To: Biology Committee, Upper Colorado River Endangered Fish Recovery Program

From: Dave Speas, USBR, with input from Matt Breen (UDWR), Tildon Jones (USFWS) and Bob Schelly (NPS).

Re: Updated floodplain wetland priorities for recovery of endangered fish in the Middle Green River

Revised January 26, 2017

Introduction

The year 2016 marked the twentieth anniversary of the publication of Modde (1996) which drew attention to the occurrence of wild-spawned young-of-year (YOY) razorback sucker *Xyrauchen texanus* in the Old Charley floodplain wetland in the middle Green River reach. Additionally, 1996 saw the publication of the Levee Removal Strategic Plan (Lentsch et al. 1996) which was followed closely by several years of floodplain wetland acquisition, restoration, management and research, the ultimate goal of which was to provide off-channel habitat conducive to the recovery of razorback sucker and possibly other endangered fish species in the Green River. These initial efforts were followed by publication of middle Green River floodplain management plans (Valdez and Nelson 2004; Modde 2007), additional research on larval drift dynamics and entrainment in floodplain wetlands (Hedrick et al 2009; Bestgen et al. 2011), survival and growth of razorback sucker in wetlands (Brunson and Christopherson 2005; Modde and Haines 2005; Birchell and Christopherson 2004; Christopherson et al. 2004; Webber 2009, 2010; Hedrick et al. 2012), and most recently, implementation of modified releases from Flaming Gorge to increase entrainment of larval razorback sucker in floodplain wetlands (Reclamation 2006; Larval Trigger ad hoc Group, 2012).

At the present time, Recovery Program partners and Reclamation coordinate closely to provide spring peak flows timed to emergence of larval razorback sucker (i.e., the Larval Trigger Study Plan, LTSP). Recovery Program investigators track larval drift during the spring peak period (project 22f) and monitor survival of razorback sucker from larvae to roughly three or four months of age prior to translocating them to the Green River (projects FR-164, FR-165). As evidence by results from project FR-165 (Stewart Lake), the LTSP is arguably successful in its ability to facilitate entrainment of drifting larval razorback sucker into to suitable rearing habitats. So far, Stewart Lake has produced young-of-year (YOY) razorback sucker numbering in the hundreds to thousands of fish per year (Breen and Skorupski 2012; Skorupski et al. 2013; Schelly et al. 2014; Schelly and Breen 2015, 2016), regardless of hydrological classification.

Successful rearing of razorback sucker larvae to the YOY stage in Stewart Lake is the result of LTSP and active management of the wetland including <u>1) the ability to exclude large-bodied nonnative fish from the wetland during the larval entrainment period; 2) maintenance of water levels using water control structures and external water sources; and 3) capture, enumeration and release of YOY fish into the main channel Green River as the wetland is drained in the fall months.</u> All of these wetland management activities take a considerable amount of time and effort to complete successfully, sometimes straining the budget or labor resources of other existing projects (Breen, Jones, personal communications). While many investigators and managers had initially envisioned that entrainment and rearing of larval razorback sucker would occur more or less naturally with the ebb and flow of successive spring runoff seasons, it has become clear that considerable hands-on management actions are necessary to ensure the successful entrainment of razorback sucker larvae, their survival through summer months and eventual return to the river as juvenile fish.

Excluding Stewart Lake (and to some extent the Johnson Bottom wetland on the Ouray National Wildlife Refuge, ONWR), information on performance of individual wetlands since inception of LTSP is patchy, and a synthesis of progress toward the original goals of the floodplain management plan and remaining priorities is lacking. While Stewart Lake can produce hundreds or thousands of YOY razorback sucker per year depending on annual in-stream production, it likely falls short of the estimated 1,740 recruits (ca. age 3) per year estimated to maintain adult razorback sucker levels in the Green River at recovery levels (5,800 fish; Valdez and Nelson 2004). Thus, the search for wetland habitats amendable to management in a fashion similar to that performed at Stewart Lake continues.

The purpose of this paper is to start a conversation within the Recovery Program on what floodplain restoration has amounted to in relation to original goals set forth in Valdez and Nelson (floodplain management plan; 2004) and Modde (additional recommendations; 2007) and also in terms of our expectations for the amount of restoration, operation and maintenance necessary for razorback sucker recovery, particularly in the latter years of the Recovery Program's authorization. At this point, the Recovery Program needs to identify viable options for floodplain management to support recovery in the future (including additional restoration efforts for specific floodplain wetlands), especially if such options require use of the Recovery Program's finite capital projects funding source and annual funds for wetland management beyond that which is currently allocated.

Background

Research

Floodplains have long been thought to be important nursery and rearing habitats for razorback sucker (Bestgen 1990) and bonytail *Gila elegans* (Mueller 2003; Breen 2012). They are highly productive habitats within the riverine ecosystem which exhibit higher temperatures, nutrient concentrations and levels of primary productivity than the main channel environment. The availability of floodplains in the upper basin has been reduced by flow regulation and concomitant geomorphic changes in the river channel. The Recovery Program has long recognized the need to restore these floodplain habitats as an important aspect of recovery primarily for razorback sucker (Tyus and Karp 1990; Modde et al. 1996), although bonytail and Colorado pikeminnow *Ptychocheilus lucius* may also derive benefits from these actions (see Schelly and Breen 2016).

In the mid- to late 1990's the Recovery Program initiated a habitat restoration effort to acquire, restore and maintain floodplain habitats in the Upper Colorado Basin. A key restoration activity was the breaching of existing wetland levees which precluded frequent inundation during the spring peak flow period. Early research on these restoration efforts yielded the following key concepts regarding benefits to razorback sucker (Birchell et al. 2002):

> For floodplains to aid in recovery of razorback suckers several events must occur. First razorback suckers must spawn successfully and have larvae entrained in the

> floodplain. Second larvae must survive and grow within the environment of the floodplain. Third they must leave the floodplain and recruit into the river population. Based on these life history events a floodplain wetland that functions ideally in support of razorback sucker recovery will have the following characteristics: 1) the site is configured to maximize larval fish entrainment; 2) adequate cover to survive predation; 3) high productivity; 4) low numbers of non-native fish; 5) adequate water quality to support fish year round; and 6) site is physically self-sustaining. None of the floodplains sampled fully meet these criteria. However there are floodplain configurations that support razorback sucker recovery better than others.

Regarding requirement (1), the authors further hypothesized that wetlands that are configured to "flow through" (i.e., have inlets on the upstream end of the wetland and outlets on the lower end) tend to entrain the most larvae. This hypothesis was later supported by Hedrick et al. (2009) who found that entrainment rates of semi-buoyant beads were relatively high in flow-through wetlands and tended to occur throughout the ascending and descending limbs of the spring hydrograph. Entrainment rates were low in single-breach wetlands and decreased and ceased when the wetlands were full. The role of single breach wetlands in recovery should not be diminished, however, as they are often a closer approximation to natural configurations and do not experience the high sedimentation rates that flow-through wetlands do (Heitmeyer and Fredrickson 2005; LaGory et al. 2016). It should be noted that in recent years, it has become customary to fill floodplain wetlands (i.e., Stewart Lake) through their outlets rather than filling from the upstream breaches, effectively making them single breach wetlands. Doing so may actually enhance efficiency of entrainment and result in higher wetland volume in some years (Breen, personal communication).

Requirement (4) eventually became known as the "reset theory", whereby the problem of nonnative fish in floodplain wetlands could be solved by draining the wetlands prior to their inundation during the spring peak period and entrainment of drifting razorback larvae. Brunson and Christopherson (2005) and many others (Webber 2009, 2010; Breen and Skorupski 2012) showed that razorback sucker could survive and grow rapidly in the presence of small-bodied nonnative fish, however conditions were best if the wetland had been dry and free of established nonnative fish communities prior to inundation. Thus, a common recommendation for floodplain wetland configurations is the ability to physically drain wetlands prior to inundation, which requires adequate wetland depth in relation to base flows of the Green River, wetland contours that drain to a low-lying release point, and infrastructure to release water.

Requirement (5) regarding adequate water quality has been researched opportunistically by several investigators, but Hedrick et al. (2012) provided a more focused survey of razorback sucker survival in the Stirrup wetland under varied water quality conditions. Through this research and other studies conducted at Baeser Bend (Webber, 2009, 2010), Escalante (Thunder Ranch; Webber and Jones 2014), the Stirrup (Breen and Skorupski, 2012) and others it became evident that a direct corollary to water quality for razorback sucker was water quantity, and it has become generally accepted that maintaining full floodplain wetlands throughout the summer months (and just prior to ice-up if the object is overwintering) is essential to the survival of young razorback sucker. Pumping water or otherwise receiving supplemental water from external sources has become a commonplace activity in attempts to enhance razorback sucker survival.

Management needs

Valdez and Nelson (2004) identified 16 wetlands in the middle Green River (i.e., Jensen-Ouray) reach suitable for razorback sucker rearing and management for benefits to other endangered fish species. They estimated that an average of 2,032 acres of floodplain wetlands would be necessary as nursery and rearing habitat to support a self-sustaining population of 5,800 adult razorback sucker with average annual recruitment rate of 30% (i.e., 1,740 adults; recovery target). They considered seven sites that had either been restored (i.e., breached to connect at roughly 13,000 cfs; Bonanza Bridge, the Stirrup, Baeser Bend, Above Brennan, and Old Charley Wash) or that were recommended to be restored (Thunder Ranch and Stewart Lake) as "Phase I" of their restoration plan and providing about 1,389 acres of the 2,032 acres required for recovery. "Phase II" of the Valdez and Nelson (2004) plan called for use of the Leota Ponds and Johnson Bottom of the Ouray National Wildlife Refuge as providing an additional 1,162 acres and thus theoretically reach the recovery threshold. "Phase III" was identified as additional acreage (1,385 acres) that could be developed if Phases I and II failed to produce the necessary numbers of fish.

Following the more generalized recommendations of Valdez and Nelson (2004), Modde (2007) issued recommendations for management of specific wetlands following two different management philosophies: 1) entrainment and management of wild-spawned razorback larvae during the spring followed by their release in the fall or following spring and resetting of the wetland; and 2) acclimation of larvae, age-0 fish or stockable size fish, preferably in the absence of nonnative fish. The latter alternative is somewhat problematic in that source of surviving YOY fish (i.e., stocked or wild-spawned larvae) may not be possible to determine. These wetlands and recommendations for each are listed in Table 1, along with a summary of the extent to which recommendations have been implemented to date.

