United States Department of the Interior

FISH AND WILDLIFE SERVICE

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In Reply Refer To:
FWS/R2/ES-NM ESFO/BP034801

FEB 26 2019

Memorandum

To: Coordination Committee, San Juan River Basin Recovery Implementation Program

From: Regional Director, Southwest Region

Subject: San Juan River Basin Recovery Implementation Program Sufficient Progress

The U.S. Fish and Wildlife Service (FWS) completed the San Juan River Basin Recovery Implementation Program's Progress Toward Recovery Assessment and Review, as the Program Document defines. The FWS' responsibility number 21 requires the FWS to prepare a biennial, written "Sufficient Progress" assessing the Program's progress toward Colorado Pikeminnow and Razorback Sucker recovery, and the Program's ability to provide Endangered Species Act (ESA) compliance for San Juan River Basin water development and management activities. The report includes any corrective actions to ensure future ESA compliance in accordance with the "Principles for Conducting ESA Section 7 Consultations on Water Development and Water Management Activities Affecting San Juan River Basin Endangered Fish" (Principles).

Using the Principles, the FWS determines whether Program progress is sufficient to provide a reasonable and prudent alternative or measure, based on the following factors:

1. Actions that will result in a measurable positive population response, a measurable fish habitat improvement, legal protection for flows required for recovery, or a reduced immediate extinction threat.

2. Fish population status.

3. Flow adequacy.

4. Magnitude of the activities' impact, including, but not limited to, contaminant and fish migration impacts.

The Principles, which the Coordination Committee adopted in 2002, constitute a guide to define how Program actions will provide ESA compliance for water development and water management activities. The FWS reviewed the Principles and found them consistent with the ESA and its implementing regulations (50 CFR Part 402). The Principles rely heavily on the Program's ability to implement the activities and actions the Program's Long Range Plan outlines. For this Program assessment, the FWS uses the following criteria to determine the Program's sufficient progress:

1. Successfully implementing recovery management actions the 2002 Recovery Goals detailed (FWS 2002a, FWS 2002b).

2. Attaining metrics the Positive Population Response Criteria detailed (Bureau of Reclamation 2001).

3. Making progress toward achieving specific San Juan River sub-basin downlisting and delisting recovery demographic criteria the 2002 Recovery Goals outlined (FWS 2002a, FWS 2002b).

Determination: The FWS considers the Program's overall progress toward San Juan River Basin Colorado Pikeminnow and Razorback Sucker recovery sufficient for the Program to continue as the ESA compliance mechanism for San Juan River Basin water development, management and operations. The Program is satisfactorily carrying out the 2002 Recovery Goals' management activities, such that the Program will continue serving as a foundation for reasonable and prudent alternatives and measures in applicable Section 7 consultations. Although the Program has not achieved the downlisting and delisting recovery demographic criteria or all Positive Population Response Criteria, the overall incremental San Juan River Basin Colorado Pikeminnow and Razorback Sucker population status improvement indicates sufficient progress toward recovery based on the Program's recovery action implementation.

Recommendations: The FWS recommends two broad areas where the Program should focus its efforts to improve San Juan River Basin Colorado Pikeminnow and Razorback Sucker recovery efforts. The Program should: 1) rigorously evaluate its management actions to move toward recovery more expeditiously, and consistent with the adaptive management framework, and; 2) identify and ameliorate Colorado Pikeminnow and Razorback Sucker recruitment bottlenecks. Science-based management should guide the Program's activities. All Program actions must improve San Juan River Basin Colorado Pikeminnow and Razorback Sucker recovery prospects. While the Program should not abandon current management without compelling evidence, the FWS strongly suggests the Program explore innovative activities given that the current management paradigms have not resulted in documented wild-recruitment. Furthermore, given the lack of wild-recruitment, the Program must prioritize research efforts to determine and mitigate impediments limiting San Juan River Basin wild-recruitment.

Attachment

cc: Supervisor, Ecological Services Field Office, Albuquerque, NM
Supervisor, Ecological Services Field Office, Grand Junction, CO
Supervisor, Ecological Services Field Office, Salt Lake City, UT

U.S. Fish and Wildlife Service

Assessment and Review of the San Juan River Basin Recovery Implementation Program's Progress Toward Recovery

December 2018

U.S. Fish and Wildlife Service

Region 2

Approval:

2/26/19

Amy Lueders
Regional Director
U.S. Fish and Wildlife Service, Region 2

Table of Contents

INTRODUCTION

The San Juan River Basin Recovery Implementation Program's (Program) goal is to conserve and recover endangered Colorado Pikeminnow (*Ptychocheilus lucius*) and Razorback Sucker (*Xyrauchen texanus*) in the San Juan River Basin (Figure 1) while providing Endangered Species Act (ESA) compliance for water development and management activities. The Animas-La Plata Project biological opinion (BO) established the Program in 1992 as a reasonable and prudent alternative (RPA) to prevent jeopardizing the continued existence of both Colorado Pikeminnow and Razorback Sucker (U.S. Fish and Wildlife Service [Service] 2000). Periodically, the Service assesses the Program's progress toward species recovery to determine if the Program is sufficient to continue to serve as the RPA, or reasonable and prudent measure (RPM), and provide ESA compliance for water development and management activities in the basin (Program 2001). The Service uses the following criteria to determine the Program's sufficient progress:

1. The successful implementation of recovery management actions detailed in the 2002 Recovery Goals (Service 2002a, Service 2002b).
2. Attaining metrics detailed in Positive Population Response Criteria (U.S. Bureau of Reclamation [Reclamation] 2001).
3. Making progress toward achieving San Juan River subbasin specific recovery demographic criteria for downlisting and delisting outlined in the 2002 Recovery Goals (Service 2002a, Service 2002b).

The management actions described in the Recovery Goals outline the activities thought necessary to minimize or remove threats and support wild self-sustaining populations of Colorado Pikeminnow and Razorback Sucker (Service 2002a, Service 2002b). The Service anticipates that the successful implementation of these management actions will benefit Colorado Pikeminnow and Razorback Sucker and ultimately result in achieving the recovery demographic criteria for the endangered fishes (Service 2002a, Service 2002b). The management actions from the Recovery Goals relevant to the San Juan River Basin are:

1. Provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations.

2. Provide passage over barriers within occupied habitat to allow adequate movement and, potentially, range expansion.
3. Minimize entrainment of subadults and adults in diversion canals/out-take structures.
4. Ensure adequate protection from diseases and parasites.
5. Regulate nonnative fish releases and escapement into the San Juan River, floodplain, and tributaries.
6. Control problematic nonnative fishes as needed.
7. Minimize the risk of hazardous-materials spills in critical habitat.
8. Remediate water quality problems.
9. Reestablish populations with hatchery-produced fish.
10. Minimize the threat of hybridization with White Sucker (*Catostomus commersonii*) [only applicable to Razorback Sucker].
11. Provide for the long-term management conservation plans to protect populations and their habitats beyond delisting [efforts to develop long-term species conservation plans are not a priority until the Program is closer to meeting delisting objectives].

As a conservation measure in the Animas-La Plata BO (Service 2000), Reclamation (2001) committed to developing population response criteria to assess if Colorado Pikeminnow and Razorback Sucker were responding positively to management actions and improving their population status prior to attaining recovery demographic criteria outlined in Recovery Goals (Service 2002a, Service 2002b). Reclamation developed these criteria in consultation with the Program's Biology Committee to indicate positive response to management actions and incremental improvements in reaching recovery demographic criteria. These criteria covered two periods (Interim Response Criteria for 2002-2006 and Positive Population Response Criteria for 2007-2011) and are specific to the San Juan River. The Program has not developed positive population response criteria covering any period after 2011.

Recovery demographic criteria are the age-specific population targets for the San Juan River Basin in the Recovery Goals that guide downlisting and delisting proposals for Colorado Pikeminnow and Razorback Sucker (Service 2002a, Service 2002b). Improvements in the population status of Colorado Pikeminnow and Razorback Sucker that fall short of the recovery demographic criteria can still indicate sufficient progress toward recovery. Once recovery

demographic criteria targets are met, downlisting and delisting can proceed, and by definition, would indicate sufficient progress toward recovery.

ASSESSMENT AND REVIEW OF PROGRESS TOWARD RECOVERY

For this assessment of the Program's progress toward recovery, the Service used the following sources of information: (1) the Program's annual, research, integration, and evaluation reports; (2) relevant peer-reviewed scientific literature; and (3) BOs that rely on the Program for ESA compliance. These sources provided the best available science and summarized the Program's management actions implemented to benefit recovery of Colorado Pikeminnow and Razorback Sucker, in addition to detailing the monitoring and research activities that assessed the endangered fish responses to management actions. In this assessment and review of progress toward recovery, the Service summarized and evaluated information from these sources under headings for the implementation of each recovery management action, the Positive Population Response Criteria, and the recovery demographic criteria. The Service provides recommendations for corrective action to improve the Program's progress toward recovery at the conclusion of each section. The Service does not provide an assessment of sufficient progress based on individual recovery management actions, positive population responses, or recovery demographic criteria. Rather the Service's assessment of the Program's sufficient progress and progress toward recovery is based on the entirety of recovery management actions implemented, species responses to those management actions, and the incremental improvement in population statuses of Colorado Pikeminnow and Razorback Sucker within the San Juan River Basin.

IMPLEMENTATION OF RECOVERY ACTIONS FROM RECOVERY GOALS

1. Provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations.

FLOW REGIME

The Program developed flow recommendations for the operation of Navajo Reservoir on the San Juan River in 1999 (Holden 1999). The flow recommendations were intended to mimic a

more natural flow regime characterized by variability in flow, spring peak flow, and low base flows by releasing water from Navajo Reservoir to meet specific flow targets. The flow recommendations identified the purpose, frequency, and duration of specific flow targets (Tables 1 and 2) thought necessary to develop and maintain the habitat and hydrologic conditions needed for all life stages of Colorado Pikeminnow, Razorback Sucker, and other native fishes (Holden 1999).

Since implementation of the flow recommendations, many flow targets have been infrequently met because of hydrologic conditions and operational constraints (Table 3). In an effort to more successfully attain flow targets, particularly the higher flow targets, the Program held a series of workshops in 2015 and 2016. Through these workshops, the Program adopted an "end of water year storage target" (EWYST) concept to determine the volume of water available for release from Navajo Reservoir. In 2018, the Program implemented a revised decision tree for operating Navajo Reservoir (Figure 2) that is intended to increase the frequency of long duration releases while low duration releases are minimized (Program 2018). This strategy mimics the hydrology of any given year's climatic conditions unlike the previous decision tree when releases may not occur even if there was available water. Under the new decision tree, in a year with dry hydrological conditions, no release would be made from Navajo Reservoir; rather, that volume of water would be stored in Navajo Reservoir to increase the probability of long duration releases in future years. Conversely, in this revised strategy when there is available water, it would be released as a spring peak release timed to match peak flow from the Animas River rather than being stored for future years. Longer duration releases from Navajo Reservoir are more likely to match the Animas River peak compared to short duration releases. The new decision tree also allows other flow management options yet to be implemented such as elevated baseflows (e.g., from 500 cubic feet per second [cfs] to 1,000-1,500 cfs) to increase the area of low velocity habitats. Additionally, the Program selected the EWYST reservoir elevation of 6,063 feet (with the option of going down to 6,050 feet) to provide up to three years of storage as protection against implementing shortage sharing agreements during a prolonged severe drought.

Per the Animas-La Plata BO (Service 2000), Reclamation committed to operate Navajo Reservoir to benefit endangered fishes as a conservation measure. The inability to meet the minimum and maximum frequency criteria for 8,000 and 10,000 cfs flow recommendation targets (Table 3) may be a significant modification of the conservation measure affecting Colorado

Pikeminnow, Razorback Sucker, and their designated critical habitat, possibly requiring reinitiation of section 7 consultation of this project. As one of the Program's primary management actions to develop and maintain habitat, the inability to reach high flow targets has likely contributed to a degraded habitat condition in the San Juan River. However, the Service is optimistic that the revised operating procedures for Navajo Reservoir will result in more frequently meeting the 8,000 cfs and 10,000 cfs high flow targets that have not been attained since 2008. More regularly reaching high flow targets would likely result in reversing the long-term declines in important low velocity habitats used as nurseries for larval and juvenile Colorado Pikeminnow and Razorback Sucker (Lamarra and Lamarra 2018, N. Franssen 2018 personal communication).

Figure 1. Map of San Juan River Basin highlighting major tributaries, select geographical locations or features, and river mile (RM) reference. Stars indicate select U.S. Geological Survey (USGS) gauging stations.

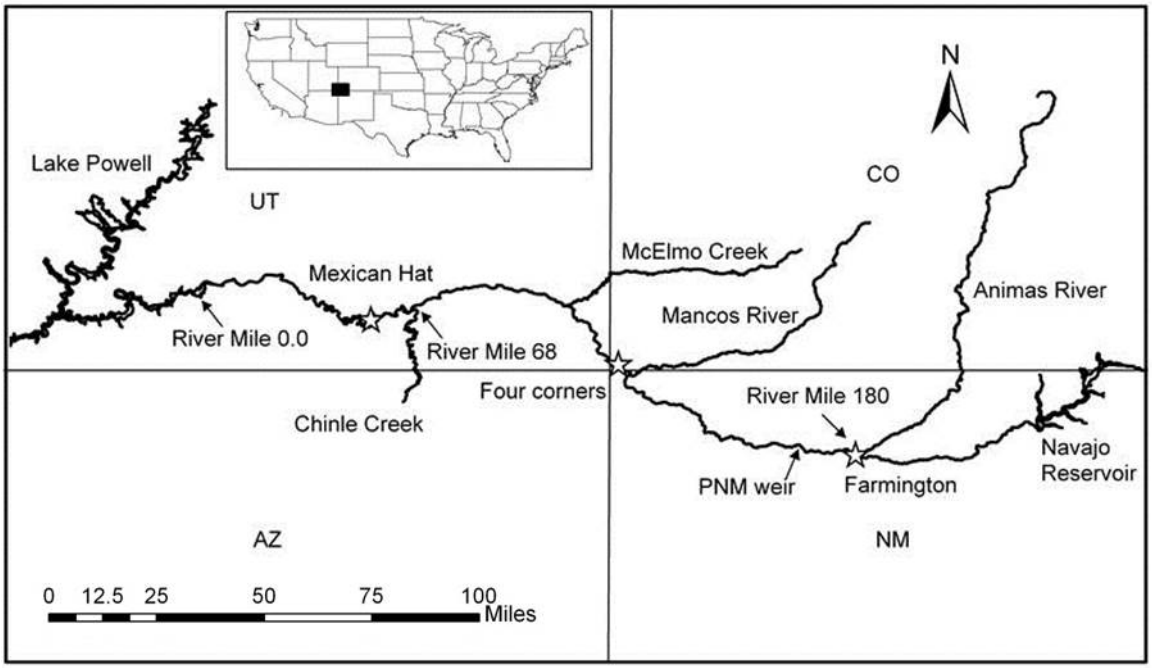


Table 1. The recommended flow duration and frequency of the four spring flow targets identified for the San Juan River downstream of the Animas River Confluence (Holden 1999).

Category	Duration	Frequency
A. Flow > 10,000 cfs during runoff period (March 1 to July 31).	A minimum of 5 days between March 1 and July 31.	Flows > 10,000 cfs for 5 days or more need to occur in 20% of the years on average for the period of record 1929-1993. Maximum number of consecutive years without meeting at least a flow of 9,700 cfs (97% of 10,000 cfs) within the 65-year period of record is 10 years.
B. Flow > 8,000 cfs during runoff period.	A minimum of 10 days between March 1 and July 31.	Flows > 8,000 cfs for 10 days or more need to occur in 33% of the years on average for the period of record 1929-1993. Maximum number of consecutive years without meeting at least a flow of 7,760 cfs (97% of 8,000 cfs) within the 65-year period of record is 6 years.
C. Flow > 5,000 cfs during runoff period.	A minimum of 21 days between March 1 and July 31.	Flows > 5,000 cfs for 21 days or more need to occur in 50% of the years on average for the period of record 1929-1993. Maximum number of consecutive years without meeting at least a flow of 4,850 cfs (97% of 5,000 cfs) within the 65-year period of record is 4 years.
D. Flow >2,500 cfs during runoff period.	A minimum of 10 days between March 1 and July 31.	Flows > 2,500 cfs for 10 days or more need to occur in 80% of the years on average for the period of record 1929-1993. Maximum number of consecutive years without meeting at least a flow of 2,425 cfs (97% of 2,500 cfs) within the 65-year period of record is 2 years.

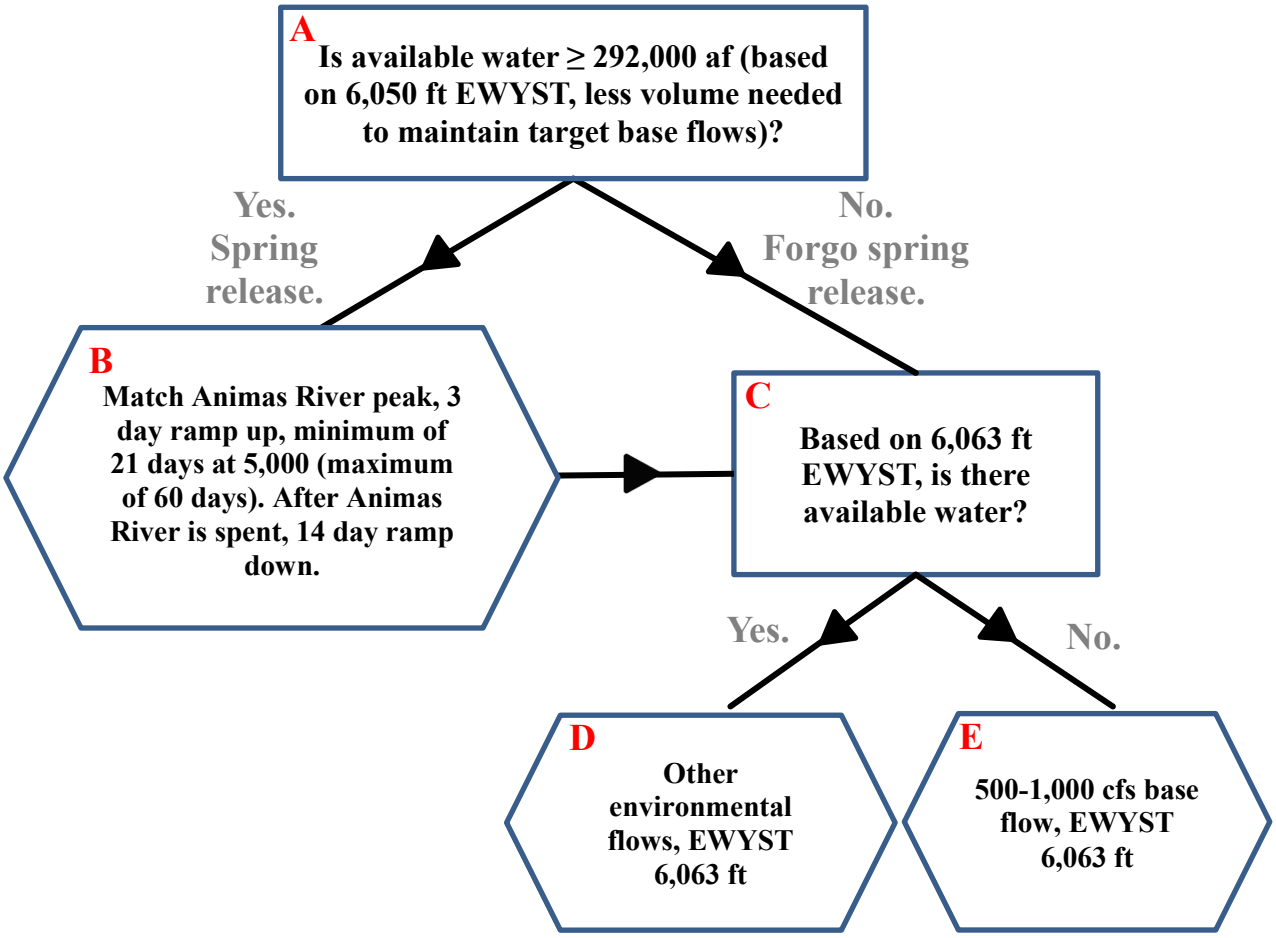
Table 2. Flow targets and their purposes identified for the San Juan River downstream of the Animas River Confluence based on the San Juan River flow recommendations (Holden 1999).

Category	Purpose
A. Flow > 10,000 cfs during runoff period (March 1 to July 31).	Flows above 10,000 cfs provide significant out-of-bank flow, generate new cobble sources, change channel configuration providing for channel diversity, and provide nutrient loading to the system, thus improving habitat productivity. Such flows provide material to develop spawning habitat and maintain channel diversity and habitat complexity necessary for all life stages of the endangered fishes. The frequency and duration are based on mimicry of the natural hydrograph, which is important for Colorado Pikeminnow reproductive success and maintenance of channel complexity, as evidenced by the increase in the number of islands following high flow conditions. Channel complexity is important to both Colorado Pikeminnow and Razorback Sucker.
B. Flow > 8,000 cfs during runoff period.	Bankfull discharge is generally between 7,000 and 10,500 cfs in the San Juan River below Farmington, New Mexico, with 8,000 cfs being representative of the bulk of the river. Bankfull discharge approximately 1 year in 3 on average is necessary to maintain channel cross-section. Flows at this level provide sufficient stream energy to move cobble and build cobble bars necessary for spawning Colorado Pikeminnow. Duration of 8 days at this frequency is adequate for channel and spawning bar maintenance. However, research shows a positive response of Bluehead Sucker and Speckled Dace abundance with increasing duration of flows above 8,000 cfs from 0 to 19 days. Therefore, the minimum duration was increased from 8 to 10 days to account for this measured response. Flows above 8,000 cfs may be important for providing habitat for larval Razorback sucker if flooded vegetation and other habitats formed during peak and receding flows are used by the species. This flow level also maintains mimicry of the natural hydrograph during higher flow years, an important feature for Colorado Pikeminnow reproductive success.
C. Flow > 5,000 cfs during runoff period.	Flows of 5,000 cfs or greater for 21 days are necessary to clean backwaters and maintain low-velocity habitat in secondary channels in Reach 3, thereby maximizing nursery habitat for the system. The required frequency of these flows is dependent upon perturbating storm events in the previous period, requiring flushing in about 50% of the years on average. Backwaters in the upper portion of the nursery habitat range clean with less flow but may be too close to spawning sites for full utilization. Maintenance of Reach 3 is deemed critical at this time because of its location relative to the Colorado Pikeminnow spawning area (RM 132) and its backwater habitat abundance.
D. Flow > 2,500 cfs during runoff period.	Flows above 2,500 cfs cause cobble movement in higher gradient areas on spawning bars. Flows above 2,500 cfs for 10 days provide sufficient movement to produce clean cobble for spawning. These conditions also provide sufficient peak flow to trigger spawning in Colorado Pikeminnow. The frequency specified represents a need for frequent spawning conditions but recognizes that it is better to provide water for larger flow events than to force a release of this magnitude each year. The specified frequency represents these tradeoffs.
E. Timing of the peak flows noted in A through D above must be similar to historical conditions, and the variability in timing of the peak flows that occurred historically must also be mimicked.	Maintaining similar peak timing will provide ascending and descending hydrograph limbs timed similarly to the historical conditions that are suspected important for spawning of the endangered fishes.
F. Target Base Flow (mean weekly non-spring runoff flow).	Maintaining low, stable base flows enhances nursery habitat conditions. Flows between 500 and 1,000 cfs optimize backwater habitat. Selecting flows at the low end of the range increases the availability of water for development and spring releases. It also provides capacity for storm flows to increase flows and still maintain optimum backwater area. This level of flow balances provision of near-maximum low-velocity habitat and near- optimum flows in secondary channels, while allowing water availability to maintain the required frequency, magnitude, and duration of peak flows important for Colorado Pikeminnow reproductive success.
G. Flood Control Releases (incorporated in operating rule).	Historically, flood control releases were made by increasing fall and winter base flows. This elevates flows above the optimum range for nursery habitat. Periodic clean-water spike flows improve low-velocity habitat quality by flushing sediment and may suppress Red Shiner and Fathead Minnow abundance.

Table 3. Number of days per year that attained each of the four spring flow targets as outlined in the San Juan River flow recommendations (Holden 1999; Table 1). Table and flow statistics courtesy of S. Behery.

	Annual duration (number of days meeting target)			
Flow target (cfs)	**10,000**	**8,000**	**5,000**	**2,500**
Minimum duration criteria	**5 days**	**10 days**	**21 days**	**10 days**
Minimum frequency criteria	**20% of years**	**33% of years**	**50% of years**	**80% of years**
Maximum frequency criteria	**10 years**	**6 years**	**4 years**	**2 years**
1998	0	4	35	66
1999	0	1	31	72
2000	0	0	6	40
2001	0	4	36	56
2002	0	0	0	0
2003	0	0	0	14
2004	0	0	1	26
2005	11	18	52	85
2006	0	0	8	24
2007	0	3	21	56
2008	6	25	62	121
2009	0	0	20	41
2010	0	0	0	19
2011	0	7	12	29
2012	0	0	6	10
2013	0	0	0	0
2014	0	0	0	22
2015	0	1	16	38
2016	0	7	35	53
2017	0	7	51	80

Figure 2. Revised decision tree for operating Navajo Reservoir. This decision tree uses a flexible end of water year storage target (EWYST) reservoir elevation of 6,050 feet or 6,063 feet to maximize the volume and frequency of 5,000 cfs releases from Navajo Reservoir. Prior to a spring release, available water is calculated based on a reservoir elevation of 6,050 feet (A). If available water is equal or greater than 292,000 acre-feet (af), a spring peak release from Navajo Reservoir will be made for at least 21 days to match the Animas River peak (B). If available water is less than 292,000 af, no spring release will be made (C). Once the spring release ceases or no spring release is made, if there is available water at a reservoir elevation of 6,063 feet (C), baseflow will be elevated or other environmental flows will be implemented to reach the EWYST of 6,063 (D). If there is no available water at a reservoir elevation of 6,063 feet after a spring release ceases or no release is made, baseflows will be maintained at 500-1,000 cfs (E).



In addition to managed flow releases from Navajo Reservoir, the Program cleared and sluiced secondary channels and removed nonnative vegetation to provide suitable habitat for the native fish community. In 2011, The Nature Conservancy (TNC), in partnership with the Program, used funding from New Mexico's River Ecosystem Restoration Initiative (RERI) to mechanically restore low velocity habitats to six sites in the San Juan River between Shiprock, New Mexico and the Four Corners RM 148-119. TNC removed nonnative vegetation, cleared existing channel inlets, and excavated new secondary channels to create low velocity habitat (Keller-Bliesner 2012). Small-bodied fish monitoring at these restored sites indicated that they had similar densities of total, native, and nonnative fish compared to reference locations (Franssen et al. 2015); however, not all restored sites were wetted at low flow conditions (Farrington et al. 2014, Gilbert 2014). TNC, in collaboration with the Program, used non-federal funds to conduct a second phase (phase 2) of channel and floodplain restoration along the San Juan River and completed secondary channel habitat restoration from RM 137.1-134.5 in November 2014. The Program deemed the restoration effort successful based on the secondary channel continuously flowing at discharges as low as 400 cfs in the main channel and documentation of native fish, particularly Colorado Pikeminnow, utilizing the restored channel (Lamarra et al. 2018). The Program is considering a phase 3 habitat restoration project as a two to three acre floodplain wetland with the goal of entraining larval Razorback Sucker to increase their survival to the juvenile life-stage given large stable low velocity habitat absent large-bodied predators (Gori et al. 2018). Juvenile Razorback Suckers produced in the wetland would be released to the San Juan River in October each year prior to draining the wetland. The Four Corners Power Plant and Navajo Mine BO provided additional funding to the Program for habitat restoration efforts and monitoring of restored sites (Service 2015).

TEMPERATURE

The hypolimnetic (i.e., coldwater) release from Navajo Reservoir suppresses the temperature of the San Juan River in spring, summer, and fall; and potentially limits spawning habitat for endangered fishes in the San Juan River. For example, although Navajo Reservoir is operated to mimic the natural hydrograph, when spring peak releases are made (~5,000 cfs) water temperature in the San Juan River is reduced by 2 °C and is not attenuated in downstream reaches (Cutler 2005). Additionally, water temperature is a primary factor affecting growth, development,

and survival of larval fish (Houde 1987, Harvey 1991). Sampling in the San Juan River upstream of its confluence with the Animas River documented both Colorado Pikeminnow (as far upstream as RM 188) and Razorback Sucker (as far upstream as RM 194) indicating at least seasonal use of this upstream cooler reach (Furr 2012, Schleicher 2018). The increased density of native fishes in this upstream reach of the San Juan River, possibly due to higher productivity or limited nonnative fish (Franssen et al. 2016), suggests this reach could play an important role for Colorado Pikeminnow and Razorback Sucker recovery despite cooler temperatures. Additionally, seasonal movements by juvenile Colorado Pikeminnow upstream from spring to summer and back downstream overwinter could be due to longitudinal temperature gradients or prey densities (Durst and Franssen 2014).

While the Service continues to be concerned about potential negative effects of temperature suppression on endangered fishes, the severity of this deleterious effect has yet to be quantified in the San Juan River. Negative effects of lowered water temperature have been hypothesized for larval Colorado Pikeminnow and Razorback Sucker, but no relationship was detected between the density of native larval fish and water temperature in the San Juan River (Miller and Swaim 2016). There has been a general upstream trend in detection of larval Colorado Pikeminnow and Razorback Sucker (at RM 162.5 and RM 155.9 in 2017 for Colorado Pikeminnow and Razorback Sucker, respectively; Farrington et al. 2017) and hence spawning further upstream in cooler reaches of the San Juan River. In collaboration with the Southwestern Native Aquatic Resources and Recovery Center (SNARRC), the Program is developing an experiment to assess the effect of temperature on larval Razorback Sucker growth and survival using funding provided by the Four Corners Power Plant and Navajo Mine BO (Service 2015).

RECOVERY ACTION 1: SUMMARY AND RECOMMENDATIONS

The Service is optimistic that the Program's efforts to implement a revised strategy for releases from Navajo Reservoir will result in attaining the duration and frequency targets for 8,000 and 10,000 cfs flows identified in the flow recommendations. However, the inability to reach the 8,000 and 10,000 cfs flow targets since 2008 is cause for serious concern. The lack of high magnitude flows at the frequency prescribed by the flow recommendations (Holden 1999) likely resulted in habitat degradation potentially impeding recruitment of wild-spawned individuals. In the absence of appropriate flows to develop and maintain habitat necessary for recovery, the

Program and its partners have conducted secondary channel and low velocity habitat restoration along the San Juan River. The Service recommends the Program continue habitat restoration as part of efforts to identify and ameliorate impediments to recovery in the San Juan River. While spring peak releases from Navajo Reservoir have been clearly linked to creation of low-velocity habitats (Lamarra and Lamarra 2018), the effects of concomitant cooler temperatures is equivocal. The Program's efforts to identify the contribution of cooler temperatures to recruitment bottlenecks in the San Juan River will inform future management actions to alleviate this potential threat.

