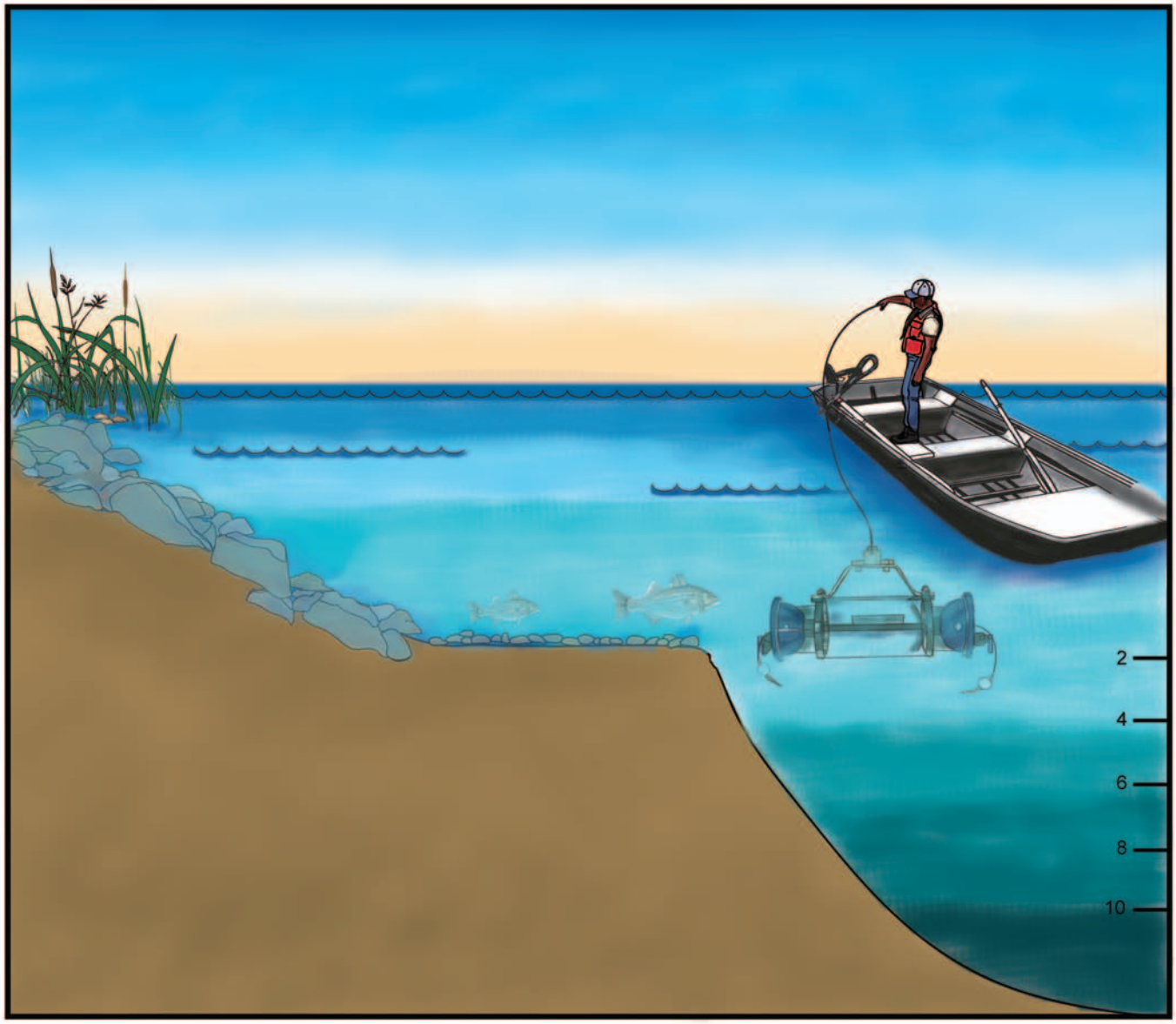
Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Colorado River Backwaters Restoration Final Model Evaluation Report



U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

February 2007

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Lower Colorado River Multi-Species Conservation Program

Colorado River Backwaters Restoration

Final Model Evaluation Report

Submitted by: BIO-WEST, Inc to Bureau of Reclamation, Lower Colorado Region

Lower Colorado River
Multi-Species Conservation Program Office
Bureau of Reclamation
Lower Colorado Region
Boulder City, Nevada
http://www.usbr.gov/lc/lcrmscp

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EXECUTIVE SUMMARY

An evaluation of the backwater site-selection classification model developed to support habitat creation goals for the Lower Colorado River Multi-Species Conservation Program (LCR MSCP), and approved by the LCR MSCP steering committee, was conducted in summer 2006. The LCR MSCP includes creation of 360 acres of backwaters dedicated to native fish repatriation, with a priority given to isolated habitats. The goal of this evaluation was to determine whether the model estimates of habitat suitability correlate well with observed success and failures of past native fish stocking efforts. Depending on these results, a second goal was to provide recommendations on revising the ratings criteria and scoring procedures prior to initiating the backwaters inventory of the river. The effort also provided an opportunity to engage in a relatively small-scale "trial run" for evaluating field methods and improving data collection efficiency.

Seven sites were evaluated using the backwater site-selection classification model. Endangered fish species of the Lower Colorado River (razorback sucker and/or bonytail) were previously stocked in these sites, and the long-term survival and reproduction of these stocked individuals ranged from very low to high, long-term survival with evidence of spawning and recruitment of young into the population. Selected sites were not restricted to the LCR MSCP planning area as restoration project areas would be, but the climactic conditions experienced at distant sites are believed to be similar to conditions experienced within the project area. At each sample site the full range of data collection efforts was conducted (except for fish sampling to determine presence/absence) to generate a rating score with the field worksheet. The resulting scores for individual sites did not align with pre-defined success levels of the stocking efforts. In general, the sites where low stocking success occurred rated lower than other sites, but moderately and highly successful sites were rated closely overall. Based on the results obtained from this effort, recommendations were made to adjust some aspects of the classification model to improve overall scoring results.

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INTRODUCTION

As a component of the Lower Colorado River Multi-Species Conservation Program (LCR MSCP 2004), BIO-WEST, Inc. (BIO-WEST) assisted the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) with developing a classification model designed to select existing backwaters that best support the habitat creation goals of the LCR MSCP. A classification system developed by BIO-WEST in the mid 1980s (Holden et al. 1986) was used as a starting point for these efforts. The earlier classification system was developed for the backwater habitats in the Lower Colorado River downstream of Davis Dam to the Southerly International Boundary with Mexico. The system developed during those efforts allowed Reclamation to assess existing backwaters for habitat value and determine necessary factors for construction of backwaters for general wildlife and fish (Holden et al. 1986). More recent interest in using isolated habitat for recovery of listed species prompted an update of that study with more emphasis on endangered fishes and isolated habitat conditions. Minckley et al. (2003) suggested that the greatest opportunity for establishment of sustainable populations of the listed fish species is to use ponds (or "backwaters") that are isolated from the main stem of the river. Of the three fish species for which habitat creation is included in the LCR MSCP, razorback sucker (*Xyrauchen texanus*) and bonytail (*Gila elegans*) are anticipated to persist in suitable habitats that are isolated from the river, but flannelmouth sucker (*Catostomas latipinnis*) is more riverine dependant (BIO-WEST 2005) and will require habitats that maintain a connection to the river. The new classification model developed for the LCR MSCP (Reclamation 2006) focuses on isolated habitats for razorback sucker and bonytail, and provides recommended parameters that are likely important factors in construction of new habitat features for flannelmouth sucker.

With the shift in focus to native fish habitat restoration, an update to the Holden et al. (1986) classification system was needed. Data collected during this earlier effort were primarily from connected backwaters, and the relationship between physical habitat conditions and fish populations focused on game fishes (since these were the only species captured in those habitats at the time) (Holden et al. 1986). The updated classification system used many of the same habitat parameters as the earlier study that characterized the anticipated range of suitable conditions through literature review. In many cases the available literature focused on riverine habitats (few efforts have focused on isolated ponds and the range of suitable habitat conditions necessary to support these fishes) and the Upper (rather than Lower) Colorado River Basin. In some instances very little data were available related to a range of conditions that may be suitable for a given endangered fish species, so general data on warm-water fish habitat suitability were used (e.g., pH). While the classification system was based on the best information available at the time of development, the range of values considered suitable for habitat conditions that would support the species might need to be modified as additional data are obtained.

One of the most valuable ways to obtain these data, as well as test the usefulness of the rating system, was to evaluate the success of past stocking efforts in isolated backwaters. A "field validation" was designed to test the applicability of the various components to the actual physiocochemical and hydrological conditions in sites where razorback sucker and bonytail were

previously stocked. As with all models, until the new classification approach is tested across a variety of different sites it will remain unknown whether the site-selection methodology is appropriate for evaluating the potential of a site to meet the LCR MSCP habitat creation goals.

The objectives addressed by this study included:

1. Conducting a field test of the classification model at sites with known histories of stocking endangered fishes to determine whether resulting habitat scores are consistent with the success or failure of the stocking efforts at each site.

2. Determining whether the appropriate variables are considered in the classification model.

3. Providing recommendations for modifying the classification model criteria and the associated ranking categories, potentially including additions or deletions of individual criteria, modifications of individual criteria weighting, or systematic changes to the rating and scoring system.

In addition to addressing these objectives, the validation project provided an opportunity to evaluate the feasibility and logistical requirements of these methods in the field. When site-selection efforts begin, numerous sites (e.g., 30) will be visited and evaluated in a short time. By providing a "trial run," the feasibility of meeting these time constraints could be evaluated. In addition, some previously unused methods (e.g., collecting bathymetry data) could be tested, which may enable more efficient execution during the actual site visits.

SITE SELECTION

Seven study sites were selected for classification model validation. Although sites to be evaluated for the LCR MSCP habitat creation efforts would be contained within the LCR MSCP planning area, the selection of sites for validating the classification model was not restricted to these boundaries. Initially, six sites were to be selected, and BIO-WEST suggested that the division of the six sites should include two sites with poor survival (few, if any, fish persisted beyond 1 year), two moderately successful sites (the majority of stocked fish survived but no reproduction was observed), and two highly successful sites (stocked fish successfully reproduced). In addition, a seventh site was added (highly successful), as some data were available for certain sites, which allowed time for an additional site visit.

The "success" of the stocking effort at a site was determined based on the best available information, including anecdotal information, collected during an extensive review of previous research and repatriation efforts where razorback sucker and/or bonytail were stocked into isolated ponds. The scale of success is relative and intended to describe sites as highly successful (successful reproduction and recruitment into the population, as well as long-term survival of the majority of the population); moderately successful (evidence of long-term survival but no successful recruitment); and unsuccessful (poor survival). However, there are a number of factors that make

each site unique and difficult to categorize into one of those three distinct groups. In many cases the only data available include the number of fish initially stocked, some capture data indicating that fish are/are not still present, and anecdotal information on successful recruitment (or lack of such). None of these stocking efforts were documented as part of a rigorous scientific study that would provide the data necessary to determine success in more detail. Some sites had information on growth of stocked fish, but this information was not consistently available across sites to permit use in discriminating success level. With the available data, evidence of successful reproduction and recruitment and a thriving current (or recently known to be thriving) population of stocked native fish provided a relatively straightforward means of discriminating high success. However, moderately successful sites and those considered unsuccessful were more difficult to differentiate. In these sites one factor, such as the presence of nonnative fish species, may be the primary or only reason for lack of survival or reproductive success. Populations that may persist may also successfully reproducing within available habitat, but predation eliminates any chance of successful recruitment. In such a case, all physical habitat characteristics may still rank as "high" or "excellent" in habitat suitability. In addition to the presence of nonnative species as a factor that complicates the interpretation of these results, acute events (e.g., unusually high temperature, wide short-term variation in water level) may have occurred since the initial stocking and may not have been evident during the site visit conducted through this study.

In all selected sites, the goal of the previous stocking efforts was to grow juvenile fish to a size that could be repatriated into the Lower Colorado River and increase the probability of survival relative to stock size classes. In some instances, however, fishes were left in a location beyond the period typically required to "grow out" individuals to an appropriate size for repatriation because of poor survival (and the assumption that all fish perished), abandoning use of a site, or because a population of fish was maintained for research purposes and slated for stocking at a later date.

Study Sites

Highly Successful Sites

Cibola High Levee Pond

Cibola High Levee Pond (CHLP) (Figure 1) is a site where native fishes exhibited high success (long-term survival and successful reproduction). The success of both razorback sucker and bonytail at CHLP provides support for the hypothesis that it may be possible to develop individual (sustainable) populations in isolated habitats (Minckley et al. 2003, Mueller 2006a), which is the preferred goal of the LCR MSCP habitat creation program for native fishes. Prior to the success observed at this site, it was generally believed that these species required access to the river to complete their life cycles (Mueller 2006a).

The CHLP is approximately 4.7 acres and located in Cibola National Wildlife Refuge (NWR) adjacent to the Lower Colorado River near Blythe, California. It was originally a part of the river channel, but dredging efforts to straighten the channel in the 1960s isolated the channel. In addition to the levee that maintains the current river channel, a second levee that provides road access along

Figure 1. Map of Cibola High Levee Pond.

the river encloses the pond. The pond was established as a native fish-rearing facility in 1993 by C.O. Minckley (U.S. Fish and Wildlife Service [USFWS]). The backwater was renovated and subsequently stocked with razorback sucker (n=14,000) and bonytail (n=58,000) (ASU Native Fish Lab, unpublished data; Mueller 2006a). Another 4,000 razorback sucker were stocked in 1995 (ASU Native Fish Lab, unpublished data). The observation of successful reproduction first occurred in 1998 (Marsh 2000). By 2003 catch data for the ponds suggest that the community was primarily (99.85%) native and contained approximately 7,800 (5,955 – 11,630, CL=95%) bonytail and 1,100 (844 – 1,190) razorback sucker, as well as thousands of <10-cm bonytail. The carrying capacity of the pond was estimated at 4,350 fish/ha (635 kg/ha) at the time (Mueller et al. 2003). Largemouth bass (*Micropterus salmoides*) were first observed in spring 2004, and the abundance of native fishes, particularly bonytail, quickly diminished. Because of the success of stocking at this site, it was anticipated to score very highly in terms of habitat suitability relative to the other locations.

Rock Tank

Rock Tank (Figure 2) is among many human-made ponds located within Buenos Aires NWR, near Tucson, Arizona. The ponds were originally created to supply water for livestock by collecting rainfall; most are small and shallow, and do not contain water year round or in dry years. Rock Tank is one of the few ponds that is deep enough to maintain water during extended dry periods (S. Gall, Buenos Aires NWR, personal communication). The history of native fish stocking on the refuge includes several (largely unsuccessful) efforts to grow fish to a suitable size for repatriation in the Lower Colorado River.

Three sites on the refuge were originally stocked with bonytail in 1986: Big Bertha, Kings, and Road Camp tanks. None had fish during a 1989 survey (Marsh and Minckley 1989). In 1987 three different sites were stocked with razorback sucker larvae (n=30,000 – 40,000). These included Mormon Lake (where 3,000 fish averaging 12.7 cm were also released), Rock Tank, and Tequila Tank. In 1989 only Rock and Tequila tanks maintained fish (Marsh and Minckley 1989). Several additional sites were stocked in 1989, but only these two and Carrizo Dam Tank had fish by October (Marsh and Minckley 1989). Because of the lack of success in refuge ponds overall, the attempt to use these habitats for grow out was abandoned. However, in 1997 four size classes of razorback sucker were found persisting in Rock Tank (approximately 1.5 – 2.5 acres in size), indicating successful reproduction in three of the preceding 10 years (Bonar et al. 2002). Although all razorback sucker were removed from the site due to perceived stress from high temperatures, this site was considered highly successful due to the rarity of successful reproduction among all stocking locations. The water level of Rock Tank was lower than normal during summer 2006 (S. Gall, USFWS, personal communication), but some rainfall was received immediately preceding our visit. At that time the surface area of the pond was approximately 0.85 acre, compared with the 1.5 – 2.5 acre estimate provided by Bonar et al. (2002). This pond is subject to extended periods of limited rainfall; the 10-year period between 1987 and 1997 when razorback sucker persisted in Rock Tank was very dry, and many of the other refuge ponds in which razorback sucker were stocked in March 1989 were dry in October of the same year. Because of the success of stocking at this site, it was anticipated to score high in terms of habitat suitability relative to the other locations.

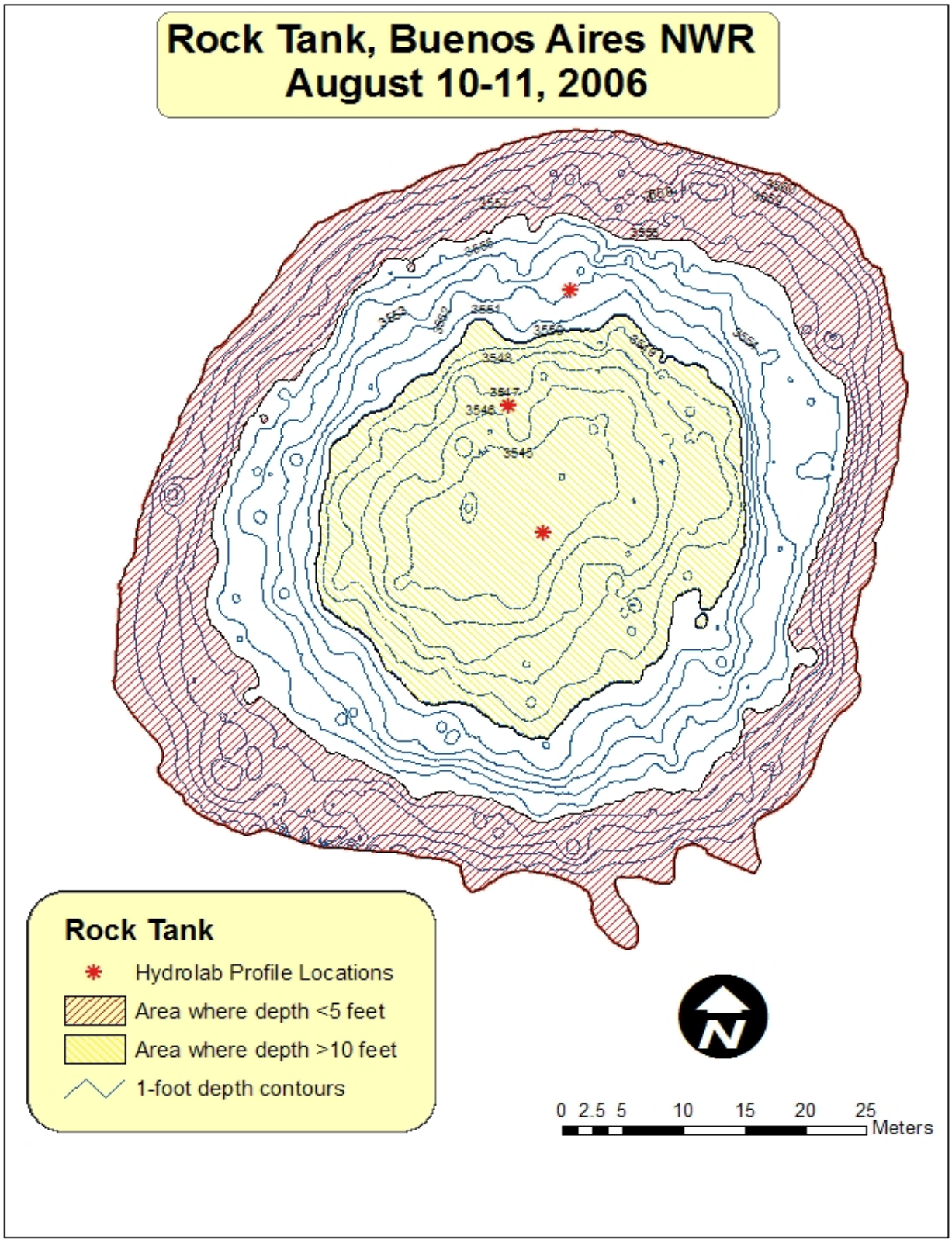

Figure 2. Map of Rock Tank.

