VOLUME I

Technical Approach for R15PS00493

Proposed Project:
Fish Entrainment on the San Juan and Animas Rivers

Request for Proposal Document Number:
R15PS00493

Request for Proposal Document Title:
Fish Entrainment for the San Juan River Basin Recovery Implementation Program

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EXECUTIVE SUMMARY

Colorado Pikeminnow and Razorback Sucker are two endangered species of cypriniform fishes native to the San Juan River, a large tributary of the Colorado River. The decline of these and other native fishes in the San Juan River has been attributed to flow modifications, instream barriers, changes to the thermal regime and channel simplification. In addition, the introduction of non-native fishes may have altered predation dynamics and competition for habitat and resources. Colorado Pikeminnow was listed as an endangered species by the U.S. Department of the Interior in 1974. It is endemic to the Colorado River Basin where it was once abundant and widespread. Currently this species occupies only about 20% of its historical range, with the majority of the remaining Upper Basin individuals occurring in the Green River. Both of these species have been stocked in the San Juan River as part of the attempt to recover these taxa.

The scientific literature is replete with studies of fish entrainment at diversion structures. This problem is particularly acute in the American West where the number of diversions is great. To evaluate entrainment susceptibility and the effectiveness of mitigation strategies such as fish screens, researchers have considered a number of factors, including water velocity into and across diversion structures, diversion rates, diversion as percent of total river flow, and avoidance behavior. These studies have found that diversion rates, sweeping velocities (flow rate in the direction parallel to a fish screen), diversion proportion, and the presence of screens can all significantly affect entrainment rates.

In the San Juan River Basin, several studies have addressed drift rates of larval fish (Dudley and Platania 2000, 2000a, 2002, 2007) and entrainment (presence/absence) of endangered fishes in selected canals (Renfro et al. 2006). Dudley and Platania (2000, 2000a, 2002) estimated the magnitude of displacement of drifting larval fish was large as a substantial proportion of the passively drifting particles and protolarval fish released just below Hogback Diversion Dam were displaced downstream of Mexican Hat and Clay Hills. Given the magnitude of drifting larval fish in the San Juan River, the numerous agricultural diversions could pose a significant risk to species recovery. Most recently, Renfro et al. (2006) documented early juvenile (ca. 100 mm TL) sub-adult Colorado Pikeminnow in the Hogback Canal and early juvenile in the Fruitland Canal. No endangered fish were collected in either the Farmers Mutual or Jewitt canals (although the authors cautioned that the sites were only sampled twice).

The objectives of this project (Fish Entrainment for the San Juan River Basin Recovery Implementation Program) is to produce a stand-alone document that provides a complete listing and risk evaluation of entrainment and impingement hazards to endangered fish in the San Juan and Animas rivers. Quantitative information on fish distribution and abundances will be obtained from SJRIP monitoring data and other previous studies in the San Juan River Basin. Assessment of potential entrainment and impingement sites will be acquired during field visits to sites and from private, tribal, and government sources.

The stated study objectives include:

1) identify locations in the San Juan and Animas rivers where entrainment and/or impingement could be a potential threat to Colorado Pikeminnow and Razorback Sucker;
2) document withdrawal amounts (CFS and acre-feet) for each diversion and relate these to proportion of river flows;
3) document withdrawal locations using a GIS and legal descriptions;
4) identify ownership of diversion facilities;
5) document diversion locations with digital images and descriptions of diversions (aspect to river, height, width, gate structure, width of canal, etc.);
6) prioritize risk of entrainment at each site using metrics based on proportion of flow, amount of screening currently present, proximity to stocking locations, quality of habitat upstream of diversion, and other metrics as identified by the SJRIP biology Committee during the initial contract meeting; and
7) produce a draft and final report that summarizes and details 1-6 above.

In early 2015, The Nature Conservancy completed a study of agricultural water use in the San Juan Basin in New Mexico, which identified several opportunities to reduce agricultural river diversions by improving diversion and conveyance efficiency. Given the importance of diversion rates and diversion as a proportion of total river flow to fish entrainment, reductions in agricultural diversions in the San Juan Basin could significantly reduce entrainment risk as well as improve environmental flow conditions. As a separate effort to the work proposed under this USBR procurement, The Nature Conservancy will develop estimates of reduced diversion through efficiency measures for identified projects in the recent report. This information constitutes an “added value” to the final work product and can be used by the USBR and San Juan River Basin Recovery Program to help prioritize limited resources and strategize implementation of eventual entrainment mitigation in the San Juan River Basin.

1.0 INTRODUCTION

1.1 Background

The scientific literature is replete with studies of fish entrainment at diversion structures. This problem is particularly acute in the American West where the number of diversions is great. Studies of salmonids in the Pacific Northwest have been conducted in the laboratory and the field to assess (quantify) not only the negative impact to populations, but to parameters that result in increased entrainment. In the Sacramento River watershed, Green Sturgeon may have to pass 3,300 unscreened diversions during their life (Mussen et al. 2014). The authors examined avoidance behaviors and entrainment susceptibility of juvenile Green Sturgeon (in a flume) when differing river flow velocities (sweeping velocities: 0.15, 0.38, 0.61 m/s) and water-diversion rates (0.28, 0.42, and 0.57 m^3/s) were present. They demonstrated a large percentage of sturgeon became entrained (26-61%). The most challenging flow for sturgeon were low sweeping velocities and high water diversion but entrainment could be reduced by 78% if water-diversion rates were decreased from 0.57 m^3/s to 0.28 m^3/s.

