Scope of Work: San Juan River Phase II Channel Restoration Site Monitoring

to

Bureau of Reclamation

From

Dave Gori, The Nature Conservancy
212 E. Marcy St., Suite 200, Santa Fe, NM
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San Juan River Phase II Channel Restoration Site Monitoring
Fiscal Year 2017 Scope of Work

Prepared By:
Dave Gori, Ph.D.
Director of Science, The Nature Conservancy
212 E. Marcy St. #200, Santa Fe, NM 87501
dgori@tnc.org

Vincent Lamarra, Ph.D.
Director, Ecosystems Research Institute (ERI)
975 South State Hwy Logan, UT 84321
vlamarra@ecosystemsresearch.com

Michael A. Farrington
American Southwest Ichthyological Researchers, LLC (ASIR)
800 Encino Place NE, Albuquerque, NM 87102
michael_farrington@asirllc.com

Matthew Zeigler
Conservation Services Division, New Mexico Department of Game and Fish
One Wildlife Way, Santa Fe, NM 87507
Matthew.Zeigler@state.nm.us

INTRODUCTION

Since the 1930s, the San Juan River's channel has become narrower, deeper and less complex; expansive sand bars and open portions of the floodplain have become vegetated by nonnative Russian olive and saltcedar, and stream banks have become densely armored by nonnative vegetation (Bliesner and Lamarra 2006; Bassett 2015). In addition, many of the secondary channels that historically supported backwaters and other low-velocity habitats are now disconnected from the main channel (i.e. perched above the river's primary channel) and are choked with nonnative vegetation (Stamp et al. 2006). As a result of these changes, there has been a greater than 50% loss of backwaters and secondary channel habitats between 1998 and 2005 (Miller 2006). Large floods that create and maintain these habitats are virtually nonexistent in the system and flow recommendations implemented since 2000 have not been successful in opening up secondary channels or in maintaining backwaters due to the extensive bank armoring by nonnative vegetation; this armoring reduces the capacity of high flows to scour sediments from secondary channels and reconnect them to main channel (Miller 2006; Michels-Boyce 2013). Backwaters and secondary channels are critical to the survival of young of the year and juvenile native fish, including Colorado pikeminnow and razorback sucker (Propst and Hobbes 1999; Archer et al. 2000). Retention studies after stocking of Colorado pikeminnow and razorback sucker showed that secondary channels are important habitats for stocked endangered fish, especially during the initial months after stocking (Golden and Holden 2005).

In 2009, The Nature Conservancy (TNC) received funds from the New Mexico Environment Department through their River Ecosystem Restoration Initiative to implement a large-scale restoration experiment—restoring channel complexity at six sites using a variety of methods including: 1) re-establishing the secondary channel inlet (connection with the river) and cleaning out (excavating) the secondary channel; and 2) mechanical clearing and chemical treatment of Russian olive and saltcedar along the secondary channel banks.

The initial channel restoration project, which was completed in the fall of 2012, was monitored using existing resources from the Small Bodied Fish, Larval Fish, and Habitat Monitoring programs. In early 2013, TNC received additional funds for a Phase II restoration effort and in August, a complex site, located between RM 134 and 137, was selected (Figure 1).