Yuma Cove

Yuma Cove (Figure 3) was a natural cove on Lake Mohave that was manually separated from the lake by an earthen berm. It was approximately 2.6 acres in size when visited. This site has been used since 1991 as a grow-out pond for juvenile razorback sucker repatriation into the lake (Reclamation, unpublished data). Among several locations used for these efforts, Yuma Cove was considered highly successful because it supported large numbers of razorback sucker that rapidly increased in size. It is also one of the very few identified sites where successful reproduction occurred. One primary reason for selecting this site was that stocking efforts were continuing during our effort (as opposed to other sites that had been abandoned), and recent reproduction in this site permitted a more direct correlation between its relative success as a refuge habitat and the current ranking score derived from the site-selection classification model. Because of the success of stocking at this site, it was anticipated to score high in terms of habitat suitability relative to the other locations.

Moderately Successful Sites

Mulberry Pond - Floyd Lamb State Park

Floyd Lamb State Park (Figure 4) is located 15 miles northeast of Las Vegas. The park includes a series of four small, spring-fed ponds. The largest of these is Mulberry Pond, which is approximately 2.7 acres in size. This pond was used for stocking razorback sucker, primarily with the intention of later retrieving the fish and transferring them to Lake Mead. In 1984 4,000 razorback sucker (from a 1982 cohort) from Dexter Hatchery were stocked in the pond at approximately 4 inches (100 mm) in size. These fish were undisturbed until approximately 1991 when they were "rediscovered" and some individuals collected for repatriation into Lake Mead. This site was considered moderately successful primarily because there was no evidence of successful reproduction within this population. Although long-term survival occurred in this pond, there were often "fall die-offs" that resulted in as many as 150 mortalities over the course of 2 – 4 days. Water quality data were collected immediately following those events, but there was no direct correlation to any parameter. It is likely that diel fluctuation in dissolved oxygen (DO) was a critical factor (J. Heinrich, NDOW, personal communication). Although this site supported long-term survival, periodic die-offs and lack of successful reproduction (and recruitment) suggest that habitat conditions are not as optimal here as in the highly successful stocking sites; hence this site was expected to rate as having moderate or high habitat suitability ranking.

Davis Cove

Davis Cove (Figure 5) is another natural cove on Lake Mohave that was manually separated from the lake for rearing razorback sucker. It was approximately the same size as Yuma Cove (2.8 acres) when visited. Initially, a net was used to create the barrier between the lake and cove, but that proved ineffective and later an earthen berm was installed. There has been evidence of reproductive success at this site, but most researchers involved in those efforts indicated only moderate success in terms of razorback sucker survival and growth. Salinity was suggested as one concern (J. Lantow, Reclamation; P. Marsh, ASU; G. Mueller, USGS; personal communications). It also appears that invasion by various nonnative species at different times (including largemouth bass, red shiner (*Cyprinella lutrensis*), common carp (*Cyprinus carpio*), and a dense crayfish (*Cambarus* sp.)

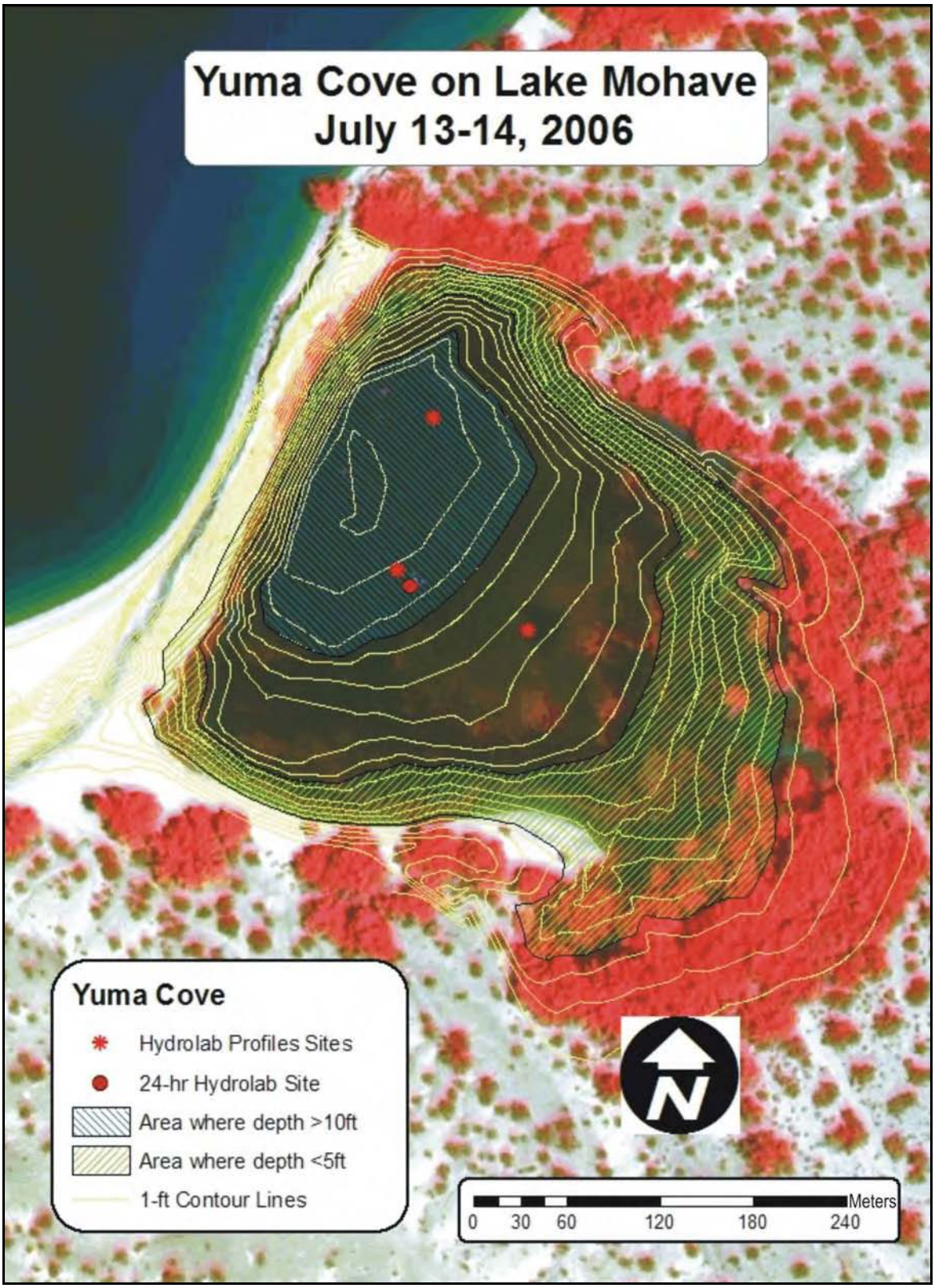

Figure 3. Map of Yuma Cove.

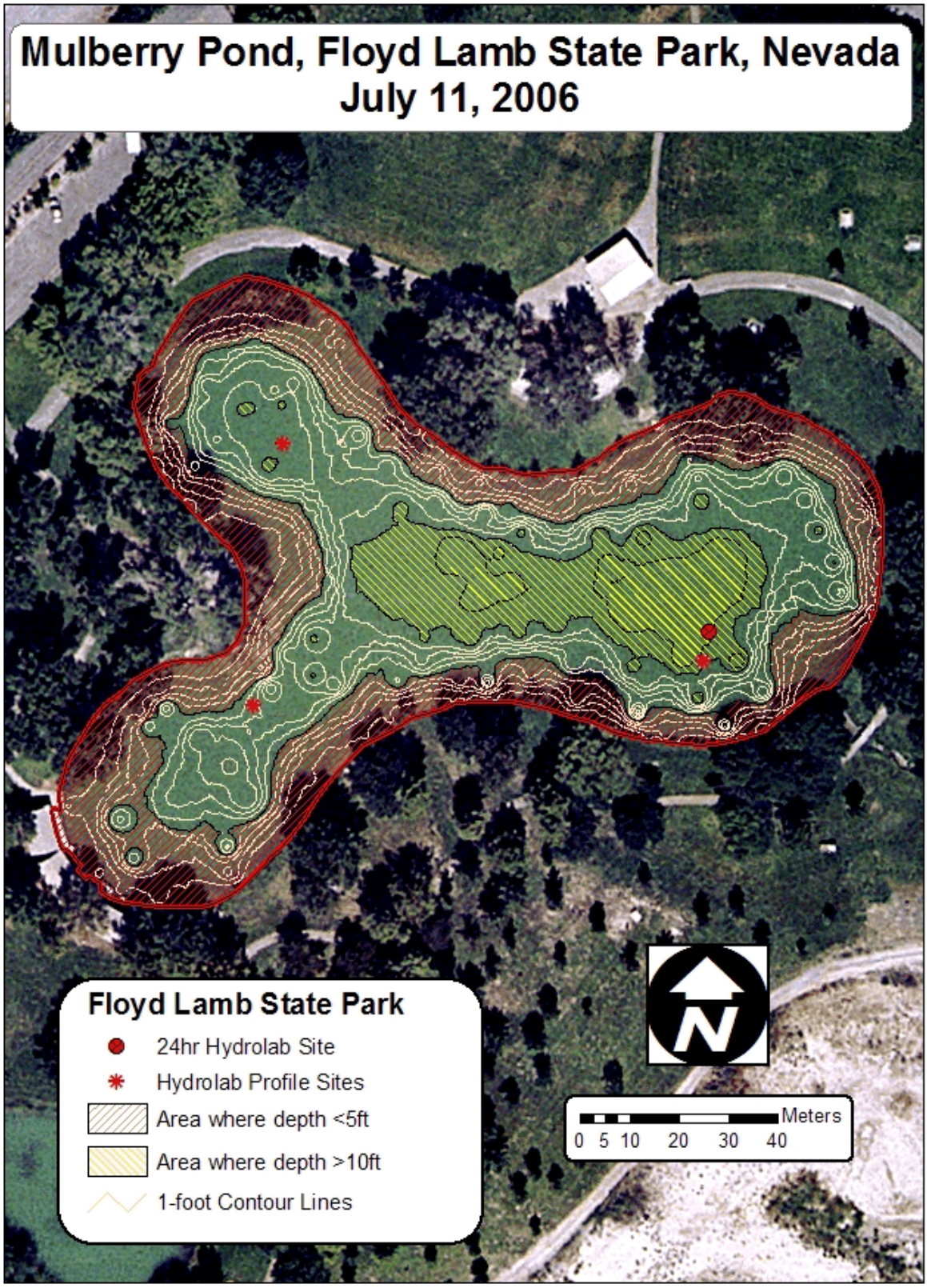

Figure 4. Map of Mulberry Pond in Floyd Lamb State Park.

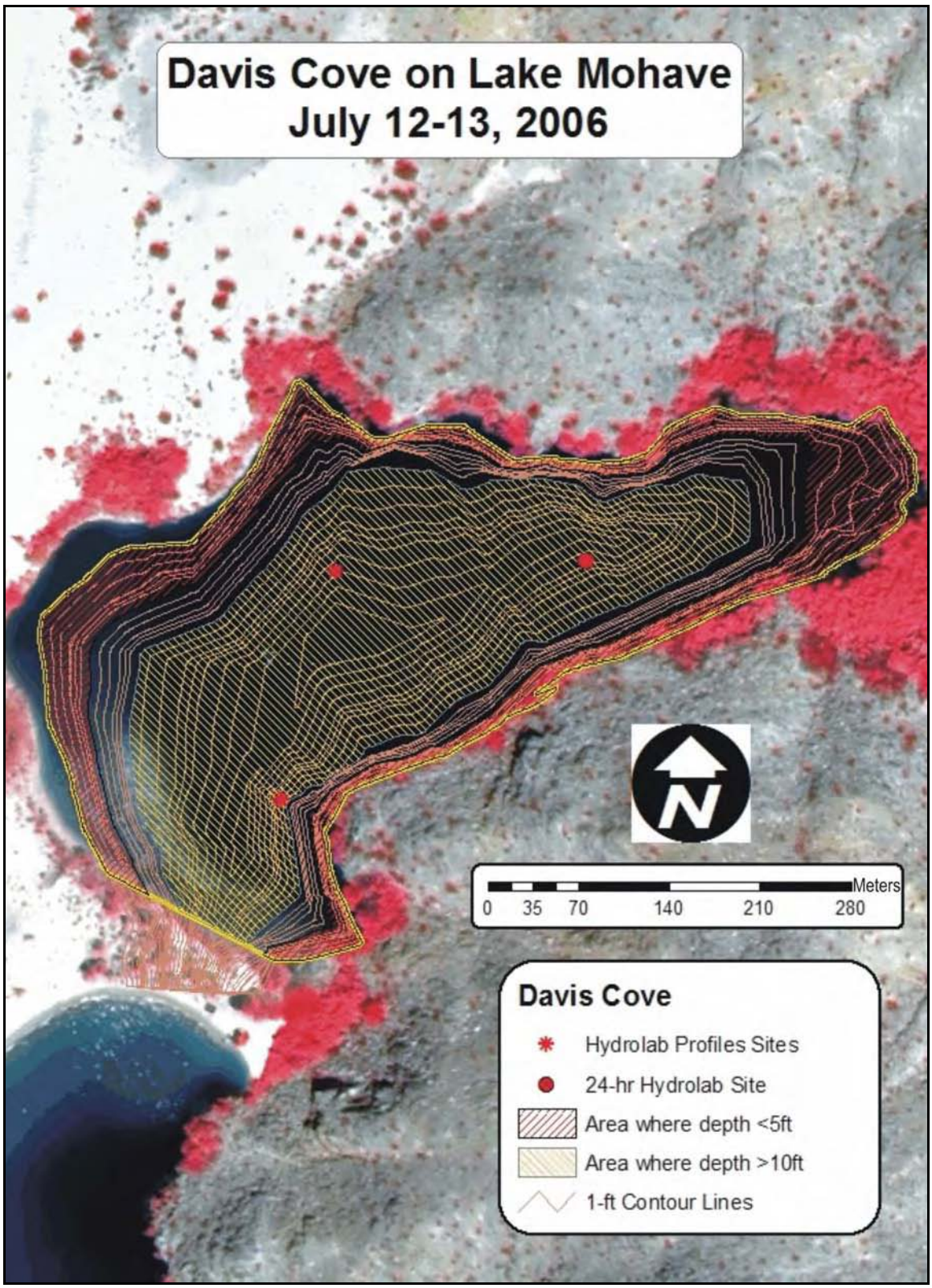

Figure 5. Map of Davis Cove.

infestation has largely contributed to the mixed success in this site. This underscores the importance of considering long-term maintenance and the relative management difficulties that occur with larger sites.

After the model validation site visit, evidence of successful razorback sucker and bonytail reproduction was observed here (G. Mueller, USGS, written communication). This was despite high salinity (>5,000 µS/cm), but it occurred in the absence of nonnative fish species. When selected for the model validation, this site was considered moderately successful because several previous razorback sucker stocking efforts for grow-out and subsequent repatriation had mixed results. However, recent observations suggest that survival and successful reproduction results were mixed primarily due to the presence of nonnative fishes and not lower-quality habitat. In addition, salinity has increased progressively over time, and concentrations were over 5,000 µS/cm within the past 2 years (J. Carpenter, USGS, oral presentation). It remains to be seen whether successful recruitment will result from this reproductive effort, but it appears likely that the stocking efforts at this site may be more appropriately labeled as "highly successful." The inconsistency of past results suggest that this site would not rate as highly as the highly successful stocking sites in spite of its moderate or high habitat suitability conditions. Since recent findings indicate that stocking efforts were more successful than previously thought, it seems likely that habitat suitability would be higher than initially expected.

Unsuccessful Sites

Surprisingly, sites with poor success were relatively difficult to find. This is largely because few sites were used primarily as native fish habitat; instead they were often used as short-term grow-out ponds. Presumably, sites where poor growth or survival occurred were not used repeatedly over multiple years. Many sites where fish were put in and left were either golf courses (which were excluded from consideration for this effort) or sites where little fish survival information was available. Only relatively successful sites were given much consideration by researchers, and unsuccessful sites were quickly forgotten. Although some locations on Lake Havasu, where extensive grow-out efforts were conducted, may have been considered "unsuccessful sites," a minimum requirement for site selection in this effort was a permanent structure (berm) separating the site from the river (lake) (C.O. Minckley, USFWS, personal communication).

Chango Tank

When fish were found in Rock Tank in 1997, some exhibited oxygen stress and as a result 1,294 were seined and stocked into Chango Tank (Bonar et al. 2002). An additional 1,175 fish were stocked into Carrizo Dam Tank, and over 400 fish were moved into Headquarters Lake in Buenos Aires NWR. Follow-up sampling by Bonar et al. (2002) occurred in 2000 and 2001, and revealed that stocked razorback sucker survived in Chango Tank (with no evidence of reproduction) but not in Carrizo Dam Tank. Hence Carrizo Dam Tank was originally labeled an unsuccessful site. Because of rainy weather, this remote site was not accessible during the site visit. Therefore, Chango Tank, which is located adjacent to Highway 286 within the refuge, was evaluated. Chango Tank might arguably be a moderately successful site because of the survival of razorback sucker

relative to Carrizo Dam Tank during the Bonar et al. (2002) study, but the site does not appear to permit long-term survival and no evidence of fish was observed during our site visit. Bonar et al. (2002) hypothesized that "lack of suitable substrate may have contributed to the decline of razorback sucker in Chango and Carrizo Dam Tanks." Because survival of stocked endangered fishes was limited in this site, we anticipated that it would rate low, compared with other sites, on the scale of habitat suitability.

Palm Lake

Palm Lake (Figure 6), located near Wickenburg, Arizona, is owned by The Nature Conservancy. It is a small, spring-fed pond (0.8 acre when visited) that has an extensive riparian canopy, which provides extensive shade. The site has many favorable factors that suggest high likelihood for successful establishment of native fish populations: it is a managed property with limited access, and it is spring fed so water temperatures remain low. Palm Lake was targeted as a grow-out pond in 1989 when approximately 35 adult razorback sucker and several hundred bonytail were stocked (M. Lawrence, The Nature Conservancy, personal communication). Additional stocking events occurred in 1991 and 1994 but resulted in little long-term success. In addition, other native fish species, including Gila topminnow (*Poeciliopsis occidentalis*) and desert pupfish (*Poeciliopsis occidentalis occidentalis*) were stocked into the pond. Unfortunately, the dynamics of the pond's spring sources (difficulty in isolating each) and numerous snags prevented an effective poisoning effort, and black bullhead (*Ameiurus melas*) persisted. There also appeared to be problems with low DO. It is very unlikely that native fish currently exist here (M. Lawrence, The Nature Conservancy, personal communication). Because survival of stocked endangered fishes was limited in this site, we anticipated that it site would rate low compared with other sites on the scale of habitat suitability.

METHODS

At each site a complete evaluation was conducted using the field worksheet developed to determine the biological suitability of the site for the classification model (Figure 7; Reclamation 2006). The goal of these classification efforts was to determine the current suitability of a site for native fishes and use this information to infer the level of effort that may be required to "restore" a site to meet the requirements of habitat creation for the LCR MSCP. The classification model includes six components: water quality, cover, depth, gravel substrate, larval forage base, and bio-indicators.