Swanson et al. (2004) used a flume to create two-vector flows that typify habitat near screened diversions. These two-vector flows were an approach flow whose velocity is perpendicular to the screen and a sweeping flow whose velocity is parallel to the screen. The swimming and behavioral response of the juvenile Chinook Salmon were tested using a combination of three approach velocities, three sweeping velocities, a 0-cm/s control, and day and nighttime conditions. While fish were able to swim at the same velocity of the highest velocity flow regimes the authors suggested this was energetically expensive. Contact with the screen differed between day and night trials. More contacts occurred at night and were independent of either sweeping or approach velocities. During the day, contacts with the screen were less as sweeping velocity increased. Sweeping velocity also had a positive relationship with the velocity at which a fish passed the screen. The authors state that this is contrary to assumption held by fish screen designers and resource managers. Fish contacts, during the day, were not impacted by changes in approach velocities.

In the field, Walters et al. (2012) modeled differences in entrainment rates of juvenile Chinook Salmon, using PIT tag readers, into unscreened diversions as a factor of water diversion rate and flow velocity. Modeling indicated entrainment probability was associated with the mean proportion of streamflow diverted. Variability in the proportion of fish entrained increased as the proportion of streamflow diverted increased, but values were similar (example: if the mean proportion of flow diverted was 0.22 the mean entrainment probability was calculated to be 0.19). Under median-streamflow conditions with unscreened diversions, the estimated cumulative effect of the diversions was a loss of 71.1% of emigrating fish. When screening was incorporated into the model, mortality at an individual diversion could be reduced by 1.9%. When 40 diversions with the highest entrainment rates were modeled as having screens, the cumulative mortality rate decreased to 39.6%.

An addition modeling study involved an assessment of mark-recapture data indicated hatchery juvenile Chinook Salmon migrating from the Sacramento and San Joaquin Rivers to the tidal delta of San Francisco Bay, California were entrained at a greater rate when water diversion increased and flows decreased (Zeug et al. 2014). Two diversions in the tidal delta, where smolt may reside for weeks before entering the ocean, divert up to 60% of total flow. These diversions have facilities that salvage entrained fish. During the study period, 749 stockings occurred comprising >28,000,000 fish throughout three runs (seasons: fall, late fall, and winter). Modeling of water diversion rates and mean daily flow indicated a strong positive relationship between the diversion rate and fish entrainment and a significant increase in the amount of fish salvaged from the Sacramento River was observed when flows decreased.

These issues are not limited to North America. Boys et al. (2013) performed a field-based experiment, in Murray-Darling Basin, Australia, to assess entrainment and injury rates of a fish assemblage comprised of 12 species. Their experiment tested rates of fish entrainment (10-200 mm TL) on intake screens using paired combinations of two approach velocities (0.1 m/sec and 0.5m/sec) and four mesh screen sizes (0.5 mm, 1.0 mm, 2.0 mm, and no screen ranged in size from. There was no effect of screen mesh size on the number of fish entrained but more fish were entrained at the 0.5 m/sec approach velocity as compared to 0.1 m/sec. The authors concluded that optimization of approach velocities was of greater importance than screen mesh size and that smaller sized fishes should be prioritized for protection from entrainment given their higher vulnerability.

A recent study applicable to the San Juan River was that of Ellsworth et al. (2010) who examined larval entrainment (during drift) of two species of endangered suckers (from the western United States) in proximity of an existing pump station. Results indicated that drift occurred almost exclusively at night with larval densities concentrated near the surface, closer to mid-channel than to shore, and more abundant on the edge of the mid-channel with higher velocities. During day, drift of larval fish were found throughout the water column. The authors suggested that a pump site where the river channel was wider would allow water withdrawal to occur further from mid-channel and reduce entrainment of larvae.

In the San Juan River Basin, several studies have addressed drift rates of larval fish (Dudley and Platania 2000, 2000a, 2002, 2007), entrainment (presence/absence) of endangered fishes in selected canals (Renfro et al. 2006), and potential effects of selected diversion structures in fish movement (Stamp et al. 2005). Dudley and Platania (2000, 2000a, 2002) estimated the magnitude of displacement of drifting larval fish was large as a substantial proportion of the passively drifting particles and protolarval fish released just below Hogback Diversion Dam were displaced downstream of Mexican Hat and Clay Hills. In their 2000 study they stated “It appears that a large magnitude of displacement occurred between Shiprock and Cudei as a result of larval Colorado Pikeminnow and passively drifting particles being entrained in the Cudei Diversion Ditch. This study provides, in the form of the loss of fishes into Cudei Diversion Ditch, a quantifiable impact to San Juan River native fish populations.”