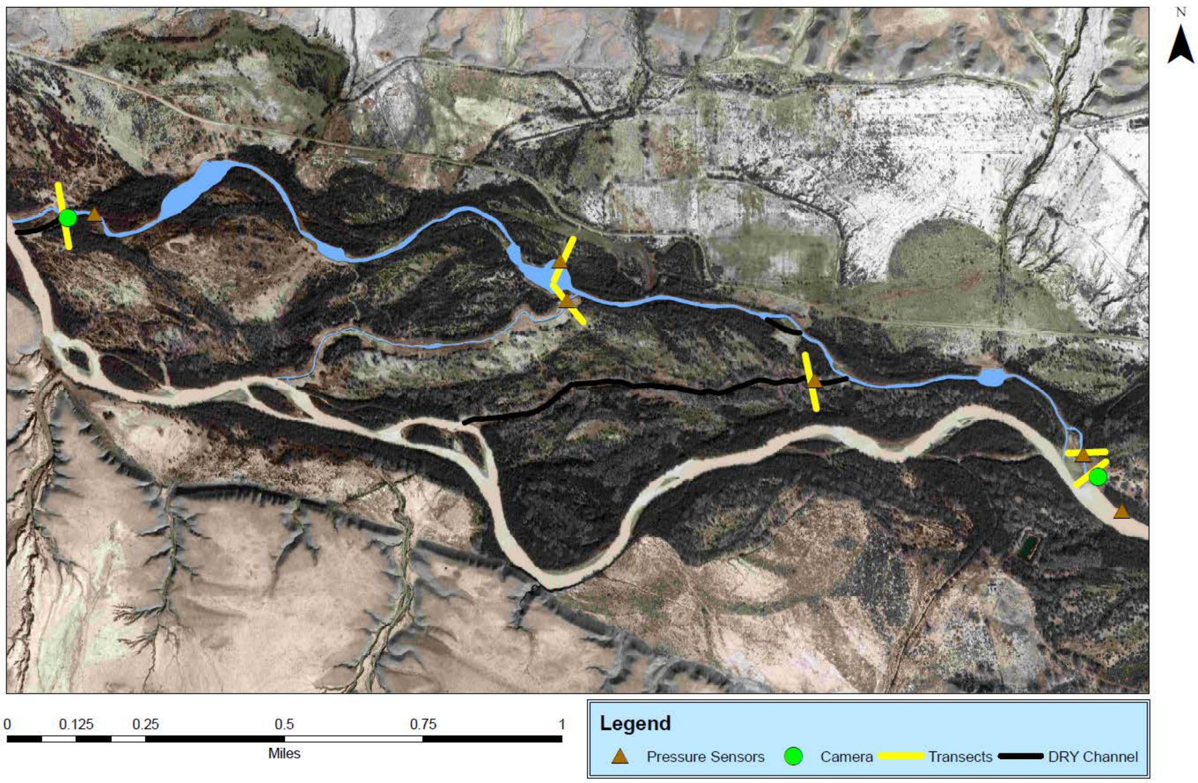


Figure 1. Phase II restoration site with the approximate location of channel cross-sections, pressure sensors, and field cameras.

As part of the site selection process, the historical habitat and the larval and small-bodied fish monitoring databases were queried to determine all available data that had been collected at the site. These data will be used as a baseline prior to construction. In terms of the Small Bodied Monitoring Program, the historical data are summarized in Table 1. There have been a total of 21 observations between 1998 and 2013. Similarly, there have been 36 collections of larval fish made during this time period.   In a similar manner, the historical habitat mapping data was queried specifically for the Phase II restoration site. The intent was to determine the status of the channel (flowing or non-flowing) at the time of mapping. In total, there were 31 observations between June 1993 and August 2013. Flows at mapping ranged between 479 cfs and 9,453 cfs. A temporal summary can be seen in Figure 2.

Table 1. Summary of the historical collections from the Small Bodied Monitoring Program between RM 134 and 137.

Query19						
Year	Site (RM)	Channel	UTM Zone	UTM East	UTM North	Coordinate System
1998	135.2	Secondary				
1998	136.5	Secondary				
1999	136.5	Secondary				
2000	134.3	Secondary				
2000	136.6	Secondary				
2001	134.25	Secondary				
2001	136.6	Secondary				
2002	134.4	Secondary				
2002	136.55	Secondary				
2003	135.5	Secondary				
2003	136.8	Secondary				
2004	136.5	Secondary				
2006	134.3	Secondary				
2006	136.5	Secondary	12S	694014	4084091	
2007	134.3	Secondary	12S	108.86046	36.8923	
2010	133.9	Secondary	12S	690100	4085104	NAD83
2010	135.9	Secondary	12S	692934	4084055	NAD83
2011	134.3	Secondary	12S	690635	4085068	NAD83
2012	134.3	Secondary	12S	690646	4085061	NAD 83
2013	135.1	Secondary	12S	691404	4084314	NAD 83
2013	136.4	Secondary	12S	690041	4084140	NAD 83

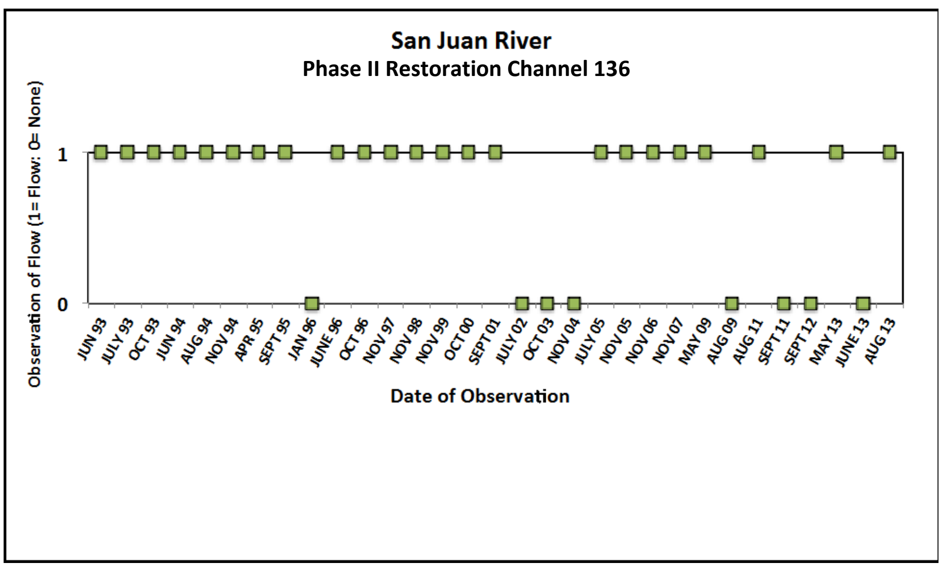


Figure 2. Temporal summary of the status (flowing or non-flowing) of the restored secondary channel located at River Mile 136 prior to its restoration.