The water quality portion of the classification model included several components, which were collected using the same methodology among sites. A multi-probe datasonde was used to collect DO, water temperature, specific conductivity, and pH at 0.5-m increments throughout the water column in three locations to develop profiles for these parameters. These data were collected between 10:00 a.m. and 2:00 p.m. local time for each site. The detailed profile of each pond provided useful information for evaluating overall water quality, but as the classification model required the hypolimnetic average for each of these parameters only the value collected at 1 m above the substrate was used for the classification efforts (in instances where total water depth was 1 m, the value measured at 0.5 m was used). Individual profile locations were selected to include the deepest portion of a pond and two other areas that were dispersed to represent the range of

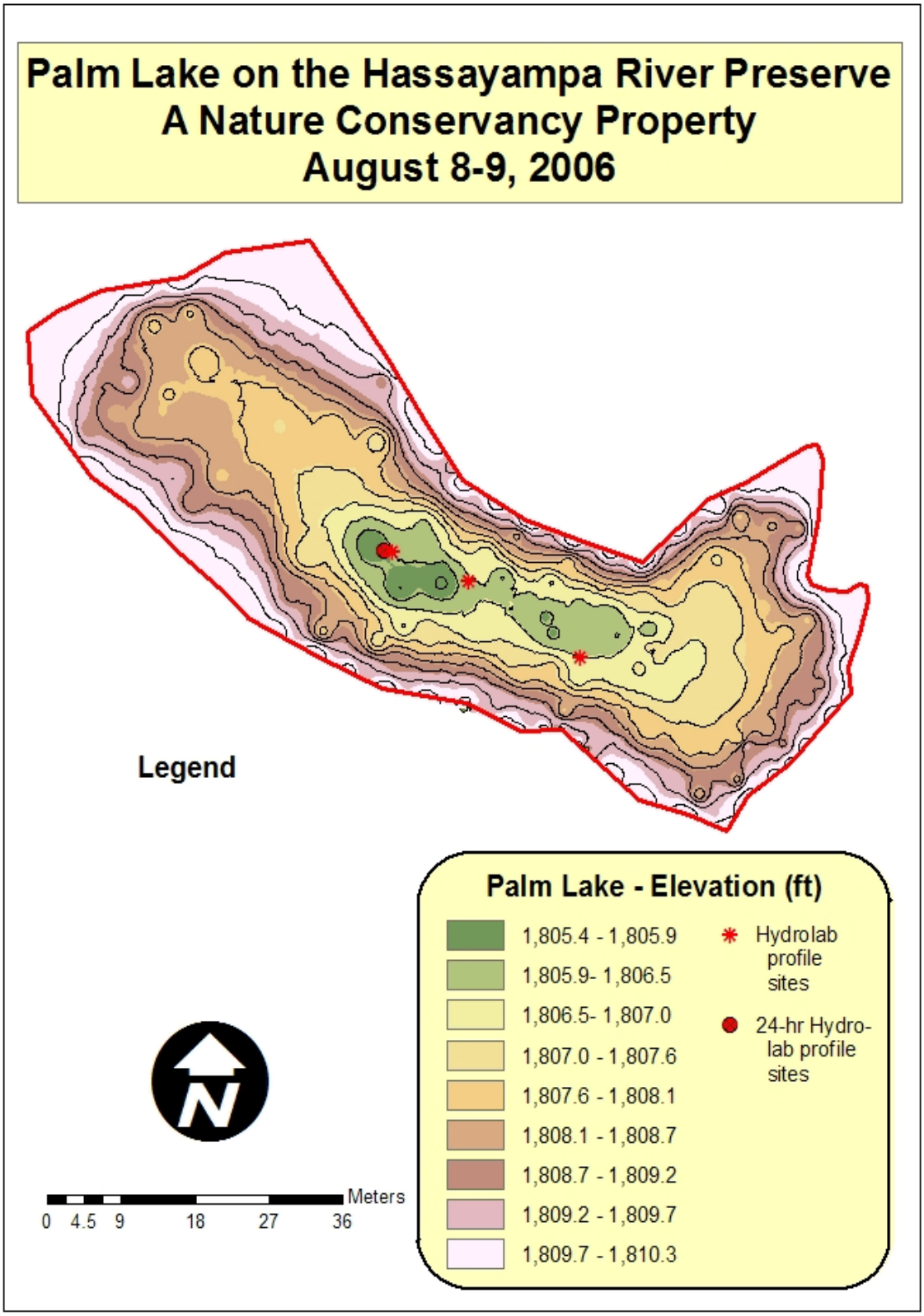

Figure 6. Map of Palm Lake.

Original Biological Suitability Criteria Worksheet

Backwater Number: _____ Location/Reach: _____

Channel Formation Type: _____

Backwater Type (circle one): Connected Isolated

Observer(s):_____ Date: _____

Shoreline Development Index Value: _____ Backwater Size _____

WATER QUALITY:			**Measured Value**	**Score**
Dissolved Oxygen	(1) >5 (mg/L)	5		
	(2) 2-5	3	_____	_____
	(3) <2	1		
Temperature	(1) <27 (degrees Celsius)	5		
	(2) 27-31	3	_____	_____
	(3) >31	1		
Salinity	(1) <5000 (µS/cm)	5		
	(2) >5000	1	_____	_____
pH	(1) 6-9	5		
	(2) outside 6-9	1	_____	_____
Selenium	(1) <5 (ppm dry weight)	5		
	(2) >5	1	_____	_____
Chlorophyll a	(1) <50 (mg/L)	5		
	(2) >50	1	_____	_____
Cyanobacteria	(1) <50% composition	5		
	(2) >50% composition	1	_____	_____

Average Water Quality Score: _____/ 7 = [ ]

COVER:				
Vegetation	(1) 10-60% (pond's area)	5		
	(2) <10%	1	_____	_____
	(3) >60%	1		

Figure 7. Original Biological Criteria Suitability Worksheet.

Turbidity	(1) 10-100 (NTU)	5		
	(2) 0-10	3	_____	_____
	(3) >100	1		
Rip-Rap	(1) Present	5		
	(2) Absent	1	_____	_____

Average Cover Score: _____/3 = ☐

DEPTH:

Depth >10feet	(1) 15-25% (of pond)	5		
	(2) >25%	3	_____	_____
	(3) <15%	1		
Depth <5feet	(1) <30%	5		
	(2) >30%	1	_____	_____

Average Depth Score: _____/2 = ☐

GRAVEL SUBSTRATE:	(1) >5% (pond's perimeter)	5	☐
	(2) <5%	1	
LARVAL FORAGE BASE:	(1) >50 (zooplankton/L)	5	☐
	(2) <50	1	
BIO-INDICATORS:	(1) Fish present (any species)	5	☐
	(2) Fish absent	1	

Total Score (sum of boldfaced line items) ☐

Additional Notes:

Evidence of water exchange: _____

Unique cover features (beaver dam, standing tree trunks, undercut banks, etc.):

_____

Other observations:

_____

_____

_____

Figure 7. (cont.).

conditions in the site. In addition to these three profiles, a multi-probe datasonde was positioned in the deepest portion of the pond at approximately 1 m below the water surface using a buoy and anchor, and programmed to collect the same water quality parameters every hour for a 24-h period. These data were not used directly in the classification model but provided a means of comparison for evaluating diel fluctuations in important parameters such as DO, which may not be apparent from the profile data. Another water quality parameter, the concentration of selenium (a potentially toxic parameter in sufficient concentration), was evaluated by collecting crayfish of any species and analyzing the concentration within the tissues of a composite of several crayfish collected at the site. We attempted to collect at least three crayfish from each site using commercial crayfish traps (Frabil brand square trap; 12"x12"x5") and combined all into a composite sample for the analysis. Crayfish samples were immediately placed into a small cooler containing dry ice until shipped to the laboratory conducting the analysis (Trace Element Research Laboratory, Texas A&M University). The final two components of water quality sampling were evaluations of chlorophyll a and cyanobacteria concentrations from a single water-grab sample collected with a Van Dorn bottle at approximately 0.2 m below the water surface. A single 0.5-L polyethylene bottle was used to store and transport the sample for chlorophyll a and algae. Although not included in the classification model, a portion of the water sample was also used to determine total nitrogen, total phosphorus, and total organic carbon. A single 250-mL polyethylene bottle was used for the total nitrogen and phosphorus samples, and an amber-colored glass bottle (100 mL) used for the total organic carbon. The total organic carbon sample was preserved on site with sulfuric acid (H_2SO_4), while the other samples were not preserved in the field. All samples were put on ice immediately and shipped within 24 hours.

The second component of the classification model was a measure of the cover available to fishes at the site. This was measured using three parameters: vegetation, turbidity, and the presence or absence of rip-rap. The abundance of vegetation was estimated as total surface area of a pond covered with submergent or emergent vegetation of any species. These were estimated either visually (when the coverage was clearly <10% or >60% coverage, which corresponds to the lowest suitability value in the classification model), or by mapping with a GPS unit, or hand-drawing polygons on a hardcopy map of the site. When a GPS unit was used for mapping, a unit capable of post-processing the data (Trimble ProXH) was used to collect point and line data around the perimeter of each vegetation patch. Data were later converted into polygons for calculation of total area coverage. The vegetation coverage data were then used to determine the proportion of vegetation coverage relative to the total surface area of the pond. Turbidity data (measured as Nephelometric Turbidity Units [NTU]) were collected using the profile data collected for the water quality parameters. The turbidity value used for the classification model was an average of the value at 1 m below the water surface among the three profiles (values at a 0.5-m depth were used when total water depth was 1 m). The presence or absence of rip-rap was determined through visual observations of substrate composition throughout the pond. Rip-rap was considered to be at least small-boulder size (approximately 250 mm or larger).

Water depth was another component of the classification model and it included two parts, the proportion of a pond that had a water depth of less than 5 feet (ft) (1.5 m), and the proportion that had depths greater than 10 ft (3.0 m). For these efforts water depth was measured using two different methods. Where possible an echosounder and GPS were attached to a jon boat to simultaneously record water depth and position of the transducer while motoring across the pond. Regular transects were conducted, and distance between transects was visually selected in the field based on size of the pond and contours of the substrate to provide a dense coverage of points sufficient to adequately develop a bathymetry map (approximately 5 – 10 m apart). Individual depths were recorded by the echosounder unit every 0.5 second, which resulted in a spacing interval between points that was determined by boat speed (generally between 1 – 3 m). When this unit was not available, individual data points were collected by measuring depth and collecting GPS coordinates on a hand-held unit capable of differential correction. In these instances the spacing of points was generally wider than with the echosounder due to the time required to collect these data; the spacing was determined based on the size of the pond and contours of the substrate to provide a dense-enough coverage of points sufficient to adequately develop a bathymetry map (approximately 5 – 10 m apart). In addition, water surface elevation was collected using the GPS unit in a location that had a clear view of the sky for a period of at least 45 minutes to generate an average elevation with an error of +/- 0.2 m in most cases. The depth data (collected by either means) were corrected to the greatest horizontal accuracy achievable by post-processing GPS data and used to generate a raster image of the substrate elevation using a standard inverse distance-weighted interpolation using the Spatial Analyst extension for ArcGIS (ESRI, Inc. 2005). The Spatial Analyst extension was then used to generate 1-ft contours, which were then used to calculate the proportional area of each of the <5-ft and >10-ft contours.

Substrate composition is another component of the classification model that is intended to provide an indicator of the suitability of the site for spawning. Two methods were used to collect substrate characteristics at all sites. For the classification model, the proportion of substrate around the pond's perimeter was used to rate site suitability. For this effort, the size of the backwater determined the number of samples to be collected. All backwaters sampled for this effort were >5 acres in size and required 20 evenly spaced transects around the perimeter; larger sites require more transects (Reclamation 2006). At each transect a GPS coordinate was collected with a hand-held unit on the shoreline, and a sounding pole was used to determine substrate class in 1-m increments from the shore out toward the middle of the pond. When a sample point was too deep to sample with a 10-ft sounding pole, no data were recorded for that point. Substrates were divided into three classes: sand/silt, gravel, and cobble/boulder. The proportion of each substrate type around the perimeter of the site was determined as the proportion of a class among all sampled points.

In addition to data on substrate composition around the perimeter of a site, substrate composition data were collected in the deeper portions of the site while collecting bathymetry data. When bathymetry data were collected manually (no echosounder), a substrate type was recorded at each depth point (same categories as the perimeter substrate method). When bathymetry data were collected with the echosounder, a sounding pole was used at regular intervals (approximately 5 – 10 m) to determine substrate type.

The final two components of the classification model were larval forage base and bio-indicators. The larval forage base component was designed to indicate the suitability of a forage base for larval fishes. This was measured as the density of zooplankton in the water column. In most sites, plankton tows were conducted with a net that had a 1-ft diameter and 80µm or 153µm mesh size. Tows were conducted horizontally around the center of the backwater, and a GPS unit was used to map the distance traveled for calculation of volume of water sampled. Samples were collected within 1 hour of sunrise to capture zooplankton that typically migrate into the epilimnion of the water column during the night. Samples were immediately preserved with approximately 5% formalin and returned to the lab for processing. This protocol was modified slightly in one instance (at Rock Tank) when samples could not be collected within 1 hour of sunrise. In this instance vertical tows were conducted in three locations near the center of the pond, and the depth of water was used to calculated volume of water sampled. All zooplankton were identified to the lowest taxon that could be efficiently determined, and density of all taxa were presented as the number of organisms per liter of water sampled. The bio-indicators component of the classification model included a determination of the presence or absence of any fish species in the pond as an indicator of the suitability of the pond for fishes in general. For all sites evaluated through this effort, the general history of fish occupancy of the site was known; no fish sampling was conducted, but all sites were considered to have fish present.

In addition to the data collected to meet the requirements of the classification model for rating sites with numerical scores, additional data were collected that might be useful in determining the suitability of a site either biologically or with regards to restoration logistics. These data included channel formation type; size of the site; shoreline development index (SDI) value; observations on water exchange, unique cover features, bullfrog presence, and riparian vegetation characteristics; and any other relevant observations. Backwater size was determined by generating a perimeter with a series of GPS-collected points around the sites (or from previously collected bathymetry data and comparison with current water surface elevation). This perimeter file was then used to calculate the SDI, which is the ratio of the length of the shoreline to the circumference of a circle of area equal to that of the lake for the site. Although no scoring value was associated with the SDI, Holden et al. (1986) found a relationship between SDI value and fish abundance that indicated that this could be a useful factor for site comparisons.

RESULTS AND DISCUSSION

The selected sites provided a range of conditions for evaluating the classification model to be used in prioritizing LCR MSCP habitat-creation opportunities. The success of stocking native fishes at these sites varied from no long-term survival to successful reproduction.

All sites were less than 5 acres; two sites were less than 1 acre. The two smaller sites would not have qualified for a site visit under the existing site-selection classification model since there is a minimum size requirement of 1 acre. The other sites would fall within the “low habitat creation opportunity” for size (1 – 5 acres). No backwaters were evaluated that would fall within the “high habitat creation opportunity” range (5 – 40 acres).

The SDI values for all sites (an indicator of the shape of the pond) ranged from 1.14 (Rock Tank) to 1.63 (Davis Cove). These would all be classified as having low shoreline development (and given the lowest scoring value) according to Holden et al. (1986).

Rating scores for all sites were in the "excellent" habitat suitability range (Table 1; Appendix A). In general, sites did not rate according to their respective stocking success levels. Sites where low stocking success occurred rated lower than the other sites, but the two sites where intermediate success occurred rated the highest among all sites, and the three sites where excellent stocking success occurred were rated in the middle of all sites. Some individual parameters were consistent across sites, but others deviated greatly. Often sub-criteria differed between sites individually, but the average value among all sub-criteria resulted in the same overall score for the category. No site had the highest or lowest rating value for all categories.

Table 1. Rating scores for each evaluated backwater site.

SITE	SIZE (ACRES)	SDI[a]	AVERAGE SCORES						TOTAL[b]
			WATER QUALITY	COVER	DEPTH	GRAVEL	LARVAL FORAGE	BIO-INDICATOR	
Chango Tank	1.85	1.55	4.7	1.0	1.0	5.0	5.0	5.0	21.7
CHLP[c]	4.68	1.40	4.7	3.0	1.0	5.0	5.0	5.0	23.7
Davis Cove	2.75	1.63	4.1	2.3	4.0	5.0	5.0	5.0	25.4
Floyd Lamb	2.68	1.46	4.7	1.0	3.0	5.0	5.0	5.0	23.7
Palm Lake	0.77	1.46	4.7	3.0	1.0	1.0	5.0	5.0	19.7
Rock Tank	0.83	1.14	4.4	2.3	2.0	5.0	5.0	5.0	23.7
Yuma Cove	2.61	1.29	3.9	2.3	3.0	5.0	5.0	5.0	24.2

[a] Shoreline Development Index
[b] Habitat quality scoring: 19 – 30 = Excellent; 14 – 18.9 = High; 9 – 13.9 = Moderate; 5 – 8.9 = Low
[c] Cibola High Levee Pond

Overall, the effort required to collect data to generate scores for the classification model was less than anticipated. Collection of bathymetry data was expected to take a full day of effort using a three person crew, but these data were generally collected within a 2 – 3 h interval. This will increase with larger sites; all sampled sites from this effort were <5 acres, whereas sites to be evaluated for the LCR MSCP will be up to 40 acres (Reclamation 2006). Each site took approximately 1 day to complete. When the stationary datasonde was set on the day preceding primary data collection, all other data collection efforts were completed and the datasonde retrieved after 24 h and moved to the next site. When sites were geographically distant this might not have been logistically possible, but when sites were close together a single day would be sufficient to complete the effort at each site. However, we did not collect fish data during the classification model validation, since the stocking history of each site was already known. When this component is added to the field sampling protocol, there will be additional time requirements.

Several attempts were made to modify the scoring system to improve the relative rating among sites, but no clear changes that could be justified with the data collected would achieve this result. Nonetheless, some useful observations were made on data collected from individual parameters that suggest that alteration of components from the original classification model is appropriate. In addition, a reorganization of the classification model is recommended below that may improve interpretation in addition to providing a single value for evaluating relative habitat suitability among sites.

Water Quality

All water quality parameters varied widely. Dissolved oxygen was lowest in Rock Tank (0.29 mg/L), a highly successful stocking site, and Rock Tank was the only site that rated in the low category for DO (Figure 8). Palm Lake also had a relatively low value (but rated in the moderate range) at 2.6 mg/L, while all other sites had average hypolimnetic values above 3.0 mg/L. Because of its shallow nature (approximately 1 m maximum depth), water quality values at 0.5-m depth were used. This resulted in a greater influence of high DO contribution during the day from the extensive mat of floating vegetation. The 24-h datasonde data, though not used for the rating system, showed that there was great diel variation near the surface of this lake and DO concentration during the night was probably 0 – 2.0 mg/L throughout the water column (Appendix B). It is believed that low DO was a major contributor to the lack of stocking success at this site. However, the DO portion of the water quality for this site was moderate and contributed a value of 3 to the overall average for the category. Using the 24-h datasonde data to supplement the hypolimnetic data was problematic because in deeper sites there might have been a wide DO swing in the epilimnion but more stable DO concentrations in deeper water. These results suggested that raising the range of DO in the moderate category to 3.0 – 5.0 mg/L might improve the classification model results. This would only affect the values in Palm Lake among the sites evaluated in this effort.

Hypolimnetic temperature values were in the high category for Rock Tank, Chango Tank, and Palm Lake, and in the moderate category for all other sites (Table 2). It is interesting that the two sites in Buenos Aires NWR had among the lowest temperatures. High temperatures were believed to be among the greatest problems for fish in these isolated sites. Chango Tank was also very shallow, which suggested susceptibility to high temperatures. Palm Lake was spring fed and had a dense riparian canopy, which shaded the majority of the pond. One potential problem with temperature as it is currently evaluated in the site-selection classification model is that a hypolimnetic temperature may not provide a true picture of habitat suitability if fish are not using the hypolimnion due to depressed DO concentrations. This was clearly the case in Rock Tank, where DO plummeted at a depth of around 1 m and remained low to the 4-m maximum depth. During our visit we saw numerous fish “finning” on the surface of the lake; they were presumably restricted to occupying only the uppermost portion of the water column. A possible alteration to the existing classification model would be to use the average water temperature value for the lowest depth (using the three profiles) where DO is in the moderate range, since this would be the limiting factor that most strongly influences habitat usage within the water column. A temperature refuge is only useful to the fish when other water quality parameters permit using the area.