Stamp et al. (2005) examined two main channel San Juan River diversion structures that might adversely affect endangered fish movement and thereby inhibit recovery efforts. Their work specifically addressed issues of passage at the Fruitland Diversion (RM 178.5) located on the western edge of Farmington, NM near the mouth of the La Plata River near and the Arizona Public Service (APS) Company diversion (RM 163.3), also known as the Four Corners Power Plant Diversion. This latter diversion is located approximately midway between Farmington and Shiprock, NM. The study goals were to quantify physical and hydraulic characteristics upstream, downstream, and at the diversion structures, and determine if and when the structures hinder or eliminate fish passage (Stamp et al. 2005). No attempt was made to quantify rates of entrainment. Most recently, Renfro et al. (2006) documented early juvenile (ca. 100 mm TL) sub-adult Colorado Pikeminnow in the Hogback Canal and early juvenile in the Fruitland Canal. No endangered fish were collected in either the Farmers Mutual or Jewitt canals (although the authors cautioned that the sites were only sampled twice).

In February of 2015, The Nature Conservancy completed the USBR funded study: Evaluation of Opportunities for Irrigation System Improvements and Water Markets to Support San Juan River Basin Environmental Flows (TNC, 2015). This study found that there is the potential to reduce agricultural and municipal diversions along the San Juan River and its tributaries in New Mexico by implementing diversion and conveyance efficiency measures, thereby supporting environmental flow conditions and also reducing entrainment risk of endangered native fish. This study identified the following potential projects in the Basin:

- Installation of automated diversion infrastructure to help Basin ditch organizations better control and limit river diversions, as well as to facilitate implementation of scheduled diversion/irrigation practices, all of which can support environmental flows.
- Installation of ditch lining and/or piping along high priority reaches of Basin ditches to minimize seepage losses and reduce river diversion, in support of environmental flows.
- Operation of a direct San Juan River diversion facility by the City of Bloomfield during the winter months, which will eliminate seepage and other inefficiency losses now incurred through delivery of municipal drinking water by the Bloomfield Irrigation District canal.
- Development of a water market program to either lease or acquire agricultural water rights from water right owners who are currently not using their full water allocation, in order to provide economic benefits to water right holders while reducing river diversions and supporting environmental flows.
- Basin-wide irrigation system optimization assessment to identify and prioritize irrigation system improvement projects among San Juan Basin ditch organizations that can reduce river diversions and support environmental flows, while at the same time benefit farmers through improved systems operation.

The primary purpose of this study is to produce a stand-alone document that synthesizes fish information (from SJRIP reports and other studies in the basin) and overlays those data with a comprehensive review of the diversion structures in the study area so that the risk of entrainment of endangered fishes can be assed by individual canal

To prioritize limited resources and strategize implementation of these projects, a necessary first step would be to develop estimates of diversion reduction/instream flow benefit associated with each project. As a separate effort to the work proposed in this proposal as part of this USBR procurement, The Nature Conservancy will develop these estimates and provide them as part of the final report. This information constitutes an “added value” to the final work product and can be used by the USBR and San Juan River Basin Recovery Program to consider means to mitigate endangered fish entrainment risk along the San Juan River and Animas River.

Study Area

The San Juan River is a major tributary of the Colorado River and drains 38,300 mi^2 in Colorado, New Mexico, Utah, and Arizona. The majority of water in the San Juan River Basin is derived from high elevation snowmelt in the San Juan Mountains in Colorado. San Juan River discharge is regulated by Navajo Dam in New Mexico. Constructed in 1963, Navajo Dam captures discharge from the Los Pinos, Navajo, Piedra, and San Juan rivers. Perennial tributaries of the San Juan River not bounded by Navajo Reservoir include the Animas, La Plata, and Mancos rivers and McElmo Creek, UT. (Figure 1).

In the San Juan River Basin numerous diversions extract water from the main-stem for agricultural and urban use. The Navajo Indian Irrigation Project (NIIP), San Juan-Chama Diversion, and Navajo-Gallup Water Supply Project allocate major depletions from the San Juan Basin at Navajo Reservoir. Downstream of Navajo Reservoir, smaller water diversion projects shunt water and act as potential portals for entrainment. Agricultural diversions include the Hammond Irrigation Project, supplying water for agricultural use from Blanco to Farmington, NM. The Public Service Company (APS) located downstream of the Animas River confluence extract water and create an instream barrier limiting fish movement. The Fruitland Irrigation Canal, Farmers Mutual, and Jewett Valley Canal, supply water for agricultural use between Farmington and the Navajo Nation. The Hogback Diversion, supplies water for crop development within the Navajo Nation between Shiprock and Cudei, NM. The Hogback Diversion is equipped with fish screens and an entrainment weir. Similarly the PNM weir supplying water to the San Juan Generating Station is equipped with a fish ladder. Downstream of these diversions small point diversions extract water from the San Juan River flowing through the Navajo Nation and in Bluff, UT.

There are numerous diversions on the Animas River in NM and CO. The largest diversion is the Animas-La Plata Project, completed in 2007 by the Bureau of Reclamation which draws water from the Animas River near Durango, CO filling an off channel reservoir, Lake Nighthorse. Over 15 small diversions exist on the Animas River flowing through NM.

Similar small diversions have been developed in the La Plata. The Mancos River has three impoundments for agricultural, hydroelectric and urban use. The Mancos River does not sustain perennial flow to the San Juan River. McElmo Creek near Aneth, UT is a perennial system due to irrigation returns back to the creek and provides important habitat to native catostomids.