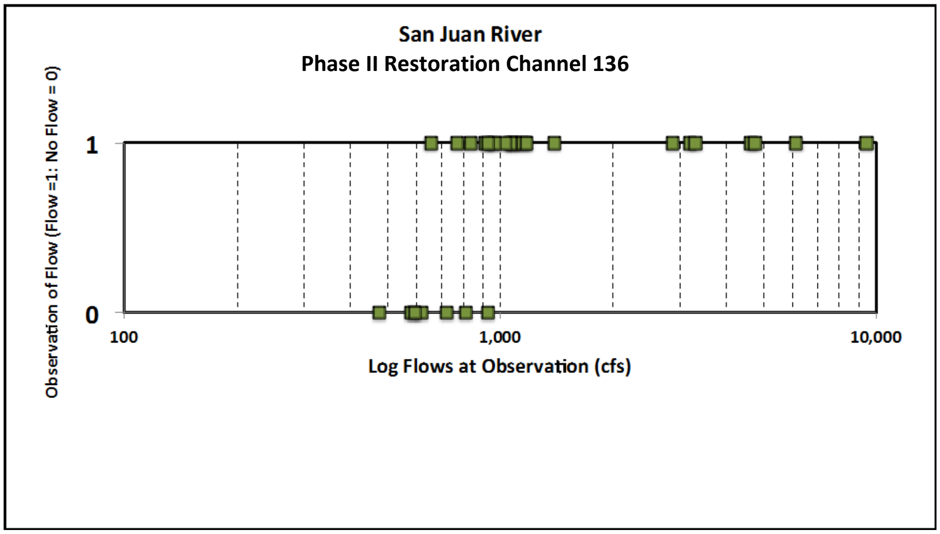


Figure 3. Status (flowing or non-flowing) of the restored secondary channel located at River Mile 136 prior to restoration as a function of flow at the time of observation.

As noted in Figure 2, there were three periods where there were over 5 continuous observations where the main secondary channel was flowing. In a similar manner, the data were plotted as a function of flow at observation time and status (Figure 3). As shown in this figure, the channel historically did not flow at river flows at or below 659 cfs and always flowed at river flows above 930 cfs. Between these two flows the channel was intermittent, flowing in 9 out of 13 observations or 70% of the time.

These three data sets obtained from the historical Larval Fish, Small-Bodied Fish and Habitat Monitoring Programs will be valuable in assessing the success of the restoration process. The restoration work at this site was completed in late fall 2014. Because of the need for better information on the availability and persistence of aquatic meso-habitats at the restored site and the occurrence and relative abundance of larval and small-bodied fish in these habitats over time and as a function of flow conditions, an integrated, stand-alone monitoring program is required. The intent of this proposal is to continue implementation of a monitoring study that addresses the following objectives:

1) To measure changes in habitat features of the restored secondary and tertiary channels, larval fish abundance, and small-bodied fish abundance over three years following completion of restoration treatments at the Phase II site; habitat features include: a) the number and surface area of different aquatic meso-habitats in restored channels, and b) channel cross-sections established in restored secondary and tertiary channels.
2) To measure seasonal changes in habitat features of the restored secondary and tertiary channels, larval fish abundance, and small-bodied fish abundance from prior to spring runoff to late fall during each of the three years following completion of restoration treatments.
3) To compare the relative abundance of small-bodied fish collected in different meso-habitats in the restored site to determine whether preferences for specific meso-habitats exist.

4) To measure changes in habitat features of the restored secondary and tertiary channels associated with environmental flow releases or large floods that may occur over three years following completion of restoration treatments.
5) To compare habitat features, larval fish abundance and small-bodied fish abundance between restored channels and a control secondary channel site.

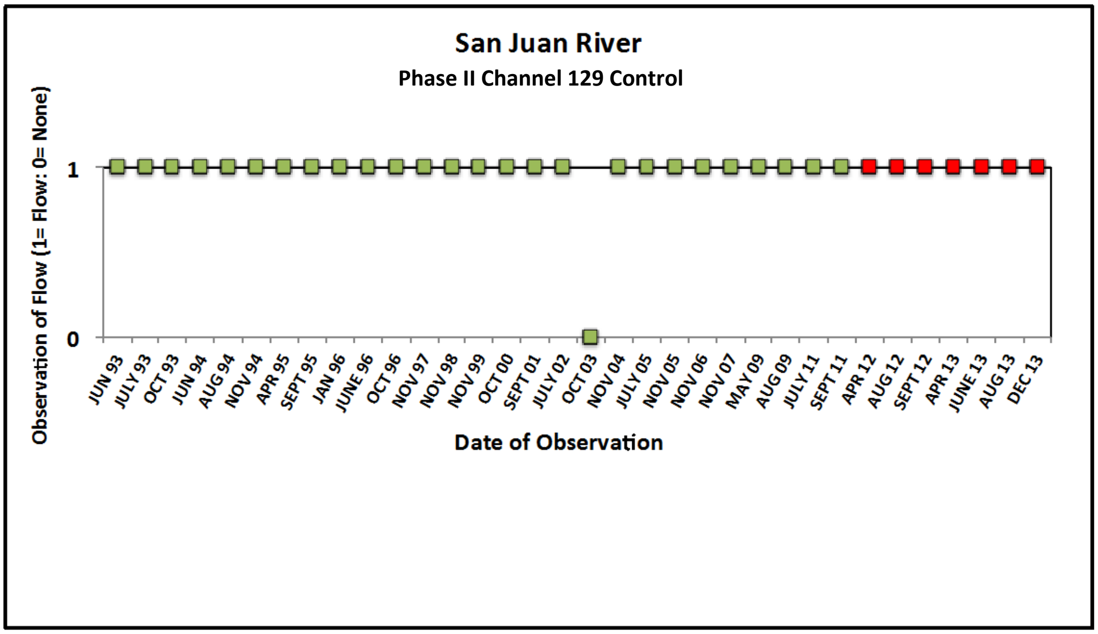
These objectives were derived from four monitoring questions that were discussed at two Biology Committee meetings in 2014.

To address these objectives, we initiated a monitoring study in 2015 that involves simultaneous collection of habitat, larval fish, and small-bodied fish data so that spatial habitat data can be linked with fish species composition and abundance information. The monitoring activities and measurements include:

Aquatic habitat mapping: 1) hand-mapping of aquatic habitats in restored secondary and tertiary channels using methods developed by Lamarra (Bliesner el al. 2008); 2) surveying of channel cross-sections along permanent transects established along restored channels; and 3) electronic data collection using sensors that simultaneously record water temperature and pressure which will be used to measure water depth in the channel. The sensors were placed strategically in restored secondary channels and the main channel (Figure 1) and the two field cameras were placed in the mouth and near the outlet of the restored secondary channel.

At the same time that habitat mapping and surveying of channel cross-sections occur, a sample of available aquatic habitats in restored secondary and tertiary channels will be sampled for larval and small-bodied fish (see Methods for details). With these data, we can address the first four objectives. Our intent is two-fold: first, to determine the number, surface area, and proportionate abundance of different meso-habitats in the restored channels, and second, to estimate the relative abundance of identified larval and small bodied fish in different meso-habitats. To detect changes in the occurrence and relative abundance of habitats, small-bodied fish and larval fish, comparisons will be made in these parameters between sampling visits (e.g., from before spring runoff to late fall) and across years.

A secondary channel site located at RM 129 that was flowing more frequently than the restored site did prior to restoration (e.g., had water and habitat at almost all times and flows) was selected as a control (Figure 4). A parallel set of measurements will be collected at the control site, however, the site was not instrumented with a field camera and pressure-temperature sensors (see below). The control channel is located just downstream of the restoration site and was used as a control site for the RERI restored channels. There are no tributaries between the two sites and their proximity to each other should insure similar physical conditions. In addition, historic larval and small-bodied fish collections made over multiple years exist for the Phase II site prior to restoration so that a comparison of fish captures (abundance, species composition) for specific meso-habitats can be made before and after treatment. If the restoration effort is successful, we expect that the restored channels will provide aquatic habitat for larval and small-bodied fish when flows are between 500-700 cfs and higher just as the control channel does. Pressure sensor data confirmed this prediction: the restored secondary channel and tertiary B flowed continuously at all flows including those < 700 cfs from late April through early November in 2015. Comparisons of the relative abundance of meso-habitats in



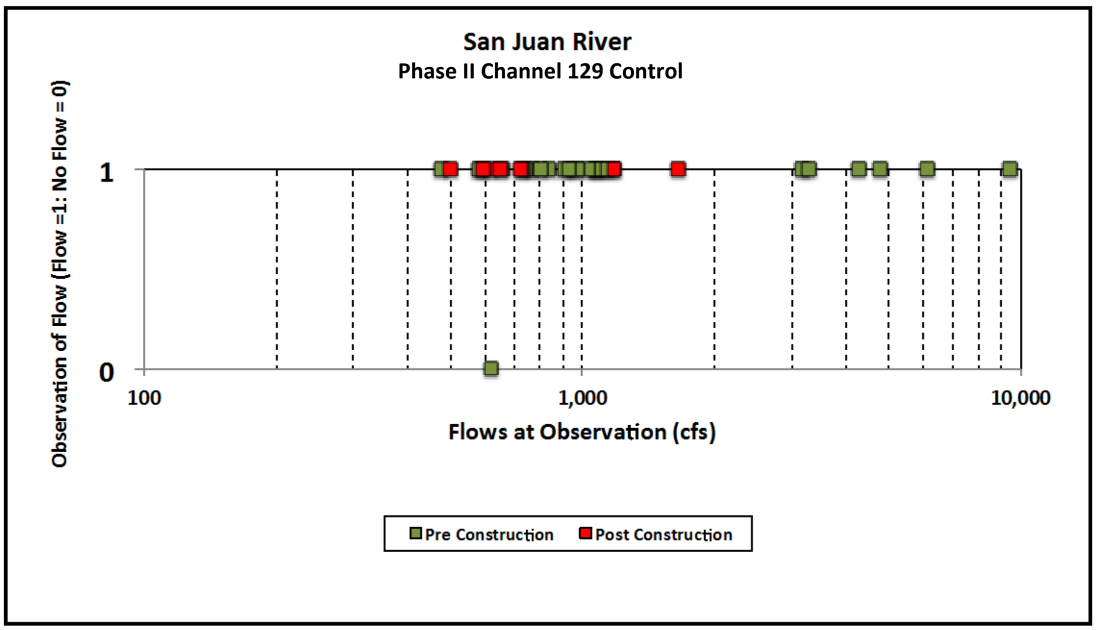


Figure 4. A temporal summary of the status (flowing or non-flowing) of the control secondary channel located at River Mile 129 in the San Juan River (above) and the observations of that same secondary channel as a function of flow at the time of observation (below). This channel was monitored as a control site before and after the Phase I channel restorations activities.

restored and control channels and the relative abundance of identified larval and small-bodied fish collected in these meso-habitats will provide additional information to assess restoration success; the comparisons between restored and control channels will be made seasonally from before spring runoff to late fall within a year and between years. In addition, comparisons of the relative abundance of small bodied fish collected in different meso-habitats will indicate whether fish are distributed randomly with respect to habitat or whether small-bodied fish disproportionately occur in certain meso-habitats (Table 2); these comparisons can be made seasonally from before spring runoff to late fall and between years.

METHODS

To address the five objectives and measure changes in aquatic habitat in the restored and control sites seasonally, from pre-runoff to late fall, and between years as a function of changing flow conditions, we propose a combination of habitat mapping, measurement of channel cross-sections, and electronic data collection.

Habitat Mapping

Post-construction geo-referenced base photography maps will be used at a scale of approximately 1 inch = 200 feet for the secondary and tertiary channel mapping. Photos will be printed on 11 x 17 inch pages with the river-miles marked and provided in sheet protectors for field mapping. Ten aquatic habitat types and three associated terrestrial types (Table 2) will be delineated on the base photographs by visual inspection in the field. The high resolution photos allow the mapper to have a high degree of confidence as to the visual location of the habitat being mapped and available reference points on the photos (i.e. debris piles, cobble bars, shoreline cover, etc.). Each polygon delineated will be marked with its corresponding code as noted in Table 2. The date of mapping and the mapper's name will be recorded on the first map sheet for each day's mapping. In as much as the mapping process is interpretive, the mappers will initially overlap 10 percent of the area of the channels to be mapped during each mapping effort. Variability in habitat interpretation and surface areas of habitats will be determined based upon the comparison between mapping results.

Table 2. The categories of habitat types on the San Juan River that will be used in this investigation.

(1) Backwater	(10) Inundated Vegetation
(2) Embayments	(11) Rootwad Piles
(3) Riffle	(12) Dry (Sand bar)
(4) Runs	(13) Dry (Channel)
(5) Rapids	(14) Dry (Cobble Bar)
(6) Slackwaters	(15) Islands
(7) Low Velocity Types: (7A) Pools, (7B) Eddies, (7C) Pocketwater	
(8) Shoals (Sand and Cobble)	
(9) Isolated Pools	

Following field mapping, the field sheets will be reviewed and missing codes or non-closed polygons will be corrected prior to processing. Following this review, the habitat polygons will be digitized and coded in ArcGIS to produce shape files. Within each channel, all polygons areas and perimeters for each habitat type will be quantified and summarized by total count and total area in each channel and date mapped.

Channel Cross Sections

Across channel transects were established at the inflow area of the restored secondary and tertiary channels in April 2015 (Figure 1). At each transect location, a field survey will be conducted and referenced to benchmarks established on the initial survey such that the year-to-year variations in the secondary and tertiary channel stream beds can be determined. The overall control benchmark will be outside the floodplain of the river with individual transect benchmarks being established on each side of the individual transects.

The survey will use a metered tape strung across the inflow channel starting at the established benchmark. The bed elevation will be measured every 0.5 m across the channel as well as in major landform topographic breaks (i.e. steep banks, substrate changes, root-wad piles, etc.). In addition, the location and elevation of the water's edge will be surveyed. All elevations will be measured to the nearest 2 cm using a metered stadia rod and a Spectra LL300N Self Leveling Laser. Surveys will occur at the time of field mapping. The main secondary channel entrance will have two transects, spaced approximately 8 m apart, due to the size of the existing cobble/sand bar at its mouth. If sand or cobble shoals are mapped at the mouth of the restored secondary and tertiary channels, water and sediment depth will be measured. A transect and benchmarks, including an overall control benchmark outside of the floodplain, have already been established at the channel entrance of the control site; the cross-section has been surveyed annually from 2012-2015.

Electronic Surveillance

Electronic water level (pressure) and temperature sensors and loggers (HOBO U20L-001) will be used to collect hourly water levels at three locations in the secondary channel and one location in each tertiary channel immediately downstream of each channel split. Sensors were installed in an "L" shaped stilling basin adjacent to the channels. The bottom of the "L" is underwater and facing downstream; basins will be cleaned, if necessary, during each trip. The relative elevations of the sensors have been surveyed. In addition, a sensor was placed in the main stream of the San Juan River upstream of the reclaimed secondary channel. A relationship between gaged flows (USGS 0936800, San Juan River at Shiprock) and the pressure sensor in the main channel (Figure 1) and the entrance to the secondary channel will be established. It is anticipated that these initial relationships will change with time as the channels become altered. The sensors will, however, provide a continuous record of when the secondary and tertiary channels have water.

A Moultrie M-1100i mini game field camera was placed at both the entrance and outlet of the reclaimed secondary channel, pointing down- and upstream respectively. Cameras are programmed to take hourly photographs from 8 am-5 pm, providing a near-continuous record of the flow conditions at the channel complex entrance and outlet and field verification of the water level (pressure) sensor readings (e.g., sensors recording water and not sediment depth). No sensors or cameras were placed at the control site since the site has been flowing in 98% of the observations since 1993. Sensor readings and visual confirmation of the entrance and outlet conditions from the cameras will provide information on: 1) the persistence of aquatic habitats in restored channels between field visits; and 2) the effect of high flows on flow conditions in restored channels (e.g. flowing or not flowing). Habitat mapping and channel cross-sections will provide additional data to address the five study objectives, as well as periodic field calibration of the electronic data.

Larval and Small Bodied Fish

To measure changes in species composition and relative abundance (catch per unit effort) seasonally, from pre-runoff through late fall, and between years, small bodied fishes will be collected with a 2.2 m x 1.9 m x 3.0 mm mesh drag seine. During the first sampling period (April 2015), habitats were mapped in restored secondary and tertiary channels and at the control site and, using the map, six study reaches were identified at the restored site and one reach at the control site (i.e. the entire length of the control secondary channel). These reaches will be sampled throughout the study. Within each of the reaches, 6 to 8 samples (seine hauls) will be taken following the small-bodied fish protocol where habitats are sampled roughly in proportion to their occurrence within the reach (Gilbert 2014). This gives a total of 42-56 small-bodied fish samples at the restoration site and 6-8 samples at the control site each field visit (Table 3). Each catch will be inspected to determine presence of protected species. Total length (TL) and standard length (SL) will be measured on all Colorado pikeminnow and razorback sucker to be consistent with information gathered by the San Juan River Basin and Upper Colorado River Basin programs. Once measured, the fish will be released. Other native species will also be measured and released. When >50 individuals of a particular species are collected in a seine haul, these individuals will be fixed in formalin and taken back to the laboratory where a subsample of >50 individuals will be selected to approximate the proportion of sizes present and measured; non-selected individuals will be counted. If native fishes are too small to identify they will be fixed in formalin and returned to the laboratory. Nonnative fishes will be removed from the river after measurements are taken and recorded. If nonnative fishes are found in such abundance that it is not feasible to measure them in the field, they will be fixed in formalin and returned to the laboratory. For each meso-habitat sampled within the reach, the length (in meters) of each seine haul will be determined in addition to the number of seine hauls per meso-habitat.

Collection efforts for larval fishes will differ from the small-bodied fish sampling and will be concentrated in low velocity habitats, such as backwaters and embayments, within study reaches using fine-mesh larval fish seines (1 m x 1 m x 0.8 mm). Several seine hauls (between two and seven) will be made through an individual meso-habitat depending on the size of that habitat. Fishes collected in a seine haul will be preserved together as a single sample. For each meso-habitat sampled, the length (in meters) of each seine haul will be determined in addition to the number of seine hauls per meso-habitat. We will target 20 larval fish collections (meso-habitats sampled) per sample period (Table 3) with roughly 70% of collections made at the restored site and the rest at the control. For additional details on the larval fish sampling protocol, see the 2013 larval fish survey report (Farrington et al. 2014).

Habitat designations used in this study will follow the classification given in Table 2. All larval and small-bodied fish sample locations will be referenced on the habitat maps developed during that specific sample period.

Laboratory Processing

All retained larval specimens will be placed in plastic bags (Whirl-Paks) containing a formalin solution and a tag inscribed with a unique alpha-numeric code that was also recorded on the field data sheet and maps. Samples will be returned to the laboratory where they will be sorted and identified to species. Specimens will be identified by personnel with expertise in San Juan River Basin larval fish identification. Stereo-microscopes with transmitted light bases and polarized light filters will be used to aid in identification of larval individuals. Ontogenetic stage will be determined for all razorback sucker and Colorado pikeminnow collected. Age-0 specimens will be separated from age-1+ specimens using published literature to define growth and development rates for individual species (Auer 1982; Snyder 1981; Snyder and Muth 2004). Both age classes will be enumerated, measured (minimum and maximum size [mm standard length] for each species at each site), and cataloged in the Division of Fishes of the Museum of Southwestern Biology at the University of New Mexico.

Monitoring Frequency

The frequency and timing of field visits to measure habitat and fish at the restoration and control sites are summarized in Table 3. These correspond to times before and after spring runoff and monsoonal storm events when changes may occur to the channels and habitats at restored and control sites and when razorback sucker and Colorado pikeminnow larvae are present in the system. The sampling in late fall and early spring pre-runoff will be particularly interesting since the distribution and relative abundance of small-bodied fish in secondary channels is not known with certainty during the overwinter period.

Table 3. Field-sampling schedule for habitat, larval fish (LF), and small-bodied fish (SBF). Habitat measurements include aquatic habitat mapping (M) in secondary and tertiary channels, surveying channel cross-sections (XS) to assess changes in channel morphology after large flow events, and checking and downloading data from camera and sensors (E).

Sampling Date	**Measurements**
Pre-spring runoff (April)	M, XS, E, LF, SBF
Post-spring runoff; includes environmental flow releases, Navajo Dam; timed with presence of razorback sucker and Colorado pikeminnow larvae (mid- to late July)	M, XS, E, LF, SBF
Post-monsoon (August-September)	XS, E
Late fall (October); after irrigation season	M, XS, E, LF, SBF

Analysis

The focus of our analyses will be to address the five study objectives. Comparisons within and between the Phase II restoration site and the control site will be made for a number of variables to determine how habitat, larval fish and small-bodied fish abundance change over time (across the three sampling periods) at both sites and how changes in the restoration site compare to those in the control (Table 4). The habitat-fish data will also be analyzed to determine whether small-bodied fish are distributed randomly with respect to aquatic habitats at restored and control sites or whether preferences or avoidance of specific habitats exist; this information will assist in identifying and refining fish-habitat relationships for small-bodied fish. Finally, the sensor and field camera data will provide information on the persistence of aquatic habitat at the restored site and, if they occur, the effect of large flows on channel cross-sections and status (flowing vs. not flowing) at both sites.

Products

A draft report summarizing the activities and analyzed results of the 2017 Phase II Channel Restoration Site monitoring, including a comparison with 2015 and 2016 results, will be submitted to the Biology Committee for their review by March 31, 2018. The report will be revised and finalized based on comments received and re-submitted to the Biology Committee and Program Office by June 30, 2018. In addition, digital copies of all habitat and fish data collected in 2017 will be delivered to the SJRIP database manager.

Project Duration

This project is designed as 3-year study, with reports submitted each year. This proposal is for the third year of the study. At the end of the third year, the final report (submitted in 2018) will contain recommendations to the Biology Committee on: (1) the effectiveness of restoring secondary channels in recovery of razorback sucker and Colorado pikeminnow; and (2) how the electronic equipment and survey transects may be used in the future to test specific hypothesis about the effect of environmental flow releases on restored channel morphology and function.

