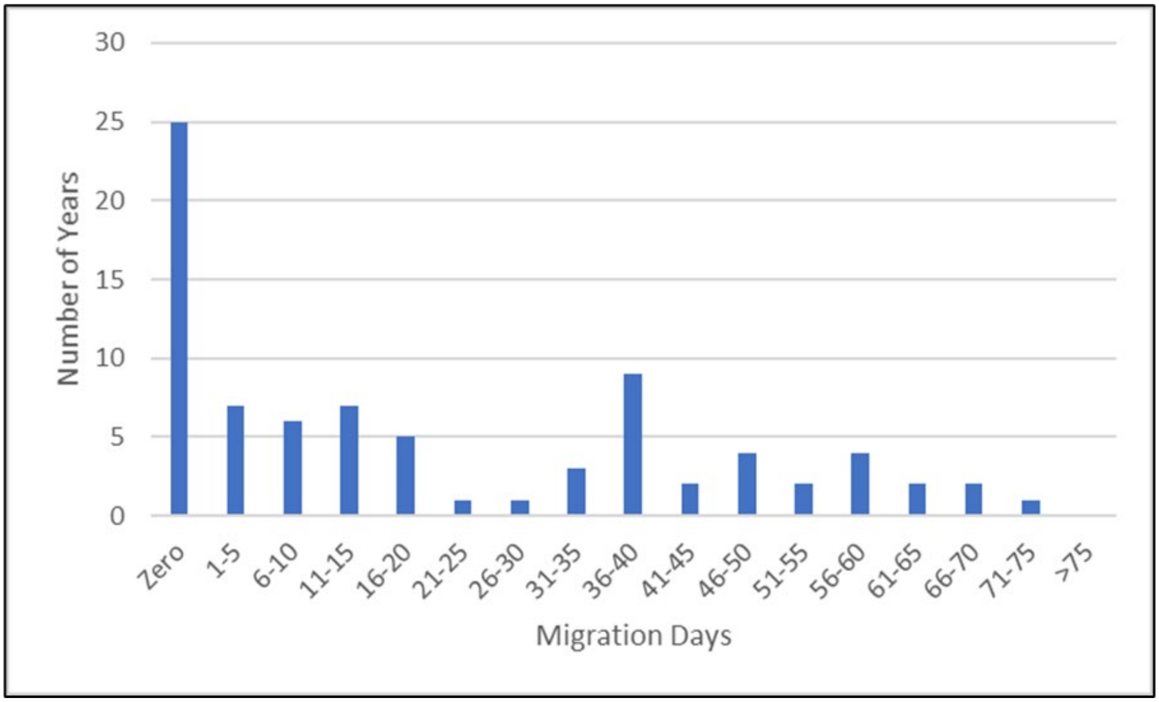

Figure 1. Distribution of total migration-days during any given year for the entire 81-year data set (1941–2021)

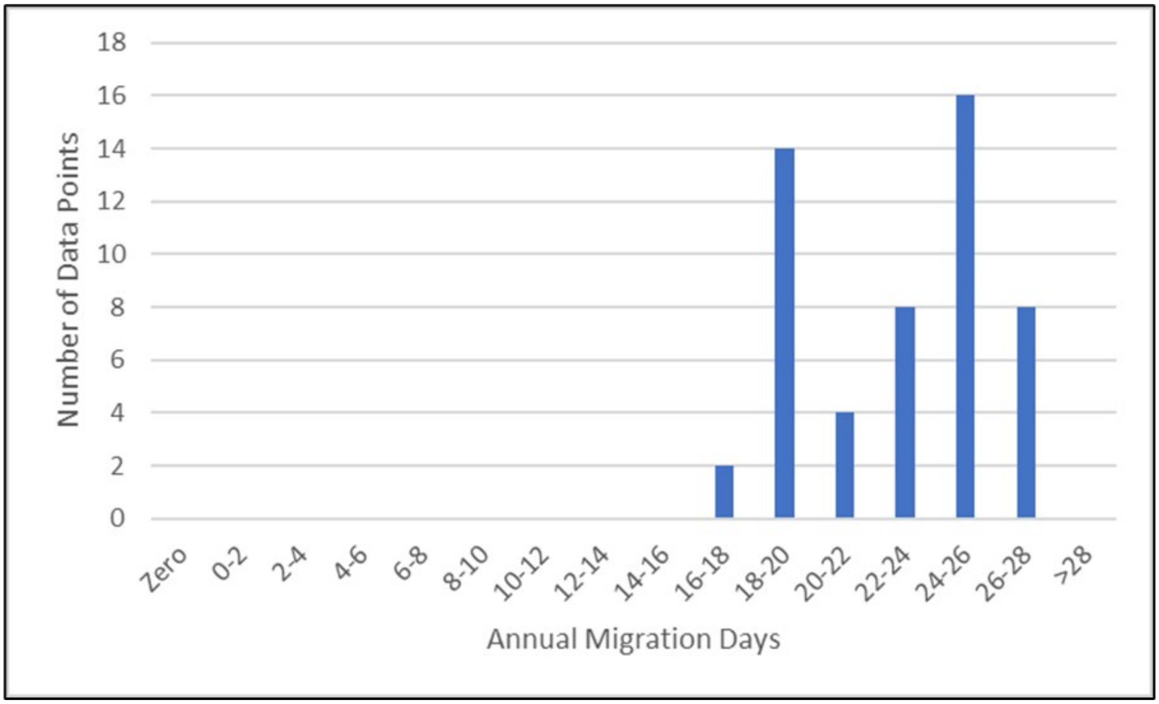

Figure 2. Distribution of the 30-year rolling average for annual migration-days, shown in migration-days per year

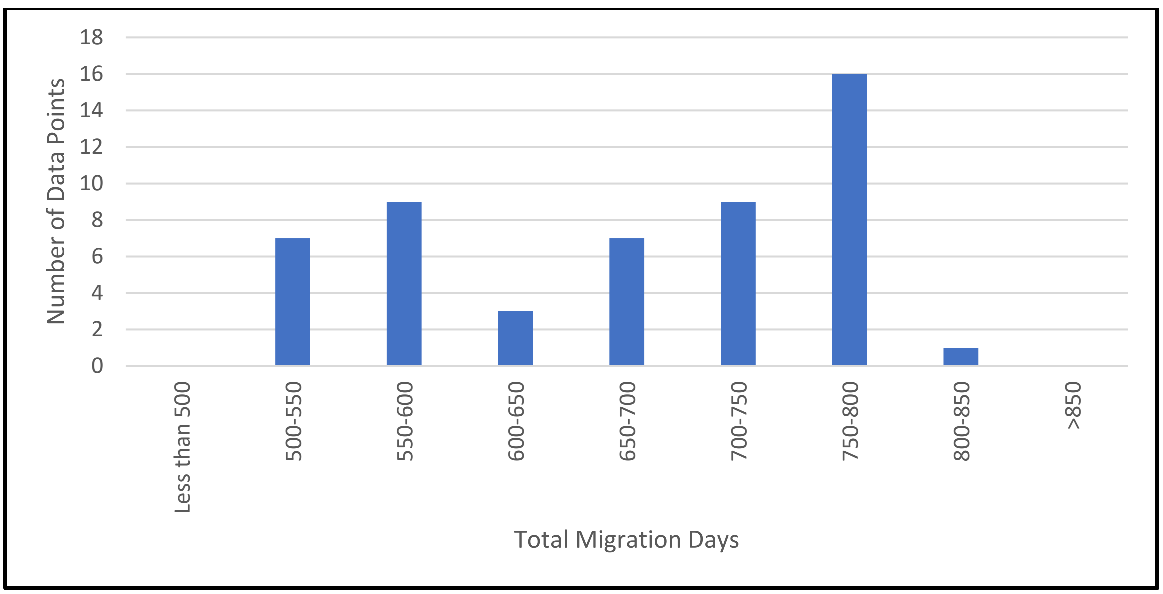

Figure 3. Distribution of the 30-year rolling average for annual migration-days, shown in total migration-days for each 30-year period

Calculation of Anticipated Frequency of Mitigation Events

A migration day is defined as days that Tonto Creek is flowing at a rate between 200 and 1,100 cfs between the dates of February 1 and May 31. For the purposes of SRP management, a mitigation event is triggered in any year in which there are 5 consecutive migration days. Thus, the historic Tonto Creek flow data were analyzed to ascertain the likely scenarios for mitigation to be triggered.

The historic flow data from 1941 to 2021 were analyzed to determine the average number of years in which a mitigation event would have occurred to inform the possible future scenarios. A summary of this data indicates that a mitigation event was triggered in approximately 3 out of every 5 years (60%) of the historic data (Table 2).

Table 2. Number of years when mitigation events occurred (1941–2021)

Parameter	All Years (1941–2021)
Total number of data points	81
Number of years with 0 mitigation events	32
Number of years with mitigation events	49
Average years with mitigation events	0.6
Standard deviation of years with mitigation events	0.49

APPENDIX L

Roosevelt Lake Operation and Spill Scenario for the RHCP Amendment No Action Alternative

Reservoir Operation and Spill Scenario for the RHCP Amendment No Action Alternative

Background on Reservoir Operations and Spill Conditions

SRP operates the Salt and Verde reservoir system based on reservoir storage, operational needs, seasonal inflow, and potential reservoir spill. During the winter runoff season, deliveries are typically made from the Verde reservoir system. The Verde has a smaller storage capacity. Winter deliveries from the Verde maximizes the storage of winter runoff in the overall system and minimizes spill from the Verde system. Deliveries are switched to the Salt system in the spring to deliver from the larger reservoir storage in Roosevelt during the higher demand and lower inflow summer months. Additionally, summer releases from the Salt reservoirs allow for the generation of electricity through the hydroelectric power plants on each of the Salt dams.

Releases for deliveries and reservoir spill vary based on reservoir conditions and inflows during the winter runoff season. For instance, when reservoirs (Salt and/or Verde) fill to capacity and reservoir spill operations begin, the following spill conditions may occur:

- **Verde reservoir spill** – Verde spill occurs with winter runoff from the Verde watershed due to storm events and/or snowmelt ranging from small to large events. Typically, Verde spills are flashy, large magnitude releases (days to weeks) during storm events due to a lack of flood control space on the Verde system. If the Verde system reaches capacity and inflows exceed demand, a spill event would occur that may result in physical spill at Granite Reef Dam until inflows decline below demands. Water deliveries to shareholders continue to be made from the Verde, and Salt reservoir releases are maintained at a minimum assuming no spill occurs from Salt system.
- **Salt reservoir spill (Roosevelt)** – Salt spill occurs with winter runoff from the Salt River and Tonto Creek due to storm events and/or snowmelt ranging from small to large events. Storm events causing Salt spill typically coincide with releases from the Verde and these Salt spill events are often of lesser peak magnitude discharge than those at Verde due to Roosevelt's larger capacity and the use of FCS at Roosevelt. Snowmelt runoff in later winter and spring can result in Salt spills of longer duration and lower to moderate level spills from Granite Reef (weeks to months). Deliveries from the Salt system are made after considering the Verde releases necessary to minimize spills from the Verde system. Releases will be made according to the WCM when Roosevelt is within FCS.
- **Verde and Salt spill** – If spill is occurring from both reservoir systems (inflows exceed demand for deliveries and storage capacity), then releases from the Verde will be made to pass excess storm/snowmelt waters and maintain Verde storage while releases from the Salt system will occur according to the WCM as Roosevelt enters FCS. Any excess water released above demand will physically spill from Granite Reef Dam into the Salt River.
- **Local inflow and/or Lower Salt inflows** – Flashy, small to moderate spills over Granite Reef Dam can occur from local inflows in the winter or the summer monsoon seasons. Local precipitation and runoff events can occur on the Lower Verde (below Bartlett Dam), lower Salt River (below Stewart Mountain Dam), or Lower Salt Lakes (i.e., Canyon Lake) and may require spills from Horse

Mesa and Stewart Mountain Dams of short duration (hours to days) that become spills over Granite Reef Dam.

During spill events, the excess water may be available for use by customers free of charge. During spills triggered by discrete storm events, the demand for this “free spill water” may be limited due to reduced need during wet seasons or an inability to receive the water at the time of the spill. For longer spills following by longer-duration snowmelt conditions, customer use of the spill water may increase (e.g., demand may be greater and/or the ability to take the water increased). Use of spill water is still limited by the ability to receive and physically use the water. Various projects and/or agreements are currently being developed that could increase the potential use of spill water from SRP reservoirs for additional on-project use, off-project use, underground storage, exchanges, or other purposes (e.g., Phoenix drought pipeline). Below are conditions for use of physical spill water (available for all users) and virtual spill water (available only for SRP shareholders):

- **Physical Spill (Salt and/or Verde, Local)** – This occurs during physical spill events when water flows over Granite Reef Dam into the lower Salt River and spill conditions are declared. The spilled water is available for use by any city or other users (does not need to be an SRP shareholder) that can obtain and put the water to use.
- **Virtual Spill** – This occurs when no physical spill is occurring over Granite Reef Dam, but Roosevelt is increasing within the New Conservation Space (NCS) zone of eligibility and “NCS credits” are being accrued. For instance, if Verde spill is not occurring and Verde inflows decrease below demand, release from the Verde system will match inflows to maximize and maintain storage on the Verde (but not spill water) while the remaining deliveries to meet demand will occur from the Salt. If inflows are exceeding the release from the Salt, and Roosevelt is increasing within NCS (but not physically spilling from FCS), then virtual spill is declared. In this instance, water that would have been physically spilling from Granite Reef prior to the 1996 modification of Roosevelt Dam is instead being stored in NCS. SRP shareholders have rights to use this “virtual” spill water. During virtual spill events, only SRP shareholders are eligible to receive the excess free water, which is delivered through SRP’s canal system.