1.2 Project Justification

Entrainment and impingement of any life stage is a recognized threat to the recovery of endangered fishes in the San Juan River (Goal 2.4, 2014 SJRRIP Long-Range Plan). Previous investigations have demonstrated that endangered species are susceptible to entrainment at diversion structures located on the San Juan River (Renfro et al., 2006.) This proposal will locate and identify, quantify, and rank all potential diversion risks to Razorback Sucker and Colorado Pikeminnow within the proposed study area.

The methodology outlined in this proposal directly addresses the following Tasks listed in the 2014 SJRRIP Long-Range Plan:

Task 2.4.1.2 Investigate the need for and construct, if appropriate, a fish screen or deflection weir at the Arizona Public Service Company (APS) Weir.

Task 2.4.1.3 Investigate the need for and construct, if appropriate, a fish screen or deflection weir at the Fruitland Canal.

Task 2.4.1.4 Investigate the need for and construct, if appropriate, a fish screen or deflection weir at the Jewett Valley Ditch.

Task 2.4.1.5 Investigate the need for and construct, if appropriate, a fish screen or deflection weir at the San Juan Generating Station.

Task 2.4.2.1 Investigate the need for and construct, if appropriate, a fish screen or deflection weir at diversion structures in the Animas River.

Task 2.4.2.2 Investigate the need for and construct, if appropriate, a fish screen or deflection weir at the Farmer's Mutual Ditch.

1.3 Project Objectives

The objectives of this project (Fish Entrainment for the San Juan River Basin Recovery Implementation Program) are to produce a stand-alone document that provides a complete listing and risk evaluation of entrainment and impingement hazards to endangered fish in the San Juan and Animas rivers. Quantitative information on fish distribution and abundances will be obtained from SJRIP monitoring data and other previous studies in the San Juan River Basin. Assessment of potential entrainment and impingement sites will be acquired during field visits to sites and from private, tribal, and government sources. The study objectives (listed below) are also in 2.0 (Plan or Study Design and Methods) along with detailed annotations about the information to be obtained and products to result from the effort.

1) Identify locations in the San Juan and Animas rivers where entrainment and/or impingement could be a potential threat to Colorado Pikeminnow and Razorback Sucker;
2) Document withdrawal amounts (CFS and acre-feet) for each diversion and relate these to proportion of river flows;
3) Document withdrawal locations using a GIS and legal descriptions;
4) Identify ownership of diversion facilities;
5) Document diversion locations with digital images and descriptions of diversions (aspect to river, height, width, gate structure, width of canal, etc.).
6) Prioritize risk of entrainment at each site using metrics based on proportion of flow, amount of screening currently present, proximity to stocking locations, quality of habitat upstream of diversion, and other metrics as identified by the SJRIP biology Committee during the initial contract meeting.
7) Produce a draft and final report that summarizes and details 1-6 above.

2.0 PLAN OR STUDY DESIGN AND METHODS

Project Outline
Phase I: Data Acquisition and Synthesis

Task #

Unless otherwise noted, tasks listed below will be collaboratively conducted and completed by ASIR and TNC.

1 Awarding of the contract is scheduled for April 2015.

2 Soon after the award of the contract, a preliminary one-day meeting with members of the SJRIP and other interested parties will be scheduled so that potential locations of diversions, methods

for data collection, and methods for determining potential risk of entrainment sites can be finalized.

3 The first major component of this project will be to identify all pertinent fish entrainment or impingement sites in the study area. While our initial assumption is that most of these (entrainment or impingement sites) will be withdrawal points for irrigation canals, we will not limit our review exclusively to irrigation diversions. For example: the City of Bloomfield, NM, operates a backup diversion facility which can withdrawal municipal drinking water from the San Juan River through a pipe. This review will result in a database (and subsequent map) containing all potential fish entrainment or impingement sites within the study area. The list of sites will be reviewed and form the foundation for the field trips to examine these locations. We anticipate being able to identify the majority of sites during the first month of the project and will have the final working list within one month of the award of the contract (by the end of June or July 2015).

4 Determination of the legal owners of the entrainment or impingement sites in the study area will likely occur concurrent with development of the draft working list of entrainment and impingement sites. Data on the legal owners of the sites will be recorded in a database and include:

a. Legal name of owner and/or entity operating the diversion.
b. Type of entity operating the diversion (i.e. individual, ditch association, municipality, state agency).
c. Contact information for representative(s) of entity operating the diversion (address, phone number(s), email address(es), and website, if available).

5 Four separate field trips will be made to visit each of the entrainment or impingement sites identified in the draft working list. Based on experience conducting field work (i.e. surveys, investigations, and construction) irrigation ditches/canals and related infrastructure, both in the Middle Rio Grande and San Juan River Basins, it is anticipated that the pertinent entrainment or impingement sites in the study area can be surveyed in three separate field trips. Part of the time involved in conducting these surveys will be to coordinate with ditch association representatives, many of whom work full-time and are only available to meet after normal office hours. For these field trips, a significant amount of time will also be spent driving from one survey location to another. The first three field trips will be attended by both ASIR and TNC staff. It is expected that the fourth field trip will be used to gather necessary follow-up data and to conduct surveys that were not able to be scheduled with ditch association representatives at the time of the first two surveys. Data to be acquired during the site visits include:

a. Coordinates of all diversion points and entrainments (GPS coordinates - UTM zone, UTM coordinates [easting and northing], UTM datum [i.e., NAD 27], longitude and latitude [degree decimals]);
b. Text description of location, river mile, USGS 7.5’ quadrangle of the diversion point, nation, state, and county.
c. Text description of access route used to survey the diversion structure.
d. Dimensions and condition of permanent structures in the river adjacent to diversion structures (including engineered/built grade control structures, dams, sills, or weirs) used to provide adequate head for diversion structures.
e. Text description of diversion structure, documenting the method of construction of the “headworks” (e.g., concrete, wood, pipe, or natural materials such as boulders) and method of diversion/flow rate control (e.g., radial or slide gate, spillways/returns, check dams)
f. Text description of any screens or grates across the face of diversion structures. This description will note the condition of the screen or grate.
g. Dimensions of diversion structure intake (i.e. height and width) when gates are fully open, dimension of major gates, and dimensions of diversion opening over the normal operating range. In the case of a pipe diversion, the diameter of the pipe will be documented

h. Dimensions of any screens or grates across the face of diversion structures, including the screen mesh or grate opening size.

i. Other measurements can be taken at each site including approach velocity (measured 8 cm in front of and perpendicular to diversion intake) and sweeping velocity (measured parallel to diversion intake) if identified as relevant measurements at the meeting with SJRIP and COTR; these variables have been shown to be important determinants of fish entrainment in other studies conducted outside of the American Southwest

j. Digital photographs of permanent structures in the river adjacent to the diversion structure, and digital photographs of diversion structures and other pertinent flow control structures such as gates and nearby spillways.

Ground measurements entrainment sites will acquired with Trimble GPS units and mapped in ArcInfo GIS to provide a detailed image for site. Pathfinder Office (or similar mapping software) will be used for all post-processing of raw data. Coordinates of the diversions and entrainment will be recorded with a backpack-mounted Pathfinder GPS Receiver and a Ranger Handheld Data Collector for reliable submeter (RMS) 2-D data collection with a published accuracy of about 20 cm RMS.

Field Work, Safety — Safety is paramount and working around diversion structures is inherently dangerous. At least one individual participating in field work are required to successfully complete an International Rescue Instructors Association (IRIA) level 2 swiftwater rescue class and American Red Cross CPR/AED training. Type III personal flotation devices (PFD's) will be worn by sampling personnel at all times while working. Safety briefings will occur before each field trip. High quality light-weight Gore-Tex waders and boots will be issued to all personnel. In addition, all personnel will be required to provide and use wide brimmed hats, sunscreen, and sunglasses (provided at no cost to the program).

Extensively stocked first aid kit replete with items necessary for most minor medical situation. Additionally, the first aid kit will contain a suite of items (i.e., splints, neck braces, butterfly stitches, snakebite kits) needed to address more serious medical conditions. First aid kits will be inventoried after each sampling trip and used and/or expired items replaced. Personal cell phones will be used (at no cost to the project) to contact outside parties should a medical situation arise. In addition, an Iridium 9505-satellite phone will be provided to field crews (at no cost to the project) for use in case of an emergency.

6 Acquisition and synthesis of the physical data acquired during the field trips as well as data acquired from other sources will be accomplished during autumn 2015. For each diversion, physical data recorded during the field trips will be summarized in a table, which will be included in an appendix in the final report. Maps depicting the entrainment and impingement sites will be prepared by the TNC. These maps will indicate the location of any permanent structures in the river adjacent to diversion structure, the location of the diversion structure itself, and any nearby pertinent flow control structures such as spillways. Photographs associated with each diversion will also be included in final report appendix.

7 The volume and timing of water withdrawals at individual diversions identified in this study will be acquired from available records. In the case of irrigation ditches, diversion records will be obtained from state agencies that administer water right use and that, in many cases, operate stream flow gages on irrigation ditches. In the case of irrigation ditches or canals not operated by private ditch associations, but rather operated by the Navajo Nation or the federal government, diversion records will be requested from the Navajo Nation or affiliated water users associations, or federal agencies that oversee operation of the diversions. In the case of municipal diversions, diversion records will be obtained from the municipality. If available, ditch diversion records will be compiled for 10 years. If digital diversion records are not available, then an effort will be made to obtain paper records from the ditch association, state agency or federal agency. If sufficient data are available, diversion rates (cfs) and volumes (acre-feet) will be summarized for each irrigation ditch on a daily and monthly average for each year.

8 Discharge data from the San Juan and Animas rivers will be acquired from USGS gaging stations throughout the study area and will match the period of records obtained under Task 8 for withdrawals. River discharge data from 2005 through 2014 are necessary to determine the percent of the river being diverted at various withdrawal points (see Task 7) over the past 10 years. Withdrawal data acquired for each of the pertinent diversion points will be analyzed and presented along spatial and temporal scales. Daily diversion amounts (in cfs and acre-feet) for each diversion will be combined with daily stream discharge to calculate percent of daily flow diverted for each of the years that withdrawal data are available (up to 10 years). Mean daily and mean monthly percent of flow diverted will be summarized by year and across years along with the number of diversion days each year. This information will be part of the risk assessment of each canal. A number of studies have shown that the percent of stream flow diverted, number of diversion days annually, and seasonality of diversion affect the magnitude of fish entrainment in diversions.

9 The 2005 – 2014 San Juan River fish monitoring and research dataset will be queried for endangered fishes. Specimens will be, following the monitoring objectives, divided into three life history stages: larval fish, small-bodied fish, and adult fish. Within each of these categories, fish distributions and relative abundance will be determined spatially and temporally (annually) so that these data can be overlaid with canal diversion information. Maps illustrating the differences in spatial and temporal distribution will be constructed and included in the final report. The endangered fish data will reported by life stage (larval, small-bodied, and adult) and presented temporarily (when available) and longitudinally. Catch rate metrics will be used as an indicator of relative abundance. The distributions and relative abundances of endangered fishes will be mapped and those data overlaid with discharge, canal withdrawal, and percent of river diverted to generate risk indices for each entrainment or impingement point.

10 This task ensures progress of the project through coordination with the COTR and contractor, and timely addressing of any issues that might arise during the tenure of the project. Project oversight, maintenance, and coordination (and monthly progress report) will be undertaken by ASIR. Tasks under this line item include coordinating project efforts between ASIR, TNC and the COTR for the USBR, being a liaison with the water users in the San Juan Basin as we acquire information related to irrigation canals, their history, workings, physical structure, and limitations, reporting as necessary to the SJRIP, and to coordinate billings and payments to contractors.

Phase II: Project Reporting

Task #

11 The monthly report will be submitted to the designated USBR point of contact and will use the Task timeline (Table 1) to track the progress of the project. The monthly report will also include a

brief summary of activities of the previous month. These reports will serve as project progress in reference to invoicing for work completed.

12 The draft final report will be written in scientific format and contain the following sections (Major Sections in **BOLD** followed by bulleted key topics for inclusion):

Executive Summary:
- Brief synopsis of the study and notable results,
- Summary of the main findings and interpretation of their importance to the entrainment of endangered San Juan River fishes.

Introduction:
- Summarizing pertinent literature on entrainment in the San Juan River and Upper Colorado River Basin with emphasis on Colorado Pikeminnow and Razorback Sucker.
- Synopsis of major findings from previous studies and their relation to the conservation of Colorado Pikeminnow and Razorback Sucker.
- Goals and objectives of the study.

Study Area:
- Description of the San Juan and Animas river, including connectivity, annual flow characteristics, and longitudinal characterization of flow and habitat.
- Summary of recent flow as measured at USGS gages in the study area.

Methods:
- Methods used for inclusion of canals in the study
- Methods used for collection, synthesis, and analysis of physical canal data,
- Description of data collected at each of study sites
- Methods used for synthesis and analysis of flow data by canal,
- Summary of the overall sampling structure/schedule for the study,
- Description of sources of fish data (for each life stage)
- Methods employed for the synthesis and analysis of fish data,
- Computational techniques used to quantify fish density,
- Methods used to determine level of risk by canal.

Results:
- Identification of pertinent diversion points,
- Longitudinal synthesis of diversion volumes,
- Longitudinal synthesis of percent of river diverted,
- Summary of longitudinal distribution of endangered fishes by life stage (larval, small-bodied, adult) and season in reference to pertinent diversion points,
- Risk identification and ordering of sites using criteria presented in Methods.

Discussion:
- Assess results of the study on the recovery of endangered fishes
- Propose means to minimize entrainment risks
- Propose means to mitigate entrainment risks
- Explore “win-win” options for water use
- Propose additional information needs that would move the process forward.

Acknowledgements:
- Individuals and institutions who assisted in the project,
- Source of funding,
- Reviewers

Literature Cited:
- List of references (in standard scientific format) used in the report.

Appendices:
- Detailed list containing location of all diversion points and entrainments including GPS coordinates (UTM zone, UTM coordinates [easting and northing], UTM datum [i.e., NAD 27],

longitude and latitude [degree decimals]), text description of location, river mile, USGS 7.5' quadrangle of the diversion point, nation, state, county, and legal owner of the canal or entrainment structure, type of entity operating the diversion, and contract information for representatives of the entity operating the diversion.

- Summary of physical characteristics for each diversion point, including photographs. Pertinent structures in canals (i.e., screens or grates, return flows to the river) will also be noted.
- Summary of discharge data for the river and for individual canals used in development of risk indices for each canal.
- Tabular presentation of endangered fish data by gross life stage (larval, small-bodied, adult) used in development of risk indices for each canal.
- Tabular presentation of fish data from individual canals presented in previous reports and used in development of risk indices for each canal.

The draft report will contain tables and figures that assist presentation of data acquired for this project. All pages, tables, figures, illustrations, and appendices will be sequentially numbered. Electronic copies of draft reports will be submitted by 31January 2016.

13 The draft final report will be distributed to SJRBRIP Peer Reviewers and to the Biology Committee for review and comment. After receipt of all comments, we will review and group comments by category of concern (i.e., similar questions will be addressed collectively) and make changes to the report accordingly. A written record of actions taken for reviewer comments will be maintained.

14 An oral presentation of this project will be given to the Biology Committee of the SJRBRIP (and interested parties) at their annual researchers meeting in February 2016. A PowerPoint presentation summarizing the purpose, methods, results, and conclusions of the project will be prepared and presented (up to 30 minutes) at the meeting. Reviewer comments or recommendation generated from the presentation will be reflected in the report and subsequent (May 2016) presentation.