The proposed monitoring project supports Goals 4.2 *Monitor Habitat Use and Availability* and 4.3 *Evaluate Habitat Restoration Strategies and Monitor Habitat Restoration Projects* and associated Actions (4.2.3 4.2.4, 4.3.1, 4.3.2) and Tasks (4.2.3.1, 4.2.3.2, 4.2.3.4; 4.2.4.4; and 4.3.1.1, 4.3.1.2, 4.3.1.3; 4.3.2.1) in the 2014 Long Range Plan.

Table 4. List of planned comparisons and statistical tests and the study objectives they address.

Objective No.	Comparison	Statistical Test
1	Comparison of number (count) of meso-habitats by habitat type seasonally (from before spring runoff to late fall) at restored site; comparison of the total areal cover of meso-habitats by habitat type seasonally (3 field visits in 2015) at the restored site; flow conditions will vary at time of field visits and between field visits which may result in changes in the count and areal cover of meso-habitats over time.	None required, all habitats mapped and counted in restored channels; table or graph for visual inspection Once we have sufficient data (more than three observations), use regression analysis to determine relationship between count and area of habitat by type and the flow at mapping.
5	Comparison of number (count) of meso-habitats by habitat type seasonally (from before spring runoff to late fall) at control site; comparison of the total areal cover of meso-habitats by type seasonally (3 field visits in 2015); flow conditions will vary at time of field visits and between field visits which may result in changes in the occurrence of meso-habitats over time.	None required, all habitats mapped and counted in control channel; table or graph for visual inspection. Once we have sufficient data (more than three observations), use regression analysis to determine relationship between count and area of habitat by type and the flow at mapping.
1, 5	Comparison of the relative proportion of different meso-habitats between field visits (from before spring runoff to late fall) at the restored site; similar comparison at the control site	Chi-square test, N (meso-habitats) x 3 (field visits); N x 3-way table
5	Comparison of the relative proportion of meso-habitats at restored vs. control sites	Chi-square test for each sampling visit
1, 5	Comparison of the relative abundance of native larval fish (CPUE) between sampling periods and by site (restored vs. control); same comparison using relative abundance of non-native fish; summarize data for razorback sucker and CO pikeminnow although probably too few individuals collected for statistical analysis.	Analysis of variance with season (sampling period) and site (restored vs. control) as factors; pairwise comparisons between field visits and between sites using the Tukey-Kramer HSD test. Alternatively, could adopt approach of larval fish monitoring study and use mixed linear models to estimate occurrence (presence-absence) and abundance separately with habitat, season, and site (restored vs. control) as covariates (Farrington et al. 2014). If samples sizes are insufficient to conduct the above analyses, restrict analysis to fewer factors, e.g., combine data across seasons and compare restored and control sites. If CPUE data are not normally distributed, may use non-parametric Kruskal-Wallis one-way analysis of variance. Data will be summarized in table or graph to highlight specific comparisons of interest.
1, 5	Comparison of relative abundance of larval fish for specific species of interest between sampling periods and by site; these species may include flannelmouth sucker, channel catfish, fathead minnow, and redshiner.	Analysis of variance with season (sampling period) and site (restored vs. control) as factors. See above comments for additional details and possibilities.
1, 5	Comparison of number (count) of meso-habitats sampled for larval fish by type between sampling periods; comparison of the number of meso-habitats sampled for larval fish by type at restored vs. control site	Sample sizes probably too small but, if not, Chi square test w/ continuity correction

Objective No.	Comparison	Statistical Test
1, 5	Comparison of the composition of native larval fish (number of individuals collected by species) by season for restored site and control site; comparison of the composition of native larval fish by site (either combining seasons or holding season constant depending on the results of the previous analysis); similar analysis for non-native larval fish	Chi-square test for independence
1, 3, 5	Comparisons of relative abundance of native small-bodied fish (CPUE) by meso-habitat type and by site for each of the 3 sampling periods; could add season as a factor if sample size permits; similar comparisons for non-native small-bodied fish (non-native spp. combined)	Analysis of variance with meso-habitat type and site as factors; pairwise comparisons between meso-habitats and sites using Tukey-Kramer HSD test. If sample sizes of fish abundance in specific meso-habitats are insufficient, restrict analysis to certain meso-habitats and compare restored vs. control sites. If CPUE data are not normally distributed, can use non-parametric Kruskal-Wallis one-way ANOVA with season, mesohabitat, and channel type (restored vs. control) as factors. Post-hoc comparisons to determine differences between groups can be made using Dunn's test for multiple comparisons following a statistically significant Kruskal-Wallis test (Dunn 1964). Data will be summarized in a table or graph to highlight specific comparisons.
1, 5	Summarize number of small-bodied RBS & CPM individuals captured by meso-habitat type and by site for the 3 sampling periods	Probably not sufficient sample sizes for statistical comparisons between meso-habitats, sampling periods and sites.
1, 3, 5	Comparisons of the relative abundance of small-bodied fish (CPUE) for specific species (where we have an adequate sample) by meso-habitat, by season, and by site.	Repeated measures analysis of variance with meso-habitat type, season, and site (channel type) as factors (see above). If sample sizes are insufficient, restrict analyses to specific meso-habitats, hold season constant, and compare by site. Alternatively if data are not normally distributed can use non-parametric Kruskal-Wallis one-way ANOVA with season, mesohabitat, and channel type (restored vs. control) as factors in separate one-way ANOVA analyses. Following a statistically significant Kruskal-Wallis test, post-hoc comparisons to determine differences between groups can be made using Dunn's test for multiple comparisons.
3	Comparisons of the number of small-bodied fish by species captured in different meso-habitats by season; analyze restored and control site separately; can also combine restored and control sites to increase sample size.	Chi-square test for independence; two types of chi-square analysis will be used to test null hypothesis of "no selection"—Pearson chi square statistic (driven by differences between observed and expected number of fish collected in meso-habitats of each type) and log-likelihood Chi-square statistic; the latter tests the selection ratio, w, calculated by dividing the proportion of fish using a specific habitat type by the proportion of that habitat sampled (Bliesner et al. 2010).

Objective No.	Comparison	Statistical Test
1, 5	Comparison of the composition of native small-bodied fish (number of individuals collected by species) by season (holding site constant) and by site (either combining or holding season constant depending on the results of the previous analysis); similar comparisons for non-native small-bodied fish	Chi-square test for independence
1	Comparison of status of the restored site (flowing vs. not flowing) before vs. after restoration (see Figure 3)	Contingency table—status (flowing vs. not flowing) by flow category: 500-569, > 569 cfs; chi-square test of independence.
1	Summarize the number of larval RBS & CPM captured by meso-habitat type at the restored site before and after treatment	Probably not sufficient sample sizes for statistical comparisons between meso-habitats and between time periods (before & after restoration).
1	Comparison of relative abundance of native larval fish (CPUE) at restored site by meso-habitat, by season and by time (before vs. after treatment); a separate comparison/analysis will be run for non-natives.	Analysis of variance with habitat, season, and time (pre- vs. post-treatment) as factors. Alternatively could use the approach of larval fish monitoring study and use mixed linear models to estimate occurrence and abundance separately with habitat and time as covariates. If samples sizes are insufficient to conduct the above analyses, restrict analysis to fewer factors, e.g., analyze meso-habitats separately, combine data across seasons and compare restored and control sites. Data will be summarized in table or graph to highlight specific comparisons of interest.
1	Summarize the number of larval RBS & CPM captured by meso-habitat type at the restored site before and after treatment	Probably not sufficient sample sizes for statistical comparisons between meso-habitats and between time periods (before & after restoration).
1	Comparison of relative abundance of native small-bodied fish (CPUE) at restored site by meso-habitat, by season and by time (before vs. after treatment); a separate analysis will be run for non-natives small-bodied fish.	Analysis of variance with habitat, season, and time (pre- vs. post-treatment) as factors; see above comments regarding restricting analyses if sample sizes are insufficient for full analysis.
1	Comparison of the composition of native small-bodied fish (number of individuals by species collected) at restored site before and after treatment; could do a similar analysis for non-native small-bodied fish	Chi square test for independence

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PROJECT BUDGET

Budget for Participation of Ecosystem Research Institute and The Nature Conservancy under BOR Cooperative Agreement No. R09AP0004 to The Nature Conservancy

Task 1A Habitat Mapping (3 Trips)	**Cost**
Field Labor: Salary & Benefits	
Director of Science (TNC)	$7,726
Senior Fisheries Biologist (ERI)	$14,596
Travel & Per Diem (TNC & ERI)	$3,594
Laboratory Labor: Salary & Benefits	
Technician (ERI)	$8,268
Materials & Supplies (ERI)	$600
Task 1B Physical Transects (1 Trip)	
Field Labor: Salary & Benefits	
Director of Science (TNC)	$1,594
Senior Fisheries Biologist (ERI)	$3,053
Laboratory Labor: Salary & Benefits	
Technician (ERI)	$689
Travel & Per Diem (TNC & ERI)	$1,068
Task 1C Pressure Sensors & Electronic Data	
Field Labor: Salary & Benefits	
Senior Fisheries Biologist (ERI)	$477
Laboratory Labor: Salary & Benefits	
Technician (ERI)	$689
Equipment (pressure sensors, field camera) (ERI)	$2,300
Final Report	
Office Labor: Salary & Benefits	
Director of Science (TNC)	$3,924
Senior Fisheries Biologist (ERI)	$7,632
Editor (ERI)	$848
Materials & Supplies	$500
Total Habitat Monitoring & Report (Direct)	**$57,588**
TNC Federal Indirect Cost Rate (22.50%; FY17)	**$12,951**
TOTAL HABITAT MONITORING & REPORT	**$70,509**

(Budget continued on next page)

Budget for Participation of American Southwest Ichthyological Researchers, L.L.C. under Contract No. GS10F0249X-12PD40037

Laboratory Labor (Pre-Spring Runoff and late Fall samples): Salary & Benefits	
Fisheries Biologist	$3,554
Fisheries Technician	$1,094
Laboratory Labor (Post-Spring Runoff sample): Salary & Benefits	
Fisheries Biologist	$2,221
Fisheries Technician	$547
Materials & Supplies	$435
TOTAL LARVAL FISH IDENTIFICATION	**$7,851**

Budget for Participation of New Mexico Department of Game and Fish (NMDGF) under Agreement Number SJ2631

Field Labor: Salary & Benefits	
NMDGF Biologists (3)	$9,877
Office Labor (Final Report Assistance): Salary & Benefits	
NMDGF Project Leader	$2,740
Travel & Per Diem	$3,158
TOTAL FISH COLLECTION & REPORT ASSISTANCE	**$15,774**

TOTAL PROJECT COST (HABITAT, FISH & REPORT) $94,134