In September 2010, the Recovery Program Biology Committee conducted a two-day site visit to the Jensen-Ouray reach of the Green River with the goal of reviewing and discussing the Program's overall floodplain management direction. Near-term recommendations resulting from that meeting included new fish and water quality sampling in wetlands that had been neglected previously, more pumping in habitats such as the Stirrup to enhance survival, and closer tracking of restoration and rearing activities at Johnson Bottom (Recovery Program Biology Committee meeting summary, Sept 2010). Mid-term recommendations included diking of the Escalante Ranch outlet and installation of a water control structure, modification of Stewart Lake operations, and investigation of Leota 4 for further rearing activities. A general need to engage in the ONWR planning process to add objectives for endangered fish was also identified, as was potential use of wetlands as rearing facilities for razorback sucker specifically to meet propagation and stocking objectives.

Many of the near- and mid-term objectives from the Sept 2010 meeting have been realized in one form or another (although Stirrup activities have tapered off in recent years, largely due to labor shortages; Breen, personal communication), but modifications recommended for Escalante Ranch have not been discussed in depth, and it appears that little if any communication on the subject with the landowner has taken place (Jones, personal communication). Also, formal integration of Recovery Program objectives with the ONWR planning process has not taken place, and investigations into usage of habitats like Leota 4 or Leota 7 need to take place yet. Reclamation of Johnson Bottom has been complete, but management objectives for this wetland are still a mix of refuge and recovery objectives, without much success in fish production (see next section). It is unclear from the Sept 2010 meeting notes whether the notion of using wetlands as growout facilities was meant to be applied to stocked or naturally entrained larvae, but in many instances neither question has been resolved in the context of razorback stocking needs.

The most recent effort to enhance razorback sucker recovery through entrainment and rearing of larval suckers in floodplain wetlands involves timing of water releases from Flaming Gorge Reservoir to coincide with presence of larval razorback sucker rather than the more traditional trigger of the Yampa River spring runoff peak. This flow management action was based on the work of Bestgen et al. (2011) and became known as the Larval Trigger Study Plan (LTSP ad hoc group 2012). The LTSP identifies a subset of the wetlands identified in Valdez and Nelson (2004) as study wetlands to track performance of LTSP flows over the full range of river hydrologies (Table 1). To date, Stewart Lake has provided the majority of evidence for the success of LTSP, although wild YOY razorback sucker occurrence was also documented at Leota 7 during the fall of 2014 (Jones et al. 2014 annual report). Collectively, data gathered since the publication of Birchell et al. (2002; FR-164 and FR-165 annual reports; Bestgen et al. 2011) tend to validate the original list of requirements for wetlands to successfully produce juvenile fish from wild-spawned, entrained larvae. As Jones (personal communication) recently remarked,

> In my mind, based on the last few years of these wetland projects, they need three things: 1) ability to control timing of water flow into the wetland 2) ability to exclude large-bodied NNF from entering and 3) ability to drain and collect fish at the end of the summer. Without those three, I think they are setting themselves up for the obstacles we have faced up here for years.

Similarly, Breen recently wrote:

> Three things have to happen for this work to be successful…: (1) we need to entrain razorback suckers…(2) large-bodied nonnative fish must be prevented from joining the party, and (3) we must have the ability to control wetland levels, entrain and drain as needed (especially essential if supplemental water is not available).

At Stewart Lake, these requirements have largely been met (albeit with minor inter-annual variations to adapt to changing hydrologic conditions) and appear to function as predicted to support survival of entrained razorback sucker, but the degree to which they have been implemented elsewhere in the middle Green River and results of such management varies from one wetland to the next.

It should be noted that water control structures are not just used to drain wetlands during the fall months, but also to control entrainment of water and larvae during the spring peak period. To maximize success under the LTSP, wetland managers have adopted the practice of restricting connection of the wetland until the presence of larval razorback sucker is confirmed. That is, instead of filling wetland with water prior to razorback emergence, managers keep water control structures closed. When razorback larvae are documented near the control structure, managers then open water control gates, increasing the entrainment rates of water and larval fish. Gates are closed when the river begins to recede to prevent loss of larvae but have occasionally been reopened if increases in discharge follow declines, which can provide a secondary pulse of larval entrainment.

Valdez and Nelson (2004) revisited

The following narratives attempt to update assessments by Valdez and Nelson (2004) by synthesizing unpublished and published findings on individual wetlands, including email communications, Program annual reports, management plans and peer-reviewed final reports, particularly those that have appeared since 2004. This is by no means an exhaustive review and input and review from principal investigators in the field offices is strongly encouraged.

We have attempted to classify individual wetlands largely first according to their ability to entrain razorback sucker larvae according to the guidelines of the LTSP and also their ability to exclude nonnative fish, to sustain wild-spawned razorback sucker at least through the first summer of life by maintaining adequate water quantity and quality, the ability to translocate fish to the river (usually involves a fish kettle or a constricted outlet suitable for temporary weir traps), and/or the ability to drain (reset) the wetlands completely. Construction needs were also factored in, with the wetlands with the most potential tending to be the most developed or the most amendable to development. This classification attempts to update previous prioritizations made by Valdez and Nelson (2004) and Modde (2007), recognizing that the latter document also included prioritization for wetlands based on their ability to acclimate stocked fish as well as entrained larval fish. Classification levels are as follows:

> High potential in present state. Some ability presently exists to exclude nonnative fish, and manage water levels for nursery purposes and/or draining (reset). Production of YOY or overwintered fish has been documented. Some minor construction or earth moving may be required.
>
> High potential with improvements. Entrainment and/or survival to YOY documented but known predation and/or water quality/quantity issues during winter and/or summer precludes survival. Significant earth moving and/or construction may be required for nonnative screening and water management.
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> Wet year or acclimation potential: Entrainment and overwinter capability demonstrated mainly in wet years. Wetlands may also be used for acclimation of stocked fish. Construction may not be necessary, but pumping may be required.
>
> Unknown or limited potential: Wetlands with very limited ability to retain water (including terrace wetlands) OR lack of data precludes evaluation. It should be noted that this designation does not necessarily imply low potential for recovery purposes if information is simply lacking.

Escalante (Thunder) Ranch. High potential with improvements. Escalante (Thunder) Ranch is located on the east bank of the Green River 4–5 miles upstream of the U.S. Highway 40 Bridge near Jensen, Utah. Thunder Ranch is privately owned, and the Recovery Program has a perpetual easement on floodplain portions of the property. In 2004, the Escalante Ranch floodplain potential inundation area was thought to be about 330 acres if levees were breached to connect to the Green River at flows of about 13,000 cfs (Hayes et al. 2005); more recent estimates by Bestgen et al. (2011) suggests surface area at 18,600 cfs is actually 261 acres. Valdez and Nelson (2004) described the multiple breach Escalante Ranch wetland as a high priority site for restoration due to its proximity to known spawning bars and recommended a host of restoration activities to enhance razorback sucker production (Table 1). The evaluation by Modde (2007) was not quite as optimistic, noting that only 50 acres remain inundated once peak flows recede and maximum depths are probably inadequate (ca. 24") to promote survival of razorback sucker. Modde recommended building water management capabilities to depths of four feet and dissolved oxygen concentrations of 3.5 mg/l in an effort to produce target YOY densities of 9 fish/acre/year.

Escalante Ranch levees on the Green River were substantially modified in 2004-2005 to allow inundation beginning at about 12,000 cfs. Levee inundation thresholds in the inlets have since increased by almost 7,000 cfs (LaGory et al. 2016) although it is unclear whether this sedimentation occurred all at once with high flow events in 2011 or perhaps 2008 or gradually over time. The Escalante Ranch outlet has decreased in elevation by about 3,600 cfs, however, indicating that low outlet elevations can probably be maintained over time through outflow sluicing following the spring peak.

Escalante Ranch experiences recurring problems associated with nonnative fish and water quality, and to date survival of razorback sucker beyond the larval stage has not been documented. Modde (2004) reported poor water quality and no over-summer survival of stocked larval fish due to low water. Hedrick and Monroe (2006) documented entrainment of larvae in spring of 2006, but no YOY were collected during fall sampling. During the high water year of 2011, 2 native fish specimens were captured, but no razorback sucker were reported that year (Webber and Jones 2011). Escalante Ranch was one of two wetlands that connected under relatively dry conditions in 2012, but no razorback sucker larvae were detected (Webber and Jones 2012). Bonytail were stocked into Escalante during the fall of 2013 to evaluate overwinter survival, which was poor due to 174 anoxic or nearly anoxic days during the winter of 2013-2014 (Webber and Jones 2013). No YOY were collected during the fall of 2014 (Webber et al. 2014). Larvae were not detected in Escalante following spring peak flows in 2016 (Jones, personal communication), although it was apparent that nonnative fish had successfully overwintered from 2015. The wetland was not sampled in 2015.

Recommendations: It seems evident from data collected sporadically to date that lack of razorback sucker production in Escalante Ranch wetland is due to a perennial problem with nonnative fish communities (including occasional northern pike) and poor water quality, which is most likely due to limited ability to retain water following the spring peak. It is generally believed that Escalante Ranch wetland cannot be fully drained due to its bathymetry and presence of perennial springs, which will make management of nonnative fish through periodic drying (resetting) very difficult (Jones, personal communication). At the same time, also, engineered levee breach inlets have all experienced substantial sedimentation since 2005, which limits entrainment of larvae in a flow-through configuration without periodic dredging of affected inlets.

The Recovery Program Biology Committee suggested in 2012 (Sept 2011 BC meeting summary) that consideration should be given to construction of a water control structure if the floodplain wetland program is to continue with previously identified goals and objectives. A water control structure in the outlet of Escalante Ranch Wetland could enable retention of water during the summer months but the ability to drain the wetland to kill nonnative fish would still be doubtful given the presence of perennial springs. Also, costs of maintaining levee inlet breaches could be significant if the problem of sedimentation persists. Thus, overall cost-effectiveness of taking further action at Escalante Ranch needs to be re-evaluated, particularly in relation to more promising potential at other wetlands.

It is unclear if anyone has corresponded with the new ownership of Escalante Ranch to discuss management options (Jones, personal communication), so the permissibility of further modification to the property per terms of the easement needs to be reviewed. Also, while levee failures reported in 2006 and 2011 were repaired using Program funding, terms of the easement related to the Recovery Program's responsibilities for such repairs should also be reviewed. Administration of the Escalante easement has been characterized at several points as being labor intensive (Schaad and Dippel 2012; Schaad and Jahrsdoerfer 2014); if the easement no longer serves a purpose in recovery in the future, the possibility of its termination should be explored.