15 An abbreviated version of the oral presentation of this project that was given in February 2016 to the Biology Committee of the SJRBRIP will be presented at a combined Biology Committee and Coordinating Committee meeting of the SJRBRIP in May 2016. The PowerPoint presentation that again summarizes the purpose, methods, results, and conclusions of the project will be created and presented (15 minutes) at the meeting. Reviewer comments or concerns generated from the presentation will be reflected in the final report.

16 The PI's will submit electronic copies of the fully revised final document after incorporating reviewer suggestions to the draft report (covered under Task 17). In addition, the database developed for this project will be submitted simultaneously with the final report. Five months have been allocated, from the submission of the draft final report (31 January 2016) to completion of the final report. The reason for allocating this time is so that the information can be presented to SJRBRIP Biology Committee (Feb 2016) and SJRBRIP Coordination Committee (May 2016) and so that the review process can track with all other SJRBRIP projects. Items completed under Task 19 include final proof reading of the report as well as review of the data included in the project database.

17 The contract end date is 31 July 2016. By this date, all deliverables will have been submitted to the contracting agency, all invoices for work accomplished will have been submitted and paid, and the report on the project will have been finalized.

2.1 CRITERIA BY WHICH PROJECT SUCCESS CAN BE DETERMINED

The product of this project will be a report, which, if successfully addressing the R15PS00493 scope of work, will be a stand-alone document (i.e., synthesizes information from other works and does not require the reader to review those supporting reports) document that provides the following information:

- Comprehensive list of canals in the study area
- Comprehensive list of diversion points in the study area
- Comprehensive list of entrainment/impingement points in the study area
- Documentation of the following for the above three items:
  - Ownership, contact information, operating entity, contact information, geographic location (GPS coordinates), physical characteristics (etc. See Task 5 for detailed listing)
- Geo-referenced maps of canal and entrainment/impingement points
- Volume of water diverted/duration of diversion/timing of diversion
- Discharge in the San Juan River, in proximity to canal diversion points, before, during, and after canal diversions
- Endangered fish (larval, small-bodied, adult) distribution and relative abundance in relation to canal diversion points
- Assessment (Priority List) of risk of entrainment/impingement of endangered fishes for each site
- Discussion of issues related to risk of endangered fish entrainment/impingement at each site
- Discussion of means to mitigate risk of endangered fish entrainment/impingement at each site

3.0 SCHEDULE

The schedule for completion of the Tasks listed under 2.0 (Plan or Study Design and Methods) is presented in Table 1. We have scheduled 16 months for the completion of the project and will be able to begin work immediately upon its award.