2. Provide passage over barriers within occupied habitat to allow adequate movement, and potentially, range expansion.

Holden (2000) identified five diversion structures between RM 180-140 as potential barriers to fish movement, particularly upstream movement: Fruitland Diversion (RM 178.5); Public Service Company of New Mexico Weir (PNM Weir; also known as San Juan Generating Station Weir; RM 166.6); Arizona Public Service Company Weir (APS Weir; also known as Four Corners Generating Station Weir; RM 163.3); Hogback Diversion (RM 158.6); and Cudei Diversion (RM 142.0). Ryden (2000) reported that Cudei Diversion, Hogback Diversion, and APS Weir were passable by fish at some flows but upstream movement was more restricted by PNM Weir, especially for nonnative fish. Davis and Coleman (2004) reported that fish passage at the APS Weir was likely related to flow and further modeling suggested the weir was a barrier at relatively low flows but not at high flows (Stamp et al. 2005). In the lower San Juan River near Piute Farms, a waterfall (RM 0.0) that has persisted almost continuously since 2002 is an upstream passage barrier to endangered fishes except during a brief period when it was inundated in July-August 2011 (Durst and Francis 2016). Additionally, Francis (2007) identified Animas Pump Station #2 and Farmers Ditch Diversion (located 11.9 and 21.9 river miles upstream of the San Juan River confluence, respectively) as locations in the Animas River that were at least partial barriers to upstream movement by native suckers. The Program's Long Range Plan (LRP) has identified all of these barriers in addition to other unnamed diversion structures in the Animas River as locations to provide and maintain fish passage (Program 2017a).

In 2002, the Program constructed a nonselective fish passage at Hogback Diversion and replaced Cudei Diversion with a subsurface siphon that does not impact fish movement, restoring

access to 36 miles of critical habitat (Davis and Coleman 2004). In 2003, the Program constructed a selective fish passage around the PNM Weir. Navajo Nation Department of Fish and Wildlife operates by the passage to allow native fish access to upstream habitat while removing nonnative fish from the San Juan River. The Four Corners Power Plant and Navajo Mine BO includes modification of the APS Weir to improve upstream fish passage (Service 2015). The San Juan River Navajo Irrigation Rehabilitation and Improvement Project BO includes modifications of the Fruitland Diversion Weir to provide and monitor fish passage once that diversion is refurbished (Service 2018). In 2015, the Program began experimental repatriation of Razorback Suckers collected downstream of the waterfall back to the mainstream San Juan River to determine if translocation is a feasible management action (C. Pennock 2018 personal communication). Finally, the City of Farmington modified Animas Pump Station #2 in the winter of 2017-2018 to improve boat passage with the added benefit that this modification may also increase fish passage in the Animas River.

Given the Program's reliance on these constructed passages to allow Colorado Pikeminnow and Razorback Sucker unimpeded access to all suitable habitats they could occupy, there is a need for a thorough evaluation of the effectiveness of these passages. The nonselective passage at Hogback has not been quantitatively evaluated although it was dry as recently as 19 February to 9 April 2018 (Program unpublished data) and has been anecdotally reported as dry during other periods since 2002. It is unclear whether operations of the Hogback Diversion or the design of the passage itself are related to these periods of dewatering at the nonselective fish passage. The Program needs to ensure this nonselective passage performs as was intended. The selective passage at PNM weir appeared to be an impediment to Razorback Sucker movement, but operating the passage non-selectively (i.e., open) during spring 2018 resulted in passing 164 Razorback Sucker compared to a total of 183 passed during the same season in 2011-2017 (Program unpublished data). The Program should continue to operate the PNM passage nonselectively during spring to allow Razorback Sucker access to possible spawning habitats upstream of the facility. The Program should also continue to investigate means of improving passage at other times of the year so native fishes can access upstream habitats without impediment. Razorback Sucker have been found in the Animas River as far upstream as Animas Pump Station #2 (at Animas RM 9.2) in 2015-2018 but none upstream of that partial barrier (Schleicher 2016, Schleicher 2017, Schleicher 2018; Program unpublished data). Navajo Nation Department of Fish and Wildlife passed two

adult Colorado Pikeminnow at the PNM Weir in 2018 that were later detected at Animas Pump Station #2, indicating both species can demonstrate potential spawning moments (Program unpublished data).

RECOVERY ACTION 2: SUMMARY AND RECOMMENDATIONS

The Service recommends the Program evaluate existing fish passages at Hogback and PNM, operate them to increase passage efficiency, and rehabilitate them as necessary so they function as intended. In addition, the Program should ensure assessment actions at to-be-constructed passages at Fruitland Diversion and APS Weir are included in their design. Finally, the Service recommends the Program continue investigating movement barriers at the waterfall in the most downstream portion of the San Juan River and at diversions in the most upstream reaches of occupied habitat in the San Juan and Animas Rivers. If these barriers constrain Colorado Pikeminnow and Razorback Sucker recovery, passage should be provided to allow fish to reach desired habitats. The Service recommends the Program address barriers sequentially by prioritizing those that are the most substantial impediments to recovery.

3. Minimize entrainment of subadults and adults in diversion canals/out-take structures.

In addition to blocking upstream movement of adult fish, diversion dams may also affect recruitment by entraining fish. In 2004 and 2005, numerous native and nonnative fishes, including over 200 Colorado Pikeminnow (up to 315 mm standard length [SL]), were detected in irrigation canals along the San Juan River but were most numerous in the Hogback Canal (Renfro et al. 2006). The Program constructed an experimental fish weir instead of a fish screen in the Hogback Canal in 2013. A similar structure will be built in the Fruitland Irrigation Canal in 2019 or 2020 to minimize entrainment at that diversion. A variety of controlled tests have been conducted to determine the effectiveness of the Hogback Weir in minimizing entrainment (M. McKinstry 2016 personal communication) but it is unknown how the population of Colorado Pikeminnow and Razorback Sucker in the San Juan River interact with the weir. Additionally, Lyons et al. (2016) identified a total of four and nine diversion sites within occupied habitat in the San Juan and Animas rivers (Schleicher 2018), respectively that pose some level of entrainment risk to Colorado Pikeminnow and Razorback Sucker. However, the recovery threat posed by entrainment remains unknown at this point. Since the Renfro et al. (2006) study was completed, Colorado Pikeminnow

and Razorback Sucker are more abundant in upstream reaches (Schleicher 2018), they spawn further upstream (Farrington et al. 2018), and stocking of age-0 Colorado Pikeminnow has occurred upstream of some diversions (Furr 2018), suggesting this risk has increased through time.

RECOVERY ACTION 3: SUMMARY AND RECOMMENDATIONS

The Program constructed a fish weir at Hogback and will construct another at Fruitland to minimize entrainment. In addition, the Lyons et al. (2016) study inventoried all diversion structures in the San Juan and Animas rivers. The Service recommends the Program evaluate the effectiveness of these weirs at preventing entrainment and use the Lyons et al. (2016) study to prioritize sites within occupied habitat that could pose the greatest entrainment risk. Given the length of time since the Renfro et al. (2006) study was conducted, and increases in the upstream distribution of endangered fish in the San Juan River, quantitatively assessing entrainment at high priority sites is long overdue. The Service recommends the Program screen or modify those diversions that pose to the greatest entrainment risk and thus the greatest impediment towards recovery in the San Juan River Basin.

4. Ensure adequate protection from diseases and parasites.

Landye et al. (1999) investigated lesions and other abnormalities from 1992-1997 using Flannelmouth Sucker (*Catostomus latipinnis*) and Bluehead Sucker (*Catostomus discobolus*) as surrogates for the endangered fishes in the San Juan River and there was no indication that fish health was a limiting factor for Colorado Pikeminnow or Razorback Sucker in the San Juan River (Holden 2000). Larval fish monitoring documented opercle deformities in native larval suckers (including Razorback Suckers) in 2011 (Brandenburg et al. 2012). Barkstedt et al. (2014) investigated the frequency and severity of opercle deformities using museum-archived Bluehead Sucker, Flannelmouth Sucker, and Razorback Sucker larval specimens. Deformities were more prevalent in endangered Razorback Suckers compared to the other native suckers but the source of the deformities and their effect on recruitment and recovery was unknown (Barkstedt et al. 2014). Diver (2016 personal communication) examined microbiota associated with external lesions found in multiple species in the San Juan River but the cause of disease and fish response remain unknown. Visual inspections of general fish health and condition occur during routine fish

handling and capture activities on the San Juan River. Any increase in abnormalities will trigger an investigation to determine the threat of disease and parasites.

RECOVERY ACTION 4: SUMMARY AND RECOMMENDATIONS

At this time, the Service considers the recovery threat posed by disease and parasites to be minimal. The Service recommends no further management actions to ensure endangered fishes have adequate protection from disease and parasites. Visual inspections of endangered fishes continue as part of routine monitoring activities. Any indication of poor health of endangered fishes will be logged and reported. If the Program finds that indicators of poor health are a concern or an impediment to recovery, the Program should identify the causes and recommend corrective actions.

5. Regulate nonnative fish releases and escapement into the San Juan River, floodplain, and tributaries.

The States of Colorado and New Mexico continue to work on a draft "Cooperative Agreement for Implementation of Procedures for Stocking Nonnative Fish Species in the San Juan River Basin" initially developed by the Service (Region 6) in February 2009. The Service (Regions 2 and 6) provided comments in June 2018 on latest version of the draft document completed by New Mexico in March 2018. Once comments are incorporated, the agreement will be distributed to partners for review and signatures.

Lake Nighthorse is an off-channel reservoir to the Animas River that was filled with water pumped from the Animas River in 2011. The Service anticipated nonnative fish becoming established in the reservoir, thus Reclamation constructed a sleeve-valve as part of the outlet works to prevent escapement of any nonnative fish life stages (Bark et al. 2013). Additionally, Reclamation's monitoring plan will determine if nonnative fish are escaping from the reservoir and Reclamation will develop a management plan to address potential escapement or the establishment of problematic nonnative fish species in Lake Nighthorse.

As part of the Four Corners Power Plant and Navajo Mine BO (Service 2015), Four Corners Power Plant constructed a wedgewire screen at the outlet of Morgan Lake to minimize escapement of nonnative fish to the San Juan River (H. Day 2018 personal communication). In addition, Four Corners Power Plant developed public education materials for recreational users of

Morgan Lake informing them of the threat of new nonnative species being introduced to Morgan Lake and the threat of transferring nonnative species from Morgan Lake to the San Juan River.