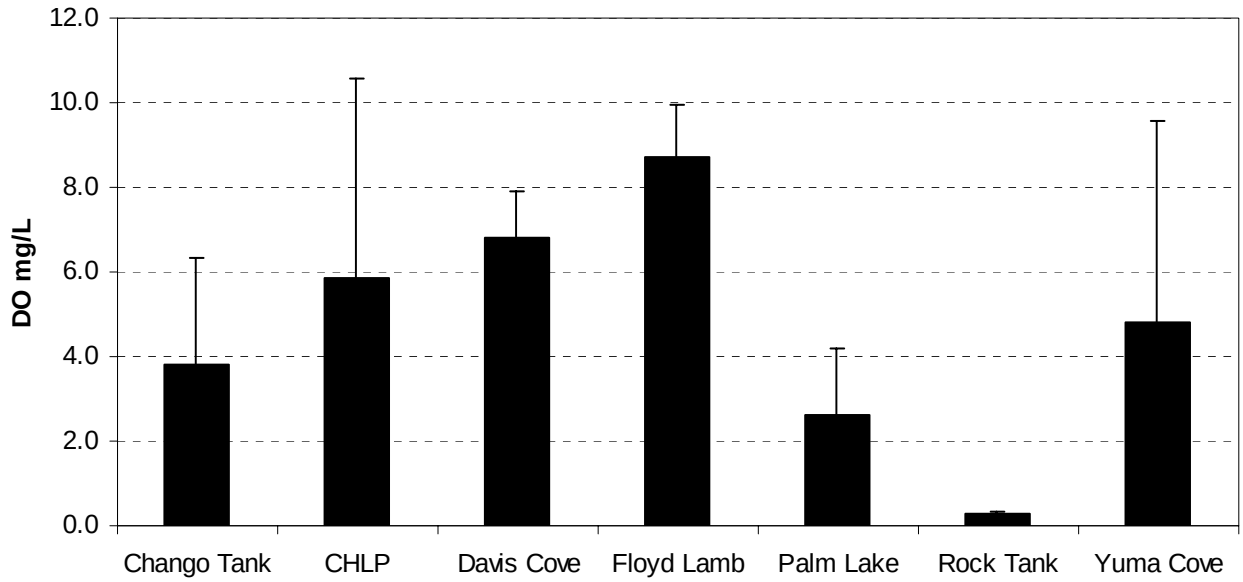

Figure 8. Dissolved oxygen (DO) measurements at 1 m above substrate for each of the seven classification model validation sites (error bars represent one standard deviation).

Table 2. Mean values of water temperature, specific conductivity, and pH from three locations in each of the seven classification model validation sites.

SAMPLE SITE	WATER TEMPERATURE (°C)	SPECIFIC CONDUCTIVITY (µS/cm)	pH
Chango Tank	24.1	61.7	7.3
Cibola High Levee Pond	29.5	1316.3	8.3
Davis Cove	30.1	5402.0	8.4
Floyd Lamb	27.4	501.3	8.2
Palm Lake	25.7	755.5	7.5
Rock Tank	22.6	65.2	6.6
Yuma Cove	28.7	1357.7	9.2

Specific conductivity was within the high habitat suitability category for all sites except Davis Cove, where recent reproduction of bonytail and razorback sucker occurred despite the high observed value (Table 2). With the relative uncertainty about the range of salinity conditions that might influence habitat suitability for razorback sucker and bonytail, a conductivity value of 5,000 µS/cm was selected as the cutoff between low and high suitability with the assumption that this concentration was higher than most fish species are tolerant of. However, it is clear that these two native fish species are more saline tolerant than initially believed, and modifications to the scoring

structure may be appropriate. It is likely that salinity does not have a strong influence on habitat suitability until a threshold tolerance for the species is exceeded. A site that is likely to have problems with salinity (conductivity) should have a reduced water quality score, but a focused research study would be necessary to provide any more detail on the threshold tolerance for this parameter. Similar to water temperature, we feel that the average conductivity value should be sampled at the lowest depth where DO is in the moderate range.

In addition, pH does not likely have a strong influence on habitat suitability until it exceeds the threshold tolerance of the species. Yuma Cove is the only site where the range of pH values chosen for the site-selection classification model (6.0 – 9.0) was exceeded, which resulted in a rating value of 1 being contributed to the water quality average for that site (Table 2). In this instance, the average pH value was 9.17. Since the development of the site-selection classification model, an evaluation of water quality data from the lakeside monitoring ponds used by Reclamation on Lake Mohave indicated that pH (particularly in late summer) might be a useful indicator of the survivorship of razorback sucker in ponds where higher values were indicative of the more successful sites (M. Horn, Reclamation, personal communication). Based on these data, it may be useful to modify the rating system for pH slightly. We recommend using pH values from 7.0 – 10.0 to indicate high suitability, 6.0 – 6.99 to indicate moderate suitability, and <6.0 or >10.0 to indicate low suitability.

Selenium was supposed to be evaluated by collecting crayfish and determining the dry weight content in a composite sample of the organisms. However, crayfish were only caught in one location, Floyd Lamb. Up to six crayfish traps were set overnight in each site, and in some cases they were set for more than one night. Traps were baited with canned cat food. The lack of success indicates that trapping crayfish cannot be relied upon to provide a measure of the selenium concentration in backwaters. Many of the sites were known to have crayfish populations, but either time of year or sampling technique prevented collection. It is clear that some modification to selenium sampling will be required for the classification model. For all sites where no crayfish were sampled, no selenium component was included in the average value for water quality.

All sites had high suitability for both chlorophyll a and cyanobacteria abundance (Table 3). Chlorophyll a concentrations were well below the threshold for shifting from high to low habitat suitability (50 mg/L). The highest value occurred in Palm Lake (28.3 mg/L); all other sites were below 20 mg/L. Only three of the seven sample sites (Chango Tank, Palm Lake, and Rock Tank) had cyanobacteria, and Chango Tank had the highest concentration, with 10.5% of the total algae composition attributable to that taxa.

Nutrient concentrations were relatively low and did not indicate problems with eutrophication in any system (except in Yuma Cove, where excessively high total nitrogen suggests a contaminated sample) (Table 4).

Table 3. Chlorophyll a concentration and proportion of cyanobacteria in planktonic algae at each sample site.

SAMPLE SITE	CHLOROPHYLL A (mg/L)	PERCENT OF CYANOBACTERIA
Chango Tank	18.6	10.5
Cibola High Levee Pond	1.5	0
Davis Cove	1.7	0
Floyd Lamb	2.5	0
Palm Lake	28.3	5.3
Rock Tank	1.7	6.4
Yuma Cove	1.6	0

Table 4. Nutrient concentrations at each sample site.

SAMPLE SITE	TOTAL NITROGEN (mg/L)	TOTAL PHOSPHORUS (mg/L)	DISSOLVED ORGANIC CARBON (mg/L)
Chango Tank	0.25	<0.05	4.39
Cibola High Levee Pond	0.36	<0.05	4.46
Davis Cove	0.42	<0.05	4.49
Floyd Lamb	0.34	<0.05	4.51
Palm Lake	0.73	<0.05	5.25
Rock Tank	0.92	<0.05	10.64
Yuma Cove	10.11	<0.05	9.96

Cover

The percent of submerged and emergent vegetation coverage ranged widely among sites. Some sites were nearly covered with submergent vegetation, while others had some patches scattered near the shorelines. Chango and Rock Tanks each had virtually zero vegetation in the water column (Chango Tank had an extensive riparian canopy). The two sites with the highest vegetation composition were two of the most successful stocking sites. Both Yuma Cove and CHLP had much more than 60% submerged vegetation coverage. The main concerns with large amounts of vegetation are that a seasonal die off would result in severely depressed DO concentrations and that the pond may be in a late ecological succession stage and have reduced longevity. However, the seasonal vegetation die off is clearly not an annual occurrence in these sites, since successful reproduction and recruitment of young fish into the population has occurred at both sites.

Turbidity was included in the classification model as another component of cover because sites with very clear water likely permit greater avian predation, particularly on small fish that may use shallow habitats. Habitats with very low turbidity (<10 NTU) were considered to be moderately suitable (Figure 9). This included Palm Lake and CHLP among the sites evaluated. In contrast, habitats with very high turbidity may have excessive eutrophication, which may cause reduced respiratory efficacy in stocked fish. This is likely more problematic than even very low turbidity. Although there is little evidence to suggest where a shift occurs from beneficial conditions to detrimental turbidity levels, some information on spawning success in Lake Mead (Golden and Holden 2003) and turbidity conditions in a few ponds sampled by Reclamation (Walker 2006) was used to target 100 NTU as the cutoff point. Sites with turbidity greater than 100 NTU were considered to have the lowest suitability; this included Chango Tank, Davis Cove, and Floyd Lamb. The only two sites with high suitability in this category were Rock Tank and Yuma Cove, two of the highly successful stocking sites. We did not feel that turbidity in Davis Cove and Floyd Lamb was excessive to the point that these sites should be considered to have low habitat suitability for this parameter. Moving these two sites to the moderate suitability category would involve increasing the upper value of that category from 100 to 150 NTU. Based on the lack of strong evidence to support the 100 NTU upper limit, we feel that this is a legitimate adjustment to the model that would more appropriately discriminate sites used in this effort. The one site that would remain in the low suitability category with this adjustment is Chango Tank; it appeared excessively turbid during the visit and had a measured value of 605 NTU, which is certainly too high. Alternatively, 100 – 150 NTU may be considered moderately suitable, as may sites with <10 NTU. Many sites that are isolated from the Lower Colorado River within the LCR MSCP planning area are likely to have high turbidity. It is not clear whether turbidity in Davis Cove and Floyd Lamb may be problematic. The lack of success in Davis Cove has been partially attributed to salinity issues, but perhaps turbidity is a factor as well. The die-offs in Floyd Lamb may also be exacerbated by high turbidity issues in the fall. Seasonal turbidity sampling would provide more information on this parameter, which may be more critical during some periods (e.g., spawning or vegetation die-offs in the fall).

Rip-rap was initially described as large cobble-sized substrate (approximately 128 mm) or larger; however, this may not meet the intended goal of this habitat component for razorback sucker and bonytail. Substrate that is at least small-boulder size (approximately 250 mm) provides substantially larger interstitial spaces. This was the size of the rip-rap in CHLP, which was the impetus for including this substrate type as a component of cover. The interstitial spaces found in the rip-rap in CHLP appeared to be important to bonytail (Mueller 2006a). This is a habitat component that is not expected to occur naturally at any site and, accordingly, only CHLP contained substrate of this size along one of the levees. This substrate was considered something of a “bonus” for initial site evaluations, but it would most likely be nonexistent among sites and have to be placed on site to achieve the desired cover conditions.

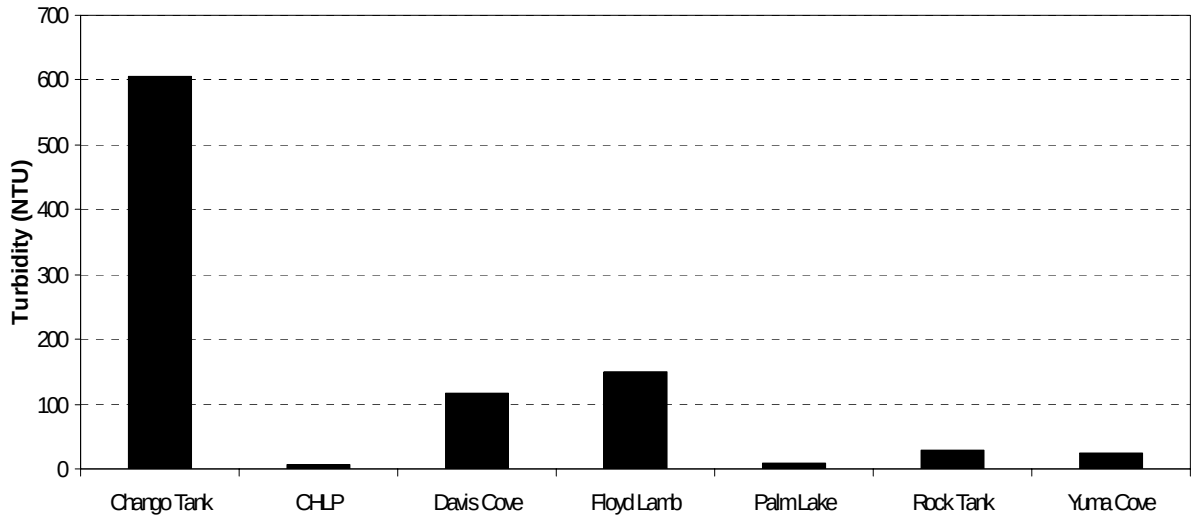

Figure 9. Turbidity (NTU) measurements at 1 m below the water surface in each of the seven classification model validation sites.

Depth

Water depth was considered important in many ways, but the primary two factors of habitat suitability related to depth were (1) whether a site provides sufficient area for a thermal refuge and cover from avian predation, and (2) ensuring that not too much of the surface area was so shallow that there would be temperature problems. It was assumed that some shallow area was important to provide an area for spawning (a steep-sided pond is not likely to supply suitable conditions), but too much shallow area allows for rapid eutrophication (ecological succession). No site evaluated during this effort had the desired combination of >15% area that was 10 ft or greater and <30% of the area that was less than 5 ft (Table 5). Cibola High Levee Pond, which was considered to have virtually ideal conditions to be replicated in all additional sites, had low suitability for both depth sub-criteria. There was only 3% total depth greater than 10 ft, and approximately 38% of the area that was less than 5 ft. Rock Tank also scored low for the amount of shallow habitat and only moderately for the percentage of deep areas. These results suggest that depth may not be as important a factor as previously believed or that shallow habitats may be more suitable. Both depth components may be similar to some of the water quality components in that there is something similar to a tolerance threshold for a pond: exceeding a certain value creates a "domino effect" that pushes other factors into unsuitable condition. The two sites that were considered unsuccessful were both shallow (>50% that was less than 5 ft deep). This is clearly an undesirable condition. The classification model may be improved by increasing the permitted shallow habitat coverage to 50% before suitability becomes low. This would result in a change from low to high suitability for this factor in CHLP, Rock Tank, Yuma Cove, and Floyd Lamb (three highly successful and one moderately successful stocking sites). Similarly, a greater percentage of deep habitat is not likely to cause significant problems until the resulting bathymetry is a steep-sided pit. Therefore,

Table 5. Proportion of total surface area that was less than 5 ft and greater than 10 ft in each of the classification model validation sites.

SAMPLE SITE	PERCENT OF TOTAL AREA <5 FT	PERCENT OF TOTAL AREA >10 FT
Chango Tank	50+	0
Cibola High Levee Pond	28	3
Davis Cove	25	53
Floyd Lamb	45	16
Palm Lake	100	0
Rock Tank	38	28
Yuma Cove	41	20

increasing the percentage of habitat that can be greater than 10 ft to 35% from 25% may similarly improve the ability of the classification model to predict habitat suitability. If this were implemented, low suitability would remain less than 15% of the total area that is less than 10 ft (this occurred on Chango Tank, Palm Lake, and CHLP), 15% – 35% would be the highest suitability, and anything greater than 35% would be moderate suitability. With these changes both Rock Tank and Yuma Cove, which were considered to have excellent physical habitat conditions, would rate highest for deep habitat availability.

Gravel Substrate

Only Palm Lake (100% sand/silt) did not contain the requisite gravel substrate around the perimeter of the lake to yield a high suitability for this parameter (Table 6). Even sites that were considered to have low prospects for spawning success due to a lack of suitable substrate for spawning (e.g., Floyd Lamb and Chango Tank) had sufficient gravel substrate (23% and 18% respectively), which indicated that sufficient gravel substrate was not likely preventing spawning success. Cibola High Levee Pond, which was considered to have excellent gravel substrate conditions for spawning, had only 13% coverage of gravel around the perimeter of the lake. This observation suggests that there may be some other component of substrate composition that may be important for spawning suitability such as size or perhaps quality (i.e., embeddedness) of the gravel that indicates the suitability of an isolated backwater for spawning success. Perhaps other habitat components, such as insufficient water quality or lack of appropriately sized forage, affected the lack of spawning success in some sites with apparently adequate spawning gravels. These issues would not be identifiable during a single summer site visit; so it would be important to conduct a full cycle of seasonal site visits during the site-selection efforts to fully evaluate a site's potential as successful spawning habitat. In addition, additional efforts need to be focused on this issue to refine the concept of excellent habitat suitability.

Table 6. Proportion of sample points along the perimeter of each classification model validation site that had gravel substrate.

SAMPLE SITE	PERCENT OF GRAVEL SUBSTRATE
Chango Tank	18
Cibola High Levee Pond	13
Davis Cove	38
Floyd Lamb	23
Palm Lake	0
Rock Tank	53
Yuma Cove	75

Larval Forage Base

All but three of the sample sites had sufficient density of organisms to rank as highly suitable for larval forage base. The three sites with low suitability sampled during the first field visit had a low suitability rating for larval forage density, which might have been due to the mesh size of the sample gear. During that trip all samples were taken with a 153 µm mesh-size net, while the three sites during the second trip were sampled with a 80 µm mesh-size net. Many of the organisms that contributed to the density estimates for the latter sites were very small (rotifers and nauplii) and were not captured with the larger mesh-size net. As an example of the influence of these small-bodied organisms on the density estimates, Rock Tank had 109.5 organisms/L including rotifers and nauplii, but it would have had only 15 organisms/L without these two groups. Based on these data, it appears likely that the three sites that had low densities using the larger-size mesh net would have been rated as highly suitable if the smaller mesh net had been used, so the score for all sites was adjusted to the high suitability value. At the very least these data indicated the importance of the net mesh size in the classification model. This could have a great influence on a site's rating, since the overall rating score for each site would be excellent if the forage value for each site was in the highest suitability range. Although it remains possible that larval forage would be low in some isolated backwaters, the anticipated level of eutrophication associated with these sites would likely lead to high densities of forage prey items. This was supported by the data collected during this classification model validation effort.

Although the presence of an appropriate forage base is an important parameter in the suitability of a backwater for native fish species, there are not enough data to evaluate forage for any life stage larger than larvae. These early life stages consume very small zooplankton, which appear to be abundant in the types of sites that would be evaluated for habitat creation potential. While there may be a limitation of larger zooplankton in some sites and/or a lack of appropriate taxa to serve as prey, not enough information was available to incorporate these factors into the model. Because all sites

would likely rate high for the zooplankton density required to support larval fish, this parameter provides little value to the backwater site-selection classification model and should be removed.

Bio-Indicators

All sites were considered to have fish present since this was clearly the case when fish were stocked. In all instances stocked fish were known to have persisted in these sites for some time. In addition, fish were visually observed in most locations during site visits. Among the two unsuccessful sites, *Gambusia* sp. were observed in Palm Lake (and it was believed that black bullhead were present as well; M. Lawrence, The Nature Conservancy, personal communication). No fish were observed in Chango Tank, and it is possible that no fish were present (large numbers of leeches were present throughout the water column, which would probably not have been the case if any fish were present that would prey on these invertebrates). It is arguable that a low suitability value could have been assigned to this site for the bio-indicator category, but future evaluations would include fish sampling since the history of fish occurrence at a site would be unknown in most cases. One recommended change for this category is that *Gambusia* sp. and bullhead (any species) not be included as fish species that would indicate the potential success of a site for razorback sucker or bonytail. These two fish groups are highly tolerant of poor water quality conditions that would not support most other fish species. The presence of species from these two genera does not provide any indication that stocked fish would persist; thus this category should be rated as having low suitability along with sites that have no fish species present.

RECOMMENDATIONS

Obtaining a larger sample size in each of the three success categories evaluated for this study may have reduced the influence of limited data availability and difficulty in objectively separating sites into those categories. However, we did collect useful information that suggests that making some modifications to the threshold levels for differentiating among low, moderate, and high suitability would be appropriate. Recommendations for each backwater classification model component are presented below. These recommendations have been incorporated into a protocol for performing an initial (summer) site visit (Appendix C).