Since the modification of Roosevelt Dam was completed in 1996, 7 out 27 years resulted in spill events. Two of these years had spill from the Salt system due to Roosevelt Lake entering FCS (see Table below for years with spill; note that this table does not include local inflow spill events; see Local inflow and/or Lower Salt inflow description above). Note that the period from 1996 to 2022 corresponds with a long duration drought period in which spill may have occurred less often. Prior to modification of Roosevelt, during a long-term pluvial (i.e., wet) cycle (i.e., 1978-1995), reservoir spills were more frequent and of higher magnitude. For example, the peak spill from Granite Reef Dam of 180,000 cfs occurred in 1980 (Verde system ~100,000 cfs, Salt System ~64,000 cfs, plus local inflow). Additional large spills occurred in 1978, 1983, 1993, and 1995 with peak Verde release up to and exceeding 100,000 cfs in response to large storm events.

<u>Reservoir Spill Events since Roosevelt Modification 1996 - 2022</u>

	Reservoir Spill	**Days**	**Dates**	**Peak Avg daily CFS**	**Total AF**
Winter 1998	**Verde**	**16**	**Mar 30 – Apr 15**	**7,000**	**83,000**

	Reservoir Spill	Days	Dates	Peak Avg daily CFS	Total AF
Winter 2005	**Verde**	**92**	**Dec 28 – Apr 1**	**25,000**	**900,000**
	Lower Salt	**34**	**Jan 3-15, Feb 11-Mar 4**	**11,000**	**75,000**
	Salt (Virtual)	**30**	**April 1-30**	**-**	**-**
Winter 2008	**Verde**	**55**	**Jan 27-Mar23**	**3,600**	**124,000**
	Salt (Virtual)	**32**	**Mar 23 – Apr 25**	**-**	**-**
Winter 2009	**Salt**	**64**	**Feb 6 – Apr 11**	**2,200**	**85,000**
Winter 2010	**Verde**	**126**	**Jan 21 – May 27**	**3,900**	**260,000**
	Lower Salt	**4**	**Jan 21-24**	**9,600**	**29,000**
	Salt	**118**	**Jan 25 – May 24**	**6,000**	**343,000**
Winter 2017	**Verde**	**30**	**Feb 12 – Mar 14**	**17,600**	**93,000**
Winter 2019	**Verde**	**30**	**Mar 2 – April 1**	**5,100**	**92,000**
Summer 2019	**Lower Salt**	**2**	**Sep 23-24**	**5,100**	**11,000**
Winter 2020	**Verde**	**12**	**Mar 20 – Apr 1**	**2,500**	**26,000**
	Salt (Virtual)	**18**	**Apr 1-18**	**-**	**-**

<u>Potential Frequency of Spill Events from Roosevelt Under the No Action Alternative</u>

RPM modeling for the 106-year modeled period completed for the Roosevelt HCP Amendment estimated that 51 out of 106 years (48%) would have resulted in physical spill from Granite Reef Dam (due to releases from the Verde, Salt or both reservoir systems) and 37 years out of the 106 years modeled (35%) would have resulted from Salt spill (i.e., Roosevelt entered FCS). This would occur less often during longer duration drought periods when only ~10% of years would have had Salt spills. Spills occur more frequently during pluvial periods and when Roosevelt starts at higher elevations going into the winter runoff season. During longer duration wet periods, ~50% of years would have Salt spill (i.e., Roosevelt within FCS) with several instances of consecutive years with spill.

Based on SRP's latest streamflow forecast (as of Jan 15, 2023), Roosevelt Lake is projected to reach 97% of capacity (~2,148' elevation) by May 31, 2023. At this high elevation, Roosevelt is more likely to enter FCS and spill within the next 1-3 years, regardless of any operational changes to implement the No Action alternative. This forecast may change (and could possibly fill Roosevelt) if additional storms impact the Salt watershed this winter.

SRP would operate in the following manner under the No Action alternative:

- SRP would seek to avoid incidental take of gartersnakes and work with the Service to as quickly as possible develop and implement a long-term ESA compliance solution.
- SRP believes that to avoid gartersnake take, it would be necessary (to the extent feasible) to maintain Roosevelt at or below the elevation as of June 2023 and avoid any increase in lake elevation thereafter until alternative authorization for gartersnake take is achieved. Roosevelt could decrease in elevation, but once decreased, subsequent rises would be avoided.

- Based upon prior ESA compliance efforts at Roosevelt and Horseshoe and Bartlett Reservoirs SRP anticipates that it could take 1 to 3 years to secure alternative authorization for gartersnake take.
- SRP would endeavor to avoid rising lake levels at Roosevelt, subject to hydrological inputs, physical limitations for releases, and human health and safety considerations, for this limited period (likely less than 3 years) until alternate authorization for gartersnake take was achieved.

The following describes the possible impacts to SRP operations and reservoir spill over Granite Reef Dam into the lower Salt River:

- Roosevelt Lake elevation would likely decline through summer and fall 2023 as seasonal inputs decrease and increased deliveries are made from the Salt system to meet summer and fall demand.
- If spills from the Salt system (Roosevelt) are necessary, they could begin earlier in the year, would be of larger volume and greater peak discharge, and could continue later into the spring. If inflows exceeded deliveries, SRP would spill inflows to Roosevelt, rather than store them. While the likelihood of some amount of winter and spring inflow into Roosevelt is high, the occurrence, magnitude and duration of spill would be dependent upon the previous summer and fall moisture conditions in the watershed, and the highly variable winter snow levels and other precipitation events.
- SRP anticipates that most of the spill water would be released from Granite Reef Dam into the Lower Salt River, as with typical past reservoir spills. Similar to existing operation protocols, SRP would inform and coordinate with SRP's customers and other water users to maximize the use of any spill water.
- For large inflow events, certain elevations might not be maintainable because of release limitations at Roosevelt at a given elevation (i.e., capacity to release from Roosevelt varies by elevation). Due to physical constraints, releases may not be able to match inflows and Roosevelt Lake could rise until inflows decrease below the ability to release. This is a physical limitation of the reservoir system and not in the control of SRP. SRP would seek to return the reservoir as quickly as feasible to the elevation before the rise occurred.
- In the event of rare large storm events, to protect the health and safety of the public, and consistent with the WCM, SRP would operate in a manner that limits spills over Granite Reef Dam to no more than 180,000 cfs. This health and safety limitation could cause a rise in Roosevelt if short-term storage is necessary to keep the spill over Granite Reef Dam at or below 180,000 cfs. But as soon as feasible, SRP would return Roosevelt to the elevation before the rise occurred.
- The occurrence of large spill events (up to 180,000 cfs) into the Salt River are primarily the result of rare extreme hydrological conditions and storm events impacting inflows into the reservoir system and any additional inputs downstream. Much of the modified Roosevelt operations occurred during a long-term drought duration with fewer years of greater hydrological input into the system resulting in less spill. Many of the years with higher magnitude spill events under pre-modified Roosevelt (1978-1995) occurred from greater hydrological inputs and larger spill events from the Verde system (100,000 cfs or more). These

large hydrological events are the primary factor for large magnitude spill events and would occur within the same variability under No Action Alternative.

- SRP might spill more water more frequently from the Verde, since it could be necessary to prioritize deliveries from the Salt to avoid increasing the level of Roosevelt. But the Verde spills are not uncommon under current conditions (see Table).
- Conservation storage at Roosevelt might be reduced if SRP is unable to store new inflow in excess of delivery. NCS storage credits may be lost or unable to accrue. Reduced storage might impact planning (such as groundwater pumping and overall system operations). Virtual spill could become physical spill from the Salt system resulting in additional amounts of spill, which might not otherwise occur, as wells as the loss of NCS storage credits gained and/or the loss of SRP shareholder vested water rights.
- Spill releases during the 1 – 3 year timeframe could cause more frequent impacts to other downstream users and the public such as temporarily limiting the ability to recharge water at GRUSP and temporary traffic impacts at low water crossings in the Salt River. Although the frequency of potential downstream impacts might slightly increase, as noted below, the magnitude and duration of spill and associated impacts would remain within the long-term variability of the system.
- While the circumstances and characteristics of spills under No Action alternative may differ from current operations, the absolute timing, frequency, volume, and rate of spill under the No Action alternative would remain within the overall range of variability observed in the past and estimated by the RPM. The spills predicted under No Action are not unusual circumstances.

APPENDIX M

Approach for Formulation of the Proposed Planned Deviation

1 INTRODUCTION TO PLANNED DEVIATION CONCEPT

Section 7-14c of the U.S. Army Corps of Engineers (USACE) water control manual (WCM) for modified Theodore Roosevelt Dam (Roosevelt Dam) identifies instances for deviations from its defined flood operating plans. Since the finalization of the WCM in 1997, total surface water use in central Arizona has grown, primarily from use of Colorado River supplies provided by the Central Arizona Project (CAP) canal. Growth in water use in the region, combined with likelihood of reductions in availability of Colorado River water resulting from shortage conditions, requires careful management of water supplies available to central Arizona, including spill waters[1] provided by flood events on the Salt River. Increased operational flexibility within the flood control space (FCS) through extension of the evacuation period at certain elevations would allow for increased beneficial use of spill waters when available through direct use or underground recharge.

To facilitate the increased use of spill water during years it is available, Salt River Project Agricultural Improvement and Power District (SRP) developed a proposal for a planned deviation in consultation with The Bureau of Reclamation (Reclamation) to extend the release period for waters contained within the first 5 feet of the FCS (elevations 2,150.78 feet above mean sea level [amsl] to 2,155.78 feet amsl) from 20 days to 120 days. The 5-foot band within the FCS proposed for the modified evacuation period is referred to in this document as planned deviation space~~(PDS)~~. SRP has requested approval for the planned deviation that would allow for use starting in January 2023 and ending in December 2028. The planned deviation would be allowable for use in up to 3 out of 5 of the years in the planned deviation period. Figure 1 provides a graphical comparison of the proposed planned deviation to the existing release plan identified in the WCM.

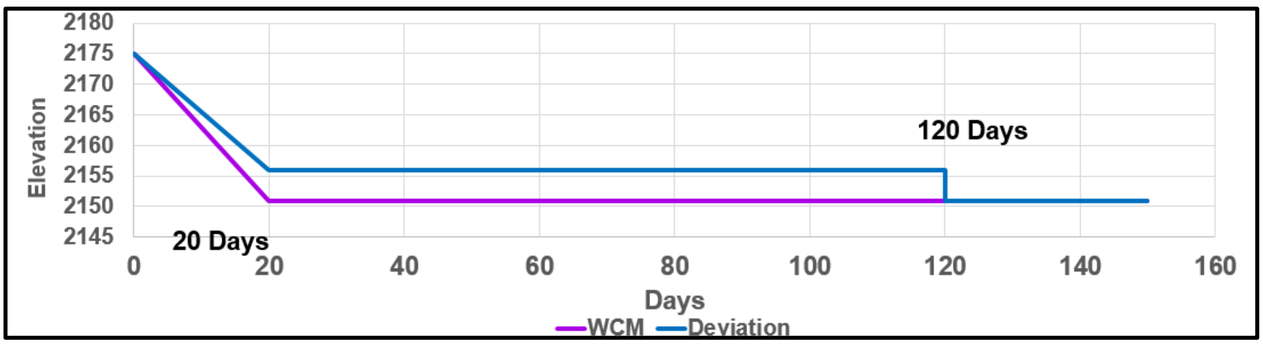

Figure 1: Proposed Deviation Compared to Existing WCM Plan

This document is intended to provide Reclamation and USACE with background necessary for understanding how SRP developed the current proposal for the planned deviation through analysis and consultation with Reclamation. Section 2 describes the approach for determining an appropriate portion of the FCS delineated by a maximum allowable elevation within the reservoir for a planned deviation from the 20-day evacuation period. Section 3 describes the modeling approach used to develop the preferred evacuation period and probability of occurrence using SRP's reservoir planning model and climate change adjusted hydrology from the historic record of the Salt and Verde Rivers. Section 4 describes the approach for determining a preferred evacuation period of the planned deviation. Section 5 describes the approach for determining the number of years to request for the planned deviation and Section 6 describes

[1] During spill conditions, water may or may not physically spill over Granite Reef Diversion Dam or from spillways on the Salt River dams, depending on whether inflows on the Verde River and the lower Salt River Reservoirs (Saguaro Lake, Canyon Lake, and Apache Lake) exceed available storage and SRP deliveries at Granite Reef Diversion Dam. During these spill conditions, SRP delivers such water to certain entities with claims to the use of the spill or flood waters without those water deliveries counting against the contractual entitlements.

the expected water volume to be produced under the proposed planned deviation under different water year types. Section 7 provides a summary weighing the costs and level of effort with potential benefits created by the proposed planned deviation. Section 8 provides a summary of this document and the variations considered in developing the planned deviation proposal.

2 DETERMINING PORTION/ELEVATION OF FCS FOR PLANNED DEVIATION

The total volume of the FCS contained within the 24 vertical feet of Modified Roosevelt Dam is 556,206 acre-feet as shown in Figure 2. Through discussions with Reclamation, it was identified that limiting the planned deviation to the first 5 feet of the FCS would not require a *new* structural risk assessment and could rather rely on existing information from the dam design and other prior analyses for Modified Roosevelt Dam and the Salt River basin. Additionally, it is expected that the 108,620 acre-feet of volume made available for extended release could also be put to beneficial use[2] by existing spill water users within the same calendar year. More detail is provided below on the development of the proposed extended-release period.

	Amount into Flood Control		Roosevelt Elevation	Roosevelt Volume
	[ft]	[AF]	[MSEL]	[AF]
	2.5	53,874	2153.28	1,685,428
Proposed Elevation	5	108,620	2155.78	1,740,174
	7.5	164,318	2158.28	1,795,872
	10	220,828	2160.78	1,852,382
	15	336,464	2165.78	1,968,018
	20	455,764	2170.78	2,087,318
	24.09	556,206	2174.87	2,187,760

Figure 2: Roosevelt Lake Volume within Flood Control Space Elevation Bands

In consultation with dam safety specialists from Reclamation, for cost and schedule efficiencies, SRP worked to identify an elevation for changing the flood release curve that could rely on existing detailed structural safety analyses thereby limiting the necessary scope of the analysis performed by Reclamation's Dam Safety Advisory Team. A risk assessment for the first 5 feet could rely on existing facility and engineering information and therefore could be completed within a year. Narrowing the necessary scope of the Dam Safety Advisory Team analysis was identified as appropriate to limit the costs and the level of effort for performing the necessary risk and safety due diligence. This limiting of the scope for the temporary planned deviation was done to not create levels of review and due diligence that would be larger than the limited benefits that can be created in a 5-year period by the planned deviation.

[2] ARS 45-181 "Beneficial use" includes but is not limited to use for domestic, municipal, recreation, wildlife, including fish, agricultural, mining, stock watering, and power purposes.

3 MODELED RESERVOIR OPERATIONS AND CLIMATE CHANGE-ADJUSTED HYDROLOGY

SRP's reservoir planning model was used to simulate reservoir storage and spill using historic hydrologic records of the Salt and Verde rivers for the period 1914–2019. The hydrologic record was adjusted for expected climate change effects on hydrology.[3] Using the climate change adjusted hydrology, the reservoir planning model runs estimate reservoir inflows, storage levels, elevations, releases, and spills based on existing dam infrastructure and operational rules in place as of 2021 and a current system demand of 750,000 acre-feet per year. Figure 3 below shows 1) the annual accrual of water supplies in the conservation storage space of Roosevelt Dam in blue; 2) the accrual of water supplies in the planned deviation space in orange; and 3) water that would be spilled from elevations 2,156–2,175 feet of the FCS and the entirety of the safety of dam space of Roosevelt Dam in grey.

The Salt River watershed follows a typical long-term oscillation pattern from wet periods (above median runoff) to dry periods (below median runoff) every 20–25 years. The long-term oscillation pattern for the modeled period is shown by red and blue boxes outlining those periods in the analysis. Water entering the FCS is more common during wet periods and less frequent during dry period. The modeled reservoir inflows, reservoir releases (for delivery and spill), and water accruals were used to further develop the proposed planned deviation.

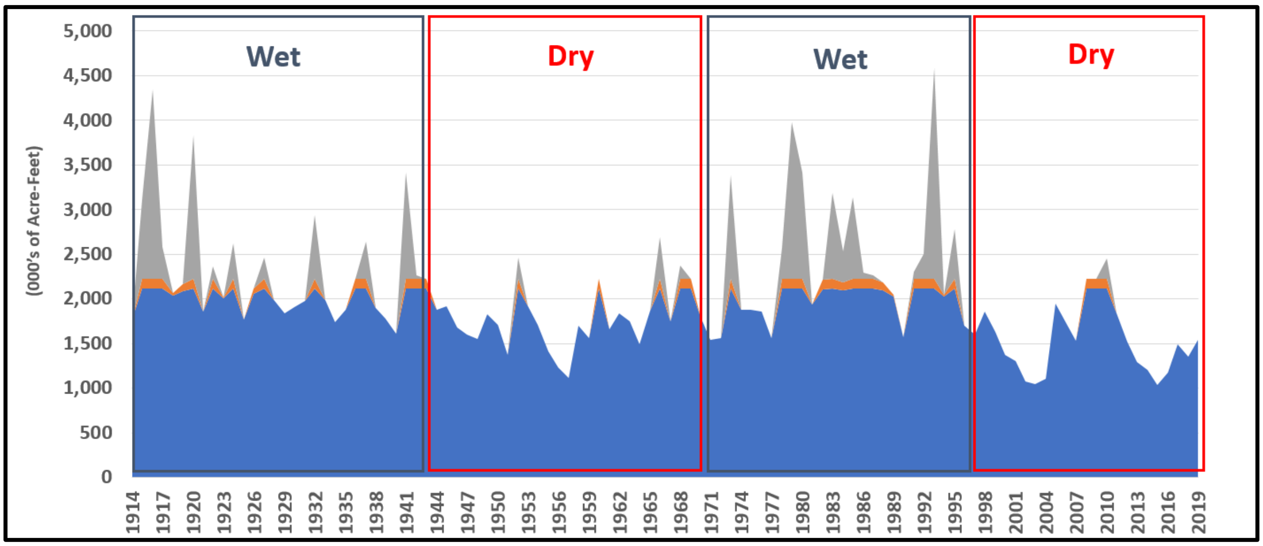

Figure 3: Modeled Reservoir Water Accruals and Spill

[3] For this work, a climate change adjusted hydrology was based on changes in temperature, precipitation mean, and precipitation variability derived from Global Climate Model projections. The applied increase in temperature over the 106-year period was around a 4 ºC increase for the Salt River watershed. The applied change in mean precipitation was around a 4.5% decrease on Salt River watershed. The change in precipitation variability was represented with an empirical cumulative distribution function with precipitation in the wettest years (above the 90th percentile) increased by 5%–10% and precipitation in the driest years (below the 10th percentile) decreased by 20%–30%.

4 INUNDATION DURATION OF FLOOD CONTROL SPACE

SRP utilized the data and results discussed in the Section 3 to identify a desired duration for an extended-release period beyond the current WCM requirement of 20 days. The analysis was conducted using the SRP reservoir planning model and replacing the existing flood control release curve from the WCM with only the minimum releases necessary to meet SRP water deliveries during the period. This hypothetical exercise allows for analysis of how long the reservoir would remain within the planned deviation space (elevations 2,151–2,156 feet) if flood control operations were not necessary and rather water conservation operations were prioritized.

Runoff events that would be expected to create FCS or spill operations typically occur between January 1 and May 31 of a calendar year (winter/spring runoff periods) and are most likely to occur between March 1 and March 31 (with March being a heavy month for snow and rain events). Of the 106-year period analyzed, 47 years had modeled reservoir inflows that could result in reservoir elevations entering the FCS (elevations greater than 2,151 feet). The model was used to identify how many days it would take to evacuate any water that accrued in the planned deviation space (elevations 2,151–2,156 feet) under normal reservoir deliveries[4] for meeting SRP system demand. Figure 4 below shows the number of years of potential inundation in the proposed planned deviation space on the vertical (y-axis) axis and the number of days to evacuate the water volume within that elevation band on the horizontal (x-axis) axis. Analysis of the evacuation duration data shows that:

- 47 years would have sufficient volume in the planned deviation space to require 30 days for the reservoir to recede below elevation 2,151 feet (back into the conservation pool);
- 45 years would have sufficient volume in the planned deviation space to require 60 days for the reservoir to recede below elevation 2,151 feet;
- 35 years would have sufficient volume in the planned deviation space to require 90 days for the reservoir to recede below elevation 2,151 feet;
- 24 years would have sufficient volume in the planned deviation space to require 120 days for the reservoir to recede below elevation 2,151 feet;
- 5 years would have sufficient volume in the planned deviation space to require 150 days for the reservoir to recede below elevation 2,151 feet; and
- Only 2 years would have sufficient volume in the planned deviation space to require more than 180 days for the reservoir to recede below elevation 2,151 feet.

The objective of the planned deviation is to extend the evacuation period within the runoff season to increase the ability to put to beneficial use spill waters and is not to store water for carryover into the following calendar year. Based on the analysis, a natural breaking point of 120 days was identified for extension of the release period. For an evacuation period less than 120 days it is expected that in most years (more than half) where reservoir inflows are sufficient to enter the planned deviation space, water would have to be physically spilled due to increased reservoir releases required to meet the evacuation period requirement. The increased release rate resulting in physical spill would limit the ability to meet the objective of the planned deviation of increasing beneficial use of spill water since the water physically spilled over Granite Reef Diversion Dam cannot be diverted into the SRP canal system for delivery to

[4] SRP used average historic water delivery distributions for each month from March 1 to August 31 to estimate the minimum releases necessary from Modified Roosevelt Dam to meet water deliveries from SRP's entire reservoir system, including all Salt and Verde River dams. The historic monthly water delivery distribution from SRP's system follows: Jan., 3.9%; Feb., 4.4%; Mar., 6.5%; Apr., 9.5%; May, 11.1%; Jun., 13.1%; Jul., 13.5%; Aug., 12.9%; Sep., 8.8%; Oct., 7.3%; Nov., 6.3%; and Dec., 2.9%.

spill water users. For an evacuation period greater than 120 days, the probability of inflows being sufficient to require physical spill of water after the end of the 120-day evacuation period decreases to close to 10% of years in the record and therefore and evacuation period greater than 120 days is expected to create only limited incremental benefits to the goal of increasing beneficial use of spill water.

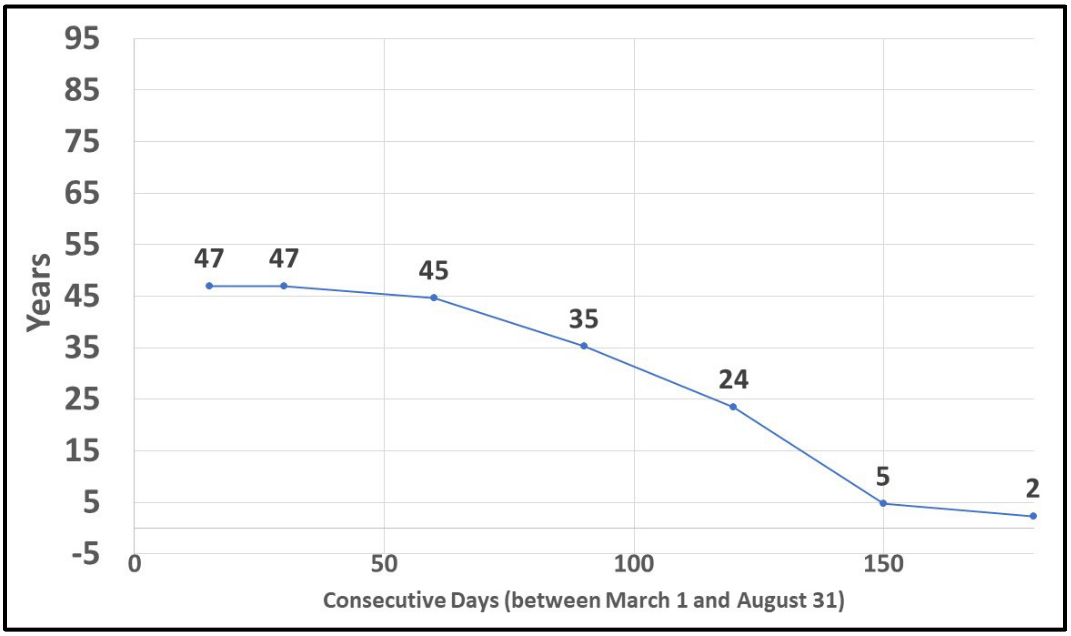

Figure 4: Consecutive Days of Inundation at Elevation

5 PROBABILITY OF OCCURRENCE AND TIMING OF PROPOSED PLANNED DEVIATION

After determining the preferred evacuation period, a temporary period of 5 years was identified as preferred for the request for the planned deviation. The 5-year period was selected to balance the temporary nature of a planned deviation with 1) the uncertainties of precipitation and climate patterns that produce spill events and 2) the significant effort and costs of conducting risk assessments, environmental compliance, and other activities necessary for SRP to seek approval of the planned deviation proposal by Reclamation and the USACE.