RECOVERY ACTION 5: SUMMARY AND RECOMMENDATIONS

The Program's efforts to finalize a cooperative agreement for stocking nonnative fish species in the San Juan River Basin and construct escapement barriers for Lake Nighthorse and Morgan Lake are positive steps to regulate nonnative fish releases and escapement into the San Juan River, floodplain, and tributaries. While other sources of nonnative fish escapement likely exist within the San Juan River Basin, the Service has no further recommendations to address nonnative fish release and escapement apart from finalizing the draft "Cooperative Agreement for Implementation of Procedures for Stocking Nonnative Fish Species in the San Juan River Basin."

6. Control problematic nonnative fishes as needed.

The Program began limited mechanical removal of nonnative fish prior to 1999 and intensive removal of nonnative fish via raft electrofishing started in the upper and lower portions of the San Juan River since 2001 and 2002, respectively (Duran 2014, Hines 2014). In 2006, the Program expanded nonnative fish removal from Shiprock, New Mexico to Mexican Hat, Utah to remove nonnative fish from a greater proportion of critical habitat. The Program held a technical workshop in May 2010 to review and assess the nonnative fish control program and make recommendations on how to effectively reduce the threat of nonnative species. Workshop participants endorsed the current level of nonnative fish removal effort and recommended implementing a river-wide Channel Catfish (*Ictalurus punctatus*) marking trip in order to generate population and exploitation estimates (Program 2011). In 2016 and 2017, the Program implemented an experimental design that included paired removal and control (i.e., with no removal) reaches from Shiprock, New Mexico to Mexican Hat, Utah to evaluate the effect of nonnative removal on Channel Catfish, Colorado Pikeminnow, and Razorback Sucker. The results indicated a reduction in the Channel Catfish size structure in a year with minimal Channel Catfish movement, but changes in Channel Catfish or endangered fishes catch rates or populations could not be attributed to experimental removal efforts. Using Fishery Analysis and Modeling Simulator (FAMS), Pennock et al. (2018) estimated the size-specific exploitation rates where Channel Catfish growth and recruitment over-fishing occur and how much Channel Catfish total number

and biomass is reduced at variable size-specific exploitation rates. Modeled results indicated Channel Catfish exploitation rates of ~25% at 275 mm total length (TL) are needed to "crash" the population. Prior to 2016, exploitations rates at 275 mm TL were ~ 15% but in 2016 Channel Catfish exploitation was 57% and 49% for juveniles and adults, respectively (Duran et al. 2018). Since the 1990s Channel Catfish size structure has decreased and since 2006 when the Program implemented river-wide removal, Channel Catfish densities have become more variable. The effect of Channel Catfish on endangered fish recovery remains unclear despite modeled reductions in Channel Catfish abundance and biomass of 30% and 65%, respectively, compared to unexploited populations. Nonnative removal efforts in 2018 and 2019 focus on supporting a Program-funded study to assess Channel Catfish consumption rates of endangered fish. Quantifying the threat posed by Channel Catfish predation will allow the Program to conduct nonnative fish management commensurate with the level of that threat, an important step toward the ability to weigh potentially competing management activities.

RECOVERY ACTION 6: SUMMARY AND RECOMMENDATIONS

The Service has no further recommendations to improve the Program's nonnative removal efforts in the San Juan River. The Program implemented an experimental design in 2016 and 2017 evaluating the effects of nonnative removal was an important step leading to the Program's current assessment of Channel Catfish predation on Colorado Pikeminnow and Razorback Sucker. Once this study is completed, the Program's nonnative management can proceed commensurately with the level of predatory threat these species pose to endangered fish recovery.

7. Minimize the risk of hazardous-materials spills in critical habitat.

Specific tasks outlined in the 2002 Recovery Goals (Service 2002a, Service 2002b) to address the risk of hazardous spills within critical habitat were reiterated in the 2006 Service draft assessment of the Program and the 2010 and 2013 final Service review and assessment of the Program (Service 2006, Service 2010, Service 2013). These tasks included: (1) review and recommend modifications to State and Federal hazardous-materials spills emergency-response plans to ensure adequate protection for Colorado Pikeminnow and Razorback Sucker populations from hazardous-materials spills, including prevention and quick response to hazardous-materials spills; (2) implement State and Federal emergency-response plans that contain the necessary

preventive measures for hazardous-materials spills; (3) identify the locations of all petroleum-product pipelines within the 100-year floodplain of critical habitat; and, (4) assess the need and install emergency shut-off valves on problematic petroleum-product pipelines within the 100-year floodplain of critical habitat to minimize the potential of spills. TNC, a program participant, conducted a San Juan River Basin-wide geographical information system (GIS) hazardous materials threat assessment that included among other factors; identifying oil and gas well locations within the floodplain and an analysis of pipeline and highway spill risk based on their proximity to San Juan River drainages or floodplains (Wood 2013). Finally, Four Corners Power Plant developed a spill contingency plan to address a potential ash pond failure as a conservation measure for the Four Corners Power Plant and Navajo Mine BO (Service 2015).

RECOVERY ACTION 7: SUMMARY AND RECOMMENDATIONS

The Service recommends the Program use the information developed by Wood (2013) to complete specific actions identified in Recovery Goals for minimizing the risks of hazardous-material spills within critical habitat (Service 2002a, Service 2002b). Having specific actions outlined in a detailed plan may provide a clearer Program response in the event of a hazardous material spill such as the Gold King Mine spill that occurred August 5, 2015. As a conservation measure for the Four Corners Power Plant and Navajo Mine BO (Service 2015), the project proponent developed a spill contingency plan to address potential ash pond failure that includes periodic table-top exercises to provide emergency response in the event of a potential ash pond failure (Arizona Public Service 2017).

8. Remediate water quality problems.

Mercury is a bioaccumulating neurotoxin that affects the reproductive health of piscivorous fish such as Colorado Pikeminnow (Crump and Trudeau 2009) and high selenium levels in Razorback Sucker can result in shedding excess dietary selenium in their eggs leading to high embryo mortality (Lemly 2002). The Four Corners Power Plant and Navajo Mine BO (Service 2015) stipulates conservation measures, RPMs, and terms and conditions to promote recovery of Colorado Pikeminnow and Razorback Sucker in the San Juan River related to water quality issues. This includes funding to study mercury effects on Colorado Pikeminnow and monitoring mercury and selenium concentrations in endangered fish in the San Juan River. In addition, the Bureau of

Indian Affairs (BIA) funded a selenium effects study on Razorback Sucker that is being completed at the time of this writing. As part of the proposed action described in the San Juan River Navajo Irrigation Rehabilitation and Improvement Project BO (Service 2018), BIA proposed a study to quantify the selenium load returned to the San Juan River from the Hogback-Cudei and Fruitland-Cambridge irrigation systems to help determine if further remediation of these systems is necessary. Finally, Office of Surface Mining Reclamation and Enforcement (OSMRE) committed to working with the Environmental Protection Agency (EPA) to develop guidelines and criteria for ESA review of National Pollutant Discharge Elimination.

RECOVERY ACTION 8: SUMMARY AND RECOMMENDATIONS

The Service has concerns with levels of mercury and selenium found in the tissues of Colorado Pikeminnow and Razorback Sucker in the Upper Colorado River Basin because of potential reproductive impairment (Service 2015). However, the Service is supportive of the Program's efforts to monitor these contaminants in the endangered fish and conduct a selenium effects study for Razorback Sucker and a mercury effects study for Colorado Pikeminnow to understand their impact on fishes' reproductive output. The Service recognizes that remediation of these contaminants is beyond the scope and capabilities of the Program and will require the assistance and actions by other Federal and State agencies. The conservation measures, RPMs, and terms and condition of future BOs related to water quality issues within the San Juan River Basin will address specific management actions to minimize and further understand the effects of mercury and selenium on Colorado Pikeminnow and Razorback Sucker.

The Service supports the Program's efforts in: (1) coordinating the development of a comprehensive contaminants monitoring plan for the San Juan River; (2) identifying the effects of contaminants on recovery of endangered fish; and (3) providing assistance in developing recommended water quality criteria for problematic contaminants for consideration by State and Federal water quality regulatory agencies when adopting enforceable water quality standards. The Program will consult with the Biology Committee, contaminant biologists, fish toxicologists, and management and policy expertise will be consulted to develop the monitoring plan and will ensure coordination between the Service's Regions 2 and 6 and with the Upper Colorado River Endangered Fish Recovery Program.

9. Reestablish populations with hatchery-produced fish.

In 2002, the Program developed an augmentation plan to guide Colorado Pikeminnow stocking in the San Juan River (Ryden 2003b). A Phase II stocking plan shifted all augmentation efforts to production and stocking of ≥ 400,000 age-0 Colorado Pikeminnow (Furr and Davis 2009) based on the relative cost and return rates of age-0 versus age-1+ Colorado Pikeminnow (Durst 2009). Thus, only age-0 Colorado Pikeminnow are currently stocked in the San Juan River Basin. Colorado Pikeminnow annual stocking goals have typically been met (Table 4), however, few adult Colorado Pikeminnow are typically captured suggesting limited post-stocking survival (Durst 2015). The Program has not evaluated the Colorado Pikeminnow augmentation program due to the logistical difficulty and expense in marking age-0 fish. However, efforts to batch-mark age-0 Colorado Pikeminnow are being explored to facilitate this assessment.

After experimental stocking of endangered fishes during 1991-1997, the Program developed an augmentation plan for Razorback Sucker (Ryden 1997). An addendum to the augmentation plan for Razorback Sucker, completed in 2003, guided stocking efforts from 2004-2011 (Ryden 2003a), and in May 2005, a second addendum was proposed to push back the starting date of the 8-year Razorback Sucker stocking plan until 2009 so measures to improve production could be implemented. Currently, Razorback Sucker are stocked from grow-out ponds at Navajo Agricultural Products Industry (NAPI) and Horsethief Canyon Native Fish Facility (Horsethief) to meet the Program's annual augmentation goals of 11,400 fish. Annual stocking goals and augmentation plan goals have typically been met for Razorback Sucker (Table 5). The Program is developing a revised draft augmentation plan for Razorback Sucker to guide the Program's stocking efforts starting in 2018 (Furr 2017). Analyses and experimental efforts are on-going to increase the efficiency of the Razorback Sucker stocking program and guide future augmentation plans. Success of the Razorback Sucker stocking program in the future will not simply be based on attaining annual augmentation goals. To establish a self-sustaining Razorback Sucker population based on hatchery-reared fish, the fish must retain, persist, spawn, and recruit in the San Juan River following stocking.

Of all the management actions to recover Colorado Pikeminnow and Razorback Sucker in the San Juan River, stocking with hatchery-produced fish has led to the largest population responses because of its direct impact on increasing numbers of endangered fishes (Durst 2015). However, because both species are long-lived, it may take many years to determine if the

Program's stocking activities will ultimately be successful. Nevertheless, populations of hatchery-reared Colorado Pikeminnow and Razorback Sucker have increased in the San Juan River through time because of stocking efforts (Franssen et al. 2016). Annual monitoring of larval fish indicates that both Colorado Pikeminnow and Razorback Sucker are reproducing; however, there has been no evidence of endangered fishes recruiting into the adult population for either species. Nevertheless, the Program has recent evidence of wild-produced fish surviving to juvenile life-stages (Zeigler and Ruhl 2017).

RECOVERY ACTION 9: SUMMARY AND RECOMMENDATIONS

The Program is meeting annual and longer-term stocking goals for Colorado Pikeminnow and Razorback Sucker. The Service views analyses and experiments to improve the efficiency of augmentation efforts as important steps to maximize the recovery benefit of this management action. However, in moving forward with augmentation plans for Colorado Pikeminnow and Razorback Sucker, because not all stocking events are equal, a more meaningful metric to evaluate the success of the Program's augmentation efforts should be based on the numbers of stocked fish that persist, spawn, and ultimately produce wild-offspring that recruit to adulthood. Basing the success of augmentation efforts simply on the number of fish stocked on a yearly basis or over some defined time is misleading if those stocked individuals do not contribute to the establishment of a wild-populations of Colorado Pikeminnow and Razorback Sucker in the San Juan River Basin.

Table 4. Age-0 and Age-1+ Colorado Pikeminnow annually stocked in the San Juan and Animas rivers. Annual stocking goals for age-0 and age-1+ Colorado Pikeminnow are also included.

	Age-0		Age-1+	
Year	Number stocked	Stocking goals	Number stocked	Stocking goals
2002	210,418	250,000	0	
2003	175,928	300,000	1,005	
2004	280,000	300,000	1,219	
2005	302,270	300,000	4,541	
2006	313,854	300,000	12,693	3,000
2007	475,970	300,000	3,256	3,000
2008	270,234	300,000	4,857	3,000
2009	468,000	300,000	6,000	3,000
2010	0	300,000	353	3,000
2011	426,588	400,000	218,444	
2012	395,640	400,000	0	
2013	439,264	400,000	0	
2014	393,442	400,000	429	
2015	402,087	400,000	0	
2016	433,963	400,000	1,520	

Table 5. Number of Razorback Sucker stocked in the San Juan and Animas Rivers 1997-2015. A 5-year augmentation effort was implemented in 1997 calling for stocking a total of 73,482 fish but no annual goals (Ryden 1997). During an interim stocking period (2002-2008), annual stocking goals were 11,400 fish > 300 mm TL but there was no goal for the entire period. An 8-year augmentation effort started in 2009 called for stocking a total of 91,200 fish or 11,400 fish annually (Ryden 2003a). The two plan total numbers represent the number of Razorback Sucker actually stocked and stocking goals for 1997-2001, 2002-2008, and 2009-2015. In 2006 and 2007 a total of 10,959 Razorback Suckers were stocked in the San Juan River without PIT tags. These fish are not included in the table. A total of 4,021 Razorback Sucker stocked in 2010 were part of the 2009 stocking effort. In 2012 a total of 2,295 Razorback Sucker stocked as a group where high mortality was observed are not included in the table.

	Number stocked		Stocking goals	
Year	**Annual**	**Plan total**	**Annual**	**Plan total**
1997	2,883			
1998	1,275			
1999	0	5,890		73,482
2000	1,044			
2001	688			
2002	140		11,400	
2003	887		11,400	
2004	2,979		11,400	
2005	1,993	41,093	11,400	
2006	13,764		11,400	
2007	16,906		11,400	
2008	4,424		11,400	
2009	8,316		11,400	
2010	28,419		11,400	
2011	18,782		11,400	
2012	13,516	103,413	11,400	91,200
2013	15,341		11,400	
2014	6,165		11,400	
2015	5,208		11,400	
2016	7,666		11,400	

10. Minimize the threat of hybridization with White Sucker.

The Program evaluated the degree of Razorback Sucker hybridization using DNA-based genetic markers on larval fish (Turner et al. 2002). Of 61 total fish screened, Turner et al. (2002) detected only two hybrids; both were Flannelmouth – Bluehead Sucker crosses. None of the eight Razorback Sucker screened indicated there was any evidence of White Sucker-Razorback Sucker hybridization (Turner et al. 2002).

There is currently no regular genetic analysis of Razorback Sucker in the San Juan River, but morphological hybrids detected visually during routine monitoring activities are noted. White Suckers are removed during monitoring, nonnative fish control, and other Program activities on the San Juan River. Annual monitoring suggests that White Suckers and their hybrids are rare in the San Juan River (Table 6) but the reliability of visually detecting hybrids is unknown.

Table 6. Catch-rates (fish/hour) of White Sucker, White Sucker – Flannelmouth Sucker hybrids, and White Sucker – Bluehead Sucker hybrids compared three native suckers based on standardized electrofishing monitoring efforts, 1991-2016 from RM 180-77.

	Catch per unit effort (fish/hour)					
YEAR	White Sucker	White-Flannelmouth Sucker	White-Bluehead Sucker	Razorback Sucker	Flannelmouth Sucker	Bluehead Sucker
1991	0.0	0.0	0.0	0.0	123.1	23.5
1992	0.0	0.0	0.0	0.0	165.8	33.5
1993	0.0	0.0	0.0	0.0	109.5	22.5
1994	0.0	0.0	0.0	0.0	101.8	15.1
1995	0.0	0.0	0.0	0.1	81.7	16.5
1996	0.0	0.0	0.0	0.1	71.0	19.8
1997	0.0	0.0	0.0	0.1	60.8	24.6
1998	0.0	0.0	0.0	0.1	62.9	21.7
1999	0.0	0.1	0.1	0.1	95.5	40.6
2000	0.1	0.0	0.0	0.1	117.1	41.3
2001	0.0	0.1	0.0	0.1	88.7	22.3
2002	0.1	0.0	0.0	0.3	71.5	40.6
2003	0.0	0.1	0.0	0.3	58.7	28.2
2004	0.1	0.2	0.0	2.1	94.4	29.8
2005	0.0	0.0	0.0	1.0	101.8	54.0
2006	0.0	0.0	0.1	2.4	73.0	35.4
2007	0.1	0.1	0.0	3.4	53.9	29.5
2008	0.1	0.0	0.1	1.2	55.2	26.3
2009	0.0	0.0	0.1	1.3	75.5	26.4
2010	0.1	0.1	0.0	2.7	99.3	37.7
2011	0.1	0.0	0.0	4.0	81.6	25.4
2012	0.1	0.1	0.0	5.9	98.1	39.5
2013	0.0	0.0	0.0	4.5	97.2	43.5
2014	0.1	0.1	0.0	4.4	85.5	26.0
2015	0.0	0.1	0.0	4.7	64.5	14.8
2016	0.1	0.1	0.0	5.6	57.0	14.8

RECOVERY ACTION 10: SUMMARY AND RECOMMENDATIONS

Given the rarity of White Sucker and their hybrids in the San Juan River, the Service does not consider the current threat level of this species to be substantial to warrant further management. However, further genetic research coupled with morphometric analysis would likely provide a better assessment of the degree of White Sucker hybridization present in the San Juan River.

POSITIVE POPULATION RESPONSE CRITERIA

As part of the Animas-La Plata BO (Service 2000), Reclamation committed to operating Navajo Dam to mimic a natural hydrograph and to developing Positive Population Response Criteria to evaluate the response of endangered Colorado Pikeminnow and Razorback Sucker to management actions. These criteria are specific to the San Juan River and designed to assess incremental improvement in the Colorado Pikeminnow and Razorback Sucker population status prior to attaining Recovery Goals (Service 2002a, Service 2002b). These criteria established expectations for improvements in Colorado Pikeminnow and Razorback Sucker population demographics and were intended to determine whether the stocked fish are capable of any of the following: (1) attaining adult size; (2) successfully reproducing and recruiting to young-of-year (YOY) age classes; or (3) re-colonizing newly opened reaches of river. The criteria were developed in consultation with the Program's Biology Committee and are divided into two parts, the Interim Response Criteria (2002-2006) and subsequent Positive Population Criteria (2007-2011) that build upon metrics in the earlier criteria (Reclamation 2001).

The Interim Response Criteria developed for 2002-2006 were met for both species. For the Colorado Pikeminnow, these short-term criteria were: (1) collection of greater than 10 individuals larger than 350 mm during a standardized monitoring trip; (2) presence of wild larvae or YOY individuals in standardized monitoring collections in two of five years; and (3) range expansion above Hogback Diversion. The Interim Response Criteria for Razorback Sucker were: (1) collection of more than 20 individuals larger than 300 mm during the annual fall standardized monitoring trip; (2) collection of greater than 0.15 individuals per hour of electrofishing larger than 300 mm; and (3) evidence of reproduction in standardized monitoring in at least two of five years.

The Positive Population Response Criteria developed for 2007-2011 builds on the Interim Response Criteria developed for 2002-2006. These criteria established expectations for

improvements in Colorado Pikeminnow and Razorback Sucker population demographics. The previous version of the Sufficient Progress Report (Service 2013) assessed the entire 2007-2011 period of the Positive Population Response Criteria and are reiterated and summarized below.

For Colorado Pikeminnow, the Positive Population Response Criteria were: (1) collection of greater than 10 individuals larger than 450 mm during a standardized monitoring trip; (2) positive trend in adult and sub-adult catch per unit effort (CPUE; fish/hour) during a standardized monitoring trip or river-wide population estimate of 400 adults (≥ 450 mm TL); (3) presence of wild larvae or YOY individuals in standardized monitoring collections in three of five years; (4) larval density of 0.67/1000 m^3 in standardized drift net monitoring or wild YOY density of 0.5/100 m^2 in standardized monitoring; and (5) range expansion above Hogback Diversion. The Positive Population Response Criteria called for all five Colorado Pikeminnow criteria to be met to indicate a positive population response. Only the criteria documenting frequency of reproduction and range expansion for Colorado Pikeminnow were attained during 2007-2011. While the Program conducted management actions with the expectation of a positive population response by Colorado Pikeminnow, all anticipated criteria were not met, particularly those based on sufficient numbers of adult Colorado Pikeminnow (i.e., reproductive output and population size).

Positive Population Response Criteria for Razorback Sucker were: (1) collection of greater than 80 individuals larger than 400 mm during a standardized monitoring trip or adult (> 400 mm TL) CPUE greater than 0.6 fish/hour during a standardized monitoring; (2) river-wide adult population estimate of 2,900 fish; (3) presence of wild larvae in at least three of five years; and (4) range expansion above Hogback Diversion. Only two of the Positive Population Response Criteria for Razorback Sucker needed to be attained to indicate a positive population response. All Razorback Sucker positive population response criteria during 2007-2011 have been met except the criterion for a river-wide adult Razorback Sucker population estimate of 2,900 individuals (although the point estimate in 2011 was 2,827; 95% confidence interval [CI]: 1,841-4,460 from RM 147.9-77.0; Figure 4).

The Animas-La Plata BO indicates that if flow recommendations and other recovery actions did not result in positive population responses for both endangered species within the time frame established in these criteria, reinitiation of section 7 consultation may be required (Service 2000). Reclamation (2001) recommended the Positive Population Response Criteria be reviewed every five years in conjunction with the review of the Program's monitoring data. The Service

considered the quantitative metrics in the 2002-2006 Interim Response Criteria and 2007-2011 Positive Population Response Criteria useful as part of earlier review and assessments of the Program (Service 2010, Service 2013). However, the Program has not developed positive population response criteria covering any period after 2011. Any revised positive population response criteria should focus on documenting recruitment of wild-spawned Colorado Pikeminnow and Razorback Sucker into adult age-classes because alleviation of recruitment bottlenecks is necessary to achieve self-sustaining populations in the San Juan River Basin.

POSITIVE POPULATION CRITERIA: SUMMARY AND RECOMMENDATIONS

The Interim Response Criteria for 2002-2006 were attained for Colorado Pikeminnow and Razorback Sucker, and the 2007-2011 Positive Population Response Criteria were met for Razorback Sucker but not for Colorado Pikeminnow. Although not all anticipated metrics detailed in the Positive Population Response Criteria have been attained, the Program conducts its management actions with the expectation that the endangered fish populations will respond positively and the status of Colorado Pikeminnow and Razorback Sucker in the San Juan River is certainly more positive based on the Program's recovery management actions. Recent research efforts identify bottlenecks that impede early life stage recruitment the Program must alleviate to improve prospects for recovery.

RECOVERY DEMOGRAPHIC CRITERIA FOR DOWNLISTING AND DELISTING BOTH SPECIES

The Service used the demographic criteria for downlisting and delisting in the Recovery Goals as measureable and objective benchmarks to assess the Program's progress toward recovery. For Colorado Pikeminnow in the San Juan River Basin, downlisting criterion call for 1,000 age-5+ Colorado Pikeminnow established through augmentation or natural reproduction and the delisting criterion is a population of 800 self-sustaining adults (Service 2002a). These target numbers for Colorado Pikeminnow are based on inferences about the carrying capacity of the San Juan River Basin (Service 2002a). The Razorback Sucker Recovery Goals target a population of 5,800 self-sustaining adults in the San Juan River for five years to meet the downlisting criterion and an additional three years beyond downlisting for the delisting criterion (Service 2002b). The

5,800 Razorback Sucker target is based on the estimated minimum population needed to ensure long-term genetic and demographic viability (Service 2002b).

Population estimates for Colorado Pikeminnow and Razorback Sucker were calculated for 2011-2015 based on capture data from four or five sampling passes conducted each year from nonnative fish removal and fall monitoring data from RM 147.9-77.0 (Program 2017b). Population estimates for 2016 were only from three sampling passes in nonnative removal reaches from RM 147.9-52.9 (so only captures and recaptures from half of these 95 river miles was used for analysis, i.e. 47.5 river miles). Estimates were conducted for Colorado Pikeminnow > 300 mm TL (all subsequent fish lengths are based on TL) and > 450 mm and Razorback Sucker > 400 mm, corresponding to age classes specified in each species' recovery goals (i.e., age-5+ Colorado Pikeminnow > 300 mm, adult Colorado Pikeminnow > 450 mm, and adult Razorback Sucker > 400 mm).

The estimated numbers of Colorado Pikeminnow was generally lower for fish > 450 mm compared to fish > 300 mm each year (Figure 3). Point estimates for Colorado Pikeminnow > 300 mm among all years ranged between 128 and 1,779 with an estimate of 128 (39-636, 95% CI) in 2016. While 16 fish > 450 mm were collected in 2013, none of these fish were recaptured, precluding population estimates for adult fish in 2013. Although, there was one recapture of five Colorado Pikeminnow > 450 mm in 2016, abundance could not be estimated for this group. Estimates for the numbers of Razorback Sucker > 400 mm were substantially higher compared to both size classes of Colorado Pikeminnow and numbers of individuals ranged between 655-3,032 among 2011-2016 (Figure 4). The estimate for adult Razorback Sucker in 2016 was 655 fish (473-954; 95% CI) but was 3,032 (2,297-4,074; 95% CI) in 2015 when a longer reach of the San Juan River was sampled. However, because the number of sampling passes and spatial extent of the sampling area was not consistent in 2016 compared to 2011-2015, assessing trends in Colorado Pikeminnow and Razorback Sucker abundance estimates through time is difficult.

The above abundances are likely minimum estimates because both Colorado Pikeminnow and Razorback Sucker were found in the San Juan River Basin outside of river miles sampled for those efforts. Juvenile Colorado Pikeminnow population estimates conducted from 2004-2015 in the San Juan River downstream of Mexican Hat, Utah ranged from 68-1,452 individuals (RM 52.9-2.9; Hines 2016). Francis et al. (2015) estimated 527 (248-1,311; 95% CI) Razorback Suckers in 2012 from Zahn Bay to Paiute Canyon in Lake Powell (approximately 20 miles of lake habitat).

Additionally, Cathcart et al. (2018) reported a minimum Razorback Sucker population of 755 individuals using the area just downstream of the waterfall in 2017 but too few Colorado Pikeminnow were encountered to provide an abundance estimate.

The delist criterion for Colorado Pikeminnow includes provisions for a self-sustaining population (i.e., entirely wild-spawned and not hatchery-supported). At the target number of 800 adult (age-7+) Colorado Pikeminnow in the San Juan River and estimated adult annual survival rate (0.82; Table 6; Miller 2018), 144 adult fish would be lost to mortality each year (800 adults × (1 – 0.82 annual survival)). The average annual number of wild-spawned sub-adults (age-6) Colorado Pikeminnow recruits to replace adult mortality is 206 (144 annual adult mortalities / 0.70 age-6 annual survival; Table 6; Miller 2018). During adult monitoring from 2012-2016, an annual median of three (range: 1-4) sub-adult Colorado Pikeminnow were collected although none of these fish were wild-spawned (Schleicher 2017). Using Colorado Pikeminnow (> 300 mm TL) mean detection probability during adult monitoring (0.042; Table 7) and the portion of the river sampled during adult monitoring (0.607; RM 196.0-77.0), an estimated 118 age-6 were present river-wide (annual median three sub-adults / 0.042 detection probability / 0.607 river sampled). However, none of the sub-adult Colorado Pikeminnow captured in the San Juan River are thought to be wild-spawned (Schleicher 2018). Notably, wild-spawned YOY Colorado Pikeminnow captured in the San Juan River in 2016 and 2017 (23 and five individuals, respectively; Zeigler et al. 2018) represent an important step toward the establishment of a self-sustaining population.

Both the downlist and delist criteria for Razorback Sucker in the San Juan River indicate the population target of 5,800 adults (age-4+) be self-sustaining (i.e., entirely wild-spawned and not hatchery-supported). At the adult Razorback Sucker population target for the San Juan River and estimated adult annual survival rate (0.81; Program unpublished data), 1,102 adult fish would be lost to mortality each year (5,800 adults × (1 – 0.81 annual survival)). A self-sustaining Razorback Sucker population of that size would require on average 1,360 sub-adult (age-3) recruits assuming sub-adults and adults have the same annual survival rate (1,102 annual adult mortalities / 0.81 age-3 annual survival). During adult monitoring from 2012-2016, an annual median of 61 (range: 12-152) age-2 to age-4 Razorback Sucker were collected (Schleicher 2017). Because multiple age cohorts of Razorback Sucker were stocked in some years, it was not always possible to distinguish age-3 from age-2 or age-4 fish in the San Juan River. Using Razorback Sucker (< 400 mm TL) mean detection probability during adult monitoring (0.023; Table 8) and the portion

of the river sampled during adult monitoring (0.607; RM 196.0-77.0), an estimated 4,369 sub-adults were present river-wide (annual median 61 sub-adults / 0.023 detection probability / 0.607 river sampled). However, none of the sub-adult Razorback Sucker captured in the San Juan River are thought to be wild-spawned (Schleicher 2018). Encouragingly, a total of 54 wild-spawned YOY Razorback Sucker were captured across all sampling efforts in San Juan River in 2018, the highest number ever observed (Program unpublished data), representing an important step toward the establishment of a self-sustaining population.

Figure 3. Mean (95% CI) estimates of the number of Colorado Pikeminnow by size class from Shiprock, New Mexico to Bluff, Utah (RM 147.9-77.0) 2011-2015 and nonnative removal treatment reaches from Shiprock, New Mexico to Mexican Hat, Utah (RM 147.9-52.9; sampling only 47.5 river miles) in 2016. Numbers of adult (>450 mm TL) Colorado Pikeminnow in 2013 and 2016 could not be estimated.

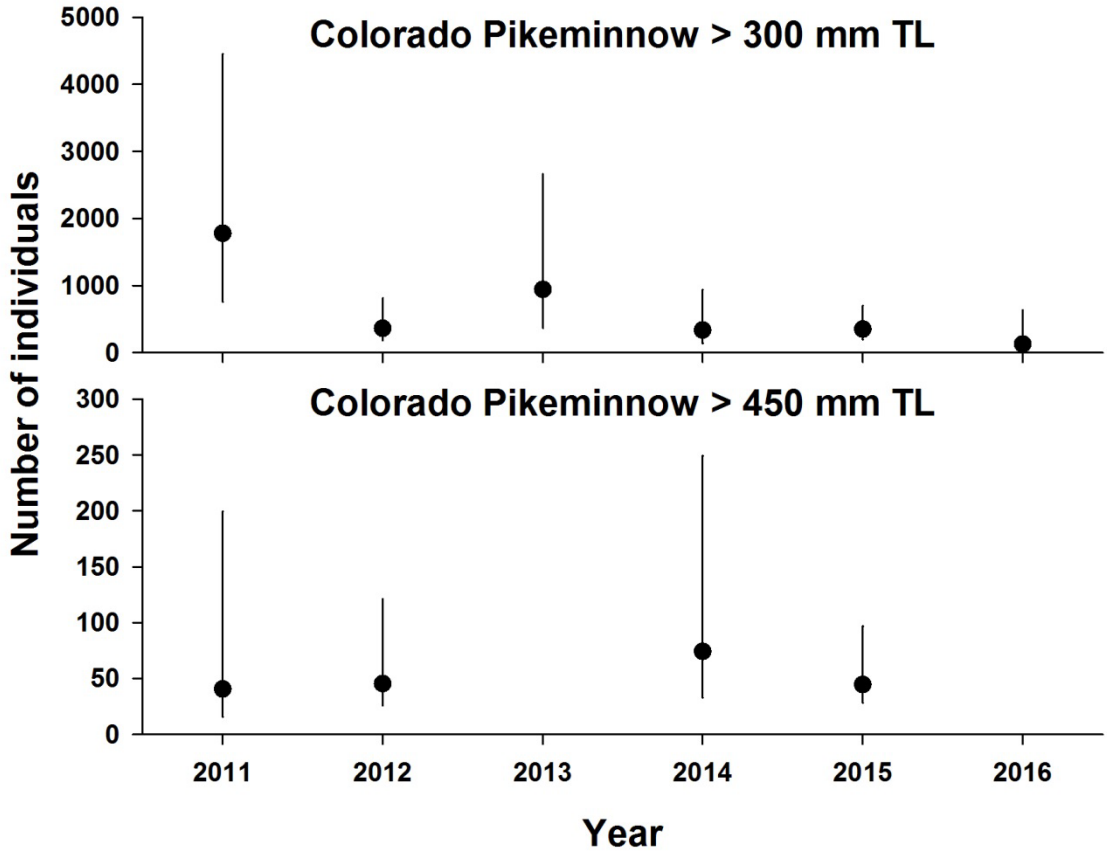


Table 6. Age-specific mean annual survival rates for Colorado Pikeminnow used in the Population Viability Analysis for the San Juan subbasin (Miller 2018).

Age	Survival
0-1	0.10
1-2	0.20
2-3	0.30
3-4	0.40
4-5	0.50
5-6	0.60
6-7	0.70
7+	0.82

Figure 4. Mean (95% CI) estimates of the number of adult Razorback Sucker (> 400 mm TL) from Shiprock, New Mexico to Bluff, Utah (RM 147.9-77.0) 2011-2015 and nonnative removal treatment reaches from Shiprock, New Mexico to Mexican Hat, Utah (RM 147.9-52.9; sampling only 47.5 river miles) in 2016.

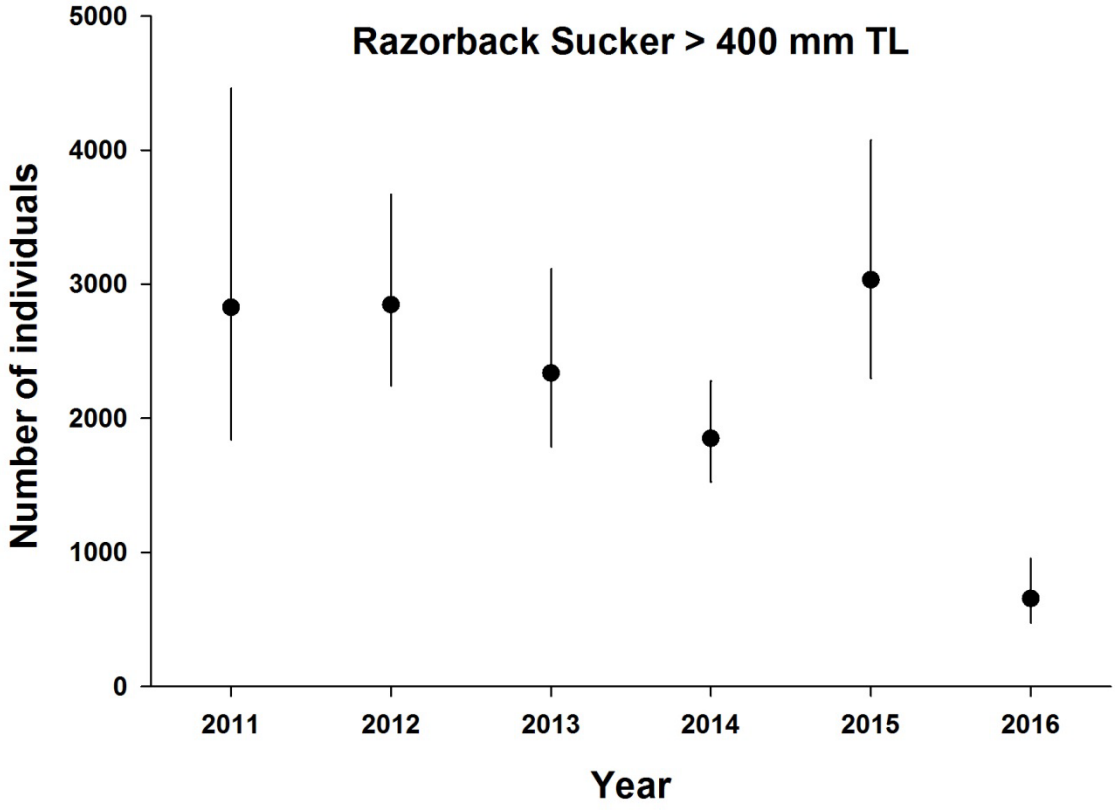


Table 7. Mean detection probability of Colorado Pikeminnow > 300 mm TL during standardized adult monitoring, 2011-2015. Lower and upper 95% confidence intervals around the annual mean are also presented along with the overall mean of annual means and overall mean of the lower and upper confidence intervals.

Year	Detection probability	Lower 95%	Upper 95%
2011	0.021	0.008	0.056
2012	0.053	0.021	0.128
2013	0.035	0.011	0.106
2014	0.063	0.020	0.183
2015	0.037	0.016	0.086
Mean	0.042	0.015	0.112

Table 8. Mean detection probability of Razorback Sucker < 400 mm TL during standardized adult monitoring, 2011-2015. Lower and upper 95% confidence intervals around the annual mean are also presented along with the overall mean of annual mean and overall mean of the lower and upper confidence intervals.

Year	Detection probability	Lower 95%	Upper 95%
2011	0.010	0.004	0.018
2012	0.010	0.005	0.016
2013	0.022	0.004	0.109
2014	0.026	0.014	0.046
2015	0.051	0.029	0.087
Mean	0.023	0.011	0.055

RECOVERY DEMOGRAPHIC CRITERIA: SUMMARY AND RECOMMENDATIONS

The Program's augmentation efforts have greatly increased the numbers of both endangered Colorado Pikeminnow and Razorback Sucker in the San Juan River Basin. Ryden (2000) estimated that there were fewer than 50 adult Colorado Pikeminnow in the San Juan River in any given year from 1991-1997. In 2000, it was estimated that there were 19 wild adult Colorado Pikeminnow in the San Juan River from RM 136.6-119.2 (10-42; 95% CI; Ryden 2000). Furthermore, no wild Razorback Suckers were found during 1991-1997 (Holden 2000). A Schnabel multiple-census population model for stocked Razorback Sucker from RM 158.6-2.9 estimated that there were 268 Razorback Suckers in October 2000 (Ryden 2001) and approximately 1,200 in October 2004 (Ryden 2005). As evident from recaptures of hatchery-reared individuals, the Program successfully increased the number of individual endangered fish in the system and demonstrated that hatchery-reared fish survive and grow in the San Juan River Basin (Program 2017b). However, augmentation, by its very nature, bypasses many stages of mortality faced by a fish population in an ecosystem; making augmented individuals and

populations relatively less fit compared to wild counterparts (Clarke et al. 2016). A level of spawning and recruitment needed to attain and maintain self-sustaining populations is currently not evident and the overarching goal of the Program is to restore self-sustaining populations of Colorado Pikeminnow and Razorback Sucker in the San Juan River. Thus, while some demographic downlist and delist criteria have been attained for Colorado Pikeminnow and Razorback Sucker in the San Juan River, the Service recommends that the Program continue to prioritize the identification and amelioration of impediments to wild recruitment to attain self-sustaining populations in the San Juan River Basin.

CONCLUSION AND RECOMMENDATIONS

The Service applauds the Program participants' cooperation in carrying out beneficial recovery actions for Colorado Pikeminnow and Razorback Sucker in the San Juan River Basin. Additionally, Program participants' efforts in securing annual funding to carry out necessary activities have been critical to ensure progress toward Colorado Pikeminnow and Razorback Sucker recovery. The Program's ability to provide ESA compliance is based on the entirety of Service's evaluation of the Program's cumulative activities, status of the endangered fishes, provision of adequate flows, and magnitude of water development projects. The Service considers the Program's overall progress toward recovery of Colorado Pikeminnow and Razorback Sucker within the San Juan River Basin to be sufficient for the Program to continue as the ESA compliance mechanism for water development, management, and operations within the San Juan River Basin. The Program's actions and tasks in carrying out management activities in the 2002 Recovery Goals are being satisfactorily met, such that the Program will continue to serve as a foundation for reasonable and prudent alternatives and measures in applicable Section 7 consultations. Although the Program has not achieved the recovery demographic criteria for downlisting and delisting or all Positive Population Response Criteria, the overall incremental improvement in the population status of Colorado Pikeminnow and Razorback Sucker within the San Juan River Basin indicates sufficient progress toward recovery based on the Program's implementation of recovery actions.

The Service recommends two broad areas where the Program must focus its efforts to improve efficiency of Colorado Pikeminnow and Razorback Sucker recovery efforts in the San Juan River Basin. The Program needs to: (1) rigorously evaluate its management actions in order to move towards recovery more expeditiously and consistent within an adaptive management

framework; and (2) identify and ameliorate recruitment bottlenecks for Colorado Pikeminnow and Razorback Sucker. Science-based management should guide the Program's activities. All actions of the Program need to be assessed to improve prospects for Colorado Pikeminnow and Razorback Sucker recovery in the San Juan River Basin. While current management should not be abandoned without compelling evidence, the Service strongly suggests the Program explore innovative activities given that the current management paradigms have not resulted in documented wild-recruitment. Furthermore, given the lack of wild-recruitment, the Program must prioritize research efforts to determine and mitigate impediments limiting wild-recruitment in the San Juan River Basin.

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