Water Quality

The hypolimnetic average of DO was higher than expected in many locations. It may be reasonable to expect 3.0 mg/L as a minimum for the moderate suitability range. In addition, the 5.0 mg/L value for the high suitability range is not excessively high, based on the data we collected. One other consideration related to DO is that some sites had distinct stratification (both thermal and DO), which resulted in very low hypolimnetic DO values but relatively high DO higher in the water column. Therefore, we recommend that when a hypolimnetic average for DO is in the low suitability range, a site can still be considered moderately suitable if the DO value is greater than 3.5 mg/L at 1 m below the water surface (Figure 10). This change would also require evaluating the 24-h datasonde data (which are also located at approximately 1 m below the surface) to determine

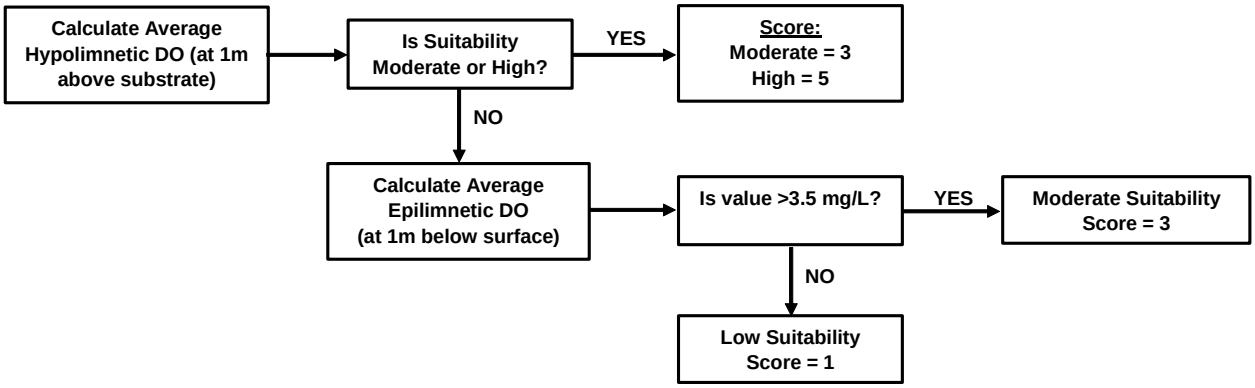

Figure 10. Flowchart illustrating the recommended evaluation of dissolved oxygen for the classification model.

whether diel variation lowers DO in the epilimnion during the night as well. If the DO value drops below 2 mg/L at 1 m below the surface and the hypolimnetic DO is low, then it should be considered to have low habitat suitability for the DO category. The reasoning for this recommended change is that fish may occupy the epilimnion when DO is too low in deeper sections (as is apparently occurring in Rock Tank), and this provides some suitability for the site, but even with very high DO at this level it is still a less-desirable condition than suitable DO conditions in the hypolimnion (Table 7).

Table 7. Average dissolved oxygen hypolimnetic values and average values using the recommended changes to the methodology.

SAMPLE SITE	HYPOLIMNETIC VALUE (mg/L)	EPILIMNETIC VALUE (mg/L)	24-HR DIEL VALUE BELOW 2.0 mg/L?	ORIGINAL RATING	UPDATED RATING
Chango Tank	3.83	N/A	N/A	Moderate	N/A
Cibola High Levee Pond	5.85	N/A	N/A	High	N/A
Davis Cove	6.81	N/A	N/A	High	N/A
Floyd Lamb	8.72	N/A	N/A	High	N/A
Palm Lake	2.64	2.64	Yes	Low	Low
Rock Tank	0.29	3.57	No	Low	Moderate
Yuma Cove	4.83	N/A	N/A	Moderate	N/A

To further account for the stratification in the water column and potential restriction of fish to the epilimnion, we feel that the other standard water quality components (temperature, conductivity, and pH) should be measured as an average from the three profiles in the deepest location where DO is suitable for fish occupancy (within the moderate range). Otherwise, we do not recommend changes to the ranges for either temperature or salinity [change salinity ranges 5,000-10,000 moderate, 10,000+ low]. Some information suggested that a change in pH might be warranted. The low suitability score for pH at Yuma Cove seemed counterintuitive to the success experienced at the site, and an evaluation of the Mohave lakeside ponds suggested that higher pH may be indicative of greater stocking success at a site (higher survival of stocked razorback sucker; M. Horn, Reclamation, personal communication). Therefore, we recommend a change in the pH ranges such that values of 7 – 10 indicate high suitability, 6 – 6.99 indicate moderate suitability, and lower than 6 or higher than 10 indicate low suitability. We do not feel that pH is a factor of direct importance to the fish, but clearly extreme values would cause problems.

The evaluation of selenium using crayfish was ineffective. The classification model was based on observations of Marr and Velasco (2005), who said that selenium concentrations in crayfish should not exceed 4 – 5 µg/g in Lower Colorado River backwaters. Lemly (2002) expands upon this basic evaluation to suggest that several potential sinks for selenium in a backwater should be tested and the results combined to provide an overall assessment of toxicity risk in aquatic ecosystems. There are five components to the protocol proposed by Lemly (2002) including concentration of selenium in water, sediments, macroinvertebrates, fish eggs, and bird eggs. There are categories that indicate the risk level for each component: none, minimal, low, moderate, and high. The units of measurements and ranges that fall within each risk category differ among components, but each risk category is assigned a score and the sum is totaled among all five sample components used to evaluate overall risk. We believe this system may be useful in a modified format for evaluating overall habitat suitability within a site but suggest that the extensive protocol of this method is more suited to conducting a detailed site evaluation later in the site-selection process. A single site visit appears to pose challenges for reliably collecting sufficient biomass of any organism, based on our observations and results presented in Marr and Velasco (2005). For the initial site visits, we recommend using a single composite sample of selenium concentration in water from three locations where <2µg/L rates as high habitat suitability and >2µg/L rates as low habitat suitability. The resulting scores would be 5, 3, and 1 for high, moderate, and low suitability.

The high variability of zooplankton density among samples suggested that these organisms were heterogeneously distributed, and it was likely that phytoplankton were similarly distributed. The single samples of chlorophyll a and algae collected in this effort provided no means to evaluate this, but we suggest that each sample collected for this model be a composite of samples from three locations in the backwater to account for some of this anticipated variation. These samples could be collected in the same locations as the three water quality data profiles, since these samples would be spatially segregated to ensure adequate representation of the pond. We do not have any recommendation for changing the range of values for these two parameters, despite the fact that all sites rated in the high suitability category, since these parameters were designed to screen out

hypereutrophic systems and only sites with very poor conditions would rate in the low suitability category.

Nutrient data collection was a low-cost component that was not incorporated into the classification model but nevertheless could add useful information that might be used to help decide the potential value of a site for a restoration project by indicating its eutrophication condition. We recommend collecting one sample of total nitrogen, total phosphorus, and total organic carbon from each site.

Cover

Very high abundance of submerged vegetation did not appear to be as problematic as initially believed since the two sites with the most vegetation (CHLP and Yuma Cove) were also two highly successful stocking sites. However, both of these sites had 80% or more coverage (by visual estimation), so increasing the high suitability cutoff to 70% or 75% would not change these results. Allowing 80% or 90% coverage of submergent vegetation in the high suitability category seems excessive and probably risks exposing fish to seasonal water quality problems if/when these plants die. Therefore, we do not have any recommendations for changing the vegetation component. Our recommendation for turbidity is to add the range of 100 – 150 NTU to the moderate suitability level. We found both Floyd Lamb and Davis Cove were in this category and, while there may be some issues with higher turbidity, these issues are not likely to be as detrimental as the 605 NTU value observed in Chango Tank. For rip-rap we recommend a larger-size substrate than originally described in the site-selection classification system. Suitable rip-rap should be considered small-boulder size (approximately 250 mm) or larger.

Depth

We believe that suitability ranges for depth should be expanded such that a larger range is allocated to high suitability. Several sites that had >30% of their area as shallow habitat (less than 5 ft) were arguably more suitable than the sites that had >50% of this shallow habitat. We believe that the classification model would be improved by including up to 50% of shallow (<5 ft) habitat in the high suitability category but labeling those sites with >50% shallow habitat as having low suitability. Similarly, the amount of deep habitat in the high suitability range should be increased to include 15% – 35% of the total area that is greater than 10 ft; less than 15% of this site should be considered low suitability, while >35% should be considered moderate suitability.

Gravel Substrate

There are no specific recommendations for changing the gravel substrate component. However, we believe that some other factor related to the gravel substrate may also be important to spawning success. This may be a specific size range, the level of embeddeness, or some other issue, but the amount of gravel around the perimeter of the sites evaluated in this effort was not limiting (except in Palm Lake) despite the lack of stocking success in most sites. We recommend collecting additional data regarding substrate conditions and their influence on spawning success.

Larval Forage Base

Larval forage base is likely more important during spring than summer when very small zooplankton are necessary for larval survival and growth. By summer the larvae will have grown and prey type and size may have shifted from that observed to be important by Papoulias and Minckley (1990). There is probably an appropriate size range of organisms that are necessary over time to support larval growth, but not enough information was available to provide this level of detail in the classification model. We believe that zooplankton monitoring would be important to incorporate in a long-term monitoring plan, but we recommend removing it from the backwater site-selection classification model at this time.

Bio-Indicators

Bio-indicators should be modified to include presence/absence of fish species other than *Gambusia* sp. or bullhead of any species. The presence of *Gambusia* or bullhead is not a good indicator that a habitat will be suitable for razorback sucker or bonytail due to the high tolerance for low-habitat quality by the former. Therefore, sites with no fish or *Gambusia* and/or bullhead should be considered to have low suitability, while the presence of any other fish species provides a high suitability rank for this category.

Other Modifications

In addition to the adjustments recommended for the individual parameters, there are some changes that may improve the classification model. During the development of the classification model, we decided to avoid the subjectivity of weighting the relative importance of different variables because of the difficulty of the relative importance of each variable. However, some facets of the existing classification model did result in "weighting" individual factors. For example, there are seven water quality components that were averaged to yield a single value, while the presence of sufficient gravel substrate was given a single value that was equivalent to water quality in the overall score. We feel that a more objective approach, one that reduces this inadvertent weighting, would be to allow each individual sub-criteria to contribute to the total value without averaging. Thus, each of the seven components of water quality would have the same influence on the total value as the presence of sufficient gravel substrate.

In addition, deviation from the avoidance of weighting individual parameters may be appropriate for the DO concentration. More than any other parameter, DO likely has the greatest influence on the suitability of a habitat for supporting razorback sucker or bonytail for an extended time period. Some factors in the classification model evaluate the potential for spawning success, which is important but secondary to long-term survival of stocked fish. Other factors influence survival, such as cover components, but not as acutely as DO. Other water quality components are arguably as important as DO, but none are as likely to be outside of the suitable range or vary so much. Therefore, we recommend a change in the scoring for DO where high suitability is increased to 10

from 5, moderate increased to 5 from 3, and low suitability remains at 1. By increasing the spread of these values, the suitability of sites will be more readily differentiated.

One other possible change to the classification model is in regards to the overall organization. While the current organization takes into account multiple components of the habitat conditions, we believe that the individual components can be grouped into categories that provide a more focused view of the relevancy of the parameters. We recommend collapsing the current six categories into four. We feel that the following categories will provide more insight about the separate components of the habitat. The recommended categories include water quality, spawning habitat, cover, and bio-indicators. The first category should remain as in the current classification model. The spawning habitat category should include the current gravel substrate category, the larval forage base category, and proportion of shallow (<5 ft) habitat. The proportion of deep (>10 ft) habitat should be added to the current cover category. The bio-indicators category should remain unchanged. This modification would essentially redistribute the current depth, gravel substrate, and larval forage base, and create a spawning habitat category to capture the intent of these categories more clearly.

Final Rating Categories

One of the reasons that the model did not differentiate among sites very well was that the categories for low, high, moderate, and excellent habitat were chosen without any field data or testing of the model to define the breakpoints between categories. After this effort, we believe that there is some justification in modifying these cutoff values along with the other changes to the scoring system. We recommend that the "excellent" category be composed of those sites that yield an overall score of 60 or higher. This constitutes 80% of the available "points" (60 out of a possible 75). Those sites scoring between 52 and 59.9 should be considered to have "high" habitat suitability. This includes sites with approximately 70-80% of the total possible points available for a site. Sites with scores between 45-51.9 (60-70% of total points) should be considered to have "moderate" habitat suitability and those sites with less than 45 points should be classified as having "low" habitat suitability.

Results of the Modified Site Classification Model

Table 8 provides a comparison of original model results with the updated scores, and Figure 11 provides an example of a modified field worksheet that incorporates all changes suggested in this report. Unfortunately selenium concentration in the water column was not available for incorporation into the updated results, so we have assumed that selenium was highly suitable for all sites evaluated. The results provide a greater spread in scores among sites than the initial classification model, but highly successful and moderately successful sites rated similarly. With the modifications to the model incorporated and category ranges for determination of habitat suitability updated, five of the seven sites rated as having excellent habitat. Three of these were considered to have high stocking success, so the results correlate well with the history of those sites. Floyd Lamb and Davis Cove were considered to have had moderate stocking success, yet these two sites were rated as having excellent habitat. Recent observations of successful razorback sucker and

Table 8. Rating scores for each evaluated backwater site using the modified classification model.

SITE	SIZE (ACRES)	SDI [a]	AVERAGE SCORES				UPDATED SCORE	ORIGINAL SCORE
			WATER QUALITY	SPAWNING	COVER	BIO-INDICATOR		
Floyd Lamb	2.68	1.46	40	10	10	5	65	23.7
Cibola High Levee Pond	4.68	1.40	38	10	10	5	63	23.7
Davis Cove	2.75	1.63	36	10	12	5	63	25.4
Rock Tank	0.83	1.14	35	10	12	5	62	23.7
Yuma Cove	2.61	1.29	33	10	12	5	60	24.2
Chango Tank	1.85	1.55	35	6	4	5	50	21.7
Palm Lake	0.77	1.46	31	2	10	5	48	19.7

[a] Shoreline Development Index.

bonytail reproduction at Davis Cove suggested that this site may have been originally misclassified) and that the excellent habitat category was an appropriate rank. The relative stocking success at Floyd Lamb may have primarily resulted from non-native fish presence at the time of stocking. This may explain why no successful reproduction and recruitment have been observed. The periodic razorback sucker die-offs may be due to a change in habitat suitability that occurs during the fall, but that was not occurring during the summer site visit. This observation reinforces the importance of multiple (seasonal) site visits for candidate sites before deciding to invest restoration dollars into a prospective site. The most valuable observation from this validation effort is that the two sites considered to have poor stocking success (Chango Tank, Palm Lake) rated lower than the other sites in the moderate habitat suitability category. While it may be argued that a low habitat suitability rating would be more appropriate, it should be noted that there were sites with substantially worse habitat conditions than these sites (they must have shown some promise or they likely would not have been used in the first place). In addition, no fishes were observed in Chango Tank and only Gambusia observed in Palm Lake, yet each was given a score of five points for this category.

Updated Biological Suitability Criteria Worksheet

Backwater Number: _____ Location/Reach: _____

Channel Formation Type: _____

Backwater Type (circle one): Connected Isolated

Observer(s):_____ Date: _____

Shoreline Development Index Value: _____ Backwater Size _____

WATER QUALITY:			**Measured Value**	**Score**
Dissolved Oxygen	(1) >5 (mg/L)	10		
	(2) 3.0-5	5	_____	_____
	(3) <3.0	1		
Temperature	(1) <27 (degrees Celsius)	5		
	(2) 27-31	3	_____	_____
	(3) >31	1		
Salinity	(1) <5,000 (µS/cm)	5		
	(2) 5,000-10,000	3		
	(3) >10,000	1	_____	_____
pH	(1) 7-10	5		
	(2) 6-6.99	3		
	(3) <6 or >10	1	_____	_____
Selenium	(1) <2 µg/L	5		
	(2) >2	1	_____	_____
Chlorophyll a	(1) <50 (mg/L)	5		
	(2) >50	1	_____	_____
Cyanobacteria	(1) <50% composition	5		
	(2) >50% composition	1	_____	_____
			WATER QUALITY SCORE:	

SPAWNING HABITAT:				
Depth <5feet	(1) <50%	5		
	(2) >50%	1	_____	_____

Figure 11. Updated Biological Suitability Criteria Worksheet.

Gravel Substrate	(1) >5% (pond's perimeter)	5		
	(2) <5%	1	_____	_____

SPAWNING HABITAT SCORE: ☐

COVER:

Vegetation	(1) 10-60% (pond's area)	5		
	(2) <10%	1	_____	_____
	(3) >60%	1		
Turbidity	(1) 10-100 (NTU)	5		
	(2) 0-10; 101-150	3	_____	_____
	(3) >150	1		
Rip-Rap	(1) Present	5		
	(2) Absent	1	_____	_____
Depth >10feet	(1) 15-35% (of pond)	5		
	(2) >35%	3	_____	_____
	(3) <15%	1		

COVER SCORE: ☐

BIO-INDICATORS:	(1) Fish present (except Gambusia or bullhead)	5
	(2) Fish absent	1

BIO-INDICATORS SCORE: ☐

TOTAL SCORE (sum of all items): ☐

Additional Notes:

Evidence of water exchange: _____

Unique cover features (beaver dam, standing tree trunks, undercut banks, etc.):

_____

Other observations:

_____

_____

Figure 11. (cont.).