Identifying an appropriate subset of the 5-year period (such as 3 out of 5 years) for allowance of use of the planned deviation was identified as desirable since it is not possible to forecast an exact year when precipitation and runoff conditions would enable use of the planned deviation. Due to the large variability in runoff from year-to-year within the Salt River watershed, it is not likely that a planned deviation would be used in 5 consecutive years. To account for this, contingent probability analysis was conducted to identify a desired number of years to request allowance for use of the extended evacuation period in the planned deviation.

To perform the contingent probability analysis, the climate change adjusted hydrology was used to produce subsets of 5 consecutive years, randomly selected from the full data set of 106 years. This was conducted 100 times to produce a sample of 100 5-year periods of streamflow. The 100 sample periods were then used as input for the reservoir planning model to identify the total maximum reservoir fill within the first 5 feet of the FCS for each year.

Figure 5 below presents the results into three subsets of 5-year periods to identify ranges of uncertainty, depending on water year types. It is not possible to forecast with enough precision or certainty to predict[5] reservoir inflows for a future year or a future 5-year period, so an analysis was performed to inform the likelihood of using the planned deviation under different water year types. The “All years” row shows the probability of inflows into Roosevelt Dam being sufficient to create inundation in planned deviation space. The “Wet Year” (above median runoff) row is the subset of all years in the analysis that only includes the 5-year periods that have a 5-year reservoir inflow volume greater than the median 5-year reservoir inflow volume observed from the 100 5-year samples. The “Dry Year” (below median runoff) row is the subset of all years in the analysis that only includes the 5-year periods that have a total reservoir inflow volume for the 5-year period less than the median 5-year reservoir inflow volume observed from the 100 5-year samples.[6] The columns of Figure 5 show the probability of reservoir inflows sufficient to inundate the planned deviation space in 0 years out of the 5-year period, at least 1 year, at least 2 years, at least 3 years, at least 4 years, and all 5 years of a planned deviation.

Based on the analysis, the probability of 0 years of runoff inundating the FCS is low even during dry periods. In evaluating All Years, Wet Years, and Dry Years, the most probable use of the extended duration period (20 to 120 days) occurs between at least 1 year and at least 3 years of inundation in the 5-year period. Limiting the planned deviation to use in only 1or 2 out of 5 years would decrease the ability to meet the objective of the planned deviation of increasing beneficial use of spill water by 53% and 20%, respectively, when compared to the use in 3 out of 5 years. In all year types, the probability of occurrence of at least 4 years and 5 out of 5 years is very low and would create only limited potential for furthering the goal of increasing beneficial use of spill water. A planned deviation with ability to use the extended evacuation period in up to 3 out of 5 years was identified to maximize the likelihood of meeting the objective of the planned deviation of increasing the ability to put to beneficial use spill waters on the Salt River. Since it is not possible to predict exactly when precipitation patterns will allow for use of the planned deviation during a temporary period of 5 years, a planned deviation that aims to maximize the probability of use provides the greatest opportunity for meeting the objective of increasing beneficial use of spill water.

Probability of Inundation (At Least X Out of 5 Years)						
Number of Years Inundating FCS 5 feet	0 Years	At Least 1 Year	At Least 2 Years	At Least 3 Years	At Least 4 Years	At Least 5 Years
All Years	18%	82%	57%	38%	13%	2%
Wet Years (Above Median Run-Off)	0%	100%	96%	72%	24%	4%
Dry Years (Below Median Run-Off)	36%	64%	20%	4%	2%	0%

Figure 5: Probability of Use of Planned Deviation in Number of Years of the 5-Year Period

[5] This analysis should not be viewed as a predictive exercise, but rather informative of the likelihood of using the planned deviation in multiple years within a 5-year period, given different water year categorization.

[6] This separation into wet and dry periods was completed to account for the long-term oscillation between wet and dry periods that naturally occurs on the Salt River system. Understanding the difference between wet and dry periods is important since 2021 represents around the 25th year of a dry period. With this, it is possible that the Salt River system could be entering a wet period in the next couple of years.

6 EXPECTED WATER PRODUCTION OF PROPOSED PLANNED DEVIATION

Based on the contingent probability analysis presented in the previous section, the proposed planned deviation allowing for 1) an extension of the evacuation period from 20 days to 120 days; 2) for water contained within the first 5 feet of the FCS; and 3) in up to 3 out of 5 years is expected to produce between 95,000 and 290,000 acre-feet. Figure 6 shows the expected volume of water available for the extended evacuation period under the planned deviation based on probability of occurrence by water year type.[7]

The objective of the proposed planned deviation is to increase the ability to put to beneficial use spill waters controlled by Roosevelt Dam without compromising dam and flood management safety for downstream resources and communities. The estimates provided in Figure 6 indicate that the proposed planned deviation is expected to increase the ability to increase beneficial use of spill waters routed through Roosevelt Dam at a time where impacts from shortages on the Colorado River will begin reducing deliveries of surface water to central Arizona. Further evaluation through Reclamation's Dam Safety Advisory Team process identified a risk neutral finding for the proposed planned deviation to Modified Roosevelt Dam and downstream communities—a critical finding in support of meeting the objective of the planned deviation of not reducing ability to safely manage flood events.

Expected Water Production in 5-Year Period (Acre-Feet)			
Water Year Type	1 out of 5 Years	2 out of 5 Years	3 out of 5 Years
All Years	89,380	151,510	190,000
Wet Years (Above Median)	108,620	213,640	290,000
Dry Years (Below Median)	70,000	91,560	95,000

Figure 6: Expected Water Volume Produced by Proposed Planned Deviation

7 WEIGHING COSTS AND LEVEL OF EFFORT WITH POTENTIAL BENEFITS OF PLANNED DEVIATION

Due to the temporary nature of the planned deviation and the dependence on large precipitation events that are uncertain to occur during the 5-year period, the request for the 3 out of 5 years identifies the deviation proposal that creates the greatest opportunity for meeting the objective of increasing beneficial use of spill water while maintaining the ability to safely manage flood events at Modified Roosevelt Dam.

[7] It should be noted that this is the expected value based on the contingent probability analysis. If the planned deviation space fills fully on each use of the planned deviation, the total water available would be approximately 327,000 acre-feet. If the planned deviation is not used due to lack of precipitation, the water available from the planned deviation would be 0 acre-feet. It is not possible to predict the exact volume, so these estimates are provided to inform expectations.

Significant effort is, and will continue to be, expended to formulate the proposal, perform necessary technical and safety due diligence, plan, and perform environmental compliance activities to determine necessary mitigation or implementation measures to allow for use of the planned deviation—all of which have financial costs for funding consultants, federal staff and reviews, and significant SRP staff time dedicated to project formulation and management. The costs of review and level of effort for planning are substantially similar for 1-, 2-, and 3-year options within the 5-year planned deviation period. Though total cost of review and implementation are not yet known, it is expected that the planning efforts to receive necessary approvals will take nearly 3 years in total for the temporary planned deviation program. The request for use of the planned deviation looks to balance the costs and level of effort necessary to receive approval for the planned deviation with the potential benefits that may be created 1) if approved and 2) if hydrologic conditions allow for a planned deviation event during the 5-year period.
The proposed planned deviation with allowable use in 3 out of 5 years aims to maximize the objective of the planned deviation to offset all of the financial and in-kind costs of planning, federal agency review, and implementation of the planned deviation.

8 SUMMARY OF ALTERNATIVE VARIATIONS CONSIDERED AND ELIMINATED FROM FURTHER CONSIDERATION

Based on the planned deviation's objective, multiple alternative variations were considered by SRP when formulating the preferred alternative. The proposed planned deviation works to identify the optimum operational deviation based on 1) elevation of FCS, 2) inundation duration of FCS, and 3) probability of occurrence and timing during the deviation period. The overall proposal looks to balance the cost and level of effort for review and implementation with the potential benefits that could be created by the planned deviation if approved and water is made available by large runoff events. Balancing the costs of seeking approval with the potential benefits created by the planned deviation is especially important since the planned deviation is temporary and the accrual of benefits is dependent on highly variable and uncertain precipitation patterns.

The FCS elevations between 2,150.78 and 2,174.87 feet were considered for the planned deviation. However, elevation changes that would require a new detailed structural safety analysis that would require additional resources and time or would expand the water volume beyond what existing spill water users expect could be put to beneficial use within the proposed evacuation period were eliminated from further consideration.

Of the 106-year period analyzed, 47 years had modeled reservoir inflows that resulted in reservoir elevations entering the FCS (elevations greater than 2,150.78 feet). Various inundation durations were considered but eliminated from detailed study. For an evacuation period less than 120 days it is expected that in most years where reservoir inflows are sufficient to enter the FCS, water would have to be physically spilled to meet the evacuation period requirement. For evacuation periods greater than 120 days, the probability of inflows being sufficient to require physical spill after 120 days decreases to close to 10% of years. With the objective of the planned deviation being to extend the evacuation period within the runoff season to increase beneficial use of flood waters, rather than storing water for carryover into the following calendar year, evacuation periods shorter or longer than 120 days were considered but eliminated from further consideration.

A 5-year period was selected to balance the temporary nature of a planned deviation with uncertainties of precipitation and runoff volumes and the significant effort and costs associated to conduct risk assessments, environmental compliance, and other activities necessary to evaluate the planned deviation. Contingent probability analysis was conducted to identify a desired number of years to request allowance for use of the extended evacuation period in the planned deviation. Based on modeling, the most probable use of the extended duration period (20 to 120 days) occurs between at least 1 year and at least 3 years of inundation in the 5-year period. In all year types, the probability of occurrence of at least 4 years and 5 out of 5 years is very low. A planned deviation with ability to use in up to 3 out of 5 years was identified to maximize the likelihood of reducing spill from the system and instead putting water supplies to direct use. Limiting the planned deviation to use in only 1 or 2 out of 5 years would decrease the expected water volume made available for use under the extended evacuation period by 182,000 and 77,000 acre-feet, respectively, when compared to the use in 3 out of 5 years.[8] The significant effort and costs associated with review and implementation of the planned deviation is expected to take nearly 3 years, therefore a planned deviation that allows use in 3 out of 4 years is requested to balance potential benefits with costs of the planned deviation.

[8] This comparison is for wet periods shown in Figure 6. If considering all water year types, the difference would be a decrease of 101,000 and 39,000 acre-feet, respectively, for 1 and 2 out of 5 years. If in a dry period the difference would be 25,000 and 3,000 acre-feet, respectively, for 1 and 2 out of 5 years.

APPENDIX N

Proposed Amendments to Incidental Take Permit Terms and Conditions

APPLICANT'S PROPOSED AMENDMENTS TO EXISTING INCIDENTAL TAKE PERMIT TERMS AND CONDITIONS:

STRICKEN TEXT REFLECTS PROPOSED DELETIONS. UNDERLINED TEXT REFLECTS PROPOSED ADDITIONS.

E. EXTENT OF INCIDENTAL TAKE PERMITTED; ADHERENCE TO IMPACT ANALYSIS MODEL TO DETERMINE COMPLIANCE

E.1. The Permittee is authorized to "Take" ~~(kill, harm, harass)~~ the northern Mexican gartersnake (*Thamnophis eques megalops*), southwestern willow flycatcher (*Empidonax traillii extimus*), bald eagle (*Haliaeetus leucocephalus*), Yuma Ridgway's (clapper) rail (*Rallus obsoletus* [*longirostris*] *yumanensis*), and yellow-billed cuckoo (*Coccyzus americanus*~~, if subsequently listed~~) to the extent described and specified in E.2.- E.~~5~~6. herein and in the Roosevelt Habitat Conservation Plan (RHCP), incidental to the Permittee's operation of Roosevelt Dam, as described in the Permittee's application and supporting documents, and as conditioned herein.

E.2. Take of Southwestern Willow Flycatchers. During the remaining life of this Permit, as long as the RHCP is being properly implemented, the Permittee may, in carrying out the Permitted Activity, incidentally take within the conservation space and flood control space at Roosevelt Dam and Lake, as defined in Subparagraphs S.7.(1) and S.7.(2) of this Permit: ~~Area~~ (a) in the form of harm, southwestern willow flycatcher nestlings and eggs as a result of nest tree fall or nestlings falling and drowning due to high reservoir levels; and (b) in the form of harm, southwestern willow flycatchers occupying habitat modified or degraded due to inundation, desiccation, and associated effects in an amount not to exceed 750 acres annually (or up to 1,250 acres annually with adaptive management). The Parties shall adhere to the impact analysis method set forth in Subchapter III.C of the RHCP, or other method mutually agreed to by the Parties, to determine the annual amount of occupied habitat of the southwestern willow flycatcher within the conservation space and flood control space at Roosevelt Dam and Lake ~~Permit Area~~ that is modified or degraded by the Permitted Activity.

E.3. Take of Yuma ~~Clapper~~ Ridgway's Rails. During the remaining life of this Permit, as long as the RHCP is being properly implemented, the Permittee may, in carrying out the Permitted Activity, incidentally take within the conservation space at Roosevelt Dam and Lake, as defined in Subparagraph S.7.(1) of this Permit ~~Area~~, in the form of harm, Yuma ~~clapper~~ Ridgway's rails occupying habitat adversely affected by inundation in an amount not to exceed 5 acres annually (or up to 10 acres annually with adaptive management). The Parties shall adhere to the impact analysis method set forth in Subchapter III.D of the RHCP, or other method mutually agreed to by the Parties, to determine the annual amount of occupied habitat of the Yuma ~~clapper~~ Ridgway's rail within the conservation space at Roosevelt Dam and Lake ~~Permit Area~~ that is inundated by the Permitted Activity.

E.4. Take of Bald Eagles. During the remaining life of this Permit, as long as the RHCP is being properly implemented, the Permittee may, in carrying out the Permitted Activity, incidentally take within the conservation space and flood control space at Roosevelt Dam and Lake, as defined in Subparagraphs S.7.(1) and S.7.(2) of this Permit: ~~in the form of harm, using nest or perch trees at Roosevelt.~~

(a) in the form of kill, no more than three fledgling bald eagles resulting from drowning. Incidental take authorized by this Subparagraph E.4.(a) will be measured by the detection of a drowned fledgling bald eagle between March 15 and June 15 that is reasonably believed to have fledged from a nest within the conservation space or flood control space at Roosevelt Dam and Lake.

(b) in the forms of kill or harm, bald eagle adults, nestlings, and eggs, that are directly or indirectly attributable to the destruction of no more than 40 bald eagle nests or supporting nest trees/snags when the bald eagle nest is also destroyed within the conservation space or flood control space at Roosevelt Dam and Lake, regardless of the mode of nest destruction or the specific breeding areas and nests that may be affected. Also to be counted against this take limit are: (1) instances where bald eagle nests with viable eggs or nestlings are abandoned by the adult breeding pair, the nest fails due to abandonment, and the proximate and reasonably certain cause of the abandonment is high water under the nest, even if the nest itself is not ultimately destroyed; and (2) instances where nest destruction resulting from SRP activities is imminent and any bald eagle eggs or nestlings are proactively salvage collected by other parties.

(c) in the forms of kill or harm, breeding bald eagles, nestlings, and eggs directly or indirectly harmed, killed, or injured by reduced foraging opportunities within the conservation space or flood control space at Roosevelt Dam and Lake. Incidental take authorized by this Subparagraph E.4.(c) shall be limited to no more than four reduced foraging events, defined as any year in which both of the following conditions are met: (1) conservation storage at Roosevelt Dam and Lake is below elevation 2,100 feet above mean sea level for either (a) at least 60 consecutive days between January 1 and March 31, or (b) at least 90 total days between January 1 and June 30; and (2) the combined productivity rate of all monitored bald eagle breeding areas relying on food resources at Roosevelt Dam and Lake is less than 1.0.

~~Additionally, during the life of this Permit, and as long as the RHCP is being properly implemented, the Permittee may, in carrying out the Permitted Activity, incidentally take no more than 18 fledgling bald eagles resulting from reduced productivity of bald eagles in the Permit Area during periods of declining water levels.~~

The Parties shall adhere to the impact analysis method set forth in Subchapters ~~III.E~~4.C of the Roosevelt Habitat Conservation Plan addendum ~~RHCP~~ (2023), or other method mutually agreed to by the Parties, to ensure that the amount of incidental take of bald eagles permitted by ~~this~~ these Subparagraphs E.4.(a) through E.4.(c) is not exceeded. ~~During the life of this Permit, as long as the RHCP is being properly implemented, the Permittee may, in carrying out the Permitted Activity, incidentally take, in the form of harm, bald eagles using nest or perch trees within the Permit Area at Roosevelt.~~ Pursuant to the Bald and Golden Eagle Protection Act implementing regulations, an incidental take authorization under Section 10(a)(1)(B) of the ESA constitutes a valid permit issued under the Bald and Golden Eagle Protection Act (50 C.F.R. 22.10(a)). The incidental take authorizations set forth in Subparagraphs E.4.(a) through E.4.(c) constitute a valid permit for take under the Bald and Golden Eagle Protection Act, as described in the implementing regulations.

E.5. Take of Yellow-Billed Cuckoos. During the remaining life of this Permit, as long as the RHCP is being properly implemented, the Permittee may, in carrying out the Permitted Activity, incidentally take within the conservation space and flood control space at Roosevelt Dam and Lake, as defined in Subparagraphs S.7.(1) and S.7.(2) of this Permit: ~~Permit Area~~ (a) in the form of harm, yellow-billed cuckoo nestlings and eggs as a result of nest tree fall or nestlings falling and drowning due to high-reservoir levels; and (b) in the form of harm, yellow-billed cuckoos occupying habitat modified or degraded due to inundation or desiccation and associated effects in an amount not to exceed 313 acres annually (or up to 1,113 acres annually with adaptive management). The Parties shall adhere to the impact analysis method set forth in Subchapter III.F of the RHCP, or other method mutually agreed to by the Parties, to determine the annual amount of occupied habitat of the yellow-billed cuckoo within the conservation space and flood control space at Roosevelt Dam and Lake ~~Permit Area~~ that is modified or degraded by the Permitted Activity. ~~This Permit shall become effective for the yellow-billed cuckoo as specified in Part E.1. above.~~

E.6. Take of Northern Mexican Gartersnakes. During the remaining life of this Permit, as long as the RHCP is being properly implemented, the Permittee may, in carrying out the Permitted Activity, incidentally take:

(a) in the form of kill, wound, or harm, northern Mexican gartersnakes occupying the conservation space and flood control space at Roosevelt Dam and Lake, as defined in Subparagraphs S.7.(1) and S.7.(2) of this Permit, which is directly or indirectly attributable to:

(1) the unavailability, alteration, movement, or loss of occupied northern Mexican gartersnake habitat, due to recurring inundation or desiccation of all or any portion of the conservation space or flood control space at Roosevelt Dam and Lake; or

(2) the alteration of all or any portion of occupied northern Mexican gartersnake habitat within the conservation space or flood control space at Roosevelt Dam and Lake, which is attributable to predation and competition from nonnative predatory fish produced in the conservation space at Roosevelt Dam and Lake.

Incidental take authorized by this Subparagraph E.6.(a) is measured by the cumulative number of acres of northern Mexican gartersnake habitat made unavailable in a given year as described in Subchapter 4.A.ii of the Roosevelt Habitat Conservation Plan addendum (2023), totaled over the remaining life of this Permit ("Acre-Years" of reduced habitat availability). The amount of authorized take in the conservation space and flood control space at Roosevelt Dam and Lake shall not exceed 2,742.9 acre-years of reduced habitat availability. The Parties shall adhere to the impact analysis method set forth in Subchapter 4.A.ii of the Roosevelt Habitat Conservation Plan addendum (2023), or other method mutually agreed to by the Parties, to ensure that take is not exceeded.

(b) in the form of harm, northern Mexican gartersnakes occupying the Lower Tonto Creek segment of the Permit Area, as defined in Subparagraph S.7.(3) of this Permit, which is attributable to predation and competition from nonnative predatory fish produced in the conservation space at Roosevelt Dam and Lake. Incidental take is quantified in terms of the number of days in which hydraulic conditions are suitable to support migration of nonnative predatory fish from the conservation space at Roosevelt Dam into Lower Tonto Creek ("Migration Days"). The amount of authorized incidental take pursuant to this Subparagraph E.6.(b) shall not exceed 906 Migration Days. The Parties shall adhere to the impact analysis method set forth in Subchapter 4.A.iii of the addendum to the Roosevelt Habitat Conservation Plan (2023), or other method mutually agreed to by the Parties, to ensure that take is not exceeded.

F. INCORPORATION OF RHCP AND AGREEMENT; GOVERNING LAW

F.1. The RHCP, the Implementing Agreement (IA) for the RHCP (2002), and each of their provisions are intended to be, and by this reference are, incorporated herein. In the event of any direct contradiction among the terms of the IA, the RHCP, and this Permit, the terms of this Permit shall control. In all other cases, the terms of the IA, the RHCP, and this Permit shall be interpreted to be supplementary to each other.

F.2. This Permit, the RHCP, and the IA, and the Parties' compliance therewith, shall be governed by the ESA and implementing regulations as the same exist on the Effective Date. Any reference in this Permit, the RHCP, or the IA to any provision of the ESA or to any regulation or rule of the U.S. Fish and Wildlife Service (FWS) shall be deemed to be a reference to such statute, regulation, or rule in existence as of the Effective Date. If Federal statutes are enacted or rules or regulations are issued by FWS after the Effective Date that conflict with any provision of this Permit, the RHCP, or the IA, the provisions of this Permit, the RHCP, and the IA shall control and continue to govern the rights and obligations of the Salt River Project (SRP) and the U.S. Fish and Wildlife Service (FWS).

F.3. Acceptance of this Permit serves as evidence that the Permittee understands and agrees to abide by the terms of this Permit and all sections of title 50 Code of Federal Regulations (C.F.R.), Part 13 and 17, pertinent to issued permits. Section 11 of the Endangered Species Act of 1973, as amended, provides for civil and criminal penalties for failure to comply with permit conditions.

G. PROPER IMPLEMENTATION OF RHCP

G.1. The RHCP will be deemed properly implemented if the commitments and provisions of the RHCP, IA, and this Permit have been or are being implemented in accordance with their terms. The Permittee shall timely and completely comply with and perform their obligations under the RHCP and the IA.

G.2. Transfer of a mitigation property(s) to a third-party management entity acceptable to the FWS, shall in no way impair the Permittee's responsibility to fully implement management and monitoring of the transferred or any other such property(s) as described in the RHCP. The management obligations will be incorporated into conservation easements placed on the mitigation property(s) in question.

G.3. The Permittee shall submit an annual report detailing implementation of the RHCP, as described at Chapter IV, part E.6. of the RHCP. Annual reports will be submitted by February 1 of each year (detailing accomplishments in the previous calendar year) to the U.S. Fish and Wildlife Service, Arizona Ecological Services Office, 9828 North 31st Avenue, Suite C3, Phoenix, AZ 85051, and to the U.S. Fish and Wildlife Service, Branch of Environmental Review, P.O. Box 1306, Room 6034, Albuquerque, New Mexico 87103.~~U.S. Fish and Wildlife Service, 2321 West Royal Palm Road, Suite 103, Phoenix, AZ 85021, and to the U.S. Fish and Wildlife Service, 500 Gold Avenue SW, Room 4012, Albuquerque, New Mexico 87102.~~

H. ACCESS TO MITIGATION PROPERTIES AND SITES

Upon reasonable notification to the Permittee (50 C.F.R. 13.47), the FWS will be allowed access to mitigation properties and sites to inspect the condition of the properties and to ensure that the RHCP is being implemented according to its terms for the benefit of the listed species. In the event the FWS finds that the RHCP is not being implemented according to its terms, the FWS has the option of terminating and revoking this Permit in accordance with applicable regulations.

I. TERM

This Permit shall have a duration beginning on the Effective Date, and continuing in full force and effect until its expiration on February 27, 2053, ~~for a period of 50 years~~

thereafter, or until revocation or surrender and cancellation of this Permit as provided for in Subparagraphs M.2. and M.3. hereof, whichever occurs earlier.

J. PERMIT IN EFFECT UNDER ESA SECTION 10 FOR LISTED SPECIES UPON EFFECTIVE DATE; PERMIT AND TO BECOME EFFECTIVE FOR UNLISTED SPECIES UPON LISTING; PERMIT UNDER ESA SECTION 10 FOR BALD EAGLES IN EFFECT UPON EFFECTIVE DATE

J.1 Pursuant to Section 10(a)(1)(B) of the ESA, this Permit will take effect:

a) This Permit will take effect fFor Plan Species that are federally listed as threatened or endangered, on the Effective Date at the time this Permit is issued; and

b) For Plan Species that are Unlisted Species at the time of this Permit is issued, upon the listing of such species as threatened or endangered by FWS, -subject to the Permittee's compliance with all other terms of this Permit, the RHCP, and the IA, this Permit will take effect for Unlisted Species upon the listing of such species as threatened or endangered by FWS.

J.2 The authorization to incidentally take bald eagles under Section 10(a)(1)(B) of the ESA, constituting a valid permit issued under the implementing regulations for the Bald and Golden Eagle Protection Act (50 C.F.R. 22.10(a)), as provided in Subparagraph E.4, will take effect on the Effective Date and will continue in effect through the date of expiration of this Permit on February 27, 2053.

K. DISPOSITION OF DEAD, INJURED, OR SICK INDIVIDUALS OF LISTED SPECIES

Upon locating an individual of a dead, injured, or sick species listed in parts E.1.2. E.5., above, within the Permit Area and Compensation Lands, the Permittee is required to contact the FWS Law Enforcement Office, U.S. Fish and Wildlife Service, Office of Law Enforcement, Chandler, AZ Investigations Office, P.O. Box 6342, Chandler, Arizona 85246, Office: (480) 967-7900, Cell: (480) 268-1153 (or Southwest Region of the U.S. Fish and Wildlife Service, 500 Gold Avenue SW, Albuquerque, New Mexico 87103, Office: (505) 248-6911), for care and disposition instructions. Extreme care should be taken in handling sick or injured individuals to ensure effective and proper treatment. Care should also be taken in handling dead specimens to preserve biological materials in the best possible state for analysis of cause of death. In conjunction with the care of sick or injured endangered/threatened species, or preservation of biological materials from a dead specimen, the Permittee and its contractor/subcontractor have the responsibility to ensure that evidence intrinsic to the specimen is not unnecessarily disturbed.

L. SATISFACTION OF PERMITTING REQUIREMENTS UNDER MIGRATORY BIRD TREATY ACT AND BALD AND GOLDEN EAGLE PROTECTION ACT

L.1. Special Purpose Permit for Listed Species Other Than Bald Eagles

This Permit shall constitute a Special Purpose Permit under 50 C.F.R. § 21.27 for take of the southwestern willow flycatcher, the Yuma Ridgway's ~~clapper~~ rail, and~~,~~ ~~in the event it is listed by FWS as threatened or endangered,~~ the yellow--billed cuckoo, in the amount and subject to the terms and conditions specified in this Permit, the IA, and the RHCP. Any such take will not be in violation of the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. §§ 703--712).

L.2. Non-enforcement of Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act Provisions Pertaining To Eagles

FWS will not refer the incidental take of any bald eagle for prosecution under the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. §§ 703-712), or the Bald and Golden Eagle Protection Act of 1940, as amended (16 U.S.C. §§ 668-668d), as long as such take is in compliance with the terms and conditions of this Permit, the IA, and the RHCP.

M. PERMIT SUSPENSION, REVOCATION AND SURRENDER

M.1. Permit Suspension

(a) FWS may suspend this Permit if the Permittee is not in compliance with the conditions of this Permit, or with any applicable Federal laws or regulations governing the conduct of the Permitted Activity, as such laws and regulations exist on the Effective Date. The suspension shall remain in effect until FWS determines that the Permittee has corrected the deficiencies. Notwithstanding the foregoing, FWS shall not suspend this Permit without first: (1) notifying the Permittee in writing that this Permit may be subject to suspension pursuant to this Subparagraph M.1.(a), including a statement of the deficiencies that must be corrected by the Permittee; and (2) providing the Permittee with a period of 30 days after the date that the notice of the deficiencies is given in which to correct the deficiencies.

(b) A partial suspension of this Permit may apply only to specified Plan Species, or to only a portion of the Permit Area or Permitted Activity. In the event of a partial suspension, the portion of this Permit not subject to the suspension shall remain in full force and effect.

M.2. Permit Revocation

(a) FWS shall not revoke this Permit for any reason except those listed in 50 C.F.R. 13.28 (a) (1)-(4) (as amended June 17, 1999), or unless the Permitted Activity would be inconsistent with the criteria set forth in 16 U.S.C. § 1539(a)(2)(B)(iv) and this inconsistency has not been remedied in a timely fashion. Notwithstanding the foregoing, this Permit will only be revoked if FWS and its cooperators have not been successful in remedying any such inconsistency through other means.

(b) A partial revocation of this Permit may apply only to specified Plan Species, or to only a portion of the Permit Area or Permitted Activity. In the event of a partial revocation, the portion of this Permit not subject to the revocation shall remain in full force and effect.

(c) All minimization and mitigation measures in the RHCP and the IA that are continued in effect after revocation of the Permit shall be taken into account by FWS and credited toward any future efforts by the Permittee or other responsible entities to ensure that the operation of Roosevelt Dam satisfies the requirements of the ESA. This provision shall survive the revocation of this Permit and remain in full force and effect thereafter.

M.3. Surrender and Cancellation of Permit

In the event that the Permittee, or any successor in interest to the Permittee, permanently discontinues the Permitted Activity, the Permittee or successor in interest shall return this Permit to FWS within 30 calendar days of the discontinuance with a written statement surrendering this Permit for cancellation. This Permit will be deemed cancelled only upon a determination by FWS, in collaboration with the Permittee, that sufficient measures have been implemented by the Permittee to mitigate for take of Plan Species that occurred pursuant to the terms of this Permit, before its surrender. Upon surrender of this Permit, no further take of the Plan Species by the Permittee shall be authorized.

N. LIMITATION ON IMPOSITION OF ADDITIONAL CONSERVATION MEASURES

N.1. Changed Circumstances, Notice of Same & Implementation of Response

(a) Changed Circumstances Pertaining to the Southwestern Willow Flycatcher, the Yellow-Billed Cuckoo and the Yuma Ridgway's Rail

The following are Changed Circumstances that specifically pertain to the southwestern willow flycatcher, the yellow-billed cuckoo, and the Yuma Ridgway's rail, and corresponding conservation and mitigation measures, if any, that the Permittee shall implement in response to such Changed Circumstances, should they occur during the remaining life of this Permit:

As long as the terms of the RHCP are being properly implemented, FWS shall not require the implementation of any conservation and mitigation measures by the Permittee in response to Changed Circumstances, other than those measures specified in this Subparagraph N.1.(a).

Changed Circumstances	Conservation, Mitigation, or Management Measures
Pilot project at Rockhouse is unsuccessful	Acquire and permanently manage other riparian habitat (see RHCP Subchapter IV C.2)
Habitat protection and management measures at Roosevelt are ineffective	Acquire and permanently manage other riparian habitat and implement other conservation efforts (see RHCP Subchapter IV.C.3)
Habitat acquisition and management in target area is infeasible	Acquire and permanently manage other riparian habitat and implement other conservation efforts (see RHCP Subchapters IV.C.4 and IV.C.6)
Decline of population at mitigation sites	Implement additional monitoring and management (see RHCP Subchapter IV.E and Appendix 6)
Invasion of exotic species at mitigation sites	Implement eradication or control efforts (see RHCP Appendix 6)

Changed Circumstances	Conservation, Mitigation, or Management Measures
Increase in occupied habitat at Roosevelt above 750 acres for southwestern willow flycatchers, 5-acres for Yuma ~~clapper~~ Ridgway's rails, or 313 acres for yellow-billed cuckoos	Acquire and permanently manage other riparian habitat and implement other conservation efforts (see RHCP Subchapters IV.C.1.a, IV.C.1.b and IV.C.1.d)
Reversion of title to Arizona or United States with loss of ability to achieve RHCP goal	Acquire and permanently manage replacement habitat (see RHCP Subchapter IV.F.I.a)
Habitat loss from scouring floods at Roosevelt or mitigation sites	No additional measures by SRP
Habitat loss from fire at Roosevelt or mitigation sites	No additional measures by SRP
Critical habitat designation for species covered by the RHCP	No additional measures by SRP
Downlisting or delisting the RHCP species due to recovery	No change in measures implemented by SRP
Riparian restoration effort with the Fort McDowell Indian Community is unsuccessful	No additional measures by SRP

(b) Changed Circumstances Pertaining to the Northern Mexican Gartersnake

The following are Changed Circumstances that specifically pertain to the northern Mexican gartersnake, and the corresponding responsive actions that the Permittee shall implement in response to such Changed Circumstances, should they occur during the remaining life of this Permit:

Changed Circumstances Specifically Pertaining to the Northern Mexican Gartersnake	**Responsive Actions**
Northern Mexican gartersnake detections in the Salt Arm of the Permit Area (as described in Subchapter 7.A of the addendum to the Roosevelt Habitat Conservation Plan [2023]).	SRP will seek an amendment to the RHCP and ITP to add coverage for the northern Mexican gartersnake in the Salt Arm and apply a portion of its current incidental take authorization to any ongoing take in the Salt Arm while the amendment is in progress (see Subchapter 7.A of the addendum to the Roosevelt Habitat Conservation Plan [2023]).
Actual take approaches the authorized take limit (as described in Subchapter 7.B of the addendum to the Roosevelt Habitat Conservation Plan [2023]).	SRP will notify the FWS when the amount of remaining gartersnake incidental take reaches either 457.2 acre-years or 151 migration days and will begin the process for amending the RHCP and ITP or seeking a new permit (see Subchapter 7.B. of the addendum to the Roosevelt Habitat Conservation Plan [2023]).
Mitigation lags take in the CS* and FCS** (as described in Subchapter 7.C of the addendum to the Roosevelt Habitat Conservation Plan [2023]).	SRP will coordinate with FWS and seek to make up the shortfall and, if unsuccessful, will increase its conservation obligation by 5% for each subsequent 5-year shortfall (see Subchapter 7.C of the addendum to the Roosevelt Habitat Conservation Plan [2023]).
Gartersnake extirpation from a mitigation reach (as described in Subchapter 7.D of the addendum to the Roosevelt Habitat Conservation Plan [2023]).	SRP and FWS will identify an alternative location to implement gartersnake conservation measures that is occupied by the gartersnake (as described in Subchapter 7.D of the addendum to the Roosevelt Habitat Conservation Plan [2023]).

*CS refers to Roosevelt Conservation Space

**FCS refers to Roosevelt Floodplain Space

As long as the terms of the RHCP are being properly implemented, FWS shall not require the implementation of any conservation and mitigation measures for the northern Mexican gartersnake by the Permittee in response to Changed Circumstances, other than those responsive actions specified in this Subparagraph N.1.(b).

(c) Changed Circumstances Pertaining to the Bald Eagle

The following are Changed Circumstances that specifically pertain to the bald eagle, and corresponding responsive actions that the Permittee shall implement in response to such Changed Circumstances, should they occur during the remaining life of this Permit:

Changed Circumstances Specifically Pertaining to the Bald Eagle	**Responsive Actions**
Actual Take Approaches the Authorized Take Limit (as described in Subchapter 7.B of the addendum to the Roosevelt Habitat Conservation Plan	SRP will notify the FWS when the amount of remaining bald eagle incidental take reaches two drowned fledglings, 30-destroyed nests, or three reduced foraging events and will begin the process for amending the RHCP and ITP or seeking a new permit (see Subchapter 7.B of the addendum to the Roosevelt Habitat Conservation Plan [2023]).

As long as the terms of the RHCP are being properly implemented, FWS shall not require the implementation of any conservation and mitigation measures for the bald eagle by the Permittee in response to Changed Circumstances, other than those responsive actions specified in this Subparagraph N.1.(c).

(d) Notice of Changed Circumstances & Implementation of Response

i) Permittee-initiated response to Changed Circumstances. The Permittee shall give written notice to FWS within 30 days after learning that any of the Changed Circumstances listed in the RHCP and Subparagraph N.1.(a), N.1.(b), or N.1.(c) hereof has occurred. As soon as practicable thereafter, but no later than 90 days after learning of the Changed Circumstances, the Permittee shall modify its activities in the manner and to the extent required by the RHCP and Subparagraph N.1.(a), N.1.(b), or N.1.(c) hereof and report to the FWS on its actions. The Permittee shall make any such required modifications without awaiting notice from FWS.

ii) FWS-initiated response to Changed Circumstances. If FWS determines that Changed Circumstances have occurred and that the Permittee has not responded in accordance with the RHCP and Subparagraph N.1.(a), N.1.(b), or N.1.(c) hereof, FWS shall so notify the Permittee and direct the Permittee to make the required changes in writing. Within 90 days after receiving such notice, the Permittee shall make the required changes and report to FWS on its actions.

(e) Effect of Changed Circumstances on Permit and RHCP

i) In General. Changed Circumstances are provided for in the RHCP and, hence, do not constitute Unforeseen Circumstances or require amendment of this Permit, the RHCP or the IA. Changed Circumstances do not constitute "new information" under 50 C.F.R. § 402.16(b), and, hence, the occurrence of Changed Circumstances does not require the reinitiation of formal consultation by FWS under Section 7 of the ESA on its action of issuing this Permit.

ii) Critical Habitat. FWS shall consider the RHCP in its preparation of any proposed designation of critical habitat concerning any Plan Species. Consistent with 50 C.F.R. § 424.12, the RHCP incorporates special management considerations necessary to conservation of the Plan Species. If critical habitat is designated for any Plan Species, as long as the RHCP is being properly implemented, FWS shall not require, through the formal consultation process of Section 7 of the ESA or otherwise, the commitment by the Permittee of additional land, water, financial compensation, or other measures beyond those already provided for in the RHCP.

N.2 Unforeseen Circumstances

(a) No Surprises Assurances

The "Covered Species" listed in parts E.12. E.5. above, are considered adequately addressed under the RHCP and are, therefore, covered by no surprises rule assurances. In the event that it is demonstrated by FWS that Unforeseen Circumstances exist during the life of this Permit, and additional conservation and mitigation measures are deemed necessary to respond to Unforeseen Circumstances, FWS may require additional measures of the Permittee where the RHCP is being properly implemented, but only if such measures are limited to modifications within the Compensation Lands conserved pursuant to the terms of the RHCP, or to the RHCP's operating conservation program for the Plan Species, and maintain the original terms of the RHCP to the maximum extent possible. Notwithstanding the foregoing, FWS shall not:

i) Require the commitment of additional land, water or financial compensation by the Permittee without the consent of the Permittee; or

ii) Impose additional restrictions on the use of land, water or natural resources otherwise available for use by the Permittee under the original terms of the RHCP, including additional restrictions on the Permitted Activity and restrictions on the operation of other dams by the Permittee to mitigate the effects of the Permitted Activity.

(b) Effect of Unforeseen Circumstances on Permit

Except as provided in Subparagraph M.2. hereof, notwithstanding the occurrence of Unforeseen Circumstances, as long as the Permittee continues to properly implement the provisions of the RHCP and any additional measures required by FWS in accordance with Subparagraph N.2.(a) hereof, this Permit will remain in full force and effect.

(c) Notice of Unforeseen Circumstances

FWS shall notify the Permittee in writing of any Unforeseen Circumstances of which FWS becomes aware that may affect the obligations of the Permittee under this Permit, the RHCP or the IA.

O. AMENDMENT OF THE PERMIT

O.1. This Permit may be amended in accordance with the provisions of 50 C.F.R. § 13.23. The proponent of the amendment shall provide a written statement of the reasons for the proposed amendment and an analysis of its environmental effects, including its effects on operations under the RHCP and on Plan Species.

O.2. Conditions of this Permit shall be binding on and for the benefit of the Permittee and its respective successors and assigns. If this Permit requires an amendment because of change of ownership, the FWS will process that amendment without the requirement of the Permittee preparing any new documents or providing any mitigation over and above that required in the original permit. The activities proposed or in progress under an original permit may not be interrupted provided the required conditions of an issued permit are being followed.

O.3. If during the tenure of this Permit, the Permitted Activity and/or the extent of the habitat impact described in the RHCP is altered, such that there may be an increase in the anticipated take of the ~~covered~~ Plan S~~s~~pecies, the Permittee is required to contact the FWS and obtain authorization and/or amendment of this Permit before commencing any construction or other activities that might result in take beyond those described in the IA and RHCP.

O.4. Any amendment to this Permit shall take effect on the date that FWS approves the amendment and shall continue in effect for the remaining life of this Permit. Except as otherwise specifically provided in any such amendment, the original terms and conditions of this incidental take permit, issued to SRP by FWS as of February 27, 2003, shall remain in full force and effect.

P. RENEWAL OF PERMIT

The Permittee may apply for the renewal of the Permit prior to its expiration date in accordance with the provisions of 50 C.F.R. § 13.22.

Q. SUCCESSORS AND ASSIGNS

The terms and conditions of this Permit shall be binding on and shall inure to the benefit of the Permittee and FWS, and their respective successors and assigns, as provided in 50 C.F.R. §§ 13.24 and 13.25.

R. SEVERABILITY

The terms and conditions of this Permit shall be deemed severable, and if any term or condition of this Permit shall be held invalid, illegal or unenforceable by a federal court, after exhaustion of all available appeals, the remainder shall continue to be effective and binding upon FWS and the Permittee. Notwithstanding the foregoing, in the event that any portion of this Permit shall be held invalid, the FWS and the Permittee shall use their best efforts to agree upon amendments to this Permit, consistent with paragraph O above.

S. DEFINITIONS

The following terms as used in this Permit shall have the meanings set forth below:

S.1. The term "Agreement or IA" shall mean the Implementing Agreement by and among Salt River Project Agricultural Improvement and Power District and Salt River

Valley Water Users' Association (SRP), and U.S. Fish and Wildlife Service (FWS) to establish a mitigation program for endangered, threatened, and candidate species at Roosevelt Dam and Lake, in Gila and Maricopa counties, Arizona, executed by the parties thereto concurrent with the issuance of this Permit. Terms identified and utilized in the IA shall have the same meaning when utilized in this Permit, except as specifically noted herein.

S.2. The term "Changed Circumstances" shall mean the changes in circumstances affecting a species or geographic area covered by the Roosevelt Habitat Conservation Plan (RHCP) that are identified in Subparagraph N.1. hereof. The term "Changed Circumstances" shall not include Unforeseen Circumstances, as that term is defined in Subparagraph S.12 hereof.

S.3. The term "Compensation Lands" shall mean the 1,500 or more acres of land acquired and managed by SRP or its designated agent pursuant to the terms of the RHCP.

S.4. The term "Effective Date" shall mean: (1) for all original terms and conditions of this incidental take permit, February 27, 2003~~the date herein above as of which FWS issues this Permit~~; and (2) for any amendments to this incidental take permit ~~No. TE 060125-0~~, the date upon which FWS approves such amendments.

S.5. The term "ESA" shall mean the Endangered Species Act, 16 U.S.C. § 1531 et seq. Terms defined and utilized in the ESA and implementing regulations shall have the same meaning when utilized in this Permit, except as specifically noted herein.

S.6. The term "Permit" shall mean: (1) this incidental take permit ~~No. TE 060125-0~~, issued by FWS to SRP as of February 27, 2003, pursuant to Section 10(a)(1)(B) of the ESA; and (2) any amendments thereto.

S.7. The term "Permit Area" shall mean: (1) the lands within the ~~total~~ conservation space ~~capacity~~ at Roosevelt Dam and Lake that correspond~~s~~ to a maximum surface elevation of 2,151 feet, as described in Subchapter I of the RHCP (2002); and (2) the lands within the flood control space at Roosevelt Dam and Lake (between elevation 2,151 feet and 2,175 feet); and (3) Lower Tonto Creek beginning at elevation 2,175 feet at the top of the flood control space at Roosevelt Dam (elevation 2,175 feet) and continuing approximately 14.1 miles upstream to East del Chi Drive.

S.8. The term "Permitted Activity" shall mean the continued operation, by the Permittee or any successor in interest to the Permittee, of: (1) the ~~total~~ conservation space ~~capacity~~ at Roosevelt Dam and Lake that corresponds to a maximum surface elevation of 2,151 feet, as described in Subchapter I of the RHCP (2002); (2) the flood control space at Roosevelt Dam and Lake between elevation 2,151 feet and 2,175 feet pursuant to the 1997 Water Control Manual issued by the U.S. Army Corps of

Engineers; and (3) the flood control space at Roosevelt Dam and Lake between elevation 2,151 feet and 2,175 feet pursuant to the planned deviation from the 1997 Water Control Manual, as described in the addendum to the Roosevelt Habitat Conservation Plan (2023), if approved by the U.S. Army Corps of Engineers ~~by the Permittee or any successor in interest to the Permittee~~.

S.9. The term "Permittee" shall mean SRP.

S.10. The term "Plan Species" shall mean the species covered by the RHCP and this Permit, as fully set forth herein.

S.11. The term "RHCP" shall mean the Roosevelt Habitat Conservation Plan (2002) and the Roosevelt Habitat Conservation Plan addendum (2023), to be implemented by SRP in conjunction with the Permitted Activity. Terms defined and used in the RHCP shall have the same meaning when used in this Permit, except as specifically noted herein.

S.12. The term "Unforeseen Circumstances" shall mean changes in circumstances affecting a species or geographic area covered by the RHCP, which could not reasonably have been anticipated by SRP and FWS at the time of the RHCP's negotiation and development, and which result in a substantial and adverse change in the status of Plan Species. The term "Unforeseen Circumstances" shall not include Changed Circumstances, as that term is defined in Subparagraph S.2 hereof.

S.13. The term "Unlisted Species" shall mean a species, or a distinct population segment of a vertebrate species, that is not listed as endangered or threatened under the ESA. The term "Unlisted Species" includes candidate species.

*** End of Permit Terms and Conditions for Permit # TE060125-1

~~For questions regarding this Permit, please contact Greg Beatty at 602/ 242-0210 x247.~~

~~--END OF PERMIT--~~

APPENDIX O

Statement Regarding SRP's Commitments under the RHCP Addendum and the 2003 Executed Implementing Agreement

The 2002 RHCP addressed incidental take of southwestern willow flycatcher, the yellow-billed cuckoo, the bald eagle, and the Yuma Ridgway's rail resulting from SRP's conservation storage operations at Modified Roosevelt Dam. The 2003 Implementing Agreement, which remains in effect, sets forth SRP's commitments to minimize and mitigate, to the maximum extent practicable, the impacts of the taking of the four bird species, as described in the 2002 RHCP. The FWS no longer enters into implementing agreements in connection with the issuance of incidental take permits. The RHCP addendum fully describes SRP's commitments with respect to the northern Mexican gartersnake, as well as the proposed additional permitted activities at Modified Roosevelt and the proposed additions to the permit area.

The 2003 Implementing Agreement, as executed, is attached. In addition to addressing the impacts of the taking described in the 2002 RHCP, the measures in the 2003 Implementing Agreement minimize and mitigate, to the maximum extent practicable, the impacts of the taking of the four covered bird species associated with the proposed additional permitted activities and the proposed additions to the permit area described in the RHCP addendum.

IMPLEMENTING AGREEMENT

By and among
SALT RIVER PROJECT AGRICULTURAL IMPROVEMENT AND POWER DISTRICT,
SALT RIVER VALLEY WATER USERS' ASSOCIATION, and
U.S. FISH AND WILDLIFE SERVICE

TO ESTABLISH A MITIGATION PROGRAM FOR ENDANGERED, THREATENED AND CANDIDATE SPECIES AT ROOSEVELT DAM AND LAKE, GILA AND MARICOPA COUNTIES, ARIZONA.

This Implementing Agreement ("Agreement") is made and entered into as of the 14th day of February 2003, by and among the Salt River Project Agricultural Improvement and Power District and the Salt River Valley Water Users' Association (collectively referred to hereinafter as "SRP"), and the United States Fish and Wildlife Service (referred to hereinafter as "FWS").

1.0 RECITALS

This Agreement is entered into with regard to the following facts:

WHEREAS, portions of the riparian vegetation complex located within the conservation storage space at Theodore Roosevelt Dam in Gila and Maricopa counties, Arizona, are occupied and utilized as habitat by the southwestern willow flycatcher, an endangered species, the yuma clapper rail, an endangered species, the bald eagle, a threatened species, and the yellow-billed cuckoo, a candidate species; and

WHEREAS, SRP, with technical assistance from FWS, has developed a series of measures, described in the Roosevelt Habitat Conservation Plan ("RHCP"), to minimize and mitigate to the maximum extent practicable the effects of SRP's continued operation of the conservation storage space at Roosevelt Dam on the subject listed and unlisted species and their associated habitats;

THEREFORE, SRP and FWS do hereby understand and agree as follows:

2.0 DEFINITIONS

The following terms as used in this Agreement shall have the meanings set forth below:

2.1 The term "Agreement" shall mean this Implementing Agreement.

2.2 The term "Compensation Lands" shall mean the 1,500 or more acres of land acquired and managed by SRP or its designated agent pursuant to the terms of the RHCP.

2.3 The term "Effective Date" shall mean the date as of which FWS issues the Permit.

2.4 The term "ESA" shall mean the Endangered Species Act, 16 U.S.C. § 1531 et seq. Terms defined and utilized in the ESA and implementing regulations shall have the same meaning when utilized in this Agreement, except as specifically noted herein.

2.5 The term "Party" or "Parties" shall mean one or more of the parties to this Agreement.

2.6 The term "Permit" shall mean an incidental take permit issued by FWS to SRP pursuant to Section 10(a)(1)(B) of the ESA. Terms utilized and defined in the Permit shall have the same meaning when utilized in this Agreement, except as specifically noted herein.

2.7 The term "Permit Area" shall mean the lands within the total conservation capacity at Roosevelt Dam that corresponds to a maximum surface elevation of 2151 feet, as described in Subchapter I of the RHCP.

2.8 The term "Permitted Activity" shall mean the continued operation of the total conservation capacity at Roosevelt Dam that corresponds to a maximum surface elevation of 2151 feet, as described in Subchapter I of the RHCP, by the Permittee or any successor in interest to the Permittee.

2.9 The term "Permittee" shall mean SRP.

2.10 The term "Plan Species" shall mean the species identified in Section 1.0 of this Agreement and covered by the RHCP and the Permit.

2.11 The term "RHCP" shall mean the Roosevelt Habitat Conservation Plan, to be implemented by SRP in conjunction with the Permitted Activity. Terms defined and utilized in the RHCP shall have the same meaning when utilized in this Agreement, except as specifically noted herein.

2.12 The term "Unforeseen Circumstances" shall mean changes in circumstances affecting a species or geographic area covered by the RHCP, which could not reasonably have been anticipated by the Parties at the time of the RHCP's negotiation and development, and which result in a substantial and adverse change in the status of Plan

Species. The term "Unforeseen Circumstances" shall not include Changed Circumstances, as that term is defined in the Permit.