IMC: Unknown or limited potential. IMC is owned by a construction aggregate firm and is located on river right just above Jensen, UT, which is in close proximity to known razorback spawning bars. The Recovery Program maintains an easement for access, flooding, and management at this site. Valdez and Nelson (2004) assigned IMC a low priority to the IMC wetland due to its terrace-like configuration and its inability to sustain fish beyond the spring peak period. Modde (2007) did not consider IMC in his review.

Recommendations: Review terms of easement and evaluate current status of the property for its utility in recovery. If the easement no longer serves a purpose in recovery in the future, the possibility of its termination should be explored.

Stewart Lake: High potential in present state. Stewart Lake is a diked depression located on the west bank of the Green River 2 miles downstream of the U.S. Highway 40 Bridge near Jensen, Utah. At an estimated 646 acres at a river flow of 18,600 cfs (Bestgen et al. 2011), and in part owing to existing water control structures, ability to reset the wetland, multiple breach configuration, state agency management authority, and proximity to known spawning locations, Valdez and Nelson (2004) considered Stewart Lake to be an important nursery habitat for razorback sucker. Modde (2007) also recognized considerable potential for Stewart Lake as a facility for rearing of entrained wild-spawned razorback larvae.

In the presence of LTSP flows in recent years, Stewart Lake currently provides the only reliable source of wild-spawned YOY razorback suckers in the Upper Colorado River Basin. In 2012, larvae were successfully entrained but expired due to rapidly drying conditions following a low peak flow under dry hydrologic conditions. Supplemental water needs were re-assessed that year. Successful water level maintenance in subsequent years resulted in improved survival rates, and 592, 749, 97 and 2105 wild-spawned YOY razorback sucker were translocated to the Green River in 2012-2016, respectively (Skorupski et al. 2013; Schelly et al. 2014; Schelly and Breen 2015). The relatively low number of razorback sucker in 2015 was thought to be due to low numbers of drifting razorback sucker larvae and high numbers of green sunfish *Lepomis cyanellus* which invaded Stewart Lake that year.

In 2015, successful spawning and survival of bonytail occurred in Stewart Lake (Bestgen et al. 2016 *in press*), a rare occurrence for this species in the Upper Colorado River Basin (but see also Modde and Haines 2005 for additional examples). In 2016, nine age-0 bonytail were released to the Green River from Stewart Lake, indicating another successful spawning attempt by bonytail in Stewart Lake (Schelly and Breen 2016). Forty-two stocked bonytail entered Stewart Lake in 2009, also, indicating somewhat selective behavior on the part of these fish for these types of habitats (UDWR, unpublished data). These relatively frequent observations of bonytail in Stewart Lake suggest that use of floodplain wetlands for bonytail recovery should probably increase in the future.

Stewart Lake currently requires substantial hands-on labor to successfully rear razorback sucker to several months of age, and challenges surrounding the management of the wetland persist. Management costs for razorback sucker rearing are at least $60,000 per year, but labor resources are frequently stretched thin in an effort to cover floodplain wetland duties in addition to other projects. Additionally, operation and maintenance costs of water control infrastructure are modest but expected to occur periodically. External water sources for maintenance of summer water levels are relatively secure, but the delivery mechanism is sometimes unreliable. Also, a regulatory dilemma currently surrounds use of Stewart Lake to rear endangered fish at the same time that a biological opinion mandates management of the wetland to remediate high levels of selenium in the area. Discussions to revisit this BO to address these two management objectives for the wetland are currently taking place.

A final consideration to bear in mind when considering future operations at Stewart Lake or other wetlands requiring the fill/drain strategy within a single year is the impact of such operations on proliferation of cattails (*Typha* sp.). Anecdotal observations by staff at Ouray NWR and others (Breen, personal communication) have noted that the regular filling and drying of wetlands can enhance cattail growth, which at once can be a source of cover for endangered fish to some extent but can curtail wetland volume if it becomes excessive. In 2017, UDWR plans to control cattail growth using herbicides, in order to open more wetland area to razorback sucker production (Breen, personal communication).

Recommendations: Continue to coordinate LTSP flows with active management of Stewart Lake to maximize razorback sucker entrainment during the spring peak period, maintain water levels, translocate fish back to the Green River in the fall and reset (drain) the wetland annually. Continue to work with the water district to assure delivery of supplemental water during summer months. Continue discussions between USBR and USFWS to resolve potential conflicts between management objectives for Stewart Lake. Discuss use of Stewart Lake as a spawning and rearing habitat for bonytail, especially if status of razorback sucker improves. Use of Stewart Lake for both adult bonytail and razorback sucker within a single year should be evaluated for risk of bonytail predation on larval razorback sucker.

Sportsman's Lake: Unknown or limited potential. This privately owned, single-breach 132 acre wetland can retain water throughout the year and is located a few miles downstream from Stewart Lake on river right. Valdez and Nelson (2004) considered Sportsman's Lake as having limited potential as a nursery habitat and one of five wetlands in a "Phase III" management package which would be pursued only if higher priority wetlands (Phases II, I) proved to be insufficient in meeting objectives for razorback sucker. Modde (2007) didn't discuss Sportsman's Lake in his evaluation. Previous authors placed a low priority on Sportsman's Lake in part due to its distance from the river and its long, narrow inlet, but these are also attributes of Stewart Lake which has since shown demonstrable success in both entraining and sustaining razorback sucker larvae.   Sportsman's Lake also has a water control structure, although it may need to be modified to drain the lake when needed.

Recommendations: In December 2016, Breen (email dated 12/27/16) visited Sportsman's Lake with one of the property's owners and evaluated restoration potential of the property for recovery purposes. While the property may have at some point had features necessary for entraining and rearing endangered fish (Valdez and Nelson 2004), at present it appears that extensive reconstruction would be necessary to make it conducive for entrainment and rearing of endangered fish. Breen characterized restoration potential of Sportsman's Lake as low in relation to other options and did not recommended it as a candidate for significant habitat restoration at this time.

Bonanza Bridge: Wet year or acclimation potential. This floodplain wetland is located on the southeast bank of the Green River immediately downstream of the State Highway 40 bridge to Bonanza, Utah, on lands administered by Bureau of Land Management (BLM). The Bonanza Bridge wetland is separated from the Green River by large natural levees and is formed as two depressions; one low and one perched. Seepage from the Green River partially fills the low depression, but the floodplain does not hold water year-around in dry years, such as 2001 and 2002.

Valdez and Nelson (2004) ranked the multiple-breach Bonanza Bridge site as potentially important for endangered fish, and it is identified as a study wetland in the LTSP. Modde (2007) did not discuss Bonanza Bridge in his review. Owing to its multiple breaches, Bonanza Bridge has often been identified as a site of high larval entrainment during the spring peak period (Christopherson, 2004, 2005; Christopherson and Hedrick, 2006). Valdez and Nelson (2004) stated that the wetland had previously been shown to overwinter fish during wet years of the mid-1990's and could thus provide rearing habitat in such years, provided fish can be harvested efficiently and transported to the river. Bonanza Bridge is not likely to sustain fish in dry years, however. Modde and Haines (2005) documented a partial fish kill during the summer of 2003, which was attributed to low water of poor quality. Hedrick and Monroe (2006) reported completed drying of Bonanza Bridge during summer of 2006, an average to moderately dry year. Larvae were detected in Bonanza Bridge as recently as 2016, but the fate of these fish is unknown at this time.

The three inlet levee breaches at Bonanza Bridge were originally intended to provide access for drifting larvae to the wetland starting at 13,000 cfs and inundation thresholds in 2005 were 13,900 cfs. Like Escalante Wetland, these breaches have received substantial inputs of sediment since 2005 and inundation thresholds have increased by an additional 1,314, 6,602 and 9,261 cfs (LaGory et al. 2016). The outlet elevation has increased by just over 1,000 cfs.

Recommendations: Monitor for presence of larvae on an annual basis; if larvae are present, and the wetland had been reset over the previous year, consider monitoring survival of larvae through the fall months and translocating YOY fish to the river. Valdez and Nelson (2004) made no recommendations for additional construction beyond levee breaching as the total inundated area is relatively small (ca. 38 acres maximum). However, owing to its confirmed entrainment rates, ability to support fish through the summer in wet years, and its role in the LTSP, Bonanza Bridge could be used as a nursery area, perhaps if water levels can be maintained through pumping and a means to translocate fish efficiently is identified. Otherwise Bonanza Bridge likely won't produce anything except during the wettest of years.

Richens/Slaugh/Slaugh property: Unknown or limited potential. The floodplain property is located on the west bank of the Green River about 3 miles downstream of the State Highway 45 Bridge to Bonanza, Utah. While the Recovery Program has a perpetual easement with landowners to flood the property to 45 acres at 18,600 cfs, there is limited value due to its terrace-like configuration. Valdez and Nelson (2004) did not recommend any construction or modification of this site unless recovery criteria were not achieved with ongoing actions, and the property was not discussed by Modde (2007).

Recommendations: Review terms of easement and evaluate current status of the property for its utility in recovery. If the easement no longer serves a purpose in recovery in the future, the possibility of its termination should be explored.

Horseshoe Bend: Unknown or limited potential: The Horseshoe Bend floodplain is located on the east bank of the Green River about 5.5 miles downstream of the State Highway 45 bridge to Bonanza, Utah, on lands administered by BLM. The levee was breached for about 1,000 feet at the downstream end between March 1997 and March 1998, and the area of inundation varies from about 17 acres at 13,000 cfs to 48 acres at 24,000 cfs. Birchell et al. (2002) determined that at the time of their study (1998-1999), Horseshoe Bend stayed connected to the river longer than most other wetlands and entrained relative large volumes of water; they also documented overwinter survival of nonnative fish in two consecutive years.

Valdez and Nelson (2004) characterized Horseshoe Bend as having limited value as a nursery for razorback sucker because it dries in most years, and the wetland was not considered by Modde (2007). Entrained larvae would likely not survive more than a few weeks (or perhaps months in wet years), although excavation to increase retention was described as a viable option should the wetland be needed to attain recovery goals.

Recommendations: Information on Horseshoe Bend since publication of Valdez and Nelson (2004) is scarce or non-existent. Owing to the lack of information, the slight potential for renovation (most likely through partnering with BLM) and its unusually wide breach, Horseshoe Bend should be reviewed for its role in recovery, particularly its ability to entrain and retain water and larvae over a range of hydrologies.

The Stirrup: High potential with improvements OR wet year/acclimation potential. The single-breach Stirrup floodplain is located on the east bank of the Green River about 14 miles downstream of the State Highway 45 Bridge to Bonanza, Utah, on lands administered by BLM. The levee was breached at the downstream end in March 1997, and the area of inundation is about 20 acres at 13,000 cfs and 22 acres at 18,600 cfs (Bestgen et al. 2011). The single levee breach in the Stirrup was engineered to connect to that river at about 13,000 cfs (LaGory et al. 2016); since 2005, that inundation threshold has increased by 2,749 cfs.

Valdez and Nelson (2004) characterized the Stirrup as potentially important nursery habitat for razorback sucker, primarily through entrainment of razorback sucker larvae. In contrast, Modde (2007) recommended that the Stirrup be used as an acclimation habitat for stocked razorback sucker larvae and recommended that the single breach be plugged and water obtained via pumping from the river.

Quite a few observations on the Stirrup have been made over the years, and a study on razorback survival was conducted during the years 2007-2011 (Hedrick et al. 2012). Results on razorback sucker survival have been mixed. In April 1999 (a high water year), 1,985 fingerling razorback sucker were stocked into the Stirrup, and growth and survival in the presence of nonnative fish were considered good to excellent (Nelson, 2001). About 49% of these fish survived over the winter of 1999-2000. About 57,000 larvae were also stocked in 1999, but apparently none survived. In 2000, a comparatively low water year, the stocking experiment was repeated, but survival over the summer months was poor and a fish kill was confirmed in in August of 2000 (Nelson 2001; Christopherson 2000). Sampling during 2001 confirmed lack of survival from either the 1999 or the 2000 stocking event (Christopherson 2001).

In 2005, a total of 55,000 excess larvae were stocked into the Stirrup in late June. Follow-up surveys indicated that fish (thought to be mostly stocked) survived through October 2005 and exhibited two- to fourfold increases in length. None of these fish survived through 2006, however (Hedrick and Monroe 2006).

In 2007, an investigation was launched to determine razorback sucker survival and escapement rates from the Stirrup. Using stocked fish of various sizes, Hedrick et al. (2012) estimated annual survival rates for YOY and age-2 razorback suckers stocked into the Stirrup in 2008 to be 0.13 and 0.20, respectively. However, two instances of winterkill were documented in 2007-2008 (severe) and 2009-2010 (partial) which were thought to be due to low dissolved oxygen levels during winter months. Surviving fish which emigrated from the wetland tended to so after spending one winter in the wetland. The vast majority of the fish did not leave the wetland at all, however, suggesting that expectations of fish leaving wetlands on their own volition—providing annual hydrologies can provide connection to the river—may be overly optimistic, and any surviving fish in any wetland may have to be physically harvested and translocated to the river, much as they are at Stewart Lake.

No fish kills were observed during the winter of 2010-2011, and some razorback sucker stocked in 2009 left the wetland in 2010. Water quality in the Stirrup appeared to be conducive for fish survival (DO > 8.0 mg/l) over the winter of 2011-2012, most likely resulting from the addition of pumped river water the previous fall (Breen 2012). Just over 6,804 bonytail were stocked into the Stirrup in 2011, and at least 16% of these fish left the wetland that year. None were collected in 2012, however, despite good water quality during the previous winter. No wild-spawned razorback sucker larvae were documented in the Stirrup following the spring peak in 2014. Larvae were observed in 2016 (Jones, personal communication), but presence of surviving YOY is unknown at this time.

In general, it appears that the Stirrup can support survival of razorback sucker during summer months and occasionally over the winter, most likely with the assistance of pumped water at certain times of the year. Wet years may require less pumping in the summer months. Modde (2007) recommended that the Stirrup breach (13,500 cfs) be plugged and a pumping station established to enable acclimation and growth of stocked razorback sucker, but this recommendation has not been considered to date.

Recommendation: Working with the BLM, identify the role of the Stirrup wetland in recovery either as a habitat for entrained razorback suckers, an acclimation habitat for stocked suckers or bonytail, or perhaps both purposes. Evaluate cost effectiveness of a nonnative fish barrier, water control structure to maintain water levels and provide capability for full draining. Until objectives are determined, monitor for presence of larvae on an annual basis; if larvae are present, and the wetland had been reset over the previous year, monitor survival of larvae through the fall months and consider translocating YOY fish to the river. Water control structures for the Stirrup have never been recommended but owing to the benefits of such infrastructure in Stewart Lake and other areas, such improvements should be considered, providing draining/resetting mechanisms and nonnative fish exclusion structures are included. the Stirrup is relatively small (ca. 22 acres), so such modifications may not be cost effective; however, its small size may lend itself better to maintenance of water quality through pumping or aeration, options which should be evaluated for cost effectiveness. If modifications to drain the wetland are not desirable, consider application of piscicides to reset the Stirrup. Use of ammonia to treat small, discrete waterbodies infested with undesirable fish was recently documented below Glen Canyon Dam on the Colorado River (Trammell et al. 2017; David Ward, USGS, personal communication) and may prove to be useful in resetting floodplain wetlands that cannot be drained.

Baeser Bend: Wet year or acclimation potential. The Baeser Bend floodplain is located on the east bank of the Green River about 15 miles downstream of the State Highway 45 Bridge to Bonanza, Utah, on lands administered by BLM. Valdez and and Nelson (2004) considered Baeser Bend to be a potentially important nursery for entrained razorback sucker, although Modde (2007) recommended that it be used as an acclimation site for stocked razorback sucker. The wetland was formally breached to inundate at about 13,000 cfs but was plugged in 2009 to prevent invasions by nonnative fish. Its current inundation threshold is over 20,000 cfs.

Like the Stirrup, Baeser Bend was stocked in the spring of 1999 with about 2,000 YOY razorback sucker, 61% of which survived to the following spring, but dry conditions in 2000 led to partial summer-kill despite addition of pumped water (Birchell et al. 2004; Nelson 2001). Razorback sucker larvae were also stocked in 1999, but no survival of these fish was documented (Nelson 2001). Following the plugging of its single breach, Baeser Bend functioned as an acclimation pond during 2008-2010 in which stocked razorback sucker YOY were reared to a taggable size, then harvested and released to the river (Webber 2009, 2010). Water levels were maintained during this period through pumping river water into the wetland. This activity was largely successful, producing hundreds of wild-acclimated juvenile razorback sucker which survived winter conditions following fall stocking events in 2008 and 2009. Harvest and release in the river is relatively labor intensive as Baeser Bend has no fish kettle or drain (Webber 2009).

Recommendations: Monitor for presence of larvae on an annual basis; if larvae are present, and the wetland had been reset over the previous year, monitor survival of larvae through the fall months and consider translocating YOY fish to the river. Based on its proven ability to overwinter stocked razorback sucker (Webber 2009, 2010) and its plugged breach, Baeser Bend could function either to entrain wild-spawned razorback sucker in the wettest of years, or could be utilized as an acclimation pond for stocked fish (including bonytail). In either option, pumped river water is likely required to ensure survival, and translocation of the matured fish to the river will be labor-intensive.

Above Brennan: High potential with improvements OR wet year/acclimation potential The multi-breach Above-Brennan floodplain is located on the east bank of the Green River about 21 miles downstream of the State Highway 45 bridge to Bonanza, Utah, on lands administered by BLM. One downstream breach was excavated in October 1997 and three upstream breaches were excavated in April 2000. Bestgen et al. (2011) estimates Above Brennan to attain 39 surface acres at a river flow elevation of 18,600 cfs. Inlet breach elevations at Above Brennan were originally engineered to begin connecting to the Green River at about 13,000 cfs. Inundation thresholds in all three inlet breaches has increased since 2005 by 2,218, 6,134 and 1,564 cfs, whereas the outlet has declined by 2,611 (LaGory et al. 2016).

The wetland can retain water to overwinter fish but generally requires wet conditions to entrain sufficient water and probably needs periodic freshening on a 12 month basis to prevent summer- or winter-kill. Valdez and Nelson (2004) characterized Above Brennan as potentially important as a nursery for razorback sucker, while Modde (2007) recommended it as an acclimation site for stocked fish. Valdez and Nelson (2004) recommended evaluation of Above Brennan for nursery habitat potential but made no recommendations other than to allow it to entrain larvae naturally.

Like the Stirrup, Baeser Bend and Bonanza Bridge, Above Brennan was stocked in the spring of 1999 with about 2,000 YOY razorback sucker, 72% of which survived to the following spring. Complete mortality of all stocked fish was documented in 2000, however, due to lack of water and water quality (Christopherson 2000; Nelson 2001). In 2003, Modde and Haines (2005) documented reproduction of bonytail in Above Brennan, a rare occurrence in the Upper Colorado River Basin. In 2014, two adult razorback sucker were documented in the wetland, but survival of bonytail stocked that year was not documented (Webber et al. 2014). Above Brennan partially connected to the Green River in 2015, but survival of native fish larvae was likely low due to nonnative fish present in the wetland since 2014 (Jones et al. 2015). Larvae were detected in Above Brennan in 2016 but their fate is currently unknown (Jones, personal communication).

Recommendations: Working with the BLM, identify the role of Above Brennan wetland in recovery either as a habitat for entrained razorback suckers, an acclimation habitat for stocked suckers or bonytail, or perhaps both purposes. Since the wetland can apparently hold water for up to a year, it could conceivably serve both purposes in its present configuration, albeit addition of supplemental water may be necessary.

Evaluate cost effectiveness of a nonnative fish barrier, water control structure to maintain water levels and provide capability for full draining. Until objectives are determined, monitor for presence of larvae on an annual basis; if larvae are present, and the wetland had been reset over the previous year, monitor survival of larvae through the fall months and consider translocating YOY fish to the river.

Re-evaluate status as low flow entrainment wetland in the LTSP (Above Brennan performs best during wet years) as inlet breach elevations may have increased since that document was completed.

Johnson Bottom: High potential with improvements. Johnson Bottom is located on the east bank of the Green River about 26 miles downstream of the State Highway 45 Bridge to Bonanza, Utah, on lands administered by ONWR. Given its large area of inundation (163 acres at 18,600 cfs; Bestgen et al. 2011), Johnson Bottom can retain water overwinter and can be an important nursery area for razorback sucker and/or bonytail. Levees have been breached several times over the years and currently inundates through a wide breach on the downstream end of the wetland. The wetland currently begins to connect to the Green River at elevations of about 10,400 to

11,500 cfs (LaGory, personal communication). Valdez and Nelson (2004) included Johnson Bottom in the "Phase II" portion of their management plan, meaning its development and management as a nursery area would be necessary to reach the desired amount of acreage needed for razorback recovery.

Johnson Bottom was modified specifically to support rearing razorback sucker under LTSP operations in 2015 through a FWS recovery grant. It currently has most features thought necessary for successful rearing of razorback sucker larvae to the YOY stage, those being the capability to exclude large nonnative fish during filling through its outlet (but not the main breach), the ability to regulate water levels, ability to add supplemental water from the river, and the ability to drain (albeit not completely). However, documented success of rearing razorback sucker to several months of age is limited, and limiting factors are somewhat unknown at this time. Modde and Haines (2005) noted failure of fish survival past summer months due to lack of water in 2004, although the wetland had retained water throughout the summer the previous year. During the high-water event of 2011, the wetland filled completely and bonytail were stocked experimentally during the fall of that year. About 5% of these fish survived the following winter, and the pond dried up during the summer of 2012 (Webber and Jones 2012). Predation by nonnative fish and birds was thought to be a significant factor of low survival.

Razorback sucker larvae were entrained in Johnson Bottom in 2014 and YOY were observed during July, but no YOY were collected the following fall when it was drained (Webber et al. 2014). In 2015, wild razorback were again documented in the wetland in the summer, but those individuals did not survive to the draining period; hypotheses for mortality include bird predation and water quality issues. Larvae were again detected in 2016, but no YOY were collected (Jones, personal communication). However, in 2016 bonytail reproduction was confirmed in Johnson Bottom (Jones, personal communication), likely from individuals stocked near the breach during high flows that were entrained into the wetland.

Recommendation: Coordinate with ONWR to utilize Johnson Bottom as an endangered fish rearing habitat as often as possible. Identify factors limiting razorback sucker survival in Johnson Bottom. Install a structure to exclude large nonnative fish from entering the wetland through the breach, somewhat like that being considered for the spillway of Starvation Reservoir (Jones, personal communication). Continue to operate Johnson Bottom according to LTSP guidelines and continue to sample for presence of larvae and YOY. Continue to add supplemental water as needed to alleviate dissolved oxygen and temperature stressors, especially if fish are to be overwintered. Consider aeration as a means to improve survival.

Leota Ponds: High potential in present state. OR High potential with improvements. Leota Ponds are located on the west bank of the Green River about 33 miles downstream of the State Highway 40 bridge to Bonanza, Utah, and about 10 miles upstream from the State Highway 88 bridge (Watson Road) near Ouray, Utah, on lands administered by ONWR. Leota Ponds are on a large floodplain (ca. 233 acres at 18,600 cfs; Bestgen et al. 2011) that is separated from the river channel by a natural and man-made levee that is topped at high river flows. The levee was breached at two locations by the Recovery Program in March 1998; one breach connects unit L-7 to the river and the second connecting unit L-7A includes a water control gate and fish kettle. These breaches allow the river to flood about 59 acres at river flows of 13,000 cfs. It should be noted also that Leota can also be flooded through the outlet gate and fish kettle on L-7A, possibly at lower river elevations. Like Johnson Bottom, it appears that infrastructure in this area can be fitted with nonnative fish barriers.

The Leota floodplain is divided into 10 ponds (L-1 through L-10) separated by internal dikes constructed by the ONWR. A conduit from Pelican Lake delivers fresh water to the Leota floodplain, although this source is not screened to prevent introduction of nonnative fish at this time. Leota Ponds cannot be completely drained, but water remaining over winter is shallow and may freeze with low fish survival. Leota Ponds has a high potential for management as a 12 or 24-month nursery for razorback sucker, but the ponds may need to be re-engineered to ensure complete draining during the “reset” period.

Like Johnson Bottom, Valdez and Nelson (2004) considered Leota Ponds as important for razorback sucker rearing and part of the “Phase II” portion of their management plan to increase total acreage required for a self-sustaining razorback sucker population in the Green River. Modde (2007) recommended that L-10 be managed as an acclimation habitat, and L-7 as a site to entrain and rear wild-spawned razorback sucker larvae. Management of emergent vegetation has proved to be problematic for any application, though, and repeated wet/dry cycles may encourage growth of cattails (Jones, personal communication).

There are several examples of razorback sucker survival in the Leota Ponds worthy of note. Hedrick and Monroe (2006) reported capture of three YOY sized fish in L-4 in 2005, although the origin of these fish is unknown. In 2010, 46,000 fingerling razorback sucker were stocked into the Leota complex. Survival of these fish was documented through 2012 in L-4, and these fish were also collected in L-1, L-3, L-5 and L-7 during 2011 (Webber and Jones 2011). Wild YOY sucker were also observed in L-4 during 2011 and were likely present in other Leota Ponds following high spring flows that year (Jones, personal communication).

In 2014, five YOY razorback sucker were collected in L-7, presumably from entrained larvae, and investigators suspected that many more fish were present in the wetland (Webber et al. 2014). No nonnative fish were observed during this sampling. Fish present in L-7 in 2014 also survived through 2015. No larvae were detected in 2016, however, most likely due to presence of nonnative fish (Jones, personal communication).

Finally, it is worth noting the Modde and Haines (2005) suspected successful bonytail reproduction in L-10, suggesting some potential for use of that pond for the purpose of bonytail propagation in a somewhat natural setting.

Recommendations: While entrainment rates may be lower than upstream wetlands and also partially due to breach configurations, the infrastructure in the Leota Ponds and presence of a supplemental water source make these habitats highly conducive for rearing razorback sucker either from stocked fish or wild-spawned larvae. Discuss management options (perhaps including a site visit with restoration engineers) with the ONWR to maximize survival of razorback sucker larvae, including entrainment, manage water levels, etc., including a schedule for draining the complex periodically to reset the fish community. Identify acreage of most favorable units within the Leota complex for recovery (L-7, L-4). If a management strategy can be agreed to, manage water levels to maximize survival of razorback larvae and translocate YOY to the river when possible, perhaps with a focus on L-7 which features breach and fish kettle.

Monitor for presence of larvae on an annual basis; if larvae are present, and the wetland had been reset over the previous year, monitor survival of larvae through the fall months and consider translocating YOY fish to the river using the fish kettle at L-7.

Wyasket Lake: Wet year or acclimation potential. Wyasket Lake (Wyasket Bottom) is located on the east bank of the Green River about 7 miles upstream from the State Highway 88 Bridge (Watson Road) near Ouray, Utah, on lands administered by ONWR but leased from the Ute Indian Tribe. Floodable area is about 304 acres at about 13,000 cfs and about 850 acres at 18,600 cfs (Valdez and Nelson 2004). Although some water and fish may hold in the depression and trench, the majority of the floodplain does not hold water during summer and over winter. Valedez and Nelson (2004) did not assign a high priority to Wyasket Lake for rearing habitat due to its shallow depth and tendency to dry up during summer months. They considered Wyasket as part of "Phase III" in the overall wetland restoration prioritization, i.e. with some potential to contribute to rearing needs but requiring substantial excavation and perhaps other modifications.

Recommendations: While its potential for successful rearing of razorback sucker is thought to be low, it should be noted that Wyasket Lake is one of only two wetlands that produced wild-spawned YOY sucker in the wake of the 2011 high flow event (Webber 2013). Therefore, if entrainment rates are in fact favorable for LTSP purposes (it is listed as a high-water study wetland), consider modifications to increase depth or enhance ability to maintain water levels throughout the summer months. At minimum, monitor for presence of larvae on an annual basis; if larvae are present, and the wetland had been reset over the previous year, monitor survival of larvae through the fall months and consider translocating YOY fish to the river.

Sheppard Bottom: High potential with improvements OR wet year/acclimation potential
Sheppard Bottom is located on the west bank of the Green River about 4.5 miles upstream from the State Highway 88 (Watson Road) near Ouray, Utah, on lands administered by ONWR. Sheppard Bottom is currently a large shallow depression that is separated from the river channel by a natural and man-made levee that is topped at high river flows of about 25,300 cfs. Sheppard Bottom is about 348 acres at a river elevation of 18,600 cfs (Bestgen et al. 2011) but can be as large as 1,350 acres if terraced wetlands are included (Valdez and Nelson 2004). For its sheer size, Valdez and Nelson (2004) considered this as potentially important for razorback sucker and included it in "Phase III" of their management plan. Other than a single record of a stocked adult captured in 2011, it is unknown whether Sheppard Bottom has produced endangered fish over the years.

Modification of Sheppard Bottom has been funded under a FWS recovery grant for the benefit of razorback sucker (Jahrsdoerfer and McAbee, personal communication). Design of the modified wetland is ongoing, but primary constituent elements are a major levee breech to allow for inundation at lower flows and more natural floodplain function. An interior portion of the wetland, unit 5, is planned to be used as a specific razorback rearing facility, with a nonnative fish exclusion and supplemental (unscreened) water from Pelican Lake. The majority of the wetland will be unscreened, allowing nonnative fish access, but the interior portion will be designed to promote razorback entrainment and rearing. Of note, fall harvest of razorback sucker may require more work than other wetlands, as it cannot be drained directly to the river.

Recommendations: On completion of its restoration, develop an operational plan for Sheppard Bottom to entrain and rear wild-spawned larvae or explore its use as an acclimation pond. Until management options are identified, monitor the restored Sheppard Bottom unit 5 for presence of larval endangered fish each year and track survival of these fish during summer months; harvest as many YOY as possible and translocate them to the river. Consider screening supplemental water from Pelican Lake to exclude non-native fish.

Old Charley Wash: High potential in present state. Old Charley Wash is a large floodplain located in Woods Bottom on the east bank of the Green River 2 miles upstream from the State Highway 88 Bridge (Watson Road) near Ouray, Utah. Old Charley Wash is owned by the Ute Indian Tribe and was managed under lease for waterfowl by ONWR; this lease expired and has not been renewed. Valdez and Nelson (2004) recognized Old Charley Wash as having value for recovery, but for unknown reasons Modde (2007) didn't assign a specific role for the wetland in recovery.

Biologists have long been aware of the potential for Old Charley Wash to be a productive rearing environment for razorback sucker (Irving 1994). Infrastructure to aid in fish management such as a water control structure and fish kettle were installed in the early 1990s. Razorback sucker larvae were documented in the outlet of Old Charley Wash in 1993, and Modde (1997) documented YOY razorback sucker in the wetland during 1995 and 1996. These fish were concluded to be the product of wild-spawned larvae entrained during the relatively high flows of 1995 and 1996. Growth rate was considered high. Stocking experiments conducted by Modde (2000, 2001) yielded poor survival of razorback sucker, however, and Old Charley failed to retain water during the summers of 2003 and 2004.

In recent years, transitions within the tribal government prevented the Service from accessing Old Charley Wash, a situation which may be improving at this time. Much like Stewart Lake, Old Charley is thought to be one of the few wetlands that connects at low flow elevations (ca. 5,000-6,000 cfs) through its outlet structure and thus should be a high priority for operations in the future.

Recommendation: Owing to its ability to entrain larvae at low flow elevations and its complement of capital improvements to allow water level control and fish harvest, Old Charley remains a potentially important habitat for rearing razorback sucker from larvae. Continue to work with the Ute Indian Tribe to negotiate access to Old Charley Wash. When access is attained, operate Old Charley to entrain larvae during the spring peak periods. Assess status of nonnative fish exclusion capabilities. Add supplemental water as necessary throughout the summer months and allow razorback sucker access to the Green River in the fall months or attempt to overwinter them.

Lamb Property: Unknown or limited potential. The Lamb Property floodplain is located on the west bank of the Green River beginning about 1 mile downstream from the State Highway 88 Bridge (Watson Road) near Ouray, Utah. This floodplain is on private property, and the Recovery Program has acquired perpetual easement for flooding of about 463 acres in three parcels. Entrainment of significant numbers of drifting larvae in this floodplain is unlikely because of the distance from the spawning bar and retention of larvae is short because of the terraced nature of the floodplain. Valdez and Nelson (2004) made no specific management recommendations for the Lamb Property floodplain, except protection from manmade changes, including filling, reshaping, draining, or other activities not consistent with the easement agreement with the Recovery Program.

Recommendations: The Lamb property easement was singled out as one of two wetlands in the Jensen-Ouray reach that requires significant amount of staff time to administer (Schaad and Dippel 2013; Schaad and Jahrsdoerfer 2014). Therefore, review terms of easement and evaluate current status of the property for its utility in recovery. If the easement no longer serves a purpose in recovery in the future, the possibility of its termination should be explored.

Discussion

Of the 16 wetlands originally identified in Valdez and Nelson (2004), eight can be considered as being partially implemented in terms of management recommendations, three can be considered as mostly implemented, and the status of the remaining five wetlands is unknown (Table 1). All eight partially implemented wetlands have been identified as study wetlands in LTSP, and of these eight, three (Wyasket, Leota, Old Charley Wash) have been observed to produce wild YOY from larvae at least sporadically in the past. Of the three "mostly implemented" wetlands, only Stewart Lake has produced YOY from wild larvae, however Johnson Bottom has been shown to support wild YOY through at least the month of July and was a site where bonytail reproduced in 2016. Baeser Bend has also been shown to successfully rear stocked razorback sucker, including through the winter months.

It seems evident that in addition to Stewart Lake, wetlands with high potential for entrainment of wild-spawned larvae and subsequent rearing are Johnson Bottom, Leota Ponds, Old Charley Wash, Sheppard Bottom, the Stirrup, and Above Brennan. The first four wetlands in this list are or have been managed by ONWR; most have been or will be extensively modified to control filling and draining and perhaps prevent access to large-bodied nonnative fish. Key remaining tasks for the ONWR wetlands include agreement on annual operations at each wetland, renovation of Sheppard Bottom, renegotiation of access to Old Charley Wash, and perhaps additional modifications within the Leota complex.

Using stage/flooded acreage estimators found in Bestgen et al. (2011), the combined total acreage of high priority wetlands described in the preceding paragraph (including Stewart Lake) is 1,704 acres at a flow of 18,600 cfs. This figure is probably an absolute maximum, however, as only portions of Leota and Sheppard Bottom will likely be useful for endangered fish. Total acreage constitutes 84% of the 2,032 acres of floodplain depressions thought to be necessary by Valdez and Nelson (2004) to support a self-sustaining population of 5,800 adult razorback sucker with average annual recruitment of 30% (i.e., 1,740 adults; recovery target). Though this evaluation falls short of the theoretical minimum to achieve recovery, it seems clear that a sizable fraction of the necessary recruitment can be realized through active management of the high priority wetlands identified above, especially if management techniques can be refined to maximize recruitment within a given year.

There are a host of significant challenges with managing additional wetlands, however. Chiefly, there has yet to be an agreement between the Recovery Program and ONWR on endangered fish operational guidelines for the Leota Ponds, mainly their filling and drying schedules. Also, access to Old Charley Wash needs to be renegotiated, and an agreement on filling and draining schedules for all wetlands needs to be developed. Perhaps some agreement to use Johnson and Leota Ponds for endangered fish on a rotational basis could be negotiated. Renovation of the Stirrup and/or Above Brennan is likely to require use of the Recovery Program's finite capital construction funds. Operation and maintenance costs will need to be covered by annual operating finds.

One potential partner that the Program hasn't interacted with formally on management of floodplain wetlands is the BLM, who manages several accessible floodplain lands in the Green River from Jensen to Sand Wash, including Bonanza Bridge, Horseshoe Bend, the Stirrup, Baeser Bend and Above Brennan. Recently, Recovery Program partners and the BLM identified the Stirrup and Above Brennan as having high potential for renovation and management for endangered fish recovery. Aside from being readily accessible to managing entities, both sites are identified as study wetlands in the LTSP, are significantly deeper than many other habitats, have successfully sustained endangered fish over summer and winter months, and are both well-studied. In the absence of physical modification to enhance entrainment and rearing capabilities, both wetlands should also lend themselves well to rearing of stocked fish and reproductive areas for bonytail.

While Escalante Ranch still may hold some potential for management with capital improvements, the Recovery Program Biology Committee does not recommend moving forward with such actions at this time. The reasons for this decision were based mainly on the extent of necessary capital renovations as they relate to existing site topography, persistent sedimentation issues in upstream breaches, persistent nonnative fish problems, and uncertainties associated with landowner cooperation. Moreover, it appears that more potential exists for successful renovation and/or management of other wetland habitats (see preceding paragraph), which makes them more immediately actionable alternatives.

Depending on the level of success realized through active management of high-priority wetlands for entrainment and rearing, the Program might also consider managing certain wetlands for acclimation of hatchery-reared larvae or fry in a wild setting. This approach was advocated by Modde (2007) and could provide additional fish reared in a wild setting if recruitment levels through entrainment and rearing are insufficient to maintain the riverine population. While any given wetland may afford opportunities for this type of management, those which retain large volumes of water during wet years may be the best candidate since maintaining water levels won't be necessary. Acclimation wetlands include Bonanza Bridge, Baeser Bend, Wyasket Lake, the Stirrup, Above Brennan, and Sheppard Bottom. The acclimation approach should be evaluated for cost effectiveness, however, as harvest can be extremely labor intensive (Webber 2009, 2010) and can be reared more cost effectively in outdoor hatchery ponds.

As a last resort, given the daunting list of tasks associated with more active management of existing wetlands, perhaps the Program should consider constructing an entirely new (preferably large) wetland habitat altogether. Perhaps unexplored areas (such as Pariette Draw) can be developed via a partnership BLM to include enhancements such as diking, water control structures, etc., for use in endangered fish rearing (both razorback sucker and bonytail).

It is apparent from LaGory et al. (2016) that many inlet breach inundation thresholds have tended to increase since they were last excavated in the late 1990's or early 2000's. Depending on the priority for a given wetland habitat, remedial excavation to maintain the desired elevation might be considered, but at a very minimum their elevations should be monitored periodically, and the LTSP updated accordingly.

In closing, perhaps the most important tasks the Program needs to consider in the coming years are to focus on the extent to which floodplain wetlands need to be managed, develop annual or bi-annual work plans for these wetlands, implement the plans, and track results (see Appendix A for potential FY17 floodplain wetland activities proposed by the Recovery Program Biology Committee). Ideally, performance of each individual wetland would be associated with a specific scope of work and monitored through the Recovery Program's annual reporting process. It is also clear that wetlands cannot produce razorback sucker or bonytail through capital projects alone, but rather careful and coordinated work must take place consistently from spring runoff into fall and winter. If wetland management is expanded beyond what is currently covered in projects FR-164 and FR-165, expenditures of annual funding will increase accordingly.

The Program Director's Office has not had a full-time habitat restoration coordinator for some years now, and consequently the need for such continuous program management in the wetland arena is appreciable, especially since agencies are working harder than ever to assure adequate flows are available for drifting larvae in the spring and early summer months (i.e., LTSP). The Program will be approaching its authorization sunset date soon (2023), capital construction dollars are disappearing, and the self-sustaining population of razorback sucker envisioned by Valdez and Nelson (2004) has not been established. The use of wetlands in the recovery of bonytail also needs to be expanded, given the recent evidence of reproduction in Stewart Lake, Johnson Bottom and managed wetlands and ponds in the Lower Colorado River Basin. In order for the floodplain wetland program to remain viable, questions surrounding the necessity and logistics for wetland management needs to be discussed soon, follow-up measures need to be established, and success and shortcomings evaluated on a more regular basis than has been realized since publication of Valdez and Nelson (2004).

Summary of recommendations.

(*NOTE:* See also Table 1 and Appendix A. Since this document was originally written, two Biology Committee meetings were held (Oct 24-26 in Vernal, UT and Dec 13, 2016) in which this paper was discussed in depth. The results of the Dec 13 meeting included a draft workplan for 2017 which took a good deal of the material discussed here and summarized it for planning purposes; this summary is present in Appendix A. As a result, recommendations presented in Appendix A are slightly different than those presented here as they represent tasks for a specific year whereas this document outlines activities for longer timeframes.)

1) Continue to operate Stewart Lake to maximize entrainment of wild endangered fish larvae and survival to the YOY stage.
2) Re-negotiate ONWR management access to Old Charley Wash and Wyasket Lake with the Ute Indian Tribe.
3) In addition to Stewart Lake, increase active management of additional high priority wetlands (the Stirrup, Above Brennan, Leota Ponds, Johnson Bottom, Sheppard Bottom and Old Charley Wash) for entrainment and rearing of wild-spawned razorback sucker and/or bonytail larvae
4) Continue to work with ONWR to expand management capabilities for endangered fish in the Leota Ponds, Johnson Bottom, Sheppard Bottom and Old Charley Wash, including evaluation of renovation or maintenance needs for wetlands located on or managed by ONWR; pursue renovations or maintenance as deemed appropriate.
5) In collaboration with the BLM, evaluate feasibility and costs of renovation of the Stirrup and/or Above Brennan, up to and including ability to exclude non-native fish, regulate water levels, and fully drain the wetlands; renovate the Stirrup and/or Above Brennan as deemed appropriate.

6) Depending on recovery needs, consider use of wetlands as acclimation sites for stocked razorback sucker and/or bonytail (larvae or YOY).
7) Update the LTSP to include current levee breach elevations (LaGory 2016).
8) Stock wetlands more frequently with adult bonytail and monitor for spawning activity; add water as necessary and translocate YOY to the river.
9) Continue discussions between Reclamation and the Service on management objectives for Stewart Lake as they apply to remediation of selenium and rearing of endangered fish; consider implications for selenium remediation in other wetlands used for recovery purposes.
10) Consider use of fish toxicants (including ammonia) to treat wetlands which cannot be reset (drained).
11) Prioritize floodplain wetland projects to maintain a realistic balance for field crews while still obtaining information needed to advance recovery efforts
12) Program participants should work to provide more consistent coordination (both on an annual and long-term basis) of the floodplain wetland aspect of habitat restoration.
13) Review terms of the Escalante Ranch easement and determine the Recovery Program's responsibilities to the landowner for impacts due to spring flooding; also, following an evaluation of its role in recovery, if Escalante Ranch does not or is unlikely to play a role in recovery, consider the possibility of terminating the easement.
14) Similar to (13), review utility and terms of easements currently held at IMC, Richens/Slaugh/Slaugh Property, and the Lamb Property. If these sites do not or are not likely to play a role in recovery, consider terminating them if possible.

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Table 1. Management recommendations by Valdez and Nelson (2004), Modde (2007), LTSP hydrologic categories and current management status of 16 floodplain wetlands in the Jensen-Ouray reach.

Wetland and estimated acreage at 18,600 cfs	**Mgmt recs from Valdez/Nelson (2004)**	**Mgmt Recs from Modde (2007)**	**LTSP inundation threshold**	**Management Status**	**Classification in present document and current recommendation**
Escalante (Thunder Ranch): 261 acres[1]	1) Modify levee for maximum flooding, entrainment of larvae, and overwintering of fish; 2) Implement selenium remediation; 3) Evaluate larval drift and entrainment; 4) Evaluate growth and survival of razorback sucker; 5) Assess effectiveness of management actions (frequency and duration of flooding, retention, water quantity and quality, growth and survival of young fish, and reconnection and escapement by fish to the main channel)	(*Note*: Modde identified as a potential nursery for entrained fish) Add a water control structure at downstream end to allow the wetland to be drained (reset capability) and establish a higher mean water surface elevation to increase depth; reduce emergent vegetation; preferably through higher water levels; install high volume pump structure; Insure that dykes are adequate height and strength to maintain increased water elevation needed to over-winter fish.	Average to wet years	**Management recommendations partially implemented.** *Valdez/Nelson*: Conservation easement acquired (2004) and is being maintained. Breach elevation lowered to connect with the Green River at about 13,500 cfs, albeit variable over time. Reduction of selenium has not taken place and production of razorback sucker has not been documented. *Modde:* Water control structure need is evident, but hasn't been constructed. Wetland cannot be fully drained; no fish kettle, no NNF exclusion. *Remarks:* Levee failure reported in 2006 and 2011, repaired by BOR with Program funds.	**High potential with improvements** 1) Evaluate overall cost-effectiveness of taking further action at Escalante Ranch, particularly in relation to more promising potential at other wetlands. 2) Review terms of conservation easement to determine Program's limits of liability to repair damage caused by flooding. 3) If Escalante Ranch no longer serves a purpose in recovery, consider terminating the conservation easement if possible.
IMC: 4 acres[2]	Low priority for entrainment-based mgmt. due to terrace-like aspects. No specific mgmt. actions other than protection within terms of easement.	N/A	N/A	**Status unknown.** *Remarks:* Recovery Program apparently has an easement for access, flooding, and management.	**Unknown or limited potential.** 1) Review terms of easement and evaluate current status of the property for its utility in recovery. 2) If the easement no longer serves a purpose in recovery in the future, the possibility of its termination should

Wetland and estimated acreage at 18,600 cfs	Mgmt recs from Valdez/Nelson (2004)	Mgmt Recs from Modde (2007)	LTSP inundation threshold	Management Status	Classification in present document and current recommendation
					be explored.
Stewart Lake: 646 acres[1]	1) Coordinate management of Stewart Lake with UDWR, Reclamation, and the Service; 2) Evaluate Se remediation; Evaluate larval drift/entrainment; 3) Evaluate larval drift and entrainment; 4) Evaluate growth and survival of razorback sucker; 5) Assess effectiveness of management actions.	(*Note*: Modde identified Stewart Lake as a nursery for entrained larvae). a.) Remove or reduce selenium contamination as a deterrent to native fish nursery habitat. b.) Determine if water available from Ashley Creek is sufficient to meet water augmentation needs during the summer and fall. c.) Construct catch basin at the outlet; d) (special project) Determine if Se concentrations hinder larval and juvenile razorback/bonytail survival.	All hydrologic categories (dry-wet)	**Management recommendations mostly implemented.** Selenium remediation ongoing; Supplemental water source appears adequate; catchment on outlet is temporary, *Remarks*: Selenium remediation ongoing; Reclamation reconsulting with Service on Stewart L. BO; some monitoring of Se accumulation in fish taking place.	**High potential in current state** I 1) Continue to coordinate LTSP flows with active management of Stewart Lake to maximize entrainment during the spring peak period 2) maintain water levels, facilitate escapement back to the Green River in the fall and reset annually. 3) Continue to work with the water district to assure delivery of supplemental water during summer months. 4) Continue to resolve conflicts between selenium/endangered fish management objectives; 5) Discuss use of Stewart Lake as a spawning and rearing habitat for bonytail (pending status of razorback sucker)
Sportsman's Lake: 132 acres[2]	1) Coordinate with property owners and Uintah Sportsman's Club for possible future use of Sportsman's Lake, if necessary;	N/A	N/A	**Status unknown.** *Remarks*: The Program apparently was discussing an easement with Sportsman's Lake owners in the early 2000's.	**Unknown or limited potential** 1) Reach out to owners of Sportsman's Lake and conduct site visit to discuss potential for endangered fish recovery activity through a partnership (complete); 2) no further action proposed at this time.

Wetland and estimated acreage at 18,600 cfs	Mgmt recs from Valdez/Nelson (2004)	Mgmt Recs from Modde (2007)	LTSP inundation threshold	Management Status	Classification in present document and current recommendation
Bonanza Bridge: 23 acres[1]	1) Monitor/evaluate effectiveness of levee breaches to entrain and retain water at various river stages; 2) Periodically assess fish entrainment, growth, and survival	N/A	Average to wet years	**Management recommendations partially implemented.** Remarks: Entrainment rates high, relatively well document; possible survival/growth in wet years, but not evaluated.	Wet year or acclimation potential 1) Monitor for presence of larval fish on annual basis; 2) if larvae are present, and the wetland had been reset over the previous year, consider cost effectiveness of monitoring survival of larvae through the fall months and translocating YOY fish to the river.
Richens/Slaugh/ Slaugh: 45 acres[2]	Coordinate with landowners to ensure protection of the Floodplain from modifications outside terms of easement.	N/A	N/A	**Status unknown.** Remarks: Recovery Program apparently entered into an easement to flood 45 acres at 18,600 cfs.	**Unknown or limited potential** 1) Review terms of easement and evaluate current status of the property for its utility in recovery. 2) If the easement no longer serves a purpose in recovery in the future, the possibility of its termination should be explored.
Horseshoe Bend: 19 acres[1]	I 1) Modify levee and excavate basin, if necessary; 2) Implement and evaluate management actions (levee modification, excavation), as necessary	N/A	N/A	**Status unknown.**	**Unknown or limited potential** Evaluate site for its role in recovery, particularly its ability to entrain and retain water and larvae over a range of hydrologic conditions.
The Stirrup: 22 acres[1]	1) Monitor/evaluate effectiveness of levee breach to entrain and retain water at	(*Note*: Modde Recommended the Stirrup as an acclimation site, not an entrainment site.)	Average to wet years	**Management recommendations partially implemented.**	**High potential with improvements OR wet year/acclimation potential**

Wetland and estimated acreage at 18,600 cfs	Mgmt recs from Valdez/Nelson (2004)	Mgmt Recs from Modde (2007)	LTSP inundation threshold	Management Status	Classification in present document and current recommendation
	various river stages; 2) Periodically assess fish entrainment, growth, and Survival; 3)	a) Install pumping station (site in which a high volume pump can be situated to move water into and out of the floodplain); b) Plug breach to prevent flooding to decrease the frequency of nonnative fish contamination; c) (special project) Estimate survival of multiple year classes of stocked razorback sucker in the Stirrup; d) (special project) Development of methods to monitor emigration of fish from the floodplain		*Remarks:* Valdez/Nelson objectives implemented; Modde acclimation objectives not implemented, but specials projects "c" and "d" were conducted.	1) Monitor for presence of larval fish on annual basis; 2) if larvae are present, and the wetland had been reset over the previous year, consider cost effectiveness of monitoring survival of larvae through the fall months and translocating YOY fish to the river 3) Determine whether the Stirrup is most effective for entrainment and rearing of wild-spawned larvae or as rearing habitat for stocked fish; 4) If entrainment and rearing option is sought under (3), evaluate cost effectiveness of a nonnative fish barrier, water control structure to maintain water levels and provide capability for full draining. 5) consider piscicide application (including ammonia) as a means to reset wetland; 6) consider aeration as a means to improve survival
Baeser Bend: 36 acres[1]	1) Monitor/evaluate effectiveness of breach to entrain/retain water at various elevations; 2) Periodically assess fish entrainment, growth, survival.	(*Note:* Modde recommended Baeser Bend as an acclimation site) a) Install pumping station (site in which a high volume pump can be situated to move water into and out of the	Moderately wet to wet years	**Management recommendations mostly implemented.** *Remarks*: Baeser Bend was breached to inundate at about 13,000 cfs in 1997, but refilled later. Used as acclimation site in 2008-2010. Currently overtops at 20,300 cfs.	**Wet year or acclimation potential**. 1) Monitor for presence of larval fish on annual basis; 2) if larvae are present, and the wetland had been reset over the previous year, consider cost effectiveness of monitoring survival of larvae

Wetland and estimated acreage at 18,600 cfs	Mgmt recs from Valdez/Nelson (2004)	Mgmt Recs from Modde (2007)	LTSP inundation threshold	Management Status	Classification in present document and current recommendation
		floodplain); b) Plug breach to prevent flooding to decrease the frequency of nonnative fish contamination			through the fall months and translocating YOY fish to the river
Above Brennan: 39 acres[1]	1) Monitor/evaluate effectiveness of levee breaches to entrain and retain water at various river stages; 2) Periodically assess fish entrainment, growth, and survival	(*Note*: Modde recommended Above Brennan as an acclimation site) a) Install pumping station (site in which a high volume pump can be situated to move water into and out of the floodplain); b) Plug breach to prevent flooding to decrease the frequency of nonnative fish contamination	All hydrologic categories (dry-wet)	**Management recommendations partially implemented.** *Remarks*: Modde recommendations not implemented.	**High potential with improvements OR wet year/acclimation potential** 1) Monitor for presence of larval fish on annual basis; 2) if larvae are present, and the wetland had been reset over the previous year, consider cost effectiveness of monitoring survival of larvae through the fall months and translocating YOY fish to the river 3) Determine whether Above Brennan is most effective for entrainment and rearing of wild-spawned larvae or as rearing habitat for stocked fish; 4) If entrainment and rearing option is sought under (3), evaluate cost effectiveness of a nonnative fish barrier, water control structure to maintain water levels and provide capability for full draining. 5) consider piscicide application (including ammonia) as a means to reset wetland; 6) consider aeration as a means to improve survival
Johnson Bottom:	1) Establish a partnership	(*Note*: Modde identified	Average to wet	**Management recommendations**	**High potential with improvements**

Wetland and estimated acreage at 18,600 cfs	Mgmt recs from Valdez/Nelson (2004)	Mgmt Recs from Modde (2007)	LTSP inundation threshold	Management Status	Classification in present document and current recommendation
163 acres[1]	between the Recovery Program and ONWR to further restore Johnson Bottom; 2) Develop a Summary Action Plan; 3) Implement and evaluate management actions	Johnson Bottom as a site to entrain wild-spawned larvae). a) widen downstream breach to100 yds; b) Install a pumping station (site in which a high volume pump can be situated to provide water into and out of the floodplain)	years	**mostly implemented.**	1) Coordinate with ONWR to utilize Johnson Bottom as an endangered fish rearing habitat as often as possible; 2) Identify factors limiting razorback sucker survival in Johnson Bottom; 3) Install a structure to exclude large nonnative fish from entering the wetland through the breach; 4) Continue to operate Johnson Bottom according to LTSP guidelines and continue to sample for presence of larvae and YOY; 5) continue to add supplemental water as needed; 6) Consider aeration as a means to improve survival. 7) consider piscicide application (including ammonia) as a means to reset wetland; .
Leota Ponds: 232 acres[1]	1) Establish a partnership between the Recovery Program and ONWR to further restore Johnson Bottom; 2) Develop a Summary Action Plan; 3) Implement and evaluate management actions	L-7: Recommended for entrainment/rearing of wild larvae. a) Install pumping stations; b) reduce emergent vegetation; c) Deepen breach to connect at 13,500 cfs. L-10: Recommended as an acclimation site. a) Maintain	Moderately wet and wet years (L-7a and L-4); average to wet years (L-7)	**Management recommendations partially implemented** *Remarks*: Partnership with ONWR has been established, but unclear whether ONWR has flexibility to manage for endangered fish to the extent required for recovery; Modde recommendations not implemented;	**High potential in present state OR High potential with improvements.** 1) Discuss management options with the ONWR (perhaps including a site visit with restoration engineers) to maximize survival of razorback sucker larvae; 2) Identify acreage of

Wetland and estimated acreage at 18,600 cfs	Mgmt recs from Valdez/Nelson (2004)	Mgmt Recs from Modde (2007)	LTSP inundation threshold	Management Status	Classification in present document and current recommendation
		pumping station; b) install drain and water control structure on outlet to ensure downstream draining; c) Reduce emergent vegetation.		need to verify whether Pelican Lake water reaches L-7.	most favorable ponds (L-4, L-7) for recovery. 3) Operate wetland during spring peak according to LTSP; 4) Monitor for presence of larvae on annual basis; 4) If larvae are detected in significant numbers, maintain adequate water levels throughout the summer months, if allowed; 5) harvest/translocate YOY razorback sucker to Green River
Wyasket Lake: 850 acres[2]	1) Establish a partnership between the Recovery Program and ONWR to further restore Wyasket Lake, if necessary; 2) Develop a Summary Action Plan	N/A	Moderately wet to wet years	**Management recommendations partially implemented** *Remarks*: Partnership with ONWR has been established, but plans for Wyasket Lake unclear.	**Wet year or acclimation potential** 1) Monitor for presence of larval fish on annual basis; 2) if larvae are present, and the wetland had been reset over the previous year, consider cost effectiveness of monitoring survival of larvae through the fall months and translocating YOY fish to the river 3) Owing to its size and ability to produce YOY suckers, consider potential for increasing ability to retain water
Sheppard Bottom: 348 acres[1]	1) Coordinate with ONWR to manage Sheppard Bottom to benefit razorback sucker; 2) Establish a partnership between the Recovery Program and	N/A	Moderately wet to wet years	**Management recommendations partially implemented** *Remarks*: Action being taken by FWS/ONWR to partially restore	**High potential with improvements OR wet year/acclimation potential** 1) Develop an operational plan for Sheppard Bottom to entrain and rear

Wetland and estimated acreage at 18,600 cfs	Mgmt recs from Valdez/Nelson (2004)	Mgmt Recs from Modde (2007)	LTSP inundation threshold	Management Status	Classification in present document and current recommendation
	ONWR to further restore Sheppard Bottom, if necessary 3) Develop a Summary Action Plan; 4) Implement and evaluate management actions			wetland, but connectivity elevations/management plans uncertain.	wild-spawned larvae or explore its use as an acclimation pond. 2) Until management options are identified, monitor the restored Sheppard Bottom unit 5 for presence of larval endangered fish each year; 3) if larvae are present in significant numbers, maintain adequate water levels throughout the summer months and track fish survival; 5) harvest/translocate YOY razorback sucker to Green River. 6) Consider screening supplemental water from Pelican Lake to exclude non-native fish.
Old Charley: 252 acres[1]	1) Monitor/evaluate effectiveness of levee breaches to entrain and retain water at various river stages; 2) Periodically assess fish entrainment, growth, and survival	N/A	All hydrologic categories (dry-wet)	**Management recommendations partially implemented.** *Remarks*: Old Charley infrastructure has been in place for over 20 years and shows much promise as an entrainment habitat, but is currently off limits currently due to tribal business council transition. Hence, monitoring during LTSP was not possible.	**High potential in present state.** 1) Continue to negotiate with the Ute Indian Tribe to regain access to Old Charley Wash; 2) When access is secured, operate Old Charley to entrain larvae during the spring peak periods according to LTSP; 3) Assess status of nonnative fish exclusion capabilities; 4) Add supplemental water as necessary throughout the summer months; 5) harvest razorback sucker and translocate to Green River in fall

Wetland and estimated acreage at 18,600 cfs	**Mgmt recs from Valdez/Nelson (2004)**	**Mgmt Recs from Modde (2007)**	**LTSP inundation threshold**	**Management Status**	**Classification in present document and current recommendation**
					months or attempt to overwinter them.
Lamb Property 463 acres[2]	Coordinate with landowner to ensure protection of the Lamb property	N/A	N/A	**Status unknown.** *Remarks:* Apparently labor requirements are significant for this wetland easement (Service, ONWR annual reports)	**Unknown or limited potential** Evaluate cost-effectiveness of maintaining Lamb Property easement.

[1]Calculated from regression equations by Argonne National Laboratories (2006).
[2]From Valdez and Nelson (2004).

APPENDIX A. Recommendations for floodplain wetland activities from the December 13, 2017 Biology Committee meeting (teleconference).

Wetland	Priority	Ownership	Access	Control Structure	Screen (non-native exclusion potential)	Fish Kettle	Supplemental Water Source	Can drain and reset?	Needs Improvement	Can Improve?	Action Items in 2017
Johnson Bottom	1 - High	Refuge	Yes	Yes	Yes	Yes	Yes, pumping	Yes	No	Yes	Continue to actively manage wetland with spring light trapping and fall outlet monitoring. Pump consistently. Add nonnative exclusion to breech.
Stewart	1 - High	UDWR	Yes	Yes	Yes	Yes	Yes, Irrigation	Yes	No	Yes	Continue to actively manage wetland with spring light trapping and fall outlet monitoring. Manage cattails, potentially install permanent screen over breech location. Potentially transition to rotational management.
Old Charley	2 - High	Ute Indian Tribe	No	Yes	Yes	Yes	Yes?	Yes	No	No	Refuge staff will continue to work with the Tribe to negotiate easement and access. If access is granted, spring light trapping and fall outlet monitoring will become a priority.
Sheppard Bottom	2 - High	Refuge / Ute Indian Tribe	Yes	Planned for portion	Planned for portion	No	Yes, Pelican Lake	Maybe not	Yes	Yes	Renovate property for active management.
Stirrup	2 - High	BLM	yes	no	no	no	no	no	yes	yes	Leading candidate for BLM managed site, with improvements completed by BOR. Jerrad Goodell will work with Matt and Dave and BOR engineers to evaluate feasibility.
Leota	3 - Medium	Refuge	Yes	Maybe?	No	Yes	Yes, Pelican Lake	Difficult, but yes	Yes	Yes	USBR engineers will evaluate to determine steps necessary to make Leota or parts of Leota a functioning wetland for endangered fish.
Wyasket Pond	3 - Medium	Refuge	Yes	Yes	No	No	No	Yes	Yes	Yes	Possible for future development but low priority.
Escalante (Thunder	3 - Medium	Private with	Yes	No	No	No	No	No	Yes	No	Maintain spring light trapping.

Ranch)		easement									
Matheson	3 - Medium	TNC	Yes	No	No	No	No	Yes?	Yes	Yes	Continue pursuing use at RZB wetland through UDWR Moab. Has higher reproductive potential than other Grand Valley wetlands.
Bonanza Bridge	4 - Low	BLM	Yes	No	No	No	No	No?	Yes	Yes	No action proposed, accessible to public
Baeser Bend	4 - Low	USBR?	Yes	No	No	No	No	No	Yes	Yes	USBR engineers will evaluate to determine potential actions.
Lamb Property	4 - Low	Private with Lease	Yes	No	No	No			Yes	Yes	No action proposed
Grand Valley Wetlands	4 - Low	Multiple	Yes	No	No	No	No	No?	Yes	Yes	No action proposed. Nonnative presence is significant and may be located too far up in the basin to serve as reproductive wetland.
Sportsman's Lake	5 - Low	Private	No	No	No	No	?	?	Yes	No	Matt Breen will follow up with owners, no action proposed in wetland
Richens/Slaugh	5 - Low	Private	?	No	No	No	?	?	Yes	No	Assess easement information to determine actions in future years.
Horseshoe Bend	5 - Low	?	?	No	No	No	?	?	?	?	Tildon Jones will determine length of water presence.
Wyasket Lake	5 - Low	Ute Indian Tribe	?	No	No	No	No	No	Yes	No	No action proposed.