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APPENDIX A: SITE VISIT WORKSHEETS

Site Visit Worksheets – Original Format

Original Biological Suitability Criteria Worksheet

Backwater Number: Change Tank Location/Reach: _____

Channel Formation Type: _____

Backwater Type (circle one): Connected (Isolated)

Observer(s): MR, RR Date: 11 May 2006

Shoreline Development Index Value: 1.55 Backwater Size 1.85

WATER QUALITY:			**Measured Value**	**Score**
Dissolved Oxygen	(1) >5 (mg/L)	5		
	(2) 2-5	3	3.83	3
	(3) <2	1		
Temperature	(1) <27 (degrees Celsius)	5		
	(2) 27-31	3	24.79	5
	(3) >31	1		
Salinity	(1) <5000 (uS/cm)	5		
	(2) >5000	1	55.91	5
pH	(1) 6-9	5		
	(2) outside 6-9	1	7.45	5
Selenium	(1) <5 (ppm dry weight)	5		
	(2) >5	1	Assumed	5
Chlorophyll a	(1) <50 (mg/L)	5		
	(2) >50	1	18.56	5
Cyanobacteria	(1) <50% composition	5		
	(2) >50% composition	1	10.5	5

Average Water Quality Score: 33 / 7 = 4.7

COVER:				
Vegetation	(1) 10-60% (pond's area)	5		
	(2) <10%	1	< 10	1
	(3) >60%	1		

Turbidity	(1) 10-100 (NTU)	5		
	(2) 0-10	3	605	1
	(3) >100	1		
Rip-Rap	(1) Present	5		
	(2) Absent	1	A	1

Average Cover Score: 3 /3 = 1

DEPTH:

Depth >10feet	(1) 15-25% (of pond)	5		
	(2) >25%	3	0	1
	(3) <15%	1		
Depth <5feet	(1) <30%	5		
	(2) >30%	1	>50	1

Average Depth Score: 2 /2 = 1

GRAVEL SUBSTRATE:	(1) >5% (pond's perimeter)	5	18	5
	(2) <5%	1		
LARVAL FORAGE BASE:	(1) >50 (zooplankton/L)	5	1299.1	5
	(2) <50	1		
BIO-INDICATORS:	(1) Fish present (any species)	5	P	5
	(2) Fish absent	1		

Total Score (sum of boldfaced line items) 21.7

Additional Notes:

Evidence of water exchange: _____

Unique cover features (beaver dam, standing tree trunks, undercut banks, etc.):

_____

Other observations:

_____

_____

_____

See "updated... work sheet"

Original Biological Suitability Criteria Worksheet

Backwater Number: Cibola HLP Location/Reach: _____

Channel Formation Type: Oxbow / old channel

Backwater Type (circle one): Connected (Isolated)

Observer(s): MR RR BA NC Date: 15 Jul 2006 – 16 Jul 2006

Shoreline Development Index Value: 1.40 Backwater Size 4.68

WATER QUALITY:			**Measured Value**	**Score**
Dissolved Oxygen	(1) >5 (mg/L)	5		
	(2) 2-5	3	5.85	5
	(3) <2	1		
Temperature	(1) <27 (degrees Celsius)	5		
	(2) 27-31	3	29.09	3
	(3) >31	1		
Salinity	(1) <5000 (uS/cm)	5		
	(2) >5000	1	296.33	5
pH	(1) 6-9	5		
	(2) outside 6-9	1	7.45	5
Selenium	(1) <5 (ppm dry weight)	5		
	(2) >5	1	Assumed	5
Chlorophyll a	(1) <50 (mg/L)	5		
	(2) >50	1	1.52	5
Cyanobacteria	(1) <50% composition	5		
	(2) >50% composition	1	0	5

Average Water Quality Score: 33 / 7 = 4.7

COVER:				
Vegetation	(1) 10-60% (pond's area)	5		
	(2) <10%	1	>60	1
	(3) >60%	1		

Turbidity	(1) 10-100 (NTU)	5		
	(2) 0-10	3	6	3
	(3) >100	1		
Rip-Rap	(1) Present	5		
	(2) Absent	1	P	5

Average Cover Score: 9 /3 = 3

DEPTH:

Depth >10feet	(1) 15-25% (of pond)	5		
	(2) >25%	3	2.8	1
	(3) <15%	1		
Depth <5feet	(1) <30%	5		
	(2) >30%	1	38.3	1

Average Depth Score: 2 /2 = 1

GRAVEL SUBSTRATE:	(1) >5% (pond's perimeter)	5	12.5	5
	(2) <5%	1		
LARVAL FORAGE BASE:	(1) >50 (zooplankton/L)	5	Assumed	5
	(2) <50	1		
BIO-INDICATORS:	(1) Fish present (any species)	5	P	5
	(2) Fish absent	1		

Total Score (sum of boldfaced line items) 23.7

Additional Notes:

See "updated ... Worksheet"

Evidence of water exchange: _____

Unique cover features (beaver dam, standing tree trunks, undercut banks, etc.):

_____

Other observations:

_____

_____

_____

Original Biological Suitability Criteria Worksheet

Backwater Number: Dennis Cove Location/Reach: _____

Channel Formation Type: _____

Backwater Type (circle one): Connected (Isolated)

Observer(s): MR, BA, CG, RR Date: 12 July 2006 - 13 July 2006

Shoreline Development Index Value: 1.63 Backwater Size 2.75

WATER QUALITY:			**Measured Value**	**Score**
Dissolved Oxygen	(1) >5 (mg/L)	5		
	(2) 2-5	3	6.81	5
	(3) <2	1		
Temperature	(1) <27 (degrees Celsius)	5		
	(2) 27-31	3	30.00	3
	(3) >31	1		
Salinity	(1) <5000 (uS/cm)	5		
	(2) >5000	1	5398	1
pH	(1) 6-9	5		
	(2) outside 6-9	1	8.32	5
Selenium	(1) <5 (ppm dry weight)	5		
	(2) >5	1	Absent	5
Chlorophyll a	(1) <50 (mg/L)	5		
	(2) >50	1	1.74	5
Cyanobacteria	(1) <50% composition	5		
	(2) >50% composition	1	0	5

Average Water Quality Score: 29 / 7 = 4.1

COVER:				
Vegetation	(1) 10-60% (pond's area)	5		
	(2) <10%	1	39	5
	(3) >60%	1		

Turbidity	(1) 10-100 (NTU)	5		
	(2) 0-10	3	116.9	1
	(3) >100	1		
Rip-Rap	(1) Present	5		
	(2) Absent	1	P	1

Average Cover Score: 7 /3 = 2.3

DEPTH:

Depth >10feet	(1) 15-25% (of pond)	5		
	(2) >25%	3	52.8	3
	(3) <15%	1		
Depth <5feet	(1) <30%	5		
	(2) >30%	1	24.7	5

Average Depth Score: 8 /2 = 4

GRAVEL SUBSTRATE:	(1) >5% (pond's perimeter)	5	37.7	5
	(2) <5%	1		
LARVAL FORAGE BASE:	(1) >50 (zooplankton/L)	5	Assumed	5
	(2) <50	1		
BIO-INDICATORS:	(1) Fish present (any species)	5	P	5
	(2) Fish absent	1		

Total Score (sum of boldfaced line items) 25.4

Additional Notes:

Evidence of water exchange: _____

Unique cover features (beaver dam, standing tree trunks, undercut banks, etc.):

_____

Other observations:

_____

_____

_____

See "spillway" worksheet

Original Biological Suitability Criteria Worksheet

Backwater Number: Floyd Lamb Location/Reach: _____

Channel Formation Type: Spring

Backwater Type (circle one): Connected (Isolated)

Observer(s): MR, RR, RA, CW Date: 11 July 2006

Shoreline Development Index Value: 1.46 Backwater Size 2.68

WATER QUALITY:			**Measured Value**	**Score**
Dissolved Oxygen	(1) >5 (mg/L)	5		
	(2) 2-5	3	8.72	5
	(3) <2	1		
Temperature	(1) <27 (degrees Celsius)	5		
	(2) 27-31	3	27.35	3
	(3) >31	1		
Salinity	(1) <5000 (uS/cm)	5		
	(2) >5000	1	527	5
pH	(1) 6-9	5		
	(2) outside 6-9	1	7.84	5
Selenium	(1) <5 (ppm dry weight)	5		
	(2) >5	1	Absent	5
Chlorophyll a	(1) <50 (mg/L)	5		
	(2) >50	1	2.48	5
Cyanobacteria	(1) <50% composition	5		
	(2) >50% composition	1	0	5

Average Water Quality Score: 33 / 7 = 4.7

COVER:				
Vegetation	(1) 10-60% (pond's area)	5		
	(2) <10%	1	80	1
	(3) >60%	1		

Turbidity	(1) 10-100 (NTU)	5		
	(2) 0-10	3	150	1
	(3) >100	1		
Rip-Rap	(1) Present	5		
	(2) Absent	1	A	1

Average Cover Score: 3 /3 = 1

DEPTH:

Depth >10feet	(1) 15-25% (of pond)	5		
	(2) >25%	3	15.7	5
	(3) <15%	1		
Depth <5feet	(1) <30%	5		
	(2) >30%	1	45.3	1

Average Depth Score: 6 /2 = 3

GRAVEL SUBSTRATE:	(1) >5% (pond's perimeter)	5	23.2	5
	(2) <5%	1		
LARVAL FORAGE BASE:	(1) >50 (zooplankton/L)	5	71.1	5
	(2) <50	1		
BIO-INDICATORS:	(1) Fish present (any species)	5		5
	(2) Fish absent	1	P	

Total Score (sum of boldfaced line items) 23.7

Additional Notes:

Evidence of water exchange: _____

Unique cover features (beaver dam, standing tree trunks, undercut banks, etc.):

_____

Other observations:

_____

_____

_____

See "updated... sheet"

Original Biological Suitability Criteria Worksheet

Backwater Number: Palm Lake Location/Reach: _____

Channel Formation Type: _____

Backwater Type (circle one): Connected Isolated

Observer(s): CU, RR, MR Date: 8 Aug 2006 – 9 Aug 2006

Shoreline Development Index Value: 1.46 Backwater Size 0.77

WATER QUALITY:			**Measured Value**	**Score**
Dissolved Oxygen	(1) >5 (mg/L)	5		
	(2) 2-5	3	2.64	3
	(3) <2	1		
Temperature	(1) <27 (degrees Celsius)	5		
	(2) 27-31	3	25.86	5
	(3) >31	1		
Salinity	(1) <5000 (uS/cm)	5		
	(2) >5000	1	754.8	5
pH	(1) 6-9	5		
	(2) outside 6-9	1	7.59	5
Selenium	(1) <5 (ppm dry weight)	5		
	(2) >5	1	Assumed	5
Chlorophyll a	(1) <50 (mg/L)	5		
	(2) >50	1	28.32	5
Cyanobacteria	(1) <50% composition	5		
	(2) >50% composition	1	5.3	5

Average Water Quality Score: 33 / 7 = 4.7

COVER:				
Vegetation	(1) 10-60% (pond's area)	5		
	(2) <10%	1	25	5
	(3) >60%	1		

Turbidity	(1) 10-100 (NTU)	5		
	(2) 0-10	3	9.3	3
	(3) >100	1		
Rip-Rap	(1) Present	5		
	(2) Absent	1	A	1

Average Cover Score: 9 /3 = 3

DEPTH:

Depth >10feet	(1) 15-25% (of pond)	5		
	(2) >25%	3	0	1
	(3) <15%	1		
Depth <5feet	(1) <30%	5		
	(2) >30%	1	100	1

Average Depth Score: 2 /2 = 1

GRAVEL SUBSTRATE:	(1) >5% (pond's perimeter)	5	0	1
	(2) <5%	1		
LARVAL FORAGE BASE:	(1) >50 (zooplankton/L)	5	416.1	5
	(2) <50	1		
BIO-INDICATORS:	(1) Fish present (any species)	5	P	5
	(2) Fish absent	1		

Total Score (sum of boldfaced line items) 19.7

Additional Notes:

Evidence of water exchange: _____

Unique cover features (beaver dam, standing tree trunks, undercut banks, etc.):

_____

Other observations:

_____

_____

_____

see "weighted... checklist"

Original Biological Suitability Criteria Worksheet

Backwater Number: Rock Tank Location/Reach: _____

Channel Formation Type: _____

Backwater Type (circle one): Connected (Isolated)

Observer(s): RR, MR Date: 10Aug 2006 - 11Aug 2006

Shoreline Development Index Value: 1.14 Backwater Size Ø.83

WATER QUALITY:			**Measured Value**	**Score**
Dissolved Oxygen	(1) >5 (mg/L)	5		
	(2) 2-5	3	Ø.29	1
	(3) <2	1		
Temperature	(1) <27 (degrees Celsius)	5		
	(2) 27-31	3	24.98	5
	(3) >31	1		
Salinity	(1) <5000 (uS/cm)	5		
	(2) >5000	1	63.80	5
pH	(1) 6-9	5		
	(2) outside 6-9	1	7.27	5
Selenium	(1) <5 (ppm dry weight)	5		
	(2) >5	1	Assumed	5
Chlorophyll a	(1) <50 (mg/L)	5		
	(2) >50	1	11.72	5
Cyanobacteria	(1) <50% composition	5		
	(2) >50% composition	1	6.4	5

Average Water Quality Score: 31 / 7 = 4.4

COVER:				
Vegetation	(1) 10-60% (pond's area)	5		
	(2) <10%	1	<5	1
	(3) >60%	1		

Turbidity	(1) 10-100 (NTU)	5		
	(2) 0-10	3	28.5	5
	(3) >100	1		
Rip-Rap	(1) Present	5		
	(2) Absent	1	A	1

Average Cover Score: 7 /3 = 2.3

DEPTH:

Depth >10feet	(1) 15-25% (of pond)	5		
	(2) >25%	3	27.9	3
	(3) <15%	1		
Depth <5feet	(1) <30%	5		
	(2) >30%	1	37.6	1

Average Depth Score: 4 /2 = 2

GRAVEL SUBSTRATE:	(1) >5% (pond's perimeter)	5	53	5
	(2) <5%	1		
LARVAL FORAGE BASE:	(1) >50 (zooplankton/L)	5	109.5	5
	(2) <50	1		
BIO-INDICATORS:	(1) Fish present (any species)	5	P	5
	(2) Fish absent	1		

Total Score (sum of boldfaced line items) 23.7

Additional Notes:

Evidence of water exchange: _____

Unique cover features (beaver dam, standing tree trunks, undercut banks, etc.):

_____

Other observations:

_____

_____

_____

See "updated... worksheet"

Original Biological Suitability Criteria Worksheet

Backwater Number: Yuma Cove Location/Reach: _____

Channel Formation Type: _____

Backwater Type (circle one): Connected (Isolated)

Observer(s): MR, RR, BA Date: 13 July 2006 - 14 July 2006

Shoreline Development Index Value: 1.29 Backwater Size 2.61

WATER QUALITY:			**Measured Value**	**Score**
Dissolved Oxygen	(1) >5 (mg/L)	5		
	(2) 2-5	3	4.83	3
	(3) <2	1		
Temperature	(1) <27 (degrees Celsius)	5		
	(2) 27-31	3	28.44	3
	(3) >31	1		
Salinity	(1) <5000 (uS/cm)	5		
	(2) >5000	1	1356.33	5
pH	(1) 6-9	5		
	(2) outside 6-9	1	9.10	1
Selenium	(1) <5 (ppm dry weight)	5		
	(2) >5	1	Assumed	5
Chlorophyll a	(1) <50 (mg/L)	5		
	(2) >50	1	1.56	5
Cyanobacteria	(1) <50% composition	5		
	(2) >50% composition	1	<50	5

Average Water Quality Score: 27 / 7 = 3.9

COVER:

Vegetation	(1) 10-60% (pond's area)	5		
	(2) <10%	1	80-90	1
	(3) >60%	1		

Turbidity	(1) 10-100 (NTU)	5		
	(2) 0-10	3	24	5
	(3) >100	1		
Rip-Rap	(1) Present	5		
	(2) Absent	1	A	1

Average Cover Score: 7 /3 = 2.3

DEPTH:

Depth >10feet	(1) 15-25% (of pond)	5		
	(2) >25%	3	19.5	5
	(3) <15%	1		
Depth <5feet	(1) <30%	5		
	(2) >30%	1	41.2	1

Average Depth Score: 6 /2 = 3

GRAVEL SUBSTRATE:	(1) >5% (pond's perimeter)	5	75.1	5
	(2) <5%	1		
LARVAL FORAGE BASE:	(1) >50 (zooplankton/L)	5	Assumed	5
	(2) <50	1		
BIO-INDICATORS:	(1) Fish present (any species)	5	P	5
	(2) Fish absent	1		

Total Score (sum of boldfaced line items) 24.2

Additional Notes:

See "updated... Worksheet"

Evidence of water exchange: _____

Unique cover features (beaver dam, standing tree trunks, undercut banks, etc.):

_____

Other observations:

_____

_____

_____

Site Visit Worksheets – Updated Format

Updated Biological Suitability Criteria Worksheet

Backwater Number: Charger Tank Location/Reach: _____

Channel Formation Type: _____

Backwater Type (circle one): Connected (Isolated)

Observer(s): MR, RR Date: 11 Aug 2006

Shoreline Development Index Value: 1.55 Backwater Size 1.85

WATER QUALITY:			**Measured Value**	**Score**
Dissolved Oxygen	(1) >5 (mg/L)	10		
	(2) 3.0-5	5	3.83	5
	(3) <3.0	1		
Temperature	(1) <27 (degrees Celsius)	5		
	(2) 27-31	3	24.79	5
	(3) >31	1		
Salinity	(1) <5,000 (~~µS/cm~~ g/L)	5		
	(2) 5,000-10,000	3		
	(3) >10,000	1	55.97	5
pH	(1) 7-10	5		
	(2) 6-6.99	3		
	(3) <6 or >10	1	7.45	5
Selenium	(1) <2 µS/cm	5		
	(2) >2	1	Absent	5
Chlorophyll a	(1) <50 (mg/L)	5		
	(2) >50	1	18.56	5
Cyanobacteria	(1) <50% composition	5		
	(2) >50% composition	1	10.5	5

WATER QUALITY SCORE: 35

SPAWNING HABITAT:				
Depth <5feet	(1) <50%	5		
	(2) >50%	1	>50	1

Gravel Substrate	(1) >5% (pond's perimeter)	5		
	(2) <5%	1	18	5

SPAWNING HABITAT SCORE: 6

COVER:

Vegetation	(1) 10-60% (pond's area)	5		
	(2) <10%	1	<10	1
	(3) >60%	1		
Turbidity	(1) 10-100 (NTU)	5		
	(2) 0-10; 101-150	3	605	1
	(3) >150	1		
Rip-Rap	(1) Present	5		
	(2) Absent	1	A	1
Depth >10feet	(1) 15-35% (of pond)	5		
	(2) >35%	3	0	1
	(3) <15%	1		

COVER SCORE: 4

BIO-INDICATORS:

(1) Fish present (except Gambusia or bullhead)	5
(2) Fish absent	1

BIO-INDICATORS SCORE: 5

TOTAL SCORE (sum of all items): 50

Additional Notes:

Evidence of water exchange: appears to have either spring/or creek input

Unique cover features (beaver dam, standing tree trunks, undercut banks, etc.):

Shallow bay near spring/creek inflows

Other observations:

Very turbid – likely from recent rain events; some gravel around edge but may not be normally in water

Updated Biological Suitability Criteria Worksheet

Backwater Number: Cibola HLP Location/Reach: _____

Channel Formation Type: Oxbow / old channel

Backwater Type (circle one): Connected (Isolated)

Observer(s): RR, BA, MR, NC Date: 15 Jul 2006 – 16 Jul 2006

Shoreline Development Index Value: 1.40 Backwater Size 4.68

WATER QUALITY:			**Measured Value**	**Score**
Dissolved Oxygen	(1) >5 (mg/L)	10		
	(2) 3.0-5	5	5.85	10
	(3) <3.0	1		
Temperature	(1) <27 (degrees Celsius)	5		
	(2) 27-31	3	29.09	3
	(3) >31	1		
Salinity	(1) <5,000 (~~µS/cm~~ g/L)	5		
	(2) 5,000-10,000	3		
	(3) >10,000	1	1296.33	5
pH	(1) 7-10	5		
	(2) 6-6.99	3		
	(3) <6 or >10	1	7.45	5
Selenium	(1) <2 µS/cm	5		
	(2) >2	1	Assumed	5
Chlorophyll a	(1) <50 (mg/L)	5		
	(2) >50	1	1.52	5
Cyanobacteria	(1) <50% composition	5		
	(2) >50% composition	1	Ø	5

WATER QUALITY SCORE: 38

SPAWNING HABITAT:				
Depth <5feet	(1) <50%	5		
	(2) >50%	1	38.3	5

Gravel Substrate	(1) >5% (pond's perimeter)	5		
	(2) <5%	1	12.5	5

SPAWNING HABITAT SCORE: 10

COVER:

Vegetation	(1) 10-60% (pond's area)	5		
	(2) <10%	1	>60	1
	(3) >60%	1		
Turbidity	(1) 10-100 (NTU)	5		
	(2) 0-10; 101-150	3	6	3
	(3) >150	1		
Rip-Rap	(1) Present	5		
	(2) Absent	1	P	5
Depth >10feet	(1) 15-35% (of pond)	5		
	(2) >35%	3	2.8	1
	(3) <15%	1		

COVER SCORE: 10

BIO-INDICATORS:

(1) Fish present (except Gambusia or bullhead)	5
(2) Fish absent	1

BIO-INDICATORS SCORE: 5

TOTAL SCORE (sum of all items): 63

Additional Notes:

Evidence of water exchange: None visible; but site clearly has exchange w/river

Unique cover features (beaver dam, standing tree trunks, undercut banks, etc.):

Rip-rap; emergent veg (cat-tails) good riparian area

Other observations:

bullfrogs heard; no crayfish seen; evidence of recreational fishing

Updated Biological Suitability Criteria Worksheet

Backwater Number: Davis Cove Location/Reach: _____

Channel Formation Type: _____

Backwater Type (circle one): Connected (Isolated)

Observer(s): MR, BA, CU, RK Date: 12 July 2006 – 13 July 2006

Shoreline Development Index Value: 1.63 Backwater Size 2.75

WATER QUALITY:			**Measured Value**	**Score**
Dissolved Oxygen	(1) >5 (mg/L)	10		
	(2) 3.0-5	5	6.81	10
	(3) <3.0	1		
Temperature	(1) <27 (degrees Celsius)	5		
	(2) 27-31	3	30.00	3
	(3) >31	1		
Salinity	(1) <5,000 (µ~~S/cm~~ g/L)	5		
	(2) 5,000-10,000	3		
	(3) >10,000	1	5398	3
pH	(1) 7-10	5		
	(2) 6-6.99	3		
	(3) <6 or >10	1	8.32	5
Selenium	(1) <2 µS/cm	5		
	(2) >2	1	Assumed	5
Chlorophyll a	(1) <50 (mg/L)	5		
	(2) >50	1	1.74	5
Cyanobacteria	(1) <50% composition	5		
	(2) >50% composition	1	Ø	5