2.13 The term "Unlisted Species" shall mean a species, or a distinct population segment of a vertebrate species) that is not listed as endangered or threatened under the ESA. The term "Unlisted Species" includes candidate species.

3.0 PURPOSES

The purposes of this Agreement are:

3.1 To ensure implementation of each of the terms of the RHCP and its associated permit; and

3.2 To describe remedies and recourse should any Party fail to perform its obligations, responsibilities, and tasks as set forth in this Agreement and the RHCP.

4.0 INCORPORATION OF RHCP AND PERMIT; GOVERNING LAW

4.1 The RHCP, the Permit and each of their provisions are intended to be, and by this reference are, incorporated herein. In the event of any direct contradiction among the terms of this Agreement, the RHCP and the Permit, the terms of the Permit shall control. In all other cases, the terms of this Agreement, the RHCP and the Permit shall be interpreted to be supplementary to each other.

4.2 This Agreement, the RHCP and the Permit, and the Parties' compliance therewith, shall be governed by the ESA and implementing regulations as the same exist on the Effective Date. Except as otherwise provided herein, any reference in this Agreement, the RHCP or the Permit to any provision of the ESA or to any regulation or rule of FWS shall be deemed to be a reference to such statute, regulation or rule in existence as of the Effective Date. If federal statutes are enacted or rules or regulations are issued by FWS after the Effective Date that conflict with any provision of this Agreement, the RHCP or the Permit, the provisions of this Agreement, the RHCP and the Permit shall control and continue to govern the rights and obligations of the Parties.

5.0 LEGAL REQUIREMENTS

In order to fulfill the requirements that will allow FWS to issue the Permit, the RHCP sets forth measures that are intended to ensure that any take occurring within the Permit Area will be incidental; that the impacts of the take will, to the maximum extent practicable, be minimized and mitigated; that procedures to deal with unforeseen circumstances will be provided; that adequate funding for the RHCP will be provided; and that the take will not appreciably reduce the likelihood of the survival and recovery of the Plan Species in the wild. It also includes measures that have been suggested by FWS as being necessary or appropriate for purposes of the RHCP.

6.0 TERM

6.1 This Agreement shall have a duration beginning on the Effective Date, and continuing in full force and effect for a period of 50 years thereafter, or until revocation or surrender and cancellation of the Permit as provided for therein, whichever occurs earlier.

6.2 Unless the Permit is revoked or surrendered and cancelled as provided for therein, the provisions of the RHCP and this Agreement requiring the acquisition and management of Compensation Lands as habitat for the Plan Species shall, if permitted by law, be permanent and extend beyond the term of this Agreement. If the Permit is revoked or surrendered and cancelled, the extent, if any, of the Permittee's continuing obligations under the RHCP and this Agreement shall be determined in accordance with Subparagraph 6.3 hereof.

6.3 In the event that the Permit is revoked or surrendered and cancelled as provided for therein, the provisions of the RHCP and of this Agreement requiring the acquisition and management of Compensation Lands as habitat for the Plan Species shall be permanent and extend beyond the term of this Agreement if permitted by law, but only to the extent necessary to mitigate for take of Plan Species that occurred pursuant to the terms of the Permit, before its revocation or surrender and cancellation, as determined by FWS in collaboration with the Permittee.

7.0 FUNDING

For the first five years that the Permit is in effect, the Permittee shall include in its annual budget such funds as are necessary to carry out the Permittee's obligations under the RHCP and this Agreement. No later than five years after the Permit is issued, the Permittee shall ensure that funding is available to meet its continuing obligations under this Agreement and the RHCP through an account or accounts solely designated for this purpose. The account or accounts may be in the form of a trust account, irrevocable letter of credit, insurance or surety bond. The account or accounts must be acceptable to FWS and must be in an amount agreed to by FWS and the Permittee that is sufficient to meet the Permittee's continuing obligations under this Agreement and the RHCP.

8.0 RESPONSIBILITIES OF THE PARTIES IN MITIGATION PROGRAM; IMPLEMENTATION AND MONITORING RESPONSIBILITIES

8.1 Responsibilities of the Permittee

a. The RHCP will be deemed properly implemented if the commitments and provisions of the RHCP, this Agreement and the Permit have been or are being implemented in accordance with their terms.

b. The Permittee shall undertake all activities set forth in the RHCP in order to meet the terms of the RHCP and comply with the Permit, including the adaptive management procedures described in the RHCP, if required.

c. As required by Chapter IV.E.6. of the RHCP, for each year that the Permit is in effect, the Permittee shall submit an annual report to FWS containing a description of its activities and an analysis of whether the terms of the RHCP were met for the reporting period. The report shall be submitted to FWS on each February 1 for the previous calendar year and shall provide all reasonably available data regarding impacts to habitat of and effects on the Plan Species, and, where requested by FWS, changes to the overall population of Plan Species that occurred in the Permit area during the reporting period. The report shall also include the following certification from a responsible company official of the Permittee who supervised or directed the preparation of the report:

> Under penalty of law, I certify that, to the best of my knowledge, after appropriate inquiries of all relevant persons involved in the preparation of this report, the information submitted is true, accurate, and complete.

d. The Permittee will provide, within 30 days of being requested by FWS, any additional information in its possession or control related to implementation of the RHCP that is requested by FWS for the purpose of assessing whether the terms and conditions of the Permit and the RHCP, including the RHCP's adaptive management plan, are being fully implemented.

8.2 Responsibilities of FWS

a. Upon execution of this Agreement by all parties, and satisfaction of all applicable legal requirements, FWS shall issue the Permittee a Permit authorizing the incidental take by Permittee of threatened or endangered Plan Species resulting from the Permitted Activity.

b. After issuance of the Permit, FWS shall monitor the implementation of the terms of the Permit, this Agreement and the RHCP in order to ensure compliance by the Permittee. FWS may conduct inspections and monitoring in connection with the Permit in accordance with 50 C.F.R. § 13.47.

c. Provided that the Permittee has complied with its obligations under the RHCP, this Agreement and the Permit, FWS may require measures of the Permittee in addition to those required by the RHCP only in accordance with the terms of the Permit governing Unforeseen Circumstances.

9.0 <u>REMEDIES</u>

9.1 Enforcement of Agreement, Remedies for Breach

Except as provided in Subparagraph 9.2 hereof, each Party shall be entitled to pursue legal action, including the filing of a suit for specific performance, declaratory or injunctive relief, to enforce the terms of this Agreement, the Permit, and the RHCP, and to seek remedies for any breach hereof.

9.2 No Monetary Damages, Effect of Agreement on Pre-existing Liabilities, Enforcement Authority of FWS

a. No Monetary Damages. No Party shall be liable in monetary damages to any other Party or other person for any breach of this Agreement, any performance or failure to perform a mandatory or discretionary obligation imposed by this Agreement or any other cause of action arising from this Agreement.

b. Retain Liability. Except as otherwise provided in Subparagraphs 4.2 and 9.2.e. hereof, the Parties shall retain whatever liability they would possess for their present and future acts or failure to act in the absence of this Agreement.

c. Land Owner Liability. All Parties shall retain whatever liability they would possess as an owner of interests in land in the absence of this Agreement.

d. Enforcement of the ESA and Other Applicable Laws by FWS. Except as otherwise provided in Subparagraphs 4.2 and 9.2.e. hereof, nothing contained in this Agreement is intended to limit the authority of FWS to seek civil or criminal penalties or otherwise fulfill its enforcement responsibilities under the ESA and other applicable laws.

e. Exception. Notwithstanding Subparagraphs 9.2.b. and 9.2.d. hereof, as long as the RHCP is being properly implemented, FWS shall not be permitted to seek civil or criminal penalties or otherwise enforce the take prohibitions of the ESA and other applicable laws against the Permittee for incidental take of Plan Species that is in accordance with the terms of the Permit.

10.0 SEVERABILITY

The provisions of this Agreement shall be deemed severable, and if any portion of this Agreement shall be held invalid, illegal or unenforceable by a federal court, after exhaustion of all available appeals, the remainder shall continue to be effective and binding upon the Parties. Notwithstanding the foregoing, in the event that any portion of this Agreement shall be held invalid, the Parties shall use their best efforts to agree upon amendments to this Agreement that are consistent with the law then existing.

11.0 PRIVATE PROPERTY RIGHTS AND LEGAL AUTHORITIES UNAFFECTED

Except as otherwise specifically provided herein, nothing in this Agreement shall be deemed to restrict the rights of the Permittee to engage in the Permitted Activity, or the Permittee's use or development of those lands or water rights, or interests in lands or water rights, constituting the Permit Area; provided, however, that nothing in this Agreement shall absolve the Permittee from such other limitations as may apply to the

Permitted Activity, or to such lands or water rights, or interests in lands or water rights, under other laws of the United States and the State of Arizona.

12.0 AMENDMENTS TO THE AGREEMENT

12.1 In General

This Agreement may be amended consistent with the ESA and with the written consent of each of the Parties hereto.

12.2 Minor Modifications

Any Party may propose minor modifications to this Agreement by providing written notice to all other Parties. Minor modifications to this Agreement may include but are not limited to corrections of typographic, grammatical, and similar editing errors that do not change the intended meaning. The notice of proposed minor modifications provided for in this Subparagraph shall include a description of the proposed minor modification and a statement of the reasons therefor. The Parties will use reasonable efforts to respond to proposed minor modifications to this Agreement within 60 days of receipt of such notice. Proposed minor modifications to this Agreement will become effective only upon all other Parties' written approval.

13.0 MISCELLANEOUS PROVISIONS

13.1 No Partnership

Except as otherwise expressly set forth herein, neither this Agreement nor the RHCP shall make or be deemed to make one Party hereto the agent for or the partner of another Party.

13.2 Successors and Assigns

This Agreement and each of its covenants and conditions shall be binding on and shall inure to the benefit of the Parties hereto and their respective successors and assigns.

13.3 Notice

Any notice permitted or required by this Agreement shall be in writing and shall be delivered personally to the persons set forth below or shall be deemed given five (5) days after deposit in the United States mail, certified and postage prepaid, return receipt requested and addressed as follows or at such other address as any Party may from time to time specify to the other Parties in writing:

Assistant Regional Director, Ecological Services
United States Fish and Wildlife Service
P.O. Box 1306
Albuquerque, New Mexico 87103-1306

Field Supervisor
United States Fish and Wildlife Service
2321 West Royal Palm Road, Suite 103
Phoenix, Arizona 85021

Associate General Manager, Water
Salt River Project
P.O. Box 52025
Phoenix, Arizona 85072-2025

13.4 Entire Agreement

This Agreement, together with the RHCP and the Permit, constitute the entire Agreement between the Parties. It supersedes any and all other agreements, either oral or in writing among the Parties with respect to the subject matter hereof and contains all of the covenants and agreements among them with respect to said matters, and each Party acknowledges that no representation, inducement, promise or agreement, oral or otherwise, has been made by any other Party or anyone acting on behalf of any other Party that is not embodied herein.

13.5 Elected Officials Not To Benefit

No member of or delegate to Congress shall be entitled to any share or part of this Agreement, or to any benefit that may arise from it.

13.6 Availability of Funds

Implementation of this Agreement and the RHCP by FWS is subject to the requirements of the Anti-Deficiency Act and the availability of appropriated funds. Nothing in this Agreement will be construed by the Parties to require the obligation, appropriation, or expenditure of any money from the U.S. Treasury. The parties acknowledge that FWS will not be required under this Agreement to expend any federally appropriated funds unless and until an authorized official of the FWS affirmatively acts to commit to such expenditures as evidenced in writing.

13.7 Duplicate Originals

This Agreement may be executed in any number of duplicate originals. A complete original of this Agreement shall be maintained in the official records of each of the Parties hereto.

13.8 Third Party Beneficiaries

Without limiting the applicability of the rights granted to the public pursuant to the provisions of 16 U.S.C. § 1540(g), this Agreement shall not create any right or interest in the public, or any member thereof, as a third party beneficiary hereof, nor shall it authorize anyone not a Party to this Agreement to maintain a suit for personal injuries or property damages pursuant to the provisions of this Agreement. The duties, obligations, and responsibilities of the Parties with respect to third parties shall remain as imposed under existing Federal or Arizona law.

IN WITNESS WHEREOF, THE PARTIES HERETO have executed this Implementing Agreement to be in effect as of the date last signed below.

BY ______________________ Date 2/26/03

Acting Deputy Regional Director
United States Fish and Wildlife Service
Albuquerque, New Mexico

SUBSCRIBED AND SWORN TO BEFORE ME THIS 26th DAY OF February, 2003,

Linda Pierce Roberts
Notary Public

BY William P. Schrader Date 2/14/03

William Schrader, President
Salt River Project
Phoenix, Arizona

SUBSCRIBED AND SWORN TO BEFORE ME THIS 14th DAY OF February, 2003,

OFFICIAL SEAL
MARGARET A. SULLIVAN
NOTARY PUBLIC-ARIZONA
MARICOPA COUNTY
My Comm. Expires Aug. 15, 2005

Margaret A Sullivan
Notary Public