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TABLES

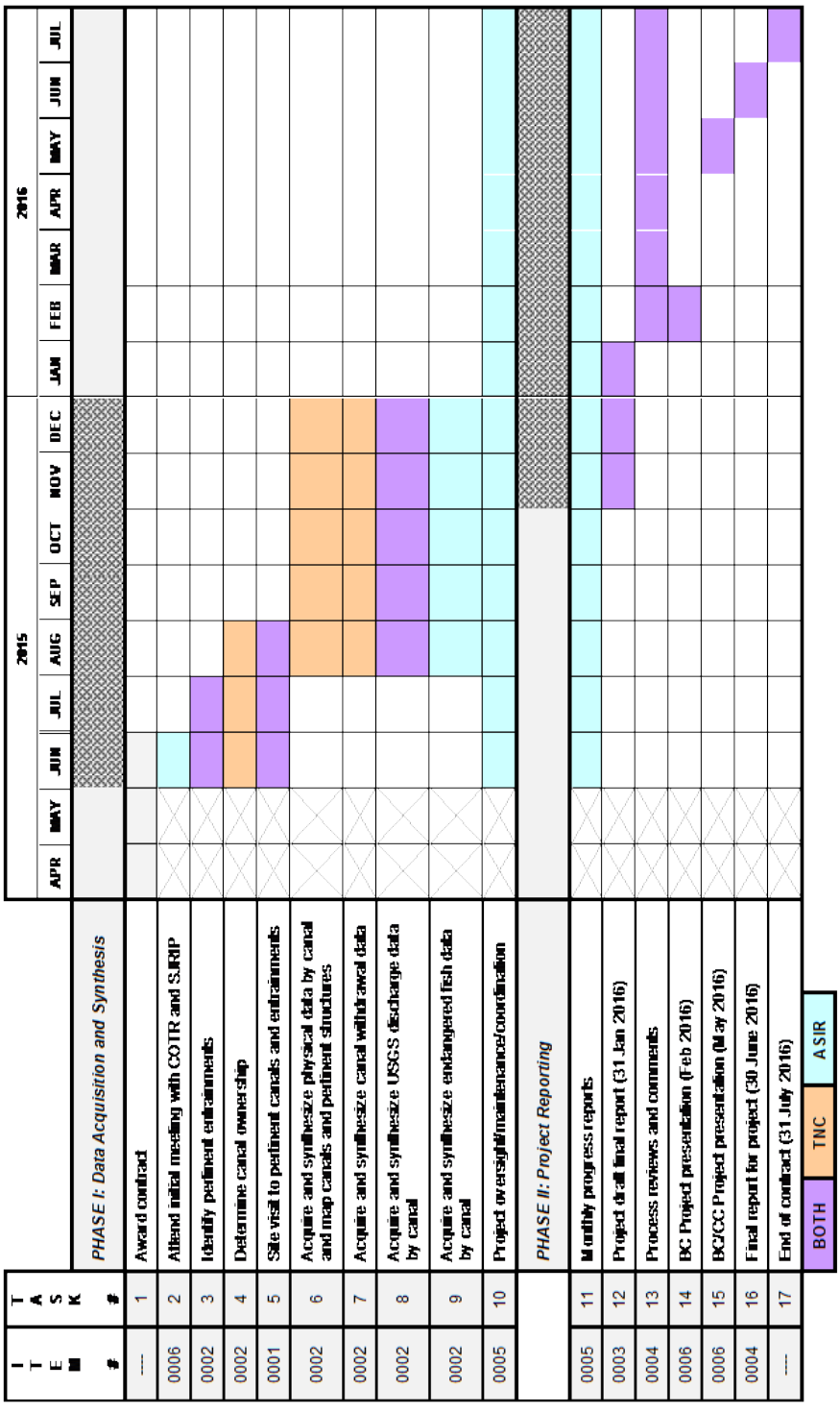

Table 1. Project timeline by Phase, Budget Item, and Task for the 2015 SJRIP fish entrainment study.

FIGURES

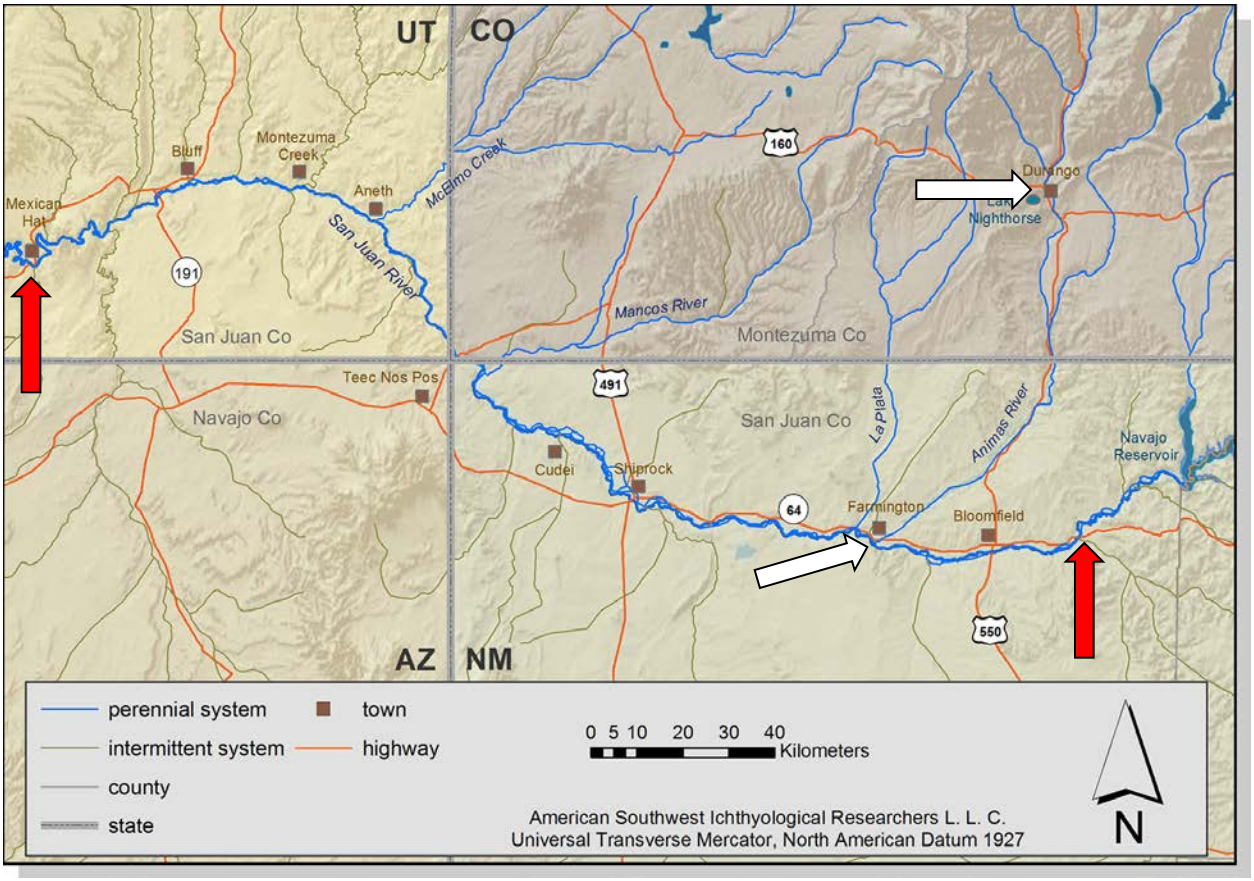

Figure 1. Map illustrating the portions (between the arrows) of the San Juan River (red arrows) and Animas River (white arrows) included in this project.