WATER QUALITY SCORE: 36

SPAWNING HABITAT:				
Depth <5feet	(1) <50%	5		
	(2) >50%	1	24.7	5

Gravel Substrate	(1) >5% (pond's perimeter)	5		
	(2) <5%	1	37.7	5

SPAWNING HABITAT SCORE: 10

COVER:

Vegetation	(1) 10-60% (pond's area)	5		
	(2) <10%	1	39	5
	(3) >60%	1		
Turbidity	(1) 10-100 (NTU)	5		
	(2) 0-10; 101-150	3	116.9	3
	(3) >150	1		
Rip-Rap	(1) Present	5		
	(2) Absent	1	A	1
Depth >10feet	(1) 15-35% (of pond)	5		
	(2) >35%	3	52.8	3
	(3) <15%	1		

COVER SCORE: 12

BIO-INDICATORS:

(1) Fish present (except Gambusia or bullhead)	5
(2) Fish absent	1

BIO-INDICATORS SCORE: 5

TOTAL SCORE (sum of all items): 63

Additional Notes:

Evidence of water exchange: separated from L. Mohave by berm

Unique cover features (beaver dam, standing tree trunks, undercut banks, etc.):

Lots of LWD, complex shoreline features (some gradual slope & some steep rocky areas

Other observations:

- Some a beer; No c.g. fish or other fish observed; No bullfrogs
- Moderate riparian zone
- relatively low turbidity (lower than Floyd Lamb)

Updated Biological Suitability Criteria Worksheet

Backwater Number: Floyd Lamb Location/Reach: Mulberry Pond

Channel Formation Type: _____

Backwater Type (circle one): Connected (Isolated)

Observer(s): BR, CY, MR, RR Date: 11 Jul 2006

Shoreline Development Index Value: 1.46 Backwater Size 2.68

WATER QUALITY:			**Measured Value**	**Score**
Dissolved Oxygen	(1) >5 (mg/L)	10		
	(2) 3.0-5	5	8.72	10
	(3) <3.0	1		
Temperature	(1) <27 (degrees Celsius)	5		
	(2) 27-31	3	26.45	5
	(3) >31	1		
Salinity	(1) <5,000 (~~µS/cm~~ g/L)	5		
	(2) 5,000-10,000	3		
	(3) >10,000	1	527	5
pH	(1) 7-10	5		
	(2) 6-6.99	3		
	(3) <6 or >10	1	7.84	5
Selenium	(1) <2 µS/cm	5		
	(2) >2	1	Assumed	5
Chlorophyll a	(1) <50 (mg/L)	5		
	(2) >50	1	2.48	5
Cyanobacteria	(1) <50% composition	5		
	(2) >50% composition	1	Ø	5

WATER QUALITY SCORE: 40

SPAWNING HABITAT:				
Depth <5feet	(1) <50%	5		
	(2) >50%	1	45.3	5

Gravel Substrate	(1) >5% (pond's perimeter)	5		
	(2) <5%	1	23.2	5

SPAWNING HABITAT SCORE: 10

COVER:

Vegetation	(1) 10-60% (pond's area)	5		
	(2) <10%	1	80%	1
	(3) >60%	1		
Turbidity	(1) 10-100 (NTU)	5		
	(2) 0-10; 101-150	3	150	3
	(3) >150	1		
Rip-Rap	(1) Present	5		
	(2) Absent	1	A	1
Depth >10feet	(1) 15-35% (of pond)	5		
	(2) >35%	3	15.7	5
	(3) <15%	1		

COVER SCORE: 10

BIO-INDICATORS: (1) Fish present (except Gambusia or bullhead) 5
(2) Fish absent 1

BIO-INDICATORS SCORE: 5

TOTAL SCORE (sum of all items): 65

Additional Notes:

Evidence of water exchange: Spring flow into lake as evident by lack of inflow but constant outflow @ Irrigation Structures

Unique cover features (beaver dam, standing tree trunks, undercut banks, etc.):

Concrete outflow & inflow (Not currently inflowing)

Other observations:

Vegetation: polygons = No Veg - Took H_2O Qual profiles X's 3 - Deployed 1 Data Sonde (24 hrs)

Softshell turtle - Floyd Lamb pics = #100-0004 - #100-0033 - 7/11/06

Bullfrogs - Gravel seemed more embedded

Dead Bass ~70-150 mm TL

Updated Biological Suitability Criteria Worksheet

Backwater Number: Palm Lake Location/Reach: _____

Channel Formation Type: _____

Backwater Type (circle one): Connected Isolated

Observer(s): MR, RP, CU Date: 8 Aug 2006 - 9 Aug 2006

Shoreline Development Index Value: 1.46 Backwater Size 0.77

WATER QUALITY:			**Measured Value**	**Score**
Dissolved Oxygen	(1) >5 (mg/L)	10		
	(2) 3.0-5	5	2.64	1
	(3) <3.0	1		
Temperature	(1) <27 (degrees Celsius)	5		
	(2) 27-31	3	25.86	5
	(3) >31	1		
Salinity	(1) <5,000 (µ~~S/cm~~ g/L)	5		
	(2) 5,000-10,000	3		
	(3) >10,000	1	754.8	5
pH	(1) 7-10	5		
	(2) 6-6.99	3		
	(3) <6 or >10	1	7.59	5
Selenium	(1) <2 µS/cm	5		
	(2) >2	1	Assumed	5
Chlorophyll a	(1) <50 (mg/L)	5		
	(2) >50	1	28.32	5
Cyanobacteria	(1) <50% composition	5		
	(2) >50% composition	1	5.3	5

WATER QUALITY SCORE: 31

SPAWNING HABITAT:				
Depth <5feet	(1) <50%	5		
	(2) >50%	1	100	1

Gravel Substrate	(1) >5% (pond's perimeter)	5		
	(2) <5%	1	0	1

SPAWNING HABITAT SCORE: 2

COVER:

Vegetation	(1) 10-60% (pond's area)	5		
	(2) <10%	1	25	5
	(3) >60%	1		
Turbidity	(1) 10-100 (NTU)	5		
	(2) 0-10; 101-150	3	9.3	3
	(3) >150	1		
Rip-Rap	(1) Present	5		
	(2) Absent	1	A	1
Depth >10feet	(1) 15-35% (of pond)	5		
	(2) >35%	3	0	1
	(3) <15%	1		

COVER SCORE: 10

BIO-INDICATORS:

(1) Fish present (except Gambusia or bullhead)	5
(2) Fish absent	1

BIO-INDICATORS SCORE: 5

TOTAL SCORE (sum of all items): 48

Additional Notes:

Evidence of water exchange: _____

Unique cover features (beaver dam, standing tree trunks, undercut banks, etc.):

_____

Other observations:

_____

_____

_____

Updated Biological Suitability Criteria Worksheet

Backwater Number: Rock Tank Location/Reach: _____

Channel Formation Type: _____

Backwater Type (circle one): Connected Isolated

Observer(s): RR, MR Date: 10 Aug 2006 - 11 Aug 2006

Shoreline Development Index Value: 1.14 Backwater Size 0.83

WATER QUALITY:			**Measured Value**	**Score**
Dissolved Oxygen	(1) >5 (mg/L)	10		
	(2) 3.0-5	5	0.29*	5
	(3) <3.0	1		
Temperature	(1) <27 (degrees Celsius)	5		
	(2) 27-31	3	24.98	5
	(3) >31	1		
Salinity	(1) <5,000 (µ~~S/cm~~ g/L)	5		
	(2) 5,000-10,000	3		
	(3) >10,000	1	63.80	5
pH	(1) 7-10	5		
	(2) 6-6.99	3		
	(3) <6 or >10	1	7.27	5
Selenium	(1) <2 µS/cm	5		
	(2) >2	1	Assumed	5
Chlorophyll a	(1) <50 (mg/L)	5		
	(2) >50	1	11.72	5
Cyanobacteria	(1) <50% composition	5		
	(2) >50% composition	1	6.4	5

WATER QUALITY SCORE: 35

SPAWNING HABITAT:				
Depth <5feet	(1) <50%	5		
	(2) >50%	1	37.6	5

* Determined to be "Moderate" for DO b/c measurement at 1.0 m below water surface was > 3.5 mg/L

Gravel Substrate	(1) >5% (pond's perimeter)	5		
	(2) <5%	1	53	5

SPAWNING HABITAT SCORE: 10

COVER:

Vegetation	(1) 10-60% (pond's area)	5		
	(2) <10%	1	<5	1
	(3) >60%	1		
Turbidity	(1) 10-100 (NTU)	5		
	(2) 0-10; 101-150	3	28.5	5
	(3) >150	1		
Rip-Rap	(1) Present	5		
	(2) Absent	1	A'	1
Depth >10feet	(1) 15-35% (of pond)	5		
	(2) >35%	3	27.9	5
	(3) <15%	1		

COVER SCORE: 12

BIO-INDICATORS:

(1) Fish present (except Gambusia or bullhead)	5
(2) Fish absent	1

BIO-INDICATORS SCORE: 5

TOTAL SCORE (sum of all items): 62

Additional Notes:

Evidence of water exchange: drain pipe ; otherwise site is just a catchment basin

Unique cover features (beaver dam, standing tree trunks, undercut banks, etc.):

drain pipe (at current elevation) ; some large cobble but no "rip-rap" size

Other observations:

large fish seen @ surface ; 2 or 3 frogs (not bullfrogs) seen around pond ; no crayfish seen ; little spawning habitat

Updated Biological Suitability Criteria Worksheet

Backwater Number: Yuma Cove Location/Reach: _____

Channel Formation Type: _____

Backwater Type (circle one): Connected (Isolated)

Observer(s): MR, BR, RR Date: 13 July 2006 – 14 July 2006

Shoreline Development Index Value: 1.29 Backwater Size 2.61

WATER QUALITY:			**Measured Value**	**Score**
Dissolved Oxygen	(1) >5 (mg/L)	10		
	(2) 3.0-5	5	4.83	5
	(3) <3.0	1		
Temperature	(1) <27 (degrees Celsius)	5		
	(2) 27-31	3	28.44	3
	(3) >31	1		
Salinity	(1) <5,000 (~~µS/cm~~ g/L)	5		
	(2) 5,000-10,000	3		
	(3) >10,000	1	1356.33	5
pH	(1) 7-10	5		
	(2) 6-6.99	3		
	(3) <6 or >10	1	9.10	5
Selenium	(1) <2 µS/cm	5		
	(2) >2	1	Removed	5
Chlorophyll a	(1) <50 (mg/L)	5		
	(2) >50	1	1.56	5
Cyanobacteria	(1) <50% composition	5		
	(2) >50% composition	1	Ø	5

WATER QUALITY SCORE: 33

SPAWNING HABITAT:				
Depth <5feet	(1) <50%	5		
	(2) >50%	1	41.2%	5

Gravel Substrate	(1) >5% (pond's perimeter)	5	75.1	5
	(2) <5%	1		

SPAWNING HABITAT SCORE: 10

COVER:

Vegetation	(1) 10-60% (pond's area)	5	80-90%	1
	(2) <10%	1		
	(3) >60%	1		
Turbidity	(1) 10-100 (NTU)	5	24	5
	(2) 0-10; 101-150	3		
	(3) >150	1		
Rip-Rap	(1) Present	5	A	1
	(2) Absent	1		
Depth >10feet	(1) 15-35% (of pond)	5	19.5%	5
	(2) >35%	3		
	(3) <15%	1		

COVER SCORE: 12

BIO-INDICATORS:

(1) Fish present (except Gambusia or bullhead)	5
(2) Fish absent	1

BIO-INDICATORS SCORE: 5

TOTAL SCORE (sum of all items): 60

Additional Notes:

Evidence of water exchange: _____

Unique cover features (beaver dam, standing tree trunks, undercut banks, etc.):

_____

Other observations:

floating veg mats over 10-15% of surface area

_____

_____

APPENDIX B: STATIONARY (24-HOUR) DATASONDE DATA

Dissolved Oxygen Concentration (mg/L)

Time	Chango	CHLP	Davis	Floyd	Palm	Rock Tank	Yuma
0:00	0.68	8.14	8.79	7.51	3.9	3.87	7.31
1:00	0.64	7.83	8.66	7.26	3.38	3.67	7.14
2:00	0.6	7.58	8.51	7.17	2.98	3.05	6.99
3:00	0.59	7.22	8.19	7.02	2.36	3.18	6.75
4:00	0.58	6.78	7.65	6.93	1.89	2.82	6.62
5:00	0.58	6.56	7.61	6.82	2.16	2.89	6.53
6:00	0.66	6.34	7.49	6.7	1.94	2.2	6.22
7:00	0.7	6.22	7.51	6.62	1.28	2.06	6.09
8:00	0.62	5.58	7.11		1.49	2.89	6.52
9:00	0.72	5.67	7.29		1.74	5.09	5.17
10:00	0.56	5.36	7.58	6.62	2.06	7.65	5.31
11:00	0.37	5.66	7.7	7.39	1.99	4.18	5.35
12:00	0.33	6.12	7.92	7.47	3.24	4.3	5.54
13:00	1.27	6.59	8.09	7.45	2.51	5.54	6.23
14:00	1.08	7.05	8.45	7.71	2.2	4.86	5.75
15:00	1.38	7.76	8.58	7.76		4.52	5.81
16:00	0.92	8	9.3	7.99	6.14	5.51	5.96
17:00	1.14	7.97	9.44	7.94	4.39	4.52	6.44
18:00	1.08	8.28	9.47	7.83	8.21	4.3	6.12
19:00	0.73	7.99	9.26	7.85	6.71	3.74	6.61
20:00	0.64	8.04	9.22	7.88	5.6	5.31	6.36
21:00	0.68	8	9.18	7.84	5.73	4.42	6.79
22:00	0.78	7.99	9.11	7.74	4.54	4.28	7.19
23:00	0.7	7.76	8.98	7.59	3.98	4.39	7.38

Dissolved Oxygen (percent saturation)

Time	Chango	CHLP	Davis	Floyd	Palm	Rock Tank	Yuma
0:00	7.8	108.8	121.1	97	47.6	46.2	98.6
1:00	7.3	104.3	119.2	93.6	41.3	43.9	96
2:00	6.8	100.7	116.8	92.2	36.4	36.4	93.7
3:00	6.8	95.7	112.2	90.1	28.8	38	90.3
4:00	6.6	89.5	104.7	88.6	23.1	33.7	88.2
5:00	6.6	86.4	104	86.9	26.5	35.2	86.8
6:00	7.5	83.4	102.2	85.1	23.7	26.3	82.4
7:00	7.9	81.6	102.4	84	15.7	24.6	80.7
8:00	7.1	73.2	97		17.9	34.5	86.3
9:00	8.2	74.3	99.5		21.2	60.8	67.6
10:00	6.4	70.3	103.8	84.1	24.6	91.7	69.6
11:00	4.2	74.5	105.8	94	24.5	49.9	70.3
12:00	3.8	81.1	109.4	95.1	39.8	51.1	73
13:00	14.5	87.9	112.4	95	30.8	66	82.8
14:00	12.3	94.6	117.7	99.1	27	57.9	76.9
15:00	15.7	104.5	120.4	99.8		53.8	78.1
16:00	10.5	108.2	130.2	103.3	74.3	65.7	80.4
17:00	13	107.8	131.9	102.5	53.3	53.9	87.3
18:00	12.3	111.8	132.1	102	99.8	51.2	82.7
19:00	8.3	107.5	128.6	102.7	81.5	44.5	89.5
20:00	7.3	107.7	128.1	103.1	68.1	63.4	85.9
21:00	7.8	106.8	127.2	102.3	69.8	52.7	92.2
22:00	8.9	106.3	125.9	100.7	55.2	51.1	97.3
23:00	8	103	124	98.4	48.5	52.4	99.6

Specific Conductivity (µS/cm)

Time	Chango	CHLP	Davis	Floyd	Palm	Rock Tank	Yuma
0:00	41	1374	5648	453	786	68	1379
1:00	40	1375	5597	453	787	68	1379
2:00	41	1376	5540	453	787	68	1379
3:00	40	1374	5537	453	787	68	1378
4:00	40	1374	5532	453	786	68	1375
5:00	40	1374	5531	453	786	68	1375
6:00	39	1375	5526	454	786	69	1374
7:00	39	1375	5526	454	785	68	1373
8:00	39	1375	5532		785	69	1376
9:00	39	1375	5533		787	68	1366
10:00	39	1375	5535	456	786	68	1366
11:00	39	1375	5552	457	785	68	1367
12:00	41	1374	5566	457	786	67	1365
13:00	38	1374	5581	456	786	67	1367
14:00	40	1374	5591	455	786	67	1370
15:00	40	1374	5615	455		67	1372
16:00	40	1374	5972	454	787	67	1372
17:00	39	1375	5962	453	787	67	1368
18:00	40	1376	5925	453	784	67	1376
19:00	41	1377	5874	453	786	68	1389
20:00	41	1377	5831	453	786	67	1371
21:00	41	1376	5779	452	786	68	1377
22:00	42	1376	5721	452	787	68	1381
23:00	42	1377	5681	452	787	68	1378

Water Temperature (ºC)

Time	Chango	CHLP	Davis	Floyd	Palm	Rock Tank	Yuma
0:00	21.55	29.89	30.78	28.2	24.95	23.93	30.48
1:00	21.54	29.68	30.71	28.05	25	23.94	30.24
2:00	21.54	29.56	30.59	27.93	24.97	23.91	30.07
3:00	21.53	29.43	30.51	27.79	25.05	23.97	29.9
4:00	21.54	29.25	30.42	27.53	25.14	23.94	29.75
5:00	21.53	29.09	30.35	27.41	25.2	23.98	29.59
6:00	21.52	29	30.25	27.26	25.16	23.92	29.43
7:00	21.48	28.85	30.22	27.1	25.24	23.97	29.36
8:00	21.49	28.78	30.23		25.11	23.97	29.38
9:00	21.48	28.78	30.32		25.03	24	28.66
10:00	21.5	28.85	30.45	27.26	25.17	24.09	28.75
11:00	21.49	29.05	30.67	27.29	25.29	24	28.91
12:00	21.48	29.42	30.95	27.29	25.3	23.73	29.1
13:00	21.55	29.81	31.26	27.42	25.34	23.79	29.65
14:00	21.57	30.13	31.46	27.82	25.41	23.78	29.99
15:00	21.54	30.37	31.87	27.9		23.77	30.27
16:00	21.55	30.56	31.68	28.19	24.47	23.83	30.43
17:00	21.53	30.6	31.58	28.14	24.61	23.83	30.72
18:00	21.56	30.5	31.45	28.62	24.69	23.81	30.62
19:00	21.57	30.3	31.2	28.86	24.73	23.77	30.69
20:00	21.55	30.08	31.2	28.9	24.73	23.97	30.52
21:00	21.55	29.85	31.09	28.77	24.84	23.91	30.74
22:00	21.57	29.68	30.99	28.55	24.81	23.9	30.7
23:00	21.56	29.51	30.88	28.37	24.88	23.92	30.49

Turbidity (NTU)

Time	Chango	CHLP	Davis	Floyd	Palm	Rock Tank	Yuma
0:00	0	6	118	12	56	144	6
1:00	0	6	119	12	66	143	6
2:00	0	6	121	12	33	142	6
3:00	0	6	123	13	27	142	5
4:00	0	6	122	12	24	141	8
5:00	0	5	121	12	16	142	5
6:00	0	6	122	12	12	140	5
7:00	1439	6	125	12	15	139	5
8:00	1301	5	121		15	141	5
9:00	1330	5	115		16	147	12
10:00	1202	5	118	13	14	148	9
11:00	1259	6	112	14	13	145	6
12:00	1311	6	116	14	14	141	90
13:00	0	6	116	14	15	146	35
14:00	0	6	116	13	15	145	293
15:00	0	6	118	13		145	6
16:00	0	6	116	13	19	147	8
17:00	0	6	112	14	27	148	7
18:00	0	6	110	13	36	144	6
19:00	0	6	109	13	42	143	6
20:00	0	6	114	13	40	145	6
21:00	0	6	115	13	39	144	6
22:00	0	6	112	13	42	144	6
23:00	0	6	114	13	49	143	6

pH

Time	Chango	CHLP	Davis	Floyd	Palm	Rock Tank	Yuma
0:00	6.26	8.77	8.51	8.48	7.46	6.97	9.47
1:00	6.25	8.73	8.51	8.47	7.44	6.96	9.46
2:00	6.25	8.75	8.5	8.46	7.45	6.91	9.44
3:00	6.24	8.66	8.48	8.46	7.43	6.93	9.43
4:00	6.19	8.6	8.46	8.45	7.41	6.88	9.42
5:00	6.19	8.58	8.46	8.45	7.42	6.89	9.39
6:00	6.15	8.57	8.45	8.44	7.49	6.87	9.38
7:00	6.09	8.54	8.46	8.43	7.44	6.84	9.36
8:00	6.11	8.44	8.43		7.46	6.86	9.4
9:00	6.07	8.47	8.44		7.47	7.28	9.29
10:00	6.12	8.41	8.46	8.45	7.47	7.84	9.32
11:00	6.07	8.44	8.47	8.44	7.48	7.28	9.31
12:00	6.11	8.51	8.47	8.46	7.58	7.02	9.32
13:00	6.06	8.61	8.48	8.47	7.47	7.2	9.37
14:00	6.06	8.66	8.5	8.44	7.52	7.05	9.33
15:00	6.11	8.71	8.5	8.44		7.02	9.33
16:00	6.09	8.75	8.47	8.45	7.6	7.09	9.35
17:00	6.12	8.77	8.5	8.46	7.54	7.07	9.37
18:00	6.15	8.81	8.52	8.48	7.69	7.03	9.33
19:00	6.22	8.78	8.52	8.49	7.59	6.99	9.37
20:00	6.19	8.79	8.53	8.49	7.58	7.14	9.4
21:00	6.16	8.81	8.53	8.49	7.54	7.07	9.36
22:00	6.21	8.88	8.53	8.49	7.5	7.05	9.38
23:00	6.25	8.87	8.52	8.49	7.46	7.04	9.38

APPENDIX C: PROTOCOL FOR BACKWATERS INITIAL SITE VISITS

Introduction

This protocol describes the field techniques to be used during the initial site visits (conducted during the summer) for each backwater site evaluated during the inventory phase of identifying candidate sites for restoration efforts. This protocol identifies the methods to be used to gather biological and physicochemical data with which to populate the site-selection model presented in the primary portion of this report.

Some deviation from these procedures may be necessary, depending on field conditions. Descriptive field notes should be taken, documenting any special conditions, deviations from established protocols, and any alternative procedures used. It may be appropriate to update this protocol with any future changes to the site-selection model to reflect current methodologies.

An initial site visit to a candidate backwater will usually consist of a 2-day visit and will occur during the summer months (preferably July-August) to provide a single-sample evaluation of the habitat conditions in each backwater during the period when water quality conditions are likely to be most stressful for native fishes. A crew of two people should be able to collect all data over a 24- to 36-h period at each site. An effort should be made to sample all candidate sites during a short period to limit biases that could result from seasonal variability. The following protocol describes the procedures for collecting all data components for each backwater. Although some components need to be collected during critical time periods, the order of data collection may be modified depending on time of day that the crew arrives at a backwater or when attempting to sample nearby backwaters simultaneously.

Prior to visiting each site, the field crew must ensure that they have copies of all appropriate permits and have contacted the property manager for notification of and access for the visit.

Stationary Datasonde

Placement of the stationary datasonde for collecting water quality data over a 24-h period is the most restrictive data collection effort in terms of time required to complete the sample; hence data collection should be initiated immediately upon reaching a site to minimize total time spent in one backwater location. The data collected from this datasonde are not used for the site-selection model, but they do provide critical information that can aid in evaluating and interpreting water quality dynamics at a site. A single datasonde should be anchored in the deepest location within the backwater. The recommended method is to attach the datasonde to a chain that has an anchor on one end (a cinder block works well) and a large buoy on the other. It is important to minimize the slack in this chain to prevent movement of the datasonde horizontally or vertically within the water column. The datasonde should be placed as close as possible to 1 meter below the water surface for this effort. The datasonde should be programmed to record at least dissolved oxygen (DO) concentration (milligrams per liter [mg/L]), DO percent saturation, water temperature, specific conductivity (microsiemens per centimeter

[µS/cm]), pH, and turbidity (nephelometric turbidity units [NTU]) at 1-h intervals. Upon removal, the data should be downloaded and the unit reprogrammed prior to placement in the next site. However, in the event that a computer is not available to complete the download, accurate records of time of deployment and retrieval (which should be recorded for all sites) will provide a means of distinguishing multiple datasets on a single datasonde. To minimize risk of data loss, no more than two backwaters should be sampled prior to downloading the data from a single datasonde. In addition, datasonde batteries should be replaced each time the data are downloaded. All sensors should also be visually inspected after each retrieval to ensure that sensors are clean. Any sensor with signs of fouling should be cleaned according to the instructions in the manual for that datasonde prior to redeployment.

Bathymetry Survey and Base Map

A bathymetry survey will be conducted on each backwater to describe the physical morphology of each water body. The area of each lake that is greater than 10-ft deep and shallower than 5 ft will be calculated from these data for incorporation into the site-selection model. In addition, the total volume of water can be determined from the bathymetric profile to ascertain concentrations required for any chemical or biological treatment.

The bathymetry survey will be conducted using Reclamation's HydroLite XP® portable hydrographic survey system, which is capable of sub-meter accuracy. Depth below surface will be logged, simultaneously with horizontal position data, using the HydroLite XP®. With this system, the field crew will use a small boat (10-12 ft jon boat recommended) with an electric trolling motor to make appropriately spaced passes to capture depth and position data throughout the water body. Spacing will be determined based on system capacity and field conditions, but it should be sufficient to provide 1-ft contours on a final map. Shorelines will be delineated using the same Global Positioning System (GPS) unit or one capable of similar accuracy. When shoreline vegetation is dense and accurate GPS locations cannot be collected, the most recent aerial imagery for the study area will be used to determine the horizontal extent of the shoreline and calculate the shoreline development index. Upon returning from the field, this information will be processed and imported into a Geographical Information System (GIS) application to produce contour lines and determine the depth, volume, and surface area relationships.

The water surface elevation of each water body should be determined using a GPS unit capable of recording carrier-phase data for an extended period of time and post-processing to within 3 cm. If no unit is available, the field crew will install a temporary staff plate in a shallow area of the water column to provide a relative reference of the water surface elevation at the time of the survey. It is also advisable to place a semi-permanent benchmark on site in the event that the stability of the staff gage is compromised or variation in water surface elevation is greater than the range of the staff gage. The benchmark consists of a 3- to 4-ft rebar stake driven into the ground and fitted with a labeled endcap. This benchmark should be placed well above any high-water

marks observed in the field. A survey level should be used to determine the water surface elevation relative to this benchmark for comparison with water surface elevation during any future site visits. While a staff gage or benchmark will not provide a real-world water surface elevation, changes in relative water surface elevation can be used to adjust water volume calculations or calculations of areal coverage of a given depth contour during subsequent site visits.

Vegetative Cover

The areal coverage of aquatic vegetation (submergent and emergent) will be estimated to incorporate into the site-selection model. Where possible, a GPS unit should be used to delineate the areal coverage of each stand of vegetation and the total area calculated using a GIS software program. Alternatively, measurements of length and width of individual stands of plants in the field can be used estimate total coverage. It is strongly recommended that these efforts be conducted when the sun is overhead to improve the ability to see into the water column. Although the model requires a combined total areal coverage estimate for submergent and emergent plants combined, these types should be estimated and recorded separately on the datasheet. Notes should be taken on specific plant types, if known, but identification is not required. When excessive depth or turbidity reduces the effectiveness of these methods, a pattern of samples using a rake or similar device should be used to determine the extent of any submergent vegetation. Presumably, sites with these conditions will have minimal vegetation due to lack of sunlight penetration, but this should be verified while in the field.

Substrate

Substrate will be classified in multiple locations throughout each backwater into one of three categories: sand/silt, gravel, and cobble/boulder. This level of classification will allow for differentiation of the two most important substrate types, gravel for spawning native fishes and cobble/boulder cover for early life stages. To be effective habitat for either of these life stages, the substrate should be readily accessible (i.e., not buried below significant silt deposits); therefore, any points with gravel or larger substrates with a distinct layer of sand/silt overtopping it (> 2 in) will be classified as sand/silt. Each backwater will be divided into two strata for sampling, near-shore habitat (within 10-m of the shore) and open water habitat. In near-shore areas, water depth is likely to be shallow and gravel or larger substrates may be used more readily for spawning and cover; open-water gravel or larger substrates may still be used for spawning, but they are likely less important than shallow water areas for these critical life stages. Therefore, the data collected on the near-shore substrate conditions will be included exclusively in the site-selection model, while the open-water substrate data will be used as a means of identifying disjunct “patches” of gravel or larger substrates away from shore or to determine the extent of these substrates when extending beyond 10 m of the shore.

A sounding pole will be used to determine substrate class for individual points. The sounding pole will be forced into the substrate at each sampling location, and substrate class will be determined by the amount of resistance. Sampling locations for near-shore

habitats will be distributed at regular intervals around the backwater, depending on its size. A minimum of 20 equally spaced transects will be conducted around the perimeter of each backwater. Each transect will extend perpendicular to shore to 10 m directly out into the backwater from the water's edge. Point measurements of substrate class will be taken at 1-m increments along each transect. For larger sites, more transects will be conducted according to the following formula: 1-5 acres, 20 transects; 6-10 acres, 25 transects; 11-15 acres, 30 transects; 16-25 acres 35 transects; 26-40 acres, 40 transects. Substrate classifications in open-water sites will be conducted concurrently with the bathymetry survey. Soundings will be conducted every 2-5 meters along the boat path. The GPS coordinates should be logged at the first point along each transect for the near-shore substrate determination and at each open-water substrate sample location.

To determine the percent composition of gravel in a backwater, the number of point measurements with gravel substrate will be divided by the total number of point measurements collected to determine the proportion of the total area covered by gravel. When sample points are too deep to sample with the available gear, no data will be recorded on these portions of the transect. Cobble/boulder substrates can be quantified in the same way as gravel. In addition, the presence or absence of rip-rap anywhere in the water body will be noted and used for incorporation into the site-selection model.

Water Sample Collection and Preservation

Water grab samples will be collected for analyses of several water quality parameters for the site-selection model. Collection of water samples for all parameters will occur between 10 a.m. and 2 p.m. in each water body using a Van Dorn bottle just below the water surface (approximately 0.2 m below the surface). Each of the water quality parameters to be evaluated with the grab samples will be a composite sample from three locations (these should correspond with vertical water quality profile locations [see below]). Each individual sample container will be rinsed first with lake water from the Van Dorn bottle and a churn-splitter will be used to mix the samples and dispense them into the sample containers. At each site 1 liter of the contents of the Van Dorn bottle will be emptied into a graduated cylinder and then into the churn splitter and the contents mixed for at least 1 minute before dispensing the composite sample into the sample bottle. The sample will then be preserved using the appropriate methods for each water quality parameter (described below) and placed on ice until shipping. Two composite samples will be collected for each water quality parameter, each will be preserved in the same manner. One will be shipped for laboratory analysis and the other retained as a backup in the event of lost or contaminated samples.

The recommended size and type of sample bottle is described below for each parameter, but these receptacles should be coordinated with the receiving laboratory to ensure compatibility with analyses to be conducted. All sample containers must be labeled correctly, including site name, date, sample parameter, preservative, and collector. Chain of custody forms (example attached) are to be completed for each sample and the original included in the shipment. A photocopy will be retained by the collector.

Selenium

The concentration of selenium (micrograms per liter [µg/L]) in the water column will be measured by collecting a single composite sample from three locations (and a duplicate). This sample will be collected into a 500 mL polyethylene bottle and preserved with HNO_3. Holding time for preserved samples is 180 days, but samples should be shipped as soon as possible.

Chlorophyll A

The concentration of chlorophyll a (mg/L) in the water column will be measured by collecting a single composite sample from three locations (and a duplicate). These samples will be collected into a 1-L amber polyethylene bottle and preserved with 3-4% gluteraldehyde. The holding time for these samples is approximately 28 days, so samples should be shipped as soon as possible to ensure laboratory analyses are conducted in sufficient time.

Planktonic Algae

The site-selection model requires the relative percent occurrence of cyanobacteria within an algae sample collected at each site. The water sample to be analyzed for chlorophyll a content will also be used to determine planktonic algae counts.

Nutrients

Although not included as a scoring factor in the site-selection model, nutrient concentrations can provide insight into eutrophication conditions in the water body. Therefore, water samples for total nitrogen (mg/L), total phosphorus (mg/L), and total dissolved organic carbon (mg/L) will be collected. Water samples for determining total nitrogen and total phosphorus samples can be combined into a single 500- mL polyethylene bottle and preserved with H_2SO_4. Total organic carbon samples will be stored in 500-mL glass (amber-colored) bottles and preserved with H_2SO_4. All preserved samples have a holding time of 28 days.

Water Quality Profiles

Three sampling locations will be identified for collecting water quality profiles in each backwater. These locations will spaced to collectively provide good representation of the open water areas of the backwater and will include the deepest location(s). A GPS receiver unit will be used to collect coordinates of each sample location.

Vertical profiles will be conducted at each of the three designated sampling stations in 0.5-m intervals using a datasonde to record DO (mg/L), DO percent saturation, temperature, specific conductivity (µS/cm), pH, turbidity and water depth between 10 a.m. and 2 p.m. in each water body. In addition to the datasonde, an 8-in diameter secchi disk tied to a rope marked in 0.1-m intervals will be used to measure water transparency

(not used in site-selection model, but it provides a useful tool for comparing/contrasting water quality conditions among sites). Water quality profiles and secchi depths should be taken between 10 a.m. and 2 p.m.

Datasondes will be calibrated according to manufacturer's standards prior to leaving for the field, and all instrument calibration and servicing will be documented in a log book (example attached). The calibration standards appropriate to these sampling conditions are listed in Table 1.

Table 1. Calibration standards for datasondes used in the backwater inventory.

Parameter	Calibration
Specific conductivity	0 and 20,000 µS/cm
pH	7 and 10
Turbidity	0 and 100 NTU

For populating the backwaters site-selection model, water quality data are extracted from each of the three vertical profiles. The DO concentration (mg/L) used in the model is the average value from 1 m above the substrate (unless the depth is ≤1.0 m, in which case the average value at 0.5 m from the substrate is used). In the event that this value falls into the low habitat suitability category for DO, then the DO concentration from 1 m below the water surface is evaluated. If this value is ≥3.5 mg/L, then the site rates in the moderate suitability category (Figure 1).

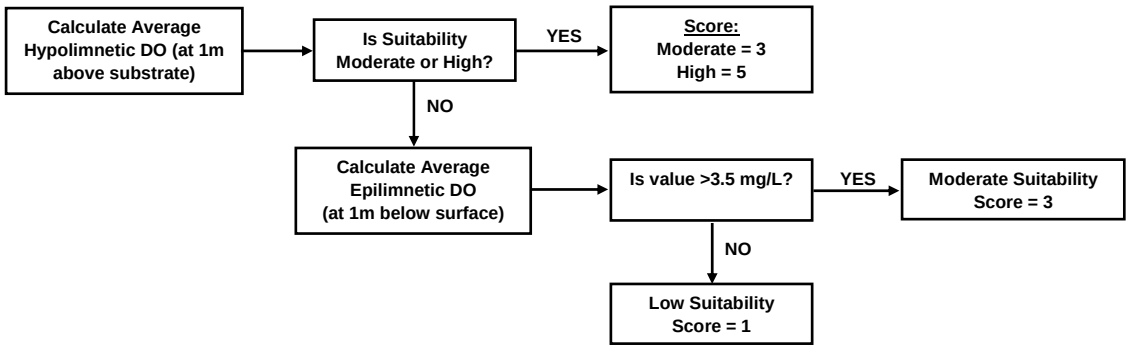

Figure C1. Flowchart describing the process for generating the DO concentration to be used in the site-selection model.

Water temperature, specific conductivity, and pH values for the model are all derived from the deepest point on each profile in which DO >2.0 mg/L (average of the three measurements). Turbidity is the average of the three measurements at 1 m below the water surface (unless the depth is ≤1.0 m, in which case the average value at 0.5 m from the surface is used).

Bio-Indicators

The presence of any fish species (other than bullhead or *Gambusia* sp.) will be evaluated first by observation. If a reliable observation of fish presence is made by the field crew leader, then no field sampling will be necessary. If no such observation occurs, then a minnow seine will be used in areas where conditions allow. The size of the seine should be selected to match the conditions and sampling with both large and small mesh sizes is recommended to target different species and size classes. If seining does not result in capture of any species other than bullhead or mosquitofish, minnow traps and trammel nets should be deployed during the late afternoon and retrieved early the following morning. The number of each deployed net and trap should be appropriate to the size of the backwater sampled. Up to three trammel nets (150 ft x 4 ft, with six 25-ft panels of mesh sizes 3/4, 1, 2, 2-1/2, and 3 in) and 3-10 minnow traps (20-1/2 in long steel-wire cylinders with a total diameter of 8-1/2 in, a throat diameter of 1-1/2 in, and a mesh size of 1/4 inch) will be used in each site depending on size. Trammel nets will be set perpendicular to the shoreline and minnow traps set so that the trap entrance is suspended within 2 in of the water surface. All fish collected will be identified by species and measured to the nearest millimeter of their total length, then released.

Other Notes

In addition to the procedures outlined above, notes should be taken in the appropriate location on field data sheets to indicate evidence of water exchange, any unique cover features (such as beaver dams, standing tree trunks, or undercut banks), and any other observations that may be useful in differentiating sites. There should also be at least one overview picture (minimum resolution of 6 megabytes or 35 mm) taken of each site to provide photo-documentation of field conditions. Any additional features of importance should also be documented with photos.

All data should be downloaded and stored in duplicate to prevent data loss. Where possible, photocopies should be made of datasheets and completed datasheets stored in a central location (rather than being repeatedly carried into the field each day). Backup batteries and additional datasheets should also be carried into the field each day.

Example Chain of Custody Form

Client Name & Address:						Analysis Required					
						Selenium	Total Nitrogen	Total Phosphorus	Total Dissolved Carbon	Chlorophyll a	Algae Counts
Project Name:											
Sampler(s) Printed Name:			Signature:								
Report Data to:	Phone:		Fax:								
Sample Name/Description	Container Type	# of Cont.	Sampling Date	Sampling Time	Preservatives						
1											
2											
3											
4											
5											
6											
7											
8											
9											

Relinquished by:	Date/ Time:	Received by:	Date/ Time:	Turnaround Time: (Check)	Sample Integrity: (Check)
					___

Example Datasonde Maintenance and Calibration Log

PARAMETERS:	CALIBRATION RESULTS:			COMMENTS / CORRECTIVE ACTIONS/ OTHER
	Pre-Calibration Reading	Calibration Standard	Post-Calibration Reading	
Temperature (°C)				
pH		7		
		10		
Spec. Conductance (µS/cm or mS/cm)		0		
		20,000		
Dissolved Oxygen (DO%)		100		
Turbidity (NTU)		0		
		100		

COMMENTS: (e.g., repairs needed, repairs performed, remarkable field conditions, supplies to be re-ordered, etc....)

Calibration details:

Time probe pulled:

Time probe deployed: