Yuma Crossing National Heritage Area
Yuma East Wetlands Restoration Project
Phase I

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Final Report

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The Arizona Water Protection Fund Commission has funded this entire Project. The views and findings presented are the Grantee's and do not necessarily represent those of the Commission, the State, or the Arizona Department of Water Resources.

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Executive Summary

The riparian areas surrounding the Yuma East Wetlands have been drastically altered by the historic damming and confinement of the river channel. These changes have decreased seasonal flooding, ended the natural process of salt removal from the soil, and impaired the ability of native cottonwood, willow, and mesquite trees to thrive and regenerate. Non-native tamarisk, (*Tamarix ramosissima* and *Tamarix pentandra*), which is well adapted to high salinity levels and regenerates rapidly, has been able to out-compete native plants. Tamarisk and common reeds (*Phragmites australis*) have invaded the lands of this highly vegetated river, altering the habitat of birds and other wildlife, including many endangered and threatened species. In 2001, a comprehensive restoration plan was produced by Fred Phillips Consulting to restore the wetlands and riparian areas into valuable wildlife habitat. The Heritage Area Arizona Water Protection Fund riparian and wetland restoration project (Grant # 06-140WPF) has helped realize the vision outlined in this Plan.

The HAAWPF 25-acre project is located within the riparian area surrounding the South Channel (a 1-mile long backwater channel connected to the Colorado River) in the Yuma East Wetlands, Yuma County, Arizona. The primary goals of the HAAWPF restoration were to restore the native ecosystem, improve ecological integrity and recover many of the missing wildlife species. In order to accomplish these goals, this project was implemented in two parts under Task #5: Revegetate 25-Acres of Native Riparian Habitat, 1.) An early action seed planting along the channel (7 acres) and, 2.) An 18 acre native riparian vegetation replanting.

The project area was cleared of non-native plant material in September 2004, during the 46-acre clearing for the South Channel project. Hand weeding of re-colonizing non-native plants occurred prior to revegetation, and the early-action seeding occurred in February 2006. The early-action seeding occurred in 8 designated areas where 12-30 inches of surface soil was removed by excavating with a low ground pressure bulldozer and excavator. This excavation created lowered areas with saturated soils that would be flooded when the level of the South Channel was raised. The planting effort in the remaining 18 acre riparian area was completed in June 2007, using the following species: Fremont cottonwood (*Populus fremontii*), Goodding willow (*Salix gooddingii*), honey mesquite (*Prosopis glandulosa*), screwbean mesquite (*Prosopis pubescens*), four-wing saltbush (*Atriplex canescens*), and wolfberry (*Lycium andersonii*).

Overall, the HA AWPF project was successful in creating a healthy, self-sustaining native ecosystem. By the end of the project all planted species were on average in good to excellent condition, with the exception of cottonwood. All species experienced positive growth and increase in height from the 2007

to the 2008 growing seasons (Figure 1-1), with the exception of cottonwoods. Four-wing saltbush experienced 100% survivorship for the two growing seasons. Screwbean mesquite experienced 98% survivorship, honey mesquite 95%, wolfberry 80%, and Goodding willow 60%. Cottonwoods were planted in an area with a high clay content, which had poor drainage and, therefore, retained high soil surface salinities. In 2007, cottonwoods experienced negative growth and by the end of the 2008 growing season they experienced 100% mortality. This area was re-planted with more salt tolerant species, such as honey and screwbean mesquite. Irrigation and weed maintenance will continue at the project site until all species are self-sustaining and have successfully reached the water table.

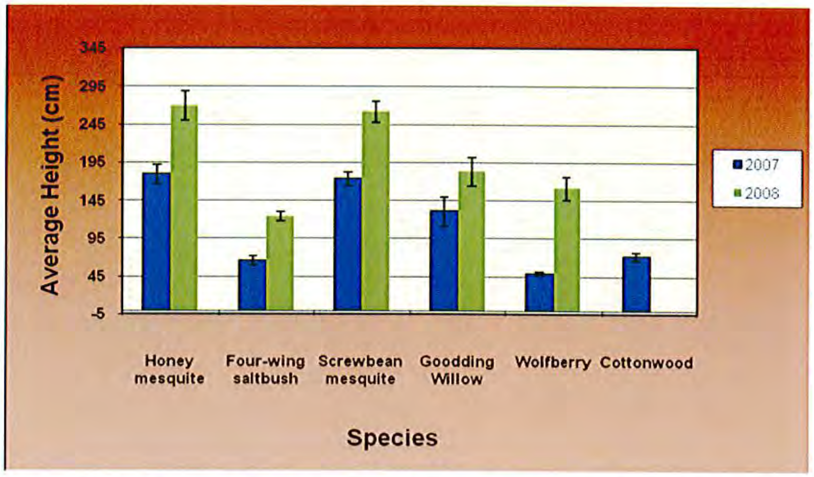

Figure 1-1: Average height (cm) for honey mesquite, four-winged saltbush, screwbean mesquite, Goodding willow, wolfberry and cottonwood at the end of the 2007 and 2008 growing seasons for the HA AWPF project site. Error bars indicate standard error.

1.0 Introduction

The riparian areas surrounding the Yuma East Wetlands have been drastically altered by the historic damming and confinement of the river channel. These changes have decreased seasonal flooding, ended the natural process of salt removal from the soil, and impaired the ability of native cottonwood, willow, and mesquite trees to thrive and regenerate. Non-native tamarisk, (*Tamarix ramosissima* and *Tamarix pentandra*), which is well adapted to high salinity levels and regenerates rapidly, has been able to out-compete native plants. Tamarisk and common reeds (*Phragmites australis*) have invaded the lands of this highly vegetated river, altering the habitat of birds and other wildlife, including many endangered and threatened species.

The Yuma East Wetlands are located along the lower Colorado River, east of downtown Yuma. For years this land was used as a dumping ground, as well as a make-shift home for transient people. However, the residents of Yuma recognized the value of the Colorado River and its wetland habitat. In 2001, a comprehensive restoration plan was produced by Fred Phillips Consulting to restore the wetlands and riparian area into valuable wildlife habitat. Partnerships between the City of Yuma, The Quechan Tribe, the State of Arizona, The Yuma Crossing National Heritage Area as well as private land owners were formed. A great deal of planning, combined with generous grants have turned the former wasteland into a vibrant ecosystem to benefit wildlife and citizens alike.

The HAAWPF 25-acre project is located within the riparian area surrounding the South Channel (a 1-mile long backwater channel connected to the Colorado River) in the Yuma East Wetlands, Yuma County, Arizona. The primary goals of the HAAWPF restoration were to restore the native ecosystem, improve ecological integrity and recover many of the missing wildlife species. In order to accomplish these goals, this project was implemented in two parts under Task #5: Revegetate 25-Acres of Native Riparian Habitat, 1.) An early action seed planting along the channel (7 acres) and, 2.) An 18 acre native riparian vegetation replanting. This report discusses the results of the restoration process and vegetation monitoring for the 2007 and 2008 growing seasons, evaluation of the project success, and guidance for future restoration activities.

2.0 Methods of Investigation

2.1 Site Clearing

Site clearing mainly focused on clearing and grubbing phragmites (*Phragmites* sp.) and tamarisk (*Tamarix ramosissima*), and included clearing of all brush, stumps, roots, rubbish, debris, and other objectionable matter from the area. Any existing native vegetation was retained on site. The masticated material and debris was piled in berms in locations of low habitat quality or along the project perimeter. The soil was disturbed down to a minimum of 8-inches below the original surface level of the ground and to a maximum of 24 inches in order to remove the root zones. The area was cleared to a "rough grade." Clearing was accomplished using low ground pressure bulldozers and excavators, since many areas had saturated soils. The clearing map is located in Appendix A.

2.2 Site Analysis

Salinity and depth to water was mapped across the 25-acre site using a Trimble GEO XT survey unit and an 8 foot hand auger to collect samples. Soil samples were collected at 2 data points per acre, totaling 55 sampling points. Soil samples were collected at 2 foot and 5 foot depths below the soil surfacc at each point for a total of 110 samples. The site analysis for this project was conducted with the site analysis of the North American Wetlands Conservation Act (NAWCA) site as well, therefore the maps display results for both project areas (Appendix B). This project area is delineated in the maps and labeled as the "YAWPF 2005 Revegetation" in the map legend. A GPS point was taken with the Trimble survey unit at each survey point to identify the location and elevation. Soil samples were collected using the hand auger to excavate the soil to the appropriate depth. The soil samples were placed in a plastic bag with the site, soil depth, name of the collector and the date. These samples were analyzed with a Kelway SST soil salinity meter. Five samples were sent to IAS Laboratories in Phoenix, AZ to insure the accuracy of the Kelway salinity meter. The depth to water was recorded at 10 sampling points by excavating the soil with the hand auger until water was reached.

This analysis was utilized to determine the appropriate planting design for the site by indentifying the site characteristics that most benefit the appropriate native species. The samples sent to the IAS laboratories coincided with the soil salinity measurements from the Kelway SST, justifying the accuracy.

2.3 Restore Approximately 20 Acres of Aquatic/Wetland/ Riparian Habitat within the North Channel Restoration Area

The Yuma East Wetlands North Channel will be comprised of 65-acres of riparian and wetland habitat along the riparian corridor of the Colorado River. The site is located adjacent to and to north of the Yuma East Wetlands North Pilot Project. The primary objective of this project is to create self-sustaining native riparian, wetland, and back water habitat. The design includes 35 acres of flood irrigated cells which will be planted with riparian vegetation. The irrigation channel drains through an outfall structure into the Quechan pond, which is a part of the Quechan Nature Park. The Quechan pond, including the Quechan Nature Park, is 22.5 acres of wetland habitat that will be planted with native marsh vegetation and will be available for non-motorized recreation. Prior to clearing, the area was over-run by nonnative tamarisk and phragmites.

The first 25 acre area was cleared in March 2006. Maintenance weeding was conducted after the initial clearing to control non-native plant re-growth. An additional 40 acres were cleared in February 2007. A topographical survey of the site was completed in April 2007 in order to determine what areas required laser leveling for the flood irrigation infrastructure. The irrigation infrastructure for the 35 acres of flood irrigation was completed in December 2008. The irrigation system is working flawlessly, and the entire 35 acres is currently growing a cover crop of winter barley, small fescue, dune evening primrose, and inland salt grass. The native tree and shrub vegetation has been ordered and will be available from the nursery in March 2009, and planting completion is anticipated for May 2009. The planting design and monitoring transect locations are in Appendix C.

The earth work for the North Channel slough was completed in February 2009. Planting in the North Channel pond and slough was completed in February 2009 (Appendix C). Most of the wetland plants were transplanted from established projects in the Yuma East Wetlands and all of the 2,200 sandbar willow, 30 Goodding willow, and 30 Fremont cottonwood poles were collected from several MSCP (Multi-species Conservation Program) restoration sites near the Cibola wildlife refuge on the Colorado river (an hour and a half north of the Yuma East Wetlands project).

2.4 Revegetate 25 Acres of Native Riparian Habitat

2.4.1 Early Action Planting

After the initial invasive species clearing, a 7 acre area within the HA AWPF site was designated as a critical area to initiate re-planting efforts due to the aggressive re-growth of phragmites. These areas were designated and approved by AWPF for early action planting. The area was maintained by hand pulling weeds and digging out emerging re-sprouts (1-4 inches high). No herbicide was used. The top 12- 30 inches of soil was removed in these areas using low ground pressure bulldozer and excavator. The excavated material was placed in spoil piles adjacent the HAAWPF site. Areas that had a very high density of phragmites re-sprouts were prioritized for excavation in order to prevent rapid recolonization.

After site excavation, the areas that had saturated soils and were frequently flooded were planted with 2.25 cubic inch plugs of the following wetland plants in the following quantities (Appendix D):

- 200 Inland saltgrass *(Distichulus Spicata)*
- 200 Creeping spikerush (Eleocharis palustris)
- 200 Threesquare *(Scirpus americanus)*
- 200 Alkali sacaton *(Sporobolus airoides)*
- 200 Alkali bulrush *(Boboschoenus maritimus)*

One gallon propogules of the following species in the following approximate quantities were planted in areas that were not frequently flooded or inundated, with the exception of cottonwood and willow trees. Cottonwood and willow species were planted in and adjacent to areas that were excavated down to the saturated soil zone.

- 125 Sandbar willow (*Salix exigua*)
- 125 Goodding willow (*Salix gooddingii*)
- 100 Fremont cottonwood (*Populus fremontii*)
- 200 Screwbean Mesquite (*Prosopis pubescens*)
- 50 Yerba mansa (*Anemopsis californica*)
- 60 Desert marigold (*Baileya multiradiata*)
- 50 Wolfberry (*Lycium andersonii*)
- 30 Evening primrose (*Oenothera speciosa*)
- 10 Baccharis (*Baccharis glutinosa*)

In addition to the plantings described above, 6 pounds total of the following species were broadcast in the wet excavated areas. Seeds were hand sown into the seed plots and raked approximately 2 inches into the soil.

- 2 lbs Inland saltgrass (*Distichlis spicata stricta*)
- 2 lbs Salt heliotrope (*Heliotropium curassavicum*)

- 2 lbs Western sea purslane (*Sesuvium verrucosum*)

In selected locations within the project area, 586 3 foot tall sandbar willow poles were planted using the water jet stinger auger (Appendix D). The poles were planted in areas where the surface soil was not saturated (like in the excavated areas), however saturated soils were within 2 feet from the soil surface. The early action planting was completed in April 2005.

2.4.2 Riparian Revegetation

The soil salinity and depth to ground water conditions in a small portion of the site, was suitable to plant riparian species, including: Fremont cottonwood and Goodding willow). The salinity in these areas ranged from 0- 12 mmhos/cm at 2 ft below the surface, 0- 8 mmhos/cm at 5 ft below the surface, and the depth to water reaching 0-4 ft, which are within the site condition tolerance thresholds of these species. The suitable range of electro-conductivity (EC; mmhos/cm) for cottonwood and willows range from 0-4 mmhos/cm, and the depth to water ranges from 0- 6 ft. In these areas the following planting design occurred (Appendix E):

- Goodding willow trees were planted 17' O.C. in five different areas. In two of these areas the tree wells were planted with western sea-purslane seed. The tree wells in one of these areas were planted with half western sea purslane and half with alkali sacaton seed, and two areas with no understory seed.

- Three areas were planted with cottonwood trees 17- 20' O.C. The tree wells in two of these areas were sown with heliotrope seed, and one area had half of the tree wells planted with heliotrope seed and the other half inland saltgrass seed.

The soil salinity and depth to water analyses showed that the majority of the site was suitable for mesquite bosque habitat, including both honey and screwbean mesquite. The salinity in this area ranged from 8- 16 mmhos/cm at 2 ft below the surface, 3- 8 mmhos/cm at 5 ft below the surface, and the depth to water reaching 2- 7 ft below the surface, which are within the tolerance thresholds of these species. The suitable range for mesquites is 3.0- 9.4 mmhos/cm, and depth to water tolerance is greater than 10 ft. Screwbean mesquite generally can tolerate more saturated soil conditions than honey mesquite. For this reason screwbean mesquite were planted in areas where inundation from flood flows were more likely and salt tolerance exceeded the threshold for cottonwood and willow trees. Honey mesquite was planted in higher areas where inundation from flood flows was less likely. In these areas the following planting design was conducted (Appendix E):

- There were four areas that were planted with screwbean mesquite 20' O.C. The tree wells of one of these areas was planted with 3" plugs of inland saltgrass, two with evening primrose seed, and one with no understory planting.

- There were three different areas that were planted with honey mesquite 20' O.C. The tree wells in one of these areas will be planted with salt heliotrope seed, one with alkali sacaton seed, and one with no understory. One area was planted with honey and screwbean mesquite. A ¼ of the tree wells were planted with alkali sacaton seed, ¼ western sea purslane seed, ¼ inland salt grass seed, and ¼ desert sunflower seed.

Soil salinity and depth to water showed to be suitable for a variety of native upland species, particularly on the berms created from the site clearing activities, including wolfberry and four-wing saltbush. The salinity in this area ranged from 12- 30 mmhos/cm at 2 ft below the surface, 12- 30 mmhos/cm at 5 ft below the surface, and the depth to water reaching 4- 10 ft below the surface, which was within the tolerance thresholds of these species. The suitable range of EC for these salt tolerant shrubs is greater than 9.4 mmhos/cm, and depth to water tolerance is greater than 10 ft. The following planting design was conducted in these areas (Appendix E):

- Wolfberry (10' O.C.) was planted in the higher berm areas where the depth to water is deep in four areas. The wolfberry tree wells in two of the areas were planted with globe mallow seed, one with heliotrope seed and one with 3" plugs of inland salt grass.

- Two areas were planted with four-wing saltbush. No understory species were planted in these areas.

2.4.3 Irrigation and Maintenance

Three different irrigation regimes were utilized at the site. The type of irrigation infrastructure utilized was determined based on the salinity, depth to water, and vegetation planted on the site (Appendix F). The majority of the site was irrigated with drip irrigation. This irrigation regime targeted riparian and upland species. Drip irrigation was necessary to insure the successful establishment of these vegetation species by providing sufficient time for their roots to establish. The water supplied for drip irrigation was obtained from pumping water from the South Channel in a central location. The pump was self contained, diesel powered and had the capacity of pumping 220 gallons per minute at 30 PSI. A 4 inch PVC mainline ran from the pump, along the length of channel. Running parallel to the mainline, 2 inch PVC laterals were divided into approximately 10 sections with approximately 10 separate valves. Sub-lateral 3/4" inch polyethylene tubing teed off of the 2" inch PVC and ran westward. Rows of sub-laterals were evenly spread across the drip-irrigated portion of the project area. The pump was fitted with an infuric acid fertilizer injection system. The infuric acid helped reduce salts in the planting wells and surrounding soils of planted trees and shrubs.

The second irrigation regime included a 6-10 inch gas/diesel-generated pump used to flood irrigate cottonwood and Goodding willow areas. During the primary growing season these areas were irrigated approximately twice monthly (April-Oct). During the secondary growing season the areas were irrigated on a monthly basis.

Finally, the third regime involved irrigating the "Early Action" area by the frequent inundation from the South Channel at higher than normal river flows (1000 cfs or higher) and/or flooding from external sources (2E agricultural run-off and treated decant line backwash water). This was accomplished through close monitoring of the projected and current river flows, especially when the farming communities reduced their water orders due to rainfall in the Yuma area. These areas had a shallow depth (less than 1.5') to the water table and the revegetation in these areas was planted with their roots submerged into the water table.

Weeding and maintenance of the revegetation site occurred on a regular basis during the first and second growing seasons. The second year transitioned into an as needed basis. Weeding was critical in maintaining the re-colonization of invasive species. Weed maintenance will need to continue until the native grasses and trees are able to out-compete them. Re-sprouting tamarisk and phragmites in the revegetation area were suppressed using various weeding methods, which ranged from mechanical to chemical techniques. Mechanical techniques included using shovels, hoes and hand pulling to small tractors and bulldozers using root knives. Chemical techniques included using Garlon 4 to control salt cedar in areas where native species were not planted.

Preventative maintenance measures included using hog wire around individual cottonwood and willows to deter beaver gnawing and tubex tree shelters around the honey mesquite trees to prevent rabbit browsing. Mammal browsing on screwbean mesquite rarely occurs, therefore tubex tree shelters were not necessary. In most areas, the polyethylene irrigation tubing was above ground and when irrigation is discontinued it can be re-used for future projects. Dead trees were replanted as needed. In areas where salt stress appeared to be the cause of tree death more salt tolerant plants/grasses were re-planted. The site is currently being irrigated on an as needed basis to promote tree establishment and moist soils.

It was decided to utilize the remaining maintenance funds (Task 5) during the third growing season to hand weed the site of non-native vegetation and to plant native salt grasses in those areas where salinity had caused the highest degree of mortality among cottonwood trees. This work was completed in May 2009.

2.5 Implement Monitoring

2.5.1 Photo Monitoring

Five photo monitoring stations were established and panoramic pictures were taken three times throughout the growing season (May, July, and October). The stations were located at higher elevations for an overall perspective. Monitoring photos, taken repeatedly over extended periods, provide a valuable scientific visual database. Photo monitoring results for the 2007 and 2008 growing seasons are located in Appendix G.

2.5.2 Plant Monitoring

Seventeen transects were established in the HA AWPF Restoration site in randomly selected locations. The transects were comprised of five individuals of the same species. The five species represented at the site include: Fremont cottonwood, Goodding willow, honey mesquite, screwbean mesquite, four-wing saltbush and wolfberry. In order to randomly select the transect locations, a gps position was randomly selected on the planting design for the initial plant in the transect. The next four plants to the north of the selected plant were included in the transect. In order to re-locate transects in subsequent monitoring sessions, transects were marked with a wooden stake in the beginning of each transect and the transect number and site name were recorded on the stake. Each tree was individually marked with a metal tag containing the transect number and tree number information. The field gps location of each transect was recorded. Plant monitoring transect locations are located in Appendix H.

For each individual, several parameters were recorded, including: height, growth rate, condition, and other influences on growth. Plant heights were measured to the tallest outstretched leaf and overall condition was estimated. Scores were assigned as follows:

- 0—dead plants
- 1—poor condition
- 2—fair condition
- 3—good condition
- 4—excellent condition

Evidence of browsing by insects or mammals was noted, along with other factors that could affect plant health, such as water stress, competition from native and non-native volunteer colonization, outgrowth of protective hog-wire fencing, and maintenance issues. Natural regeneration of both native and non-native plants was also noted.

2.5.3 Seed Plot Monitoring

One permanent quadrat (1.5 x 1m) was randomly established for each of the monitored seed plots. Since some species were planted more often than others, the number of quadrats sampled per species varied. Control plots were located outside of the 8 seed cells to monitor the natural recruitment of species when native seeds were not planted. There were a total of 69 experimental quadrats. Following is a list of the species planted and the number of quadrats sampled of that species. Locations of the seed plot monitoring quadrats are located in Appendix I.

Species	Number of Quadrats
Alkali sacaton	9
Common Three-square	2
Four-wing saltbush	8
Inland salt grass	6
Pickleweed	7
Seep willow	6
Western Sea Purslane	9
Wild Heliotrope	8
Wolfberry	4
Yerba mansa	4
Control	6

Cover was measured separately for four strata classes, including tree tall canopy (>10 m), tree middle canopy (4- 10 m), shrub (0- 4 m), and herbaceous and surface cover (<0.5 m). Ground cover, woody debris, and soil substrate was measured as a part of the herbaceous and surface cover. Cover for all species occurring in and hanging over the quadrat were estimated. If a species was unknown, the diagnostic parts were collected in order to identify. Small sprouts that did not have diagnostic characteristics remained unidentified and named "unknown herb". The Daubenmire cover scale was used to estimate percent canopy cover of each individual species.

3.0 Results and Discussion

3.1 Species-Specific Growth Rates and Conditions

The results presented below are from the second growing season for each tree and shrub species planted as part of the revegetation efforts for the 25 acre site. Field monitoring datasheets for the 2007 and 2008 growing seasons are located in Appendix J. Monitoring results are presented below for the following five species:

- Fremont Cottonwood (*Populus fremontii*)
- Goodding Willow (*Salix gooddingii*)
- Honey Mesquite (*Prosopis glandulosa*)
- Screwbean Mesquite (*Prosopis pubescens*)
- Four-Wing Saltbush (*Atriplex canescens*)
- Wolfberry (*Lycium andersonii*)

3.1.1 Fremont Cottonwood (*Populus fremontii*)

Cottonwood was not planted at the HAAWPF site until September 2007 due to the limited availability of cottonwood stock. The first monitoring session was conducted after planting in September 2007 and by October 2007 little growth had occurred (Figure 3-1). It appeared that the plants suffered from planting stress, however during the first monitoring season cottonwood had 100% survivorship.

By the first monitoring session in June 2008, only 40% of the originally planted cottonwood trees survived, by August there was only a 20% survivorship and in October there was 100% mortality. Between June and August average cottonwood height increased slightly, however declined sharply in October due to mortality (Figure 3-1).

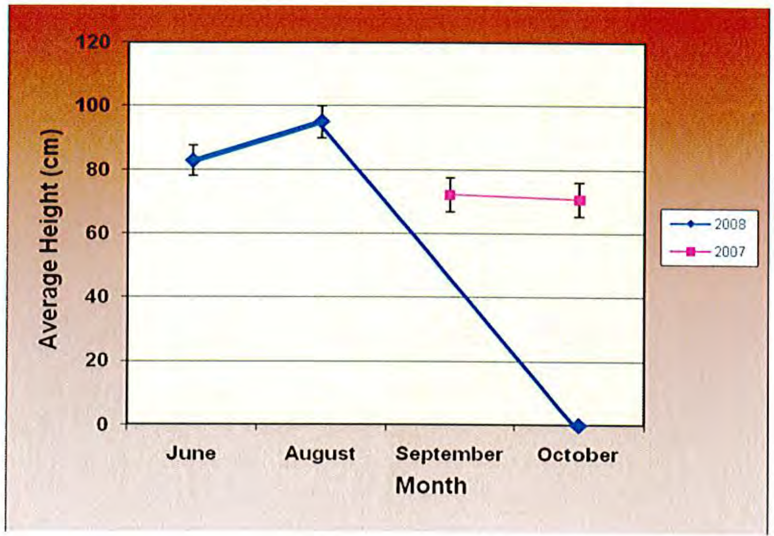

Figure 3-1: Average cottonwood height (cm) for the 2007 and 2008 monitoring seasons at the HA AWPF site, Yuma East Wetlands. Error bars signify standard error.

Although cottonwoods were not planted until September 2007, they had already started to show a decline in condition from good to fair by October 2007 (Figure 3-2). This decline was attributed to planting stress due to the hot temperatures experienced when the plants were planted. However, the mortality and declining condition from excellent in June to 100% mortality in October experienced during the 2008 growing season suggested that high soil salinity was likely the prime factor affecting cottonwood growth and condition (Figure 3-2). The HA AWPF project site was dominated by clay and high soil salinities in riparian areas where cottonwood was planted. When the site was irrigated with flood irrigation, the high clay soils prevented the necessary drainage, which pooled water and trapped salts on the soil surface and near the plant roots. This area was re-planted with mesquite which has a higher soil salinity tolerance than cottonwood.

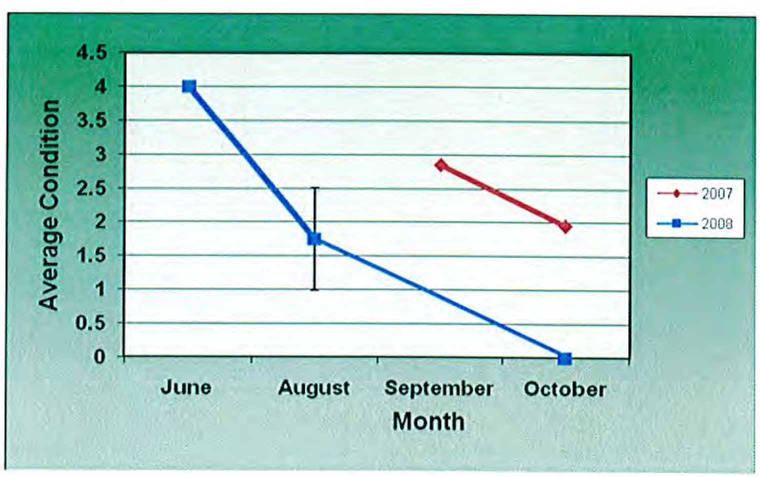

Figure 3-2: Average cottonwood condition for the 2007 and 2008 monitoring seasons at the HA AWPF site, Yuma East Wetlands. 0=dead, 1=poor, 2=fair, 3=good, and 4=excellent. Error bars signify standard error.

3.1.2 Goodding Willow (*Salix gooddingii*)

Overall, the monitored Goodding willow trees experienced positive growth throughout the 2007 growing season (Figure 3-3). The average total growth was 35.56 cm (N=3, SE=9.16) during the 2007 season. Peak growth occurred from June to July and totaled 16 cm (N=3, SE=6.1). Two individuals died the first month after planting, and survivorship for the season was 60%. These individuals were replaced, however they were not monitored during the 2008 season in order to provide consistency.

During the 2008 monitoring season Goodding willow growth continued on a positive trajectory (Figure 3-3). The average total growth was 45 cm (N=3, SE=8.11) during the 2008 season. Peak growth occurred from August to October and totaled 33 cm (N=3, SE=11). No new mortalities occurred during the 2008 monitoring season, and Goodding willow finished the season with 100% survivorship.

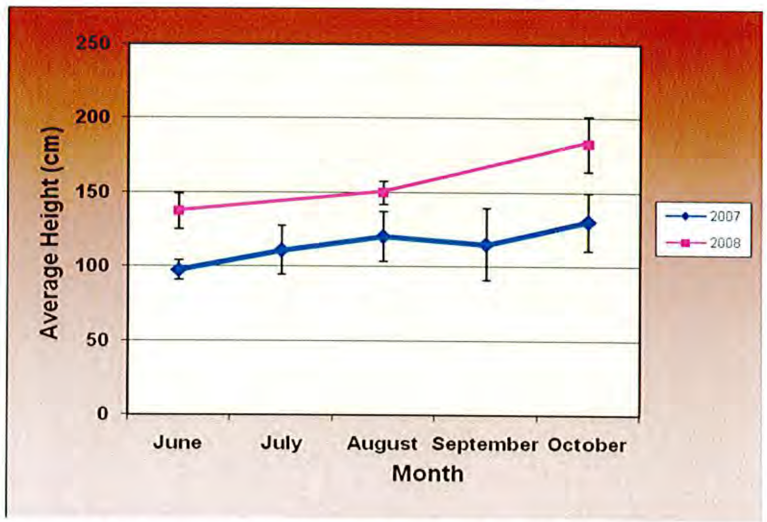

Figure 3-3: Average Goodding willow height (cm) for the 2007 and 2008 monitoring seasons at the HA AWPF site, Yuma East Wetlands. Error bars signify standard error.

Goodding willow condition was fair and two mortalities occurred during the first monitoring session in June 2007 (Figure 3-4). The fair condition and mortalities were primarily caused by planting stress. In June, 50% of the individuals were affected by planting stress, however by July only 1% of the surviving individuals were affected. June in Yuma often has temperatures rising up to three digits, which is not the most ideal time for planting. Despite the initial declined condition, by July the condition of planted Goodding willow increased and surviving individuals remained in good- excellent condition for the remainder of the growing season. By 2008 the surviving Goodding willow trees were in excellent condition throughout the growing season (Figure 3-4), with no factors affecting growth or condition.

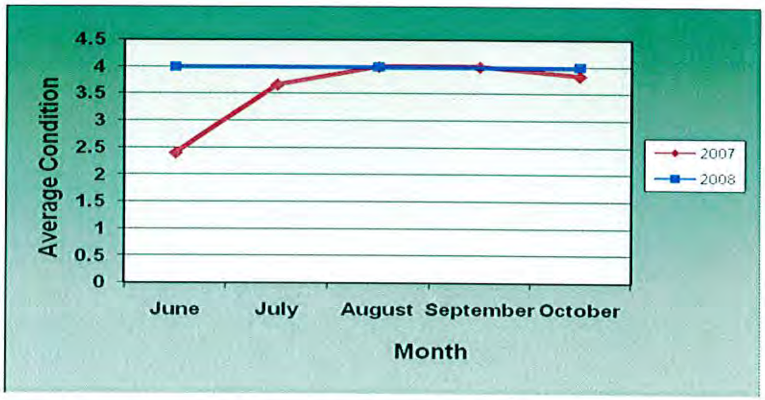

Figure 3-4: Average Goodding willow condition for the 2007 and 2008 monitoring seasons at the HA AWPF site, Yuma East Wetlands. 0=dead, 1=poor, 2=fair, 3=good, and 4=excellent. Error bars signify standard error.

3.1.3 Screwbean Mesquite (*Prosopis pubescens*)

The screwbean mesquites in the HA AWPF site experienced positive growth during the 2007 growing season (Figure 3-5). The average screwbean mesquite grew 39.4 cm (N=34, SE=9.55) over the 2007 growing season. The peak growth occurred from June- July, with an average growth of 20.55 cm (N=35, SE= 4.88). Screwbean mesquite showed a survivorship rate of 97%, with one mortality occurring from July- August.

Positive growth in screwbean mesquite continued during the 2008 growing season (Figure 3-5). The average screwbean mesquite grew 66.6 cm over the 2008 growing season (N=33, SE=8.75), almost doubling the growth that occurred during the 2007 growing season. The peak growth occurred from June- August, with an average growth of 63.7 cm (N=33, SE= 8.12). Screwbean mesquite showed a survivorship rate of 100%, with no new mortalities occurring during the 2008 growing season.

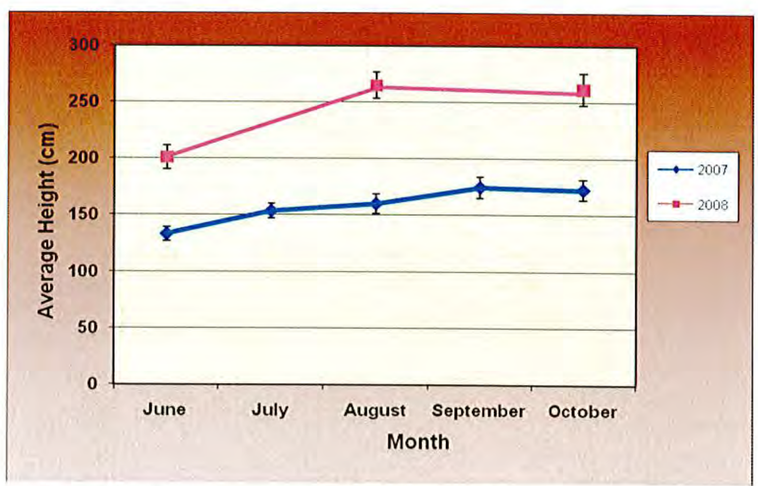

Figure 3-5: Average screwbean mesquite height (cm) for the 2007 and 2008 monitoring seasons at the HA AWPF site, Yuma East Wetlands. Error bars signify standard error.

The overall condition of the screwbean mesquites for the 2007 growing season was very good to excellent (Figure 3-6). During June, 68% of the individuals were in good to excellent condition, and by September 100% were in good to excellent condition. The primary factor affecting screwbean mesquite condition in the beginning of the monitoring season was planting stress. In June, planting stress affected 94% of the monitored individuals, however that percent affected decreased to 11% by July. Other factors that affected condition included salt stress, water stress and insect browsing. Each of these factors only affected 3% of the planted individuals.

Screwbean mesquite remained in very good to excellent condition throughout the 2008 growing season (Figure 3-6). During June and August, 100% of the individuals were in good to excellent condition, and by September 92% were in good to excellent condition. The primary factor affecting screwbean mesquite condition was salt and water stress. In June, water stress affected 3% of the monitored individuals, and increased to 12% in August. By October, 6% of monitored individuals were affected by water stress and 6% by salt stress. Some of the areas where screwbean mesquite were planted had high clay content, which retained a high salinity from a decline in drainage capability.

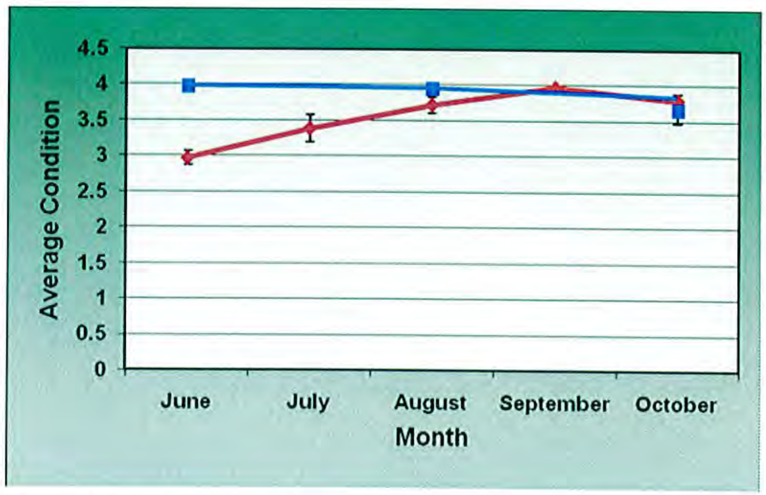

Figure 3-6: Average screwbean mesquite condition for the 2007 and 2008 monitoring seasons at the HA AWPF site, Yuma East Wetlands. 0=dead, 1=poor, 2=fair, 3=good, and 4=excellent. Error bars signify standard error.

3.1.4 Honey Mesquite (*Prosopis glandulosa*)

Honey mesquites showed the highest growth of all species during the 2007 growing season in the HA AWPF (Figure 3-7). The average total growth for the 2007 season was 108.2 cm (N=20, SE=9.3). Honey mesquite peak growth occurred during June, which was an average of 58.17 cm (N=19, SE=6.48). Honey mesquite experienced a 100% survivorship during the 2007 season.

During the 2008 growing season, honey mesquite continued to show positive growth (Figure 3-7). By the end of the 2008 growing season, honey mesquite had grown 1.4 times in height than at the end of the 2007 growing season. The average total growth for the 2008 season was 79.2 cm (N=19, SE=15.81). Honey mesquite peak growth occurred from June to August, which was an average of 57.2 cm (N=19, SE=8.7). Honey mesquite experienced one mortality that occurred prior to the 2008 monitoring season, therefore showing a 95% survivorship for the season.

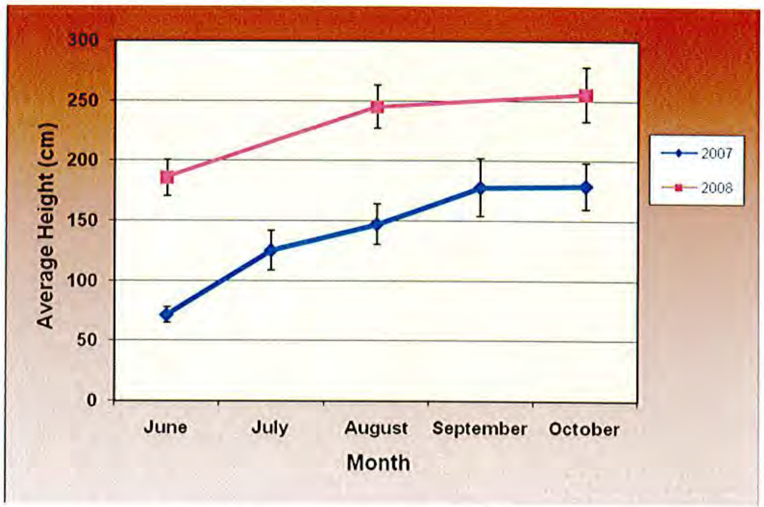

Figure 3-7: Average honey mesquite height (cm) for the 2007 and 2008 monitoring seasons at the HA AWPF site, Yuma East Wetlands. Error bars signify standard error.

The average condition of the honey mesquites for the 2007 growing season was good to excellent (Figure 3-8). Planting stress was the primary reason for the observed declined condition in June, where 75% of the individuals were affected by planting stress. However, by July none of the individuals were affected by planting stress. Planting stress became apparent again in October, affecting 15% of the individuals, however it is more likely that the individuals were being affected by an unknown factor rather than planting stress. Other factors affecting plant condition included insect browsing, volunteer competition and salt stress. Each of these played a minimal role in affecting plant condition. Insect herbivory showed to affect 20% of individuals in August, 10% in July and 5% in August. Salt stress appeared to affect 10% of honey mesquite and volunteer competition affected 5% in August.

During the 2008 growing season honey mesquite maintained and average condition of very good to excellent (Figure 3-8). Water stress, salt stress, and volunteer competition were the main factors that slightly affected honey mesquite condition. In June, 10% of the individuals were affected by water stress, which increased to 15% in August and back down to 10% in October. One mortality occurred due to water stress. Salt stress only affected 15% of the individuals in August, but did not appear to affect any individuals during June or October. Volunteer competition showed a minimal effect, and was primarily caused by recruiting or native understory species. Only one individual was affected by volunteer competition from invasive Bermuda grass.

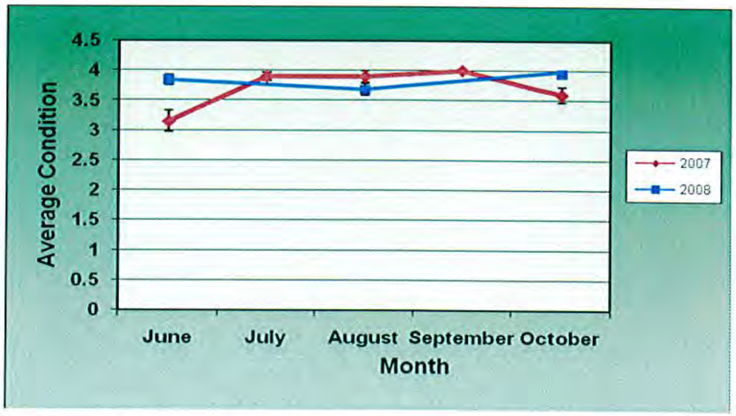

Figure 3-8: Average honey mesquite condition for the 2007 and 2008 monitoring seasons for the HA AWPF site, Yuma East Wetlands. 0=dead, 1=poor, 2=fair, 3=good, and 4=excellent. Error bars signify standard error.

3.1.5 Four-Wing Saltbush (*Atriplex canescens*)

Four-wing saltbush experienced increased growth throughout the 2007 growing season in the HA AWPF (Figure 3-9). The average total growth for the 2007 season was 41.91 cm (N=6, SE=6.1). The peak growth for four-wing saltbush occurred during June and August, which was an average of 16.51 cm (N=6, SE=3.45). Four-wing saltbush thrived throughout the 2007 season, and experienced a 100% survivorship.

Four-wing saltbush continued to experience increased growth during the 2008 growing season with a slight decline in growth from August to October in the HA AWPF (Figure 3-9). At the end of the 2008 growing season, four-wing saltbush was almost 2 times higher than at the end of the 2007 growing season. The average total growth for the 2008 season was 11.5 cm (N=6, SE=9.67). The peak growth for four-wing saltbush occurred from June to August, which was an average of 20 cm (N=6, SE=7.56). Four-wing saltbush thrived throughout the season, and experienced a 100% survivorship.

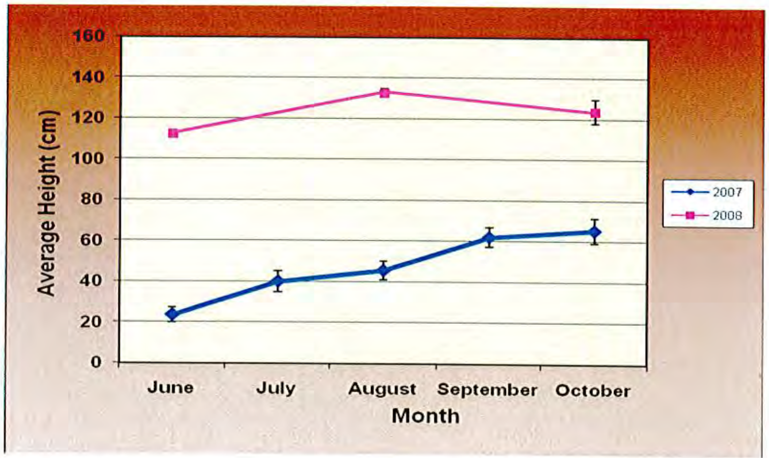

Figure 3-9: Average four-wing saltbush height (cm) for the 2007 and 2008 monitoring seasons at the HA AWPF site, Yuma East Wetlands. Error bars signify standard error.

During the first 2007 monitoring session in June, four-wing saltbush had an average condition of fair, however once established for a month, 100% of the individuals were in excellent condition for the rest of the growing season (Figure 3-10). Four-wing saltbush had a 100% survival rate. The only factor affecting condition in June was planting stress, which was responsible for decreased condition in 100% of the individuals (Figure 3-10). After the plants had an opportunity to establish, they had no factors affecting growth or condition.

During the 2008 growing season four-wing saltbush remained in excellent condition (Figure 3-10). The apparent decline in growth from August to October may have been due to field sampling discrepancy. No factors were observed to affect growth during the 2008 growing season, therefore the only explanation for the slight decline in plant height may have been due to sampling error caused by varying techniques used by different people.

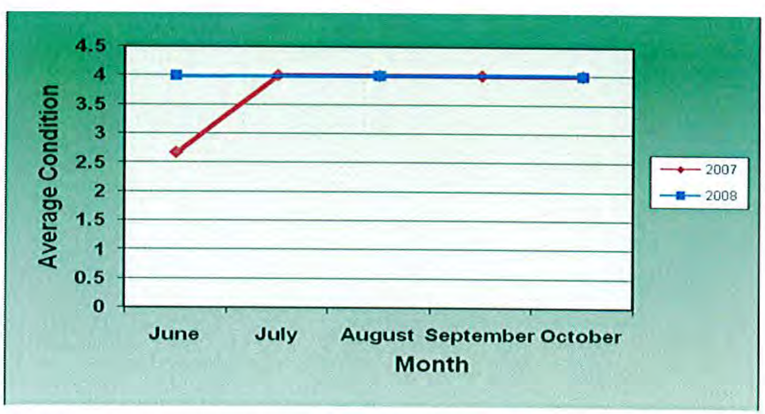

Figure 3-10: Average four-wing saltbush condition for the 2007 and 2008 monitoring seasons for the HA AWPF site, Yuma East Wetlands. 0=dead, 1=poor, 2=fair, 3=good, and 4=excellent. Error bars signify standard error.

3.1.5 Wolfberry (*Lycium andersonii*)

Wolfberry showed minimal average growth for the 2007 growing season experienced in the HA AWPF (Figure 3-11). No growth or slightly negative growth was observed for the first four months (June- September) until September to October when average growth was the highest at 9.65 cm (N=5, SE=3.71). The average total growth for the 2007 season was 8.64 cm (N=5, SE=4.32). The average total growth was less than the growth experienced during September to October, because of the negative growth experienced in previous months. Despite the minimal growth observed in wolfberry, 100% of the individuals survived.

During the 2008 growing season, wolfberry height increased steadily (Figure 3-11). Wolfberry height was 3 times greater at the end of the 2008 monitoring season than at the end of the 2007 monitoring season. The highest growth occurred during August to October, which was 9.25 cm (N=5, SE=3.57). Average total annual growth for 2008 was 14 (N=4, SE=3.9). One mortality occurred in the wolfberry individuals during 2008, which made survivorship 80%.

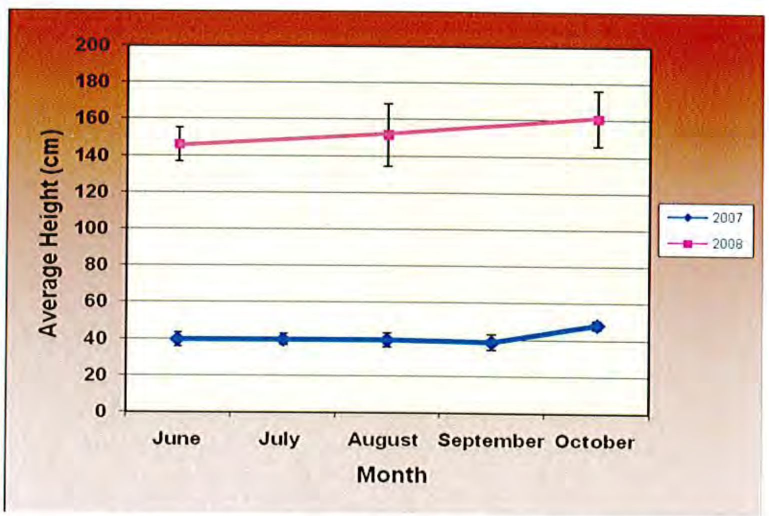

Figure 3-11: Average wolfberry height (cm) for the 2007 and 2008 monitoring seasons at the HA AWPF site, Yuma East Wetlands. Error bars signify standard error.

During the 2007 growing season, wolfberry was in fair to poor average condition during June to September and very good condition from September to October (Figure 3-12). One-hundred percent of the individuals were in fair to poor condition during June to August, and 60% of the individuals showed increased condition (very good to excellent) by September. The primary factor for decreased condition was planting stress, which affected 100% of the individuals during June to August and 60% of the individuals during September and October.

During the 2008 growing season, wolfberry was in excellent average condition during the beginning (June) and end (August) of the monitoring season, but was in fair average condition during the middle of the monitoring season (August) (Figure 3-12). All wolfberry individuals had water stress due to clogged drip irrigation emmitters during the August monitoring session, which caused the decline in wolfberry condition. This factor was also responsible for one mortality, making the survivorship 80%. By October, the emmitters were cleared and the water stress was remedied correcting an irrigation problem that was limiting water access to the plants. By October 100% of the individuals were in excellent condition.

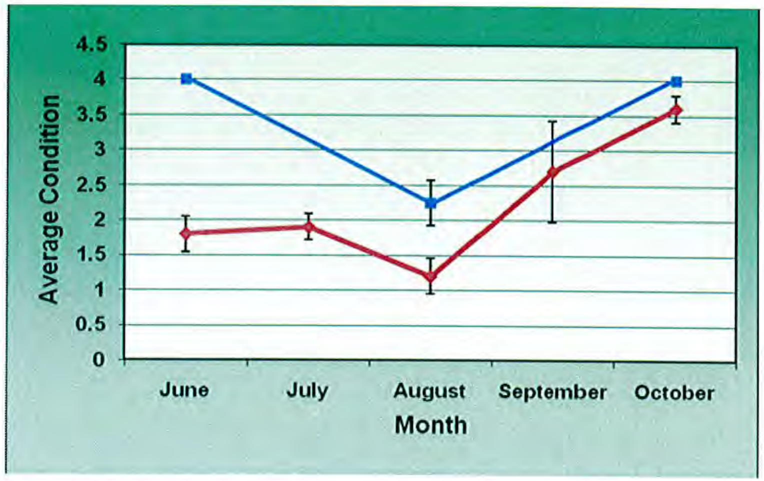

Figure 3-12: Average wolfberry condition for the 2007 and 2008 monitoring seasons at the HA AWPF site, Yuma East Wetlands. 0=dead, 1=poor, 2=fair, 3=good, and 4=excellent. Error bars signify standard error.

3.2 Seed Plot Vegetation Cover

Inland saltgrass, threesquare and alkali sacaton had the highest herbaceous cover in the HA AWPF seed plot area during both the 2007 and 2008 growing seasons (Figures 3-13- 3-15). Seed plot data has been combined to discuss the cover for the entire area instead of separating data by seed species planted, since other species, particularly inland saltgrass, were planted after the seeds were sown in February 2006. Inland saltgrass had the highest cover of any species at the site in both 2007 and 2008 (Figure 3-13). Total cover increased from 2007 to 2008, and reached its highest cover in October 2008 of approximately 38% of total cover in the seed plot area. Inland saltgrass does not grow well from seed, however during regular maintenance weeding plugs were planted to help reduce the re-colonization of invasive species. This species was very successful in re-colonizing areas in dense patches. Saltgrass was planted on 5 ft centers, and within a year the area is a dense monotypic patch. Their growth and success indicates their ability to adapt to and thrive in highly saline environments.

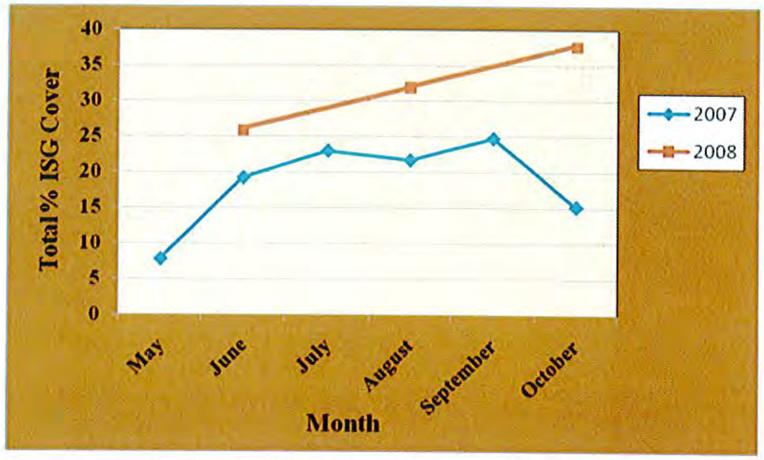

Figure 3-13: Total percent inland saltgrass cover during the 2007 and 2008 monitoring seasons at the HA AWPF early action planting sites.

Threesquare bulrush cover increased from the 2007 to the 2008 monitoring seasons (Figure 3-14). Cover declined slightly by the end of the 2008 growing season from almost 11% of the total cover in June to 9% in October. This species did not germinate by seed in the plots where it was seeded, instead it grew by colonization from established individuals and occurred in seed plots of other species.

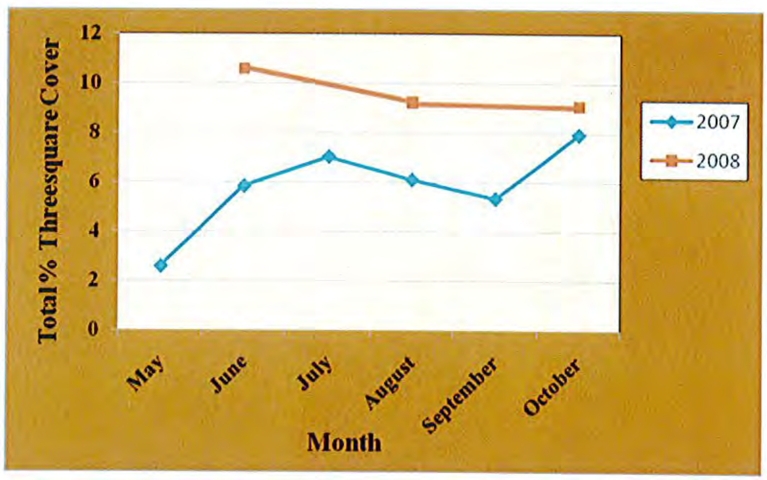

Figure 3-14: Total percent threesquare cover during the 2007 and 2008 monitoring seasons at the HA AWPF early action planting sites.

Alkali sacaton grew vigorously during the 2007 growing season with the highest cover observed during August at almost 9% (Figure 3-15). Cover declined to almost 5% at the end of the 2007 growing season, and at the beginning of the 2008 growing season only 4% cover was observed. Alkali sacaton cover declined to almost 2% by the end of the 2008 growing season. This species initially established well where their seeds were planted and as volunteers in other seed plots. Alkali sacaton propagates well from seed. The cause for this decline in cover is unknown, but it may be caused by the increased expansion of inland saltgrass.

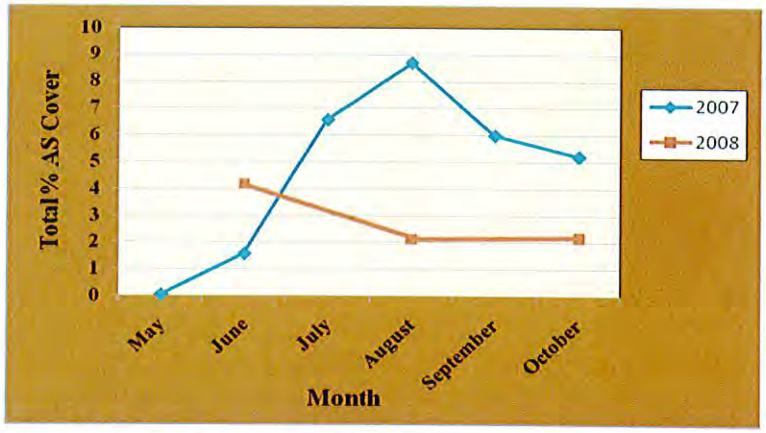

Figure 3-15: Total percent alkali sacaton cover during the 2007 and 2008 monitoring seasons at the HA AWPF early action planting sites.

Other herbaceous species that occurred in the HA AWPF early action seed plot area during the 2007 and 2008 monitoring seasons, but covered smaller areas, included western sea purslane, alkali bulrush, heliotrope, Mexican sprangletop, marsh fleabane, yerba mansa, California bulrush, cattail, Bermuda grass, phragmites and tamarisk. Sprouting sandbar willow and arrowweed occurred in the herbaceous cover class, which indicates that these species are naturally recruiting. Although invasive species, such as Bermuda grass, tamarisk and phragmites, were present at the site, they had low cover due to maintenance weeding. Each of these species had less than 1% cover throughout the growing season. This low cover of invasive species is primarily due to regular maintenance weeding at the site. Routine maintenance will continue at this site to allow native species to thrive.

Sandbar willow shrub cover at the HA AWPF early action seed plot project area increased from the 2007 to the 2008 growing seasons, however total cover still remained minimal (Figure 3-16). Sandbar willow was planted as poles within the early action sites as well as along the South Channel. This species has successfully recruited within these areas, which has contributed to the increased cover observed.

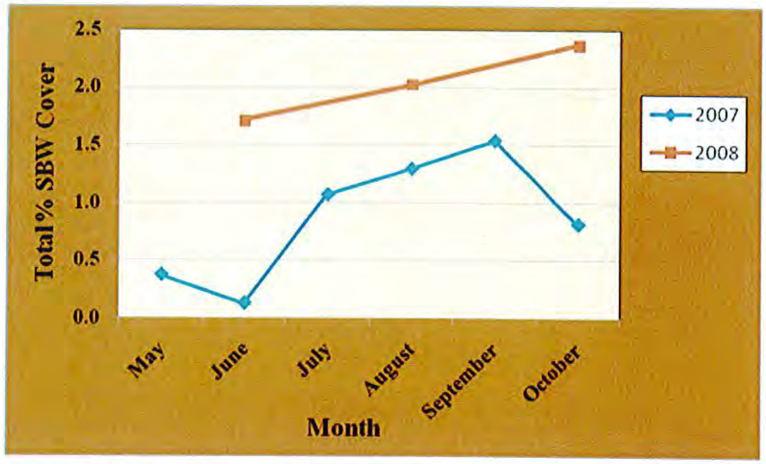

Figure 3-16: Total percent sandbar willow cover for the 2007 and 2008 monitoring seasons at the HA AWPF early action planting sites.

Other shrub species that were detected with minimal cover in the seedplots during the 2007 and 2008 growing seasons include screwbean mesquite, wolfberry and arrowweed. Screwbean mesquite containerized stock was planted within the seed plot area. The soil salinity was high in many of the seed plot areas, and the perseverance of the screwbean mesquite indicates that they can survive in higher salinities. In 2007, screwbean mesquite cover was less than 0.5% and by 2008 screwbean mesquite cover increased to just under 1%. Wolfberry germinated from seed during the 2006 monitoring season. This continued growth into the 2008 growing season indicates this plants ability to maintain in high salinity areas. Despite this persistence, wolfberry had less than 0.1% cover in 2007 and approximately 0.03% cover in 2008. Arrowweed was detected during the 2007 growing season with 0.5% cover and not detected in the 2008 growing season. This species is a weedy native and is often removed from sites when it begins to out-compete planted native species.

4.0 Conclusions and Recommendations

4.1 Project Conclusions

The Yuma East Wetlands HA AWPF Project has successfully transformed 25 acres of severely degraded habitat dominated by monotypic stands of salt cedar into a native riparian landscape. For the 2007 and 2008 growing seasons most of the planted trees, with the exception of the cottonwood, showed positive growth and healthy condition. The early action seed plots showed extensive growth from many salt tolerant native species and is providing habitat for an abundance of invertebrate and bird species. By aggressive weed maintenance and continued irrigation from the rising level of the South Channel (primarily from the Depoc 4 Bureau of Reclamation ground water well, as well as the COY decant water and rising river levels) this site is well on its way to becoming a thriving, self-sustaining native ecosystem.

Planting stress was the main factor affecting plant growth and health during the 2007 growing season. Native species planting was delayed due to the problems with the irrigation infrastructure and availability of certain species. The lateral tubing used on the drip irrigation system for the site was modified due to problems with accommodating the plant spacing within the revegetation design. Instead of using the ¾ in. polytubing with netafim in line emitters, ¾ in. polyltubing with spaghetti tubing and individual emitters was utilized. The irrigation set up was completed in June 2007, and planting was initiated after irrigation completion. During the irrigation replacement, many of the plants were on site being watered by a sprinkler system. These plants were subject to solar exposure, root confinement and irregular watering, which caused decreased conditions in the propogules at the time of planting. June is not an ideal time for planting in Yuma due to triple digit temperatures that are often achieved during this time. This added to the decreased condition observed in the plants.

Despite the initial effects of planting stress on the revegetated species in the 2007 growing season, the majority of the species thrived throughout the 2008 growing season. Most of the species showed positive growth between the 2007and 2008 growing seasons and ended the 2008 growing season in excellent condition. Water stress and salt stress were the main factors that impacted plant growth and health, particularly for cottonwood, honey mesquite and wolfberry during the 2008 growing season. Cottonwood trees were planted in an area that was dominated by clay soils with high salinities. This area was flood irrigated with water primarily from the Depoc 4 Bureau of Reclamation ground water well, which has an average salinity of over 2,300 ppm. This salinity level is near the tolerance level of cottonwood and willow species, and when combined with non-draining clay soils the site condition became intolerable for these species. More salt tolerant species, such as mesquite have been re-planted in this area. Wolfberry and honey mesquite condition was primarily affected by water stress. The water stress was caused by clogged drip irrigation emitters. The emitters were cleared after the monitoring session in August and by October water stress did not affect as many individuals.

Many native herbaceous species propagated from seed in the early action seed plots and continued to thrive in highly saline soils during the 2008 growing season where many other species perished. Alkali sacaton, western sea purslane and salt heliotrope propagated the best from seed. Many native herbaceous grassland, riparian and wetland species showed natural recruitment in areas where they were not planted. Inland saltgrass had the highest cover of any species at the site, covering up to 38% of the landscape. This species is highly adaptable to saline conditions and is the most successful herbaceous species growing in the riparian areas of the Yuma East Wetlands. During regular maintenance on the site, inland saltgrass plugs were planted on 5 ft centers to help prevent the re-colonization of invasive phragmites and tamarisk. After a year of planting at the above mentioned densities, inland saltgrass formed a dense monoculture.

Threesquare bulrush and alkali sacaton are also thriving in the seed plots and have significant cover. Threesquare bulrush propagated from seed a year after planting due to the necessity of going through a cold winter. This species and other wetland species such as California bulrush, hardstem bulrush and alkali bulrush grow more substantially when planted as plugs. When these species are planted as 4 inch deep plugs on 5 ft centers, full coverage of an area generally occurred.

Marsh fleabane is a native species that often quickly re-colonizes restoration sites in Yuma. This species was found to be successful when transplanted as plugs. Yerba mansa propagated during the 2007 growing season, and was not detected during the previous year. This indicates that this species requires the proper physical and/or environmental factors to instigate propagation. Yerba mansa requires a 24-hour freshwater soak prior to planting into containers (Munz 1973, Diggs 1999, Young 2001). These species also have a higher rate of survivorship if planted from containers onto the site. Once established this species continued to thrive during the 2008 growing season. There are several areas where large stands of yerba mansa are becoming established.

For the second growing season at the HA AWPF site, the planted native vegetation, with the exception of cottonwood species, was in very good to excellent condition and experiencing positive growth. As the plants mature and their root systems become more established, the plants will continue to thrive at the site. This site has high soil salinities, which were planted with salt tolerant species, however this may affect plant growth in the future. Maintenance will continue at the site to insure that invasive and non-native species recolonization is kept at bay and that the irrigation infrastructure is functioning. Invasive phragmites has proved to be a difficult competitor to exterminate from riparian and wetland sites in the Yuma East Wetlands. Aggressive control of this species will need to continue on a regular basis to make sure this species does not out-compete native species.

4.2 Recommendations for Future Projects

The complete mortality of cottonwood at the HA AWPF project site provided clarity on the importance of determining the site conditions and the tolerance level of native species to those conditions prior to planting. The area planted with cottonwoods was irrigated sufficiently with flood irrigation, however the proper drainage was lacking. The area where cottonwoods were planted and along the South Channel was located in the historic Gila River channel, which may be the cause of the high soil content. Other restoration project areas within the YEW that had high clay content were planted with high salt tolerant species such as marsh vegetation and mesquite. These species have shown success in high clay content areas so it is recommended that these species be planted in the future in areas that have these site conditions.

High soil salinities are going to continue to be a problem in the Yuma East Wetlands. The primary water source for the site is from the Depoc 4 Bureau of Reclamation ground water well, which has high salinity as discussed above. Rarely high flows from the Colorado River reach the project site bringing in fresh water (700 ppm). Despite these challenging site conditions, restoration techniques using salt tolerant species such as mesquite, sandbar willow, marsh and saltgrass have been successful. In sites that have high salinities these species will be utilized.

The early action seed plot planting provided great insight on propagating many native species from seed. Inland saltgrass was the most successful species planted by plugs and it appears to be tolerant of the high soil salinity levels that it was planted in. Inland saltgrass plugs planted on 5 ft centers showed to be sufficient in creating a dense monoculture in one year. This prevents invasive species such as phragmites and tamarisk from re-colonizing the site. This method will continue to be used in future restoration projects.

Other species such as alkali sacaton, western sea purslane and salt heliotrope propagated the best from seed and should continue to be planted in this way. While many of the species propagated from seed to some degree, other species such as pickleweed and seep willow did not propagate successfully. It is recommended that if these species are desired for a restoration project in the future that they are planted by a more successful means such as plugs or containerized stock. Finally, many of the species have specific requirements for propagation success, including seed scarring, freezing, inundation for a period of time and specific soil mixes. It is recommended that before propagating native species from seed that thorough research be conducted in order to determine the most successful techniques for propagation.

5.0 References

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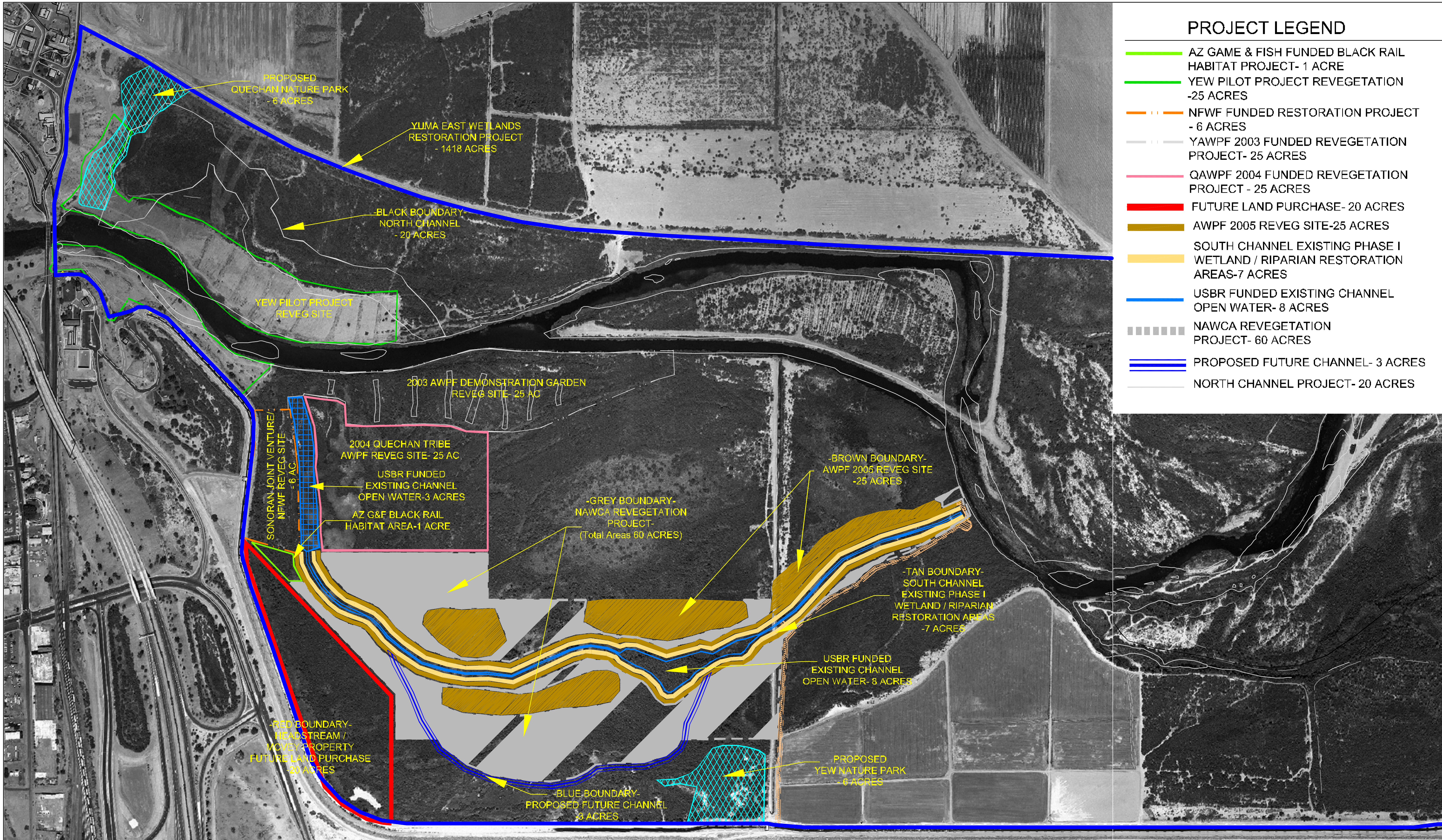
Yuma Crossing National Heritage Area
Yuma East Wetlands Restoration Project – Phase I

Appendix A.

Grant NO. 06-140WPF



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Ecosystem Restoration Land Planning

REV.	COMMENT	DATE

YUMA EAST WETLANDS

PROJECT BOUNDARIES OF ALL SUBPROJECTS

CITY OF YUMA YUMA, ARIZONA

SHEET TITLE :

PROJECT BOUNDARIES

0 163 325 650ft NORTH

DATE: JANUARY 20, 2006
JOB NO.:
DRAWN BY: AH
DESIGNED BY: FOP/AH
CHECKED BY: FOP

SHEET NO.:

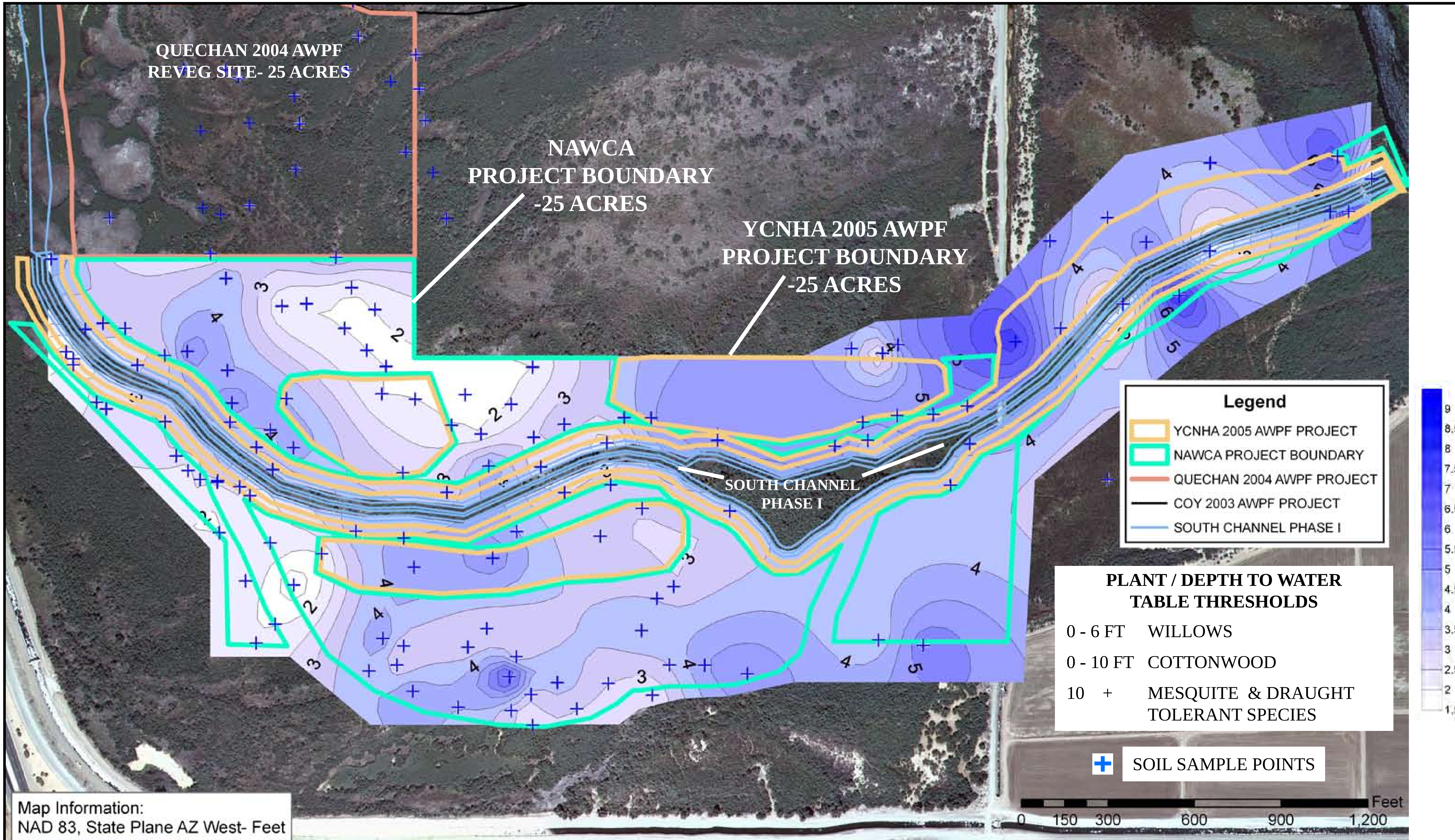
1 OF 1

DSC_0014.JPG 2006/03/09 11:02:48

Yuma Crossing National Heritage Area
Yuma East Wetlands Restoration Project – Phase I

Appendix B.

Grant NO. 06-140WPF



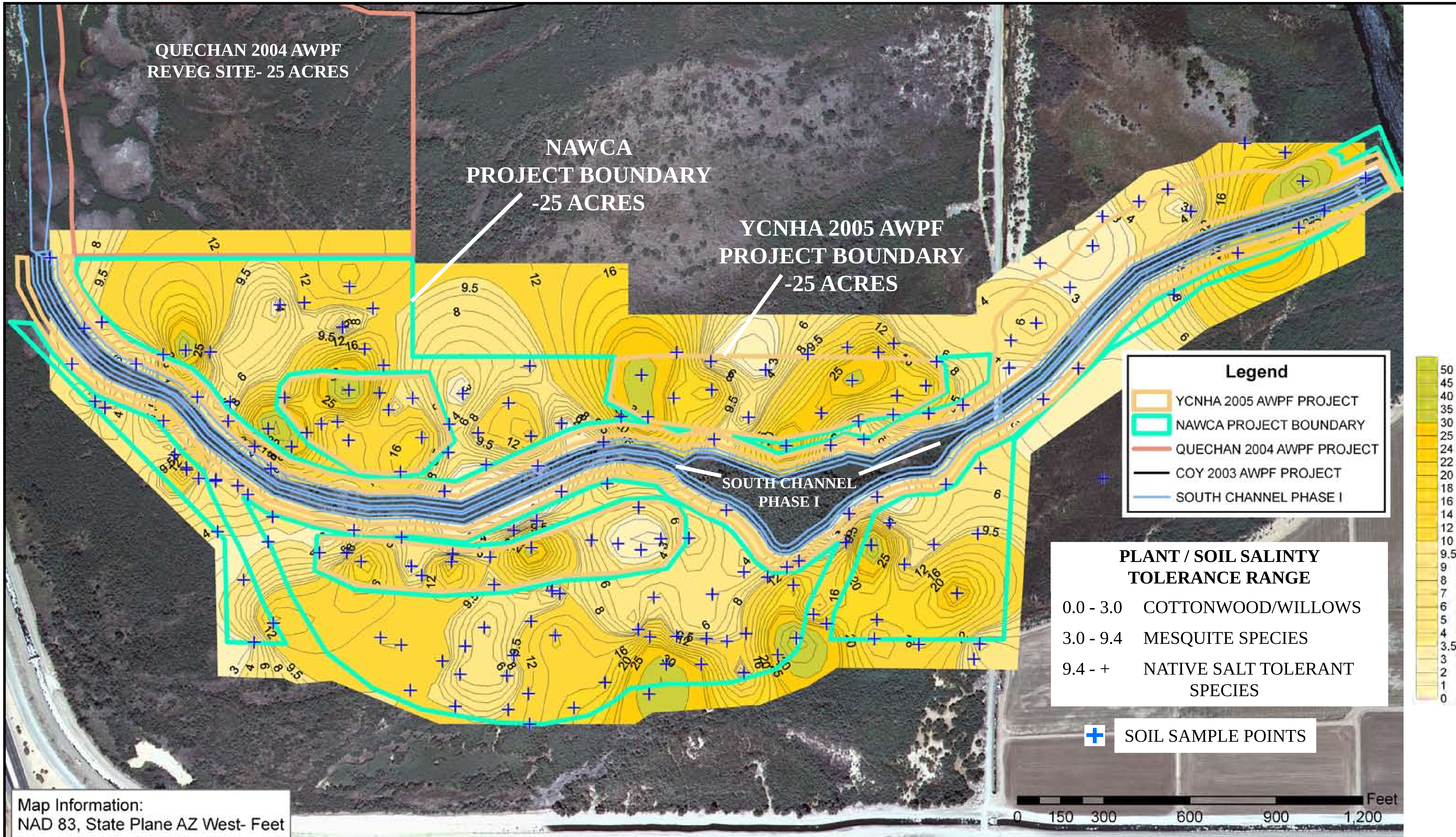
FRED PHILLIPS CONSULTING
9730 N. ROSEWOOD DRIVE
FLAGSTAFF AZ, 86004

YUMA EAST WETLANDS
YCNHA AWPF REVEGETATION PROJECT
NAWCA REVEGETATION PROJECT

DEPTH TO WATER TABLE
LEVELS

JULY 2006

FIGURE 1

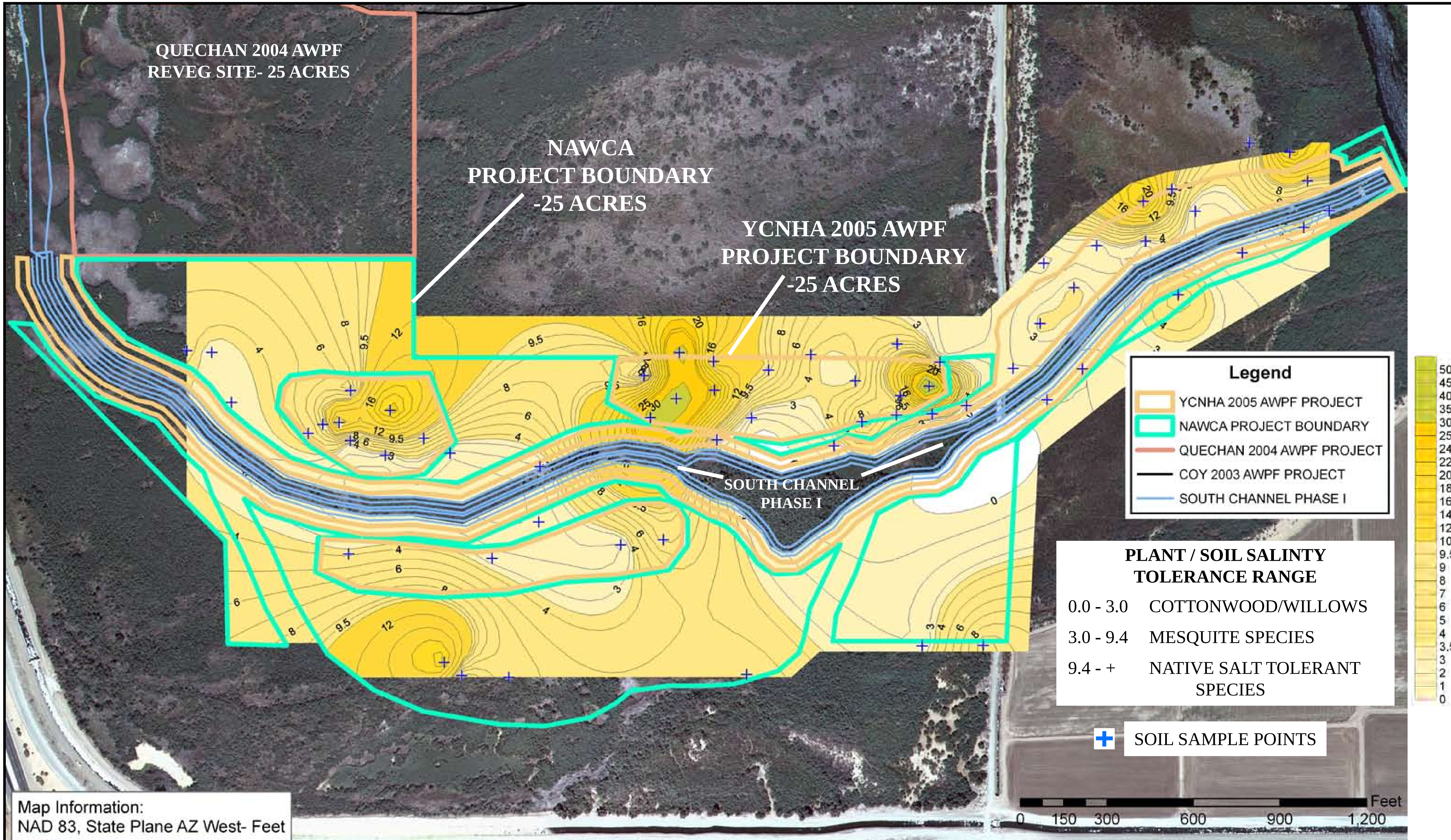


FRED PHILLIPS CONSULTING
9730 N. ROSEWOOD DRIVE
FLAGSTAFF AZ, 86004

YUMA EAST WETLANDS
YCNHA AWPF REVEGETATION PROJECT
NAWCA REVEGETATION PROJECT

SALINITY LEVELS AT
2 FOOT DEPTH

JULY 2006 FIGURE 2



FRED PHILLIPS CONSULTING
9730 N. ROSEWOOD DRIVE
FLAGSTAFF AZ, 86004

YUMA EAST WETLANDS
YCNHA AWPF REVEGETATION PROJECT
NAWCA REVEGETATION PROJECT

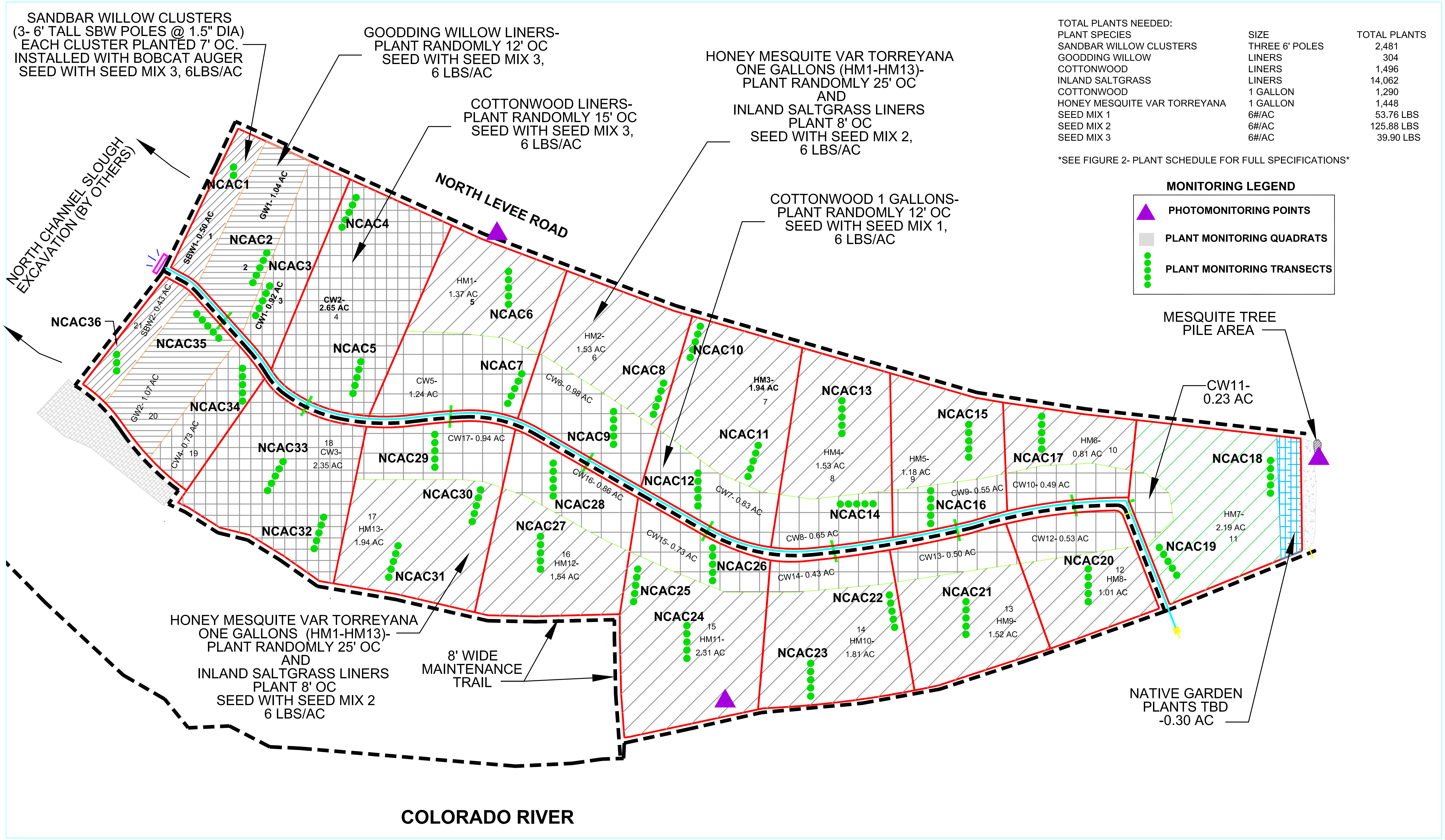
SALINITY LEVELS AT
5 FOOT DEPTH

JULY 2006 FIGURE 3

Yuma Crossing National Heritage Area
Yuma East Wetlands Restoration Project – Phase I

Appendix C.

Grant NO. 06-140WPF



TOTAL PLANTS NEEDED:

PLANT SPECIES	SIZE	TOTAL PLANTS
SANDBAR WILLOW CLUSTERS	THREE 6' POLES	2,481
GOODDING WILLOW	LINERS	304
COTTONWOOD	LINERS	1,496
INLAND SALTGRASS	LINERS	14,062
COTTONWOOD	1 GALLON	1,290
HONEY MESQUITE VAR TORREYANA	1 GALLON	1,448
SEED MIX 1	6#/AC	53.76 LBS
SEED MIX 2	6#/AC	125.88 LBS
SEED MIX 3	6#/AC	39.90 LBS

SEE FIGURE 2- PLANT SCHEDULE FOR FULL SPECIFICATIONS

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FAX 928 774 4166
Ecosystem Restoration Land Planning

Doug Mellon Farms, INC
COPPER RIVER, INC
2197 SOUTH 4TH AVE STE 206
YUMA, AZ
85364
TEL 928 782 4482
FAX 928 782 0688

REV.	COMMENT	DATE

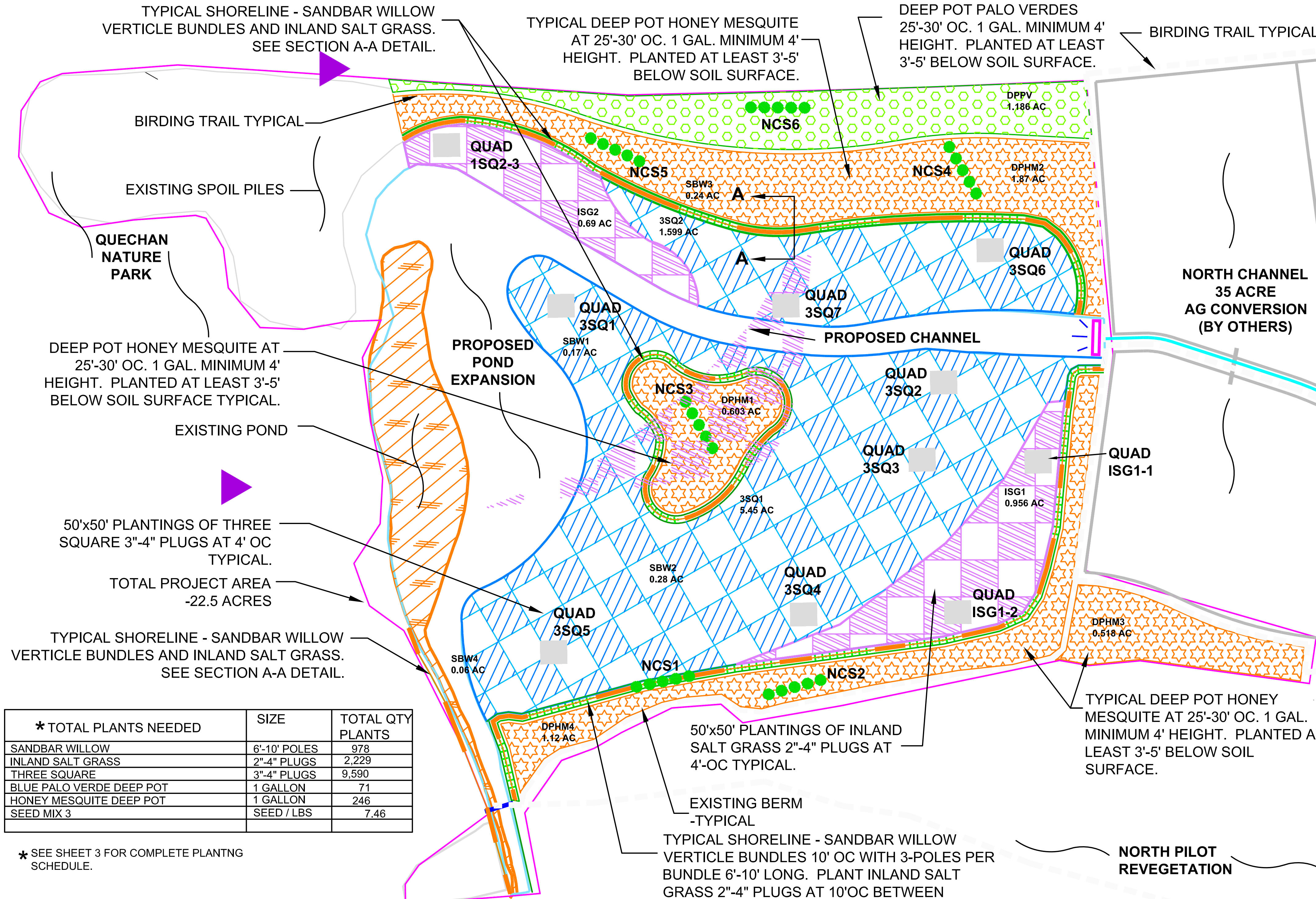
YUMA EAST WETLANDS

QUECHAN 35 ACRE NORTH CHANNEL
AG CONVERSION PROJECT + RIPARIAN REVEGETATION
–QUECHAN TRIBAL NATION–
–YUMA CROSSING NATIONAL HERITAGE AREA–

SHEET TITLE :
CMAR MONITORING PLAN

DATE: JANUARY 19, 2009
JOB NO.:
DRAWN BY: AH/BP
DESIGNED BY: FOP/AH/CM/KE/MW
CHECKED BY: FOP

SHEET NO.:
FIGURE 1



* TOTAL PLANTS NEEDED	SIZE	TOTAL QTY PLANTS
SANDBAR WILLOW	6'-10' POLES	978
INLAND SALT GRASS	2"-4" PLUGS	2,229
THREE SQUARE	3"-4" PLUGS	9,590
BLUE PALO VERDE DEEP POT	1 GALLON	71
HONEY MESQUITE DEEP POT	1 GALLON	246
SEED MIX 3	SEED / LBS	7.46

* SEE SHEET 3 FOR COMPLETE PLANTNG SCHEDULE.

MONITORING LEGEND

- PHOTOMONITORING POINTS
- PLANT MONITORING QUADRATS
- PLANT MONITORING TRANSECTS

DESIGN LEGEND

- MAINTENANCE ROAD
- BIRDING TRAILS
- PROPOSED POND EXPANSION & CHANNEL - 4.20 ACRES
- THREESQUARE- 7.05 ACRES
- INLAND SALTGRASS- 1.40 ACRES
- DEEP POT HONEY MESQUITE - 4.11 ACRES
- DEEP POT PALO VERDE - 1.19 ACRES
- SANDBAR WILLOW BUNDLES & INLAND SALT GRASS SHORELINE- 3387 LINEAR FEET
- 48" STOPLOG STRUCTURE
- OUTFALL / WATERFALL STRUCTURE (BY OTHERS)
- EXISTING POND AREA
- TOTAL PROJECT AREA- 22.5 ACRES

NC_SloughDESIGN_planting_101508.dwg

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PG&E, LLC
PO BOX 11360
PRESCOTT, AZ
86304
TEL 623 561 6094
FAX 623 561 2968

REV.	COMMENT	DATE

YUMA EAST WETLANDS

NORTH CHANNEL PROJECT– PLAN B
SLOUGH EXCAVATION CMAR DESIGN– 22.5 ACRES
QUECHAN TRIBAL NATION
YCNHA

SHEET TITLE :
N.C. SLOUGH PLANTING DESIGN

0 35 70 140ft NORTH

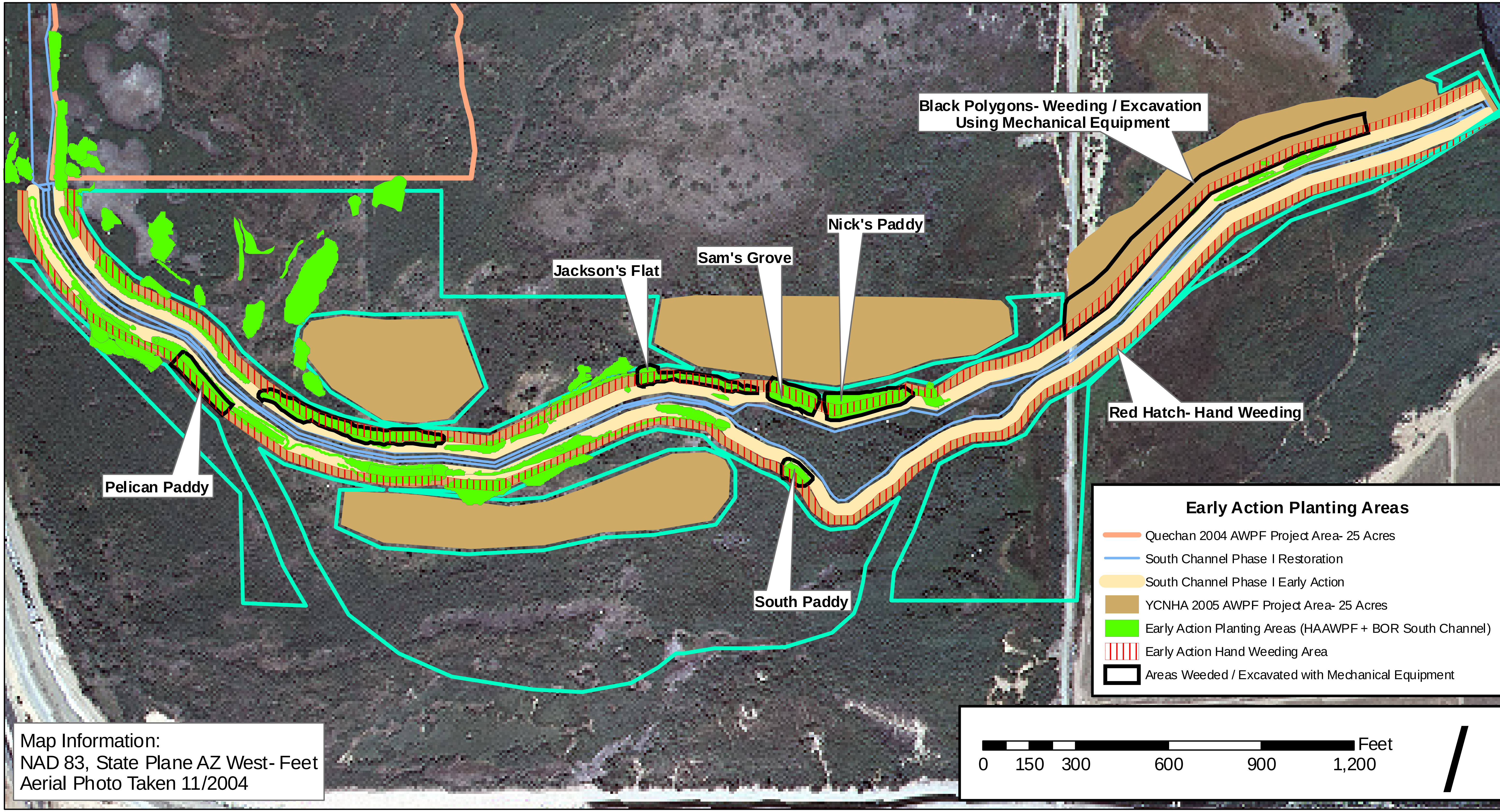
DATE: JANUARY 20, 2009
JOB NO.:
DRAWN BY: AH/DB/BP
DESIGNED BY: FOP/AH/DP/KE/MW
CHECKED BY: FOP/DP

SHEET NO.:
SHEET 1 OF 3

Yuma Crossing National Heritage Area
Yuma East Wetlands Restoration Project – Phase I

Appendix D.

Grant NO. 06-140WPF



Submitted by:
Fred Phillips Consulting, LLC
9730 N. Rosewood Dr
Flagstaff, AZ 86004

Yuma East Wetlands
YCNHA AWPF Revegetation Project
NAWCA Revegetation Project
Early Action Planting Areas

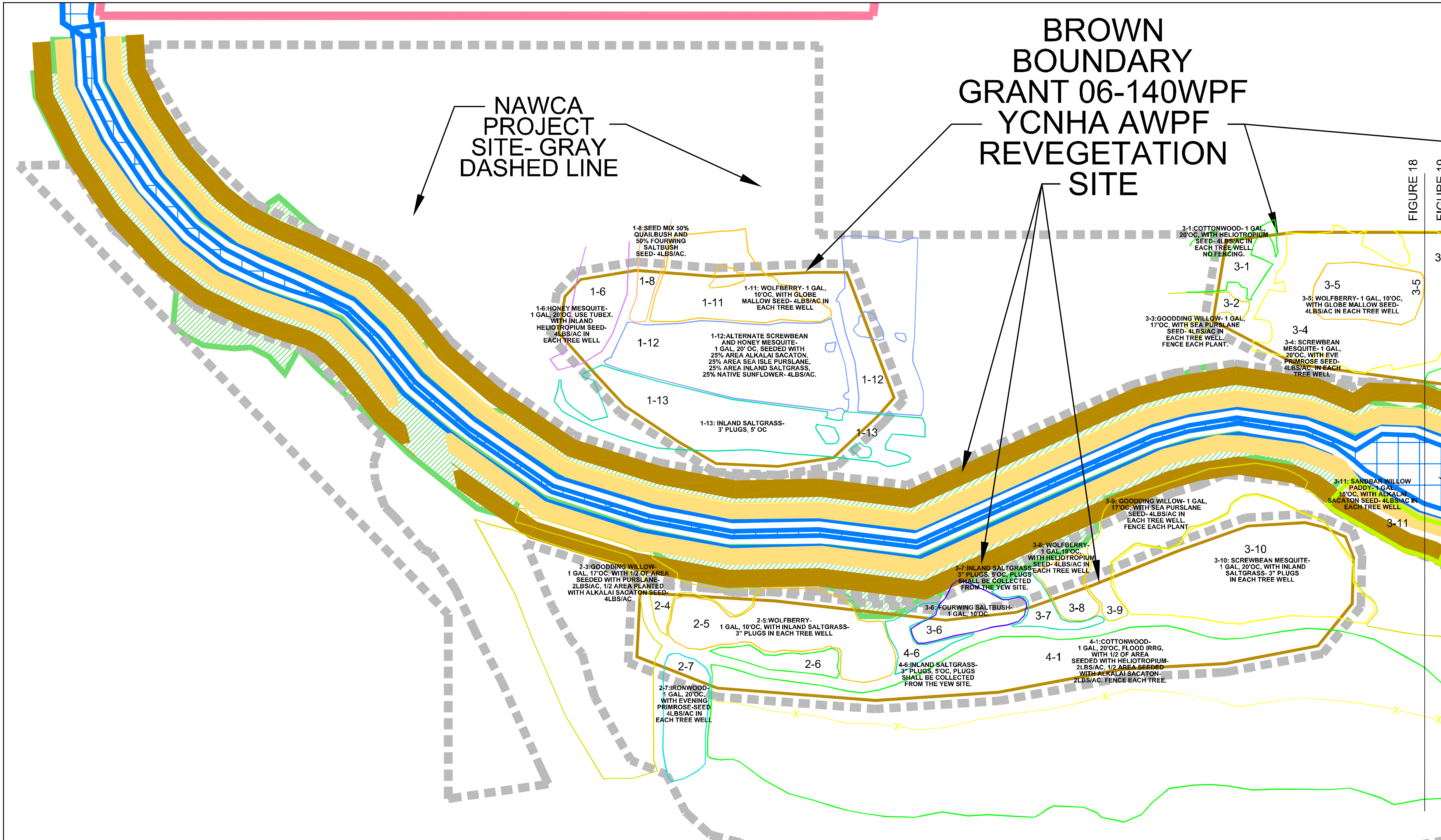
July 24, 2006

Early Action Planting Areas
Figure 1

Yuma Crossing National Heritage Area
Yuma East Wetlands Restoration Project – Phase I

Appendix E.

Grant NO. 06-140WPF



Fred Phillips Consulting, LLC
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FAX 928 774-4166
Ecosystem Restoration Land Planning

REV.	COMMENT	DATE

YUMA EAST WETLANDS

NAWCA / HAAWPF PROJECTS
BANK STABILIZATION AND
WATER DISTRIBUTION DESIGN

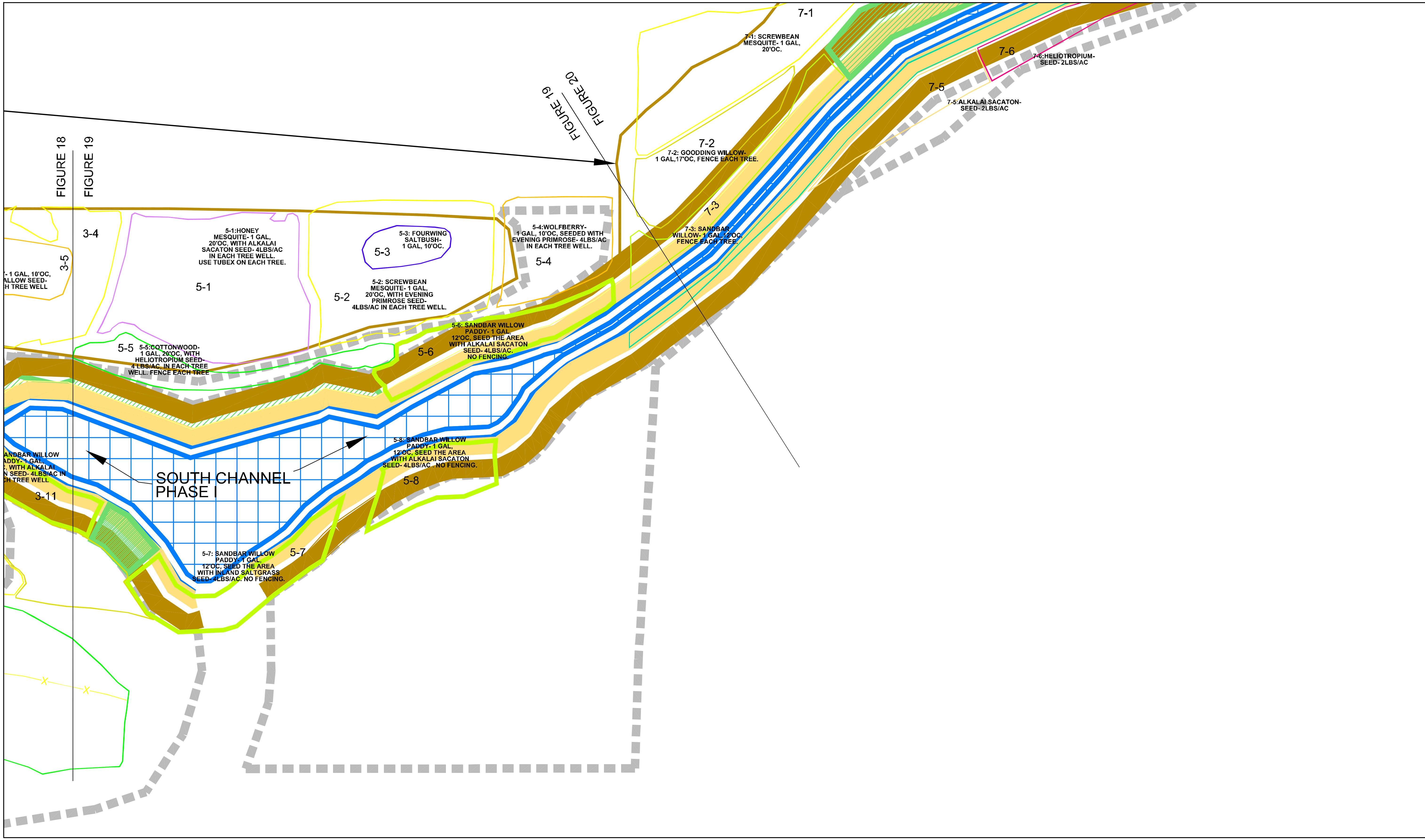
CITY OF YUMA YUMA, ARIZONA

SHEET TITLE :
ASBUILT
PLANTING 1

0 40 80 160ft NORTH

DATE: JULY 31, 2007
JOB NO.:
DRAWN BY: AH
DESIGNED BY: FOP/AH
CHECKED BY: FOP

SHEET NO.:
FIGURE 18



Fred Phillips Consulting, LLC
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FAX 928 774-4166
Ecosystem Restoration Land Planning

REV.	COMMENT	DATE

YUMA EAST WETLANDS

NAWCA / HAAWPF PROJECTS
BANK STABILIZATION AND
WATER DISTRIBUTION DESIGN

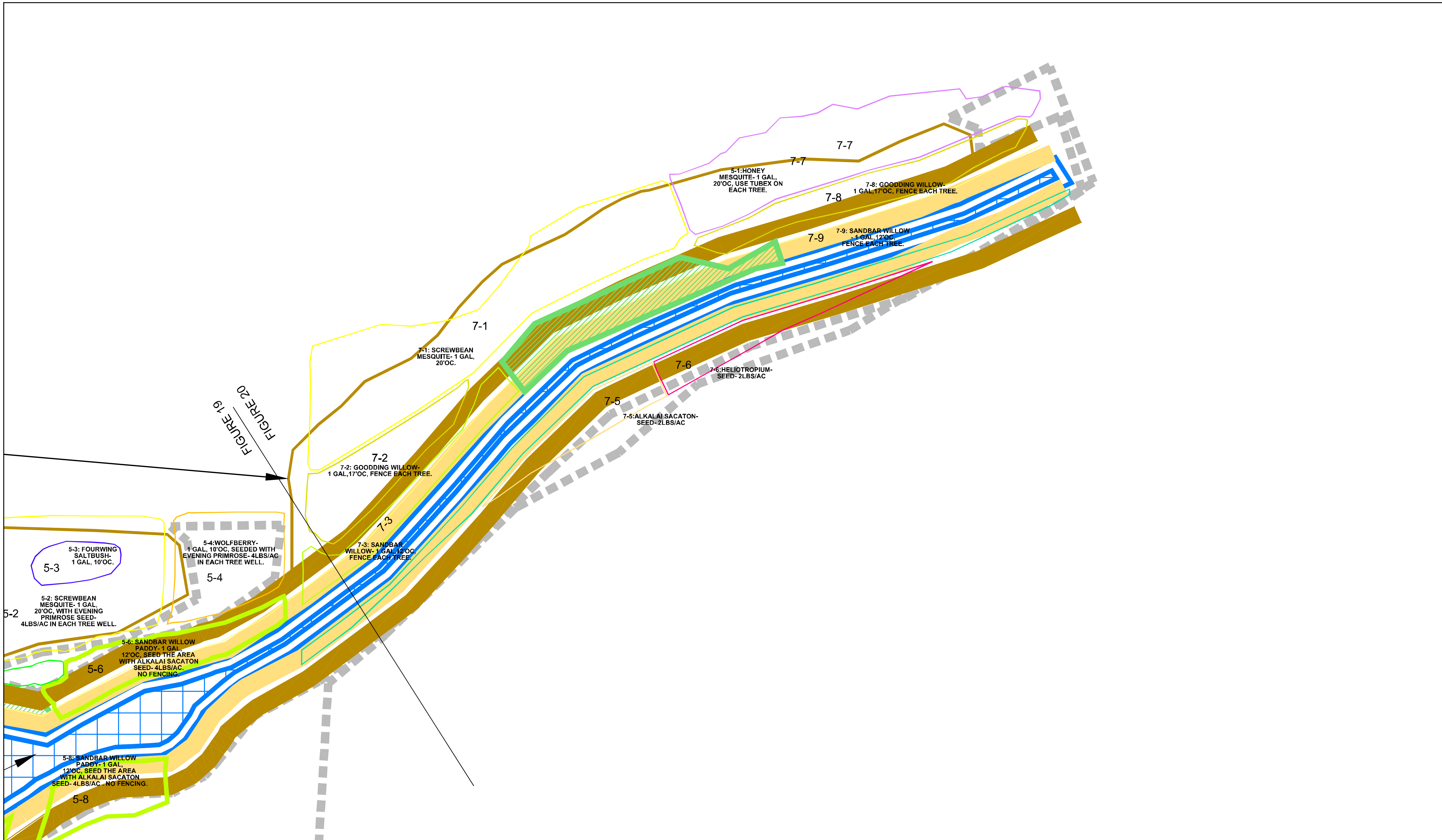
CITY OF YUMA YUMA, ARIZONA

SHEET TITLE :
ASBUILT PLANTING 2

0 40 80 160ft NORTH

DATE: JULY 31, 2007
JOB NO.:
DRAWN BY: AH
DESIGNED BY: FOP/AH
CHECKED BY: FOP

SHEET NO.:
FIGURE 19



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Ecosystem Restoration Land Planning

REV.	COMMENT	DATE

YUMA EAST WETLANDS

NAWCA / HAAWPF PROJECTS
BANK STABILIZATION AND
WATER DISTRIBUTION DESIGN

CITY OF YUMA YUMA, ARIZONA

SHEET TITLE :
ASBUILT PLANTING 3

0 40 80 160ft NORTH

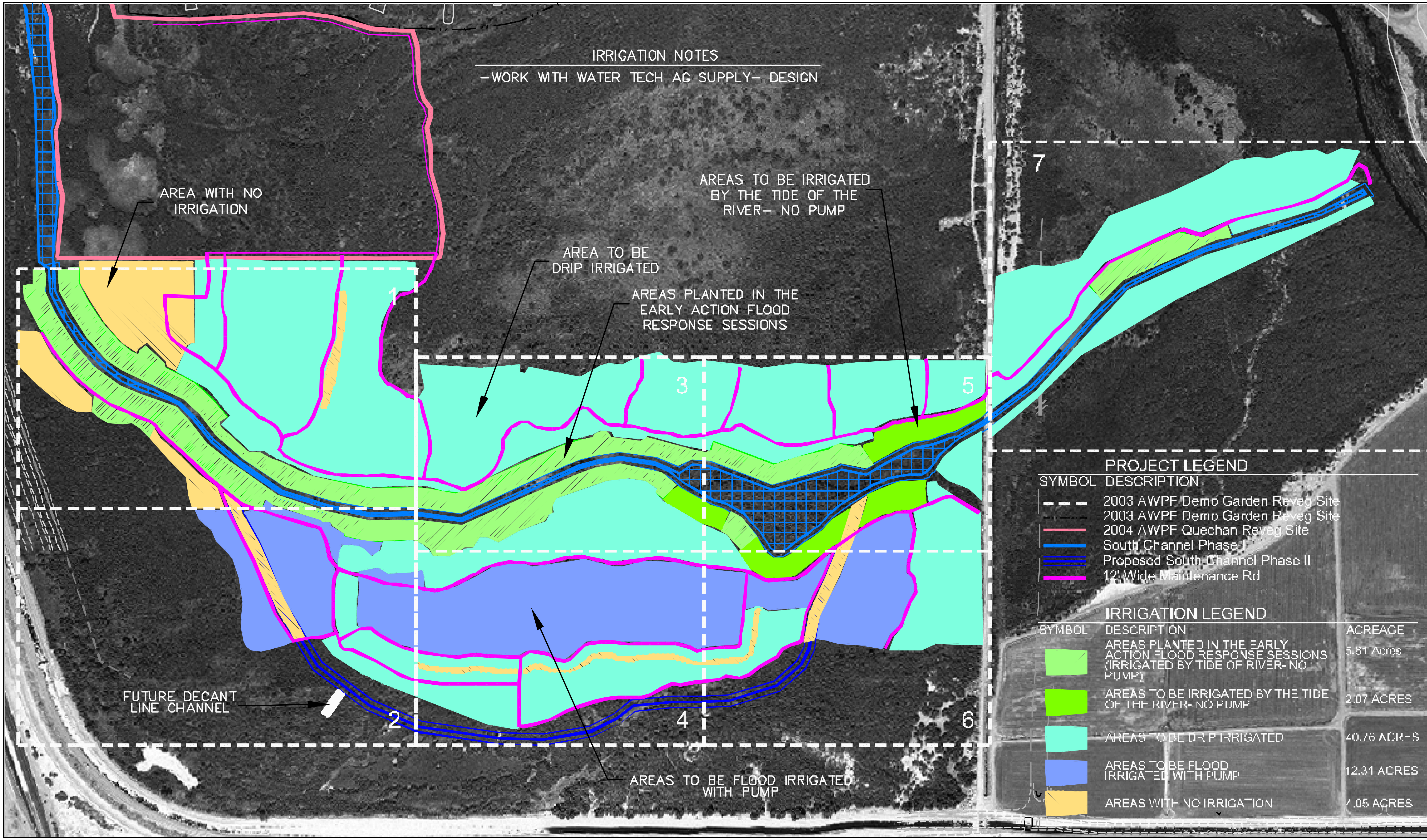
DATE: JULY 31, 2007
JOB NO.:
DRAWN BY: AH
DESIGNED BY: FOP/AH
CHECKED BY: FOP

SHEET NO.:
FIGURE 20

Yuma Crossing National Heritage Area
Yuma East Wetlands Restoration Project – Phase I

Appendix F.

Grant NO. 06-140WPF



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FAX 928 526 1643
Ecosystem Restoration Land Planning

REV.	COMMENT	DATE

YUMA EAST WETLANDS

NAWCA / HAAWPF PROJECTS
PLANTING + IRRIGATION DESIGN

CITY OF YUMA YUMA, ARIZONA

SHEET TITLE :
IRRIGATION SCHEMATIC

0 160 320 640ft NORTH

DATE: JULY 24, 2006
JOB NO.:
DRAWN BY: AH
DESIGNED BY: FOP/AH
CHECKED BY: FOP

SHEET NO.:
? OF ??

Yuma Crossing National Heritage Area
Yuma East Wetlands Restoration Project – Phase I

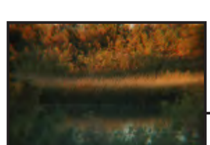
Appendix G.

Grant NO. 06-140WPF

Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #1. June 2007. Facing West North-West

Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #1. July 2007. Facing West North-West

Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #1. October 2007. Facing West North-West



Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #2. June 2007. Facing East

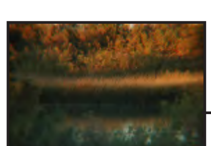
Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #2. July 2007. Facing East

Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #2 October 2007. Facing East

Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #3. June 2007. Facing North-East

Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #3. July 2007. Facing North-East

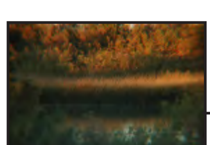
Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #3. October 2007. Facing North-East



Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #4. June 2007. Facing East

Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #4. July 2007. Facing East

Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #4. October 2007. Facing East



Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #5 June 2007. Facing South

Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #5. July 2007. Facing South

Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #5. October 2007. Facing South

Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #1. June 2008. Facing West North-West

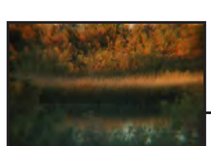
Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #1. August 2008. Facing West North-West

Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #1. September 2008. Facing West North-West

Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #2. June 2008. Facing East

Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #2. August 2008. Facing East

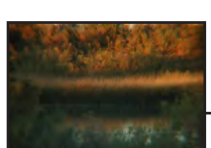
Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #2 September 2008. Facing East



Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #3. June 2008. Facing North-East

Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #3. September 2008. Facing North-East

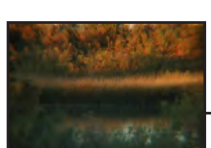
Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #3. September 2008. Facing North-East



Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #4. June 2008. Facing East

Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #4. August 2008. Facing East

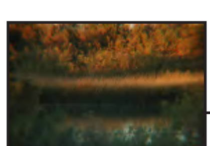
Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #4. September 2008. Facing East




Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #5 June 2008. Facing South


Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #5. August 2008. Facing South

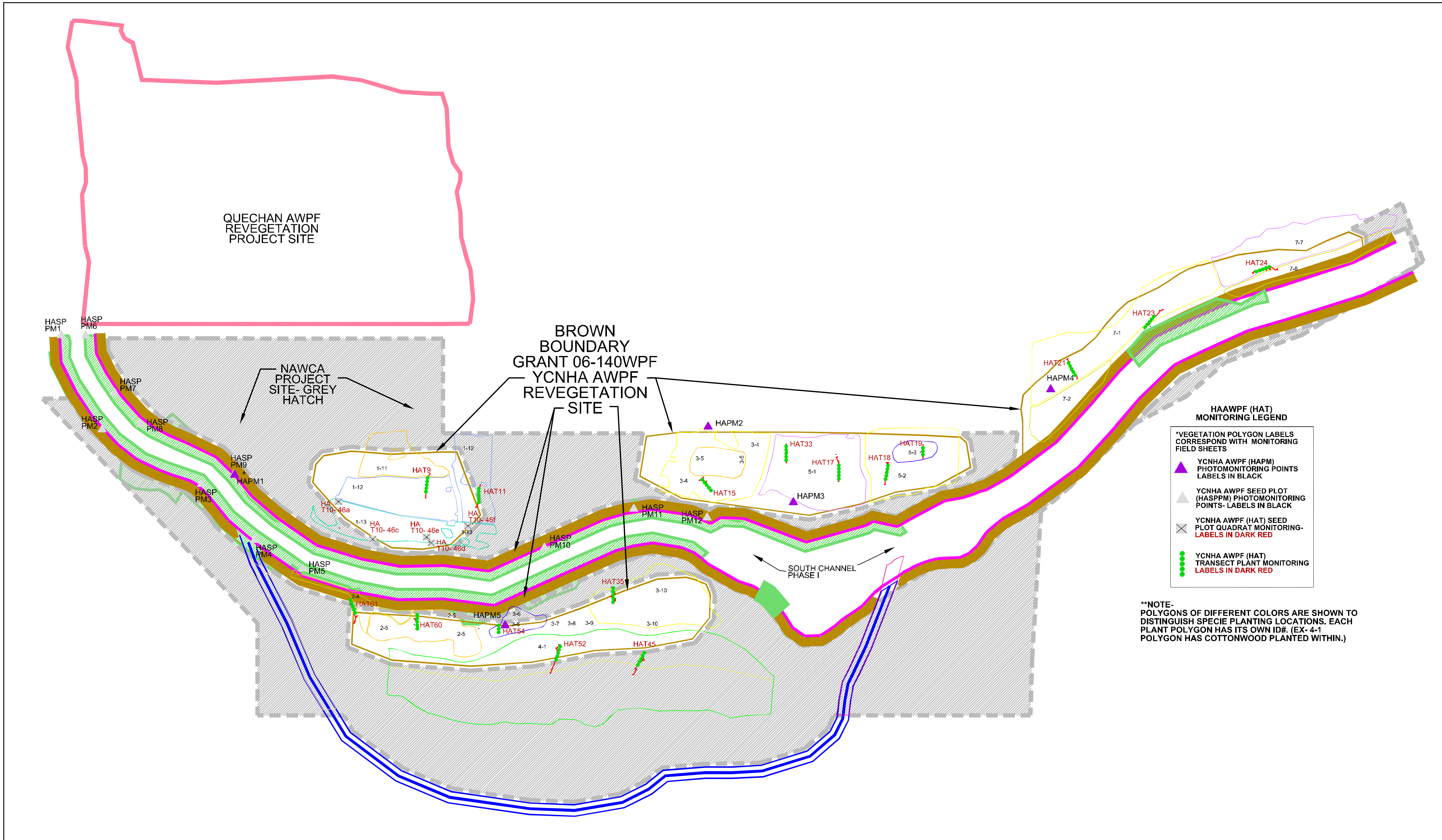

Yuma East Wetlands Heritage Area Arizona Water Protection Fund (HAAWPF) Site Photomonitoring Location #5. September 2008. Facing South



Yuma Crossing National Heritage Area
Yuma East Wetlands Restoration Project – Phase I

Appendix H.

Grant NO. 06-140WPF



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Ecosystem Restoration Land Planning

REV.	COMMENT	DATE

YUMA EAST WETLANDS

HAAWPF PROJECT
BANK STABILIZATION AND
WATER DISTRIBUTION DESIGN

CITY OF YUMA YUMA, ARIZONA

SHEET TITLE :
PROJECT LOCATION COVER

0 80 160 320ft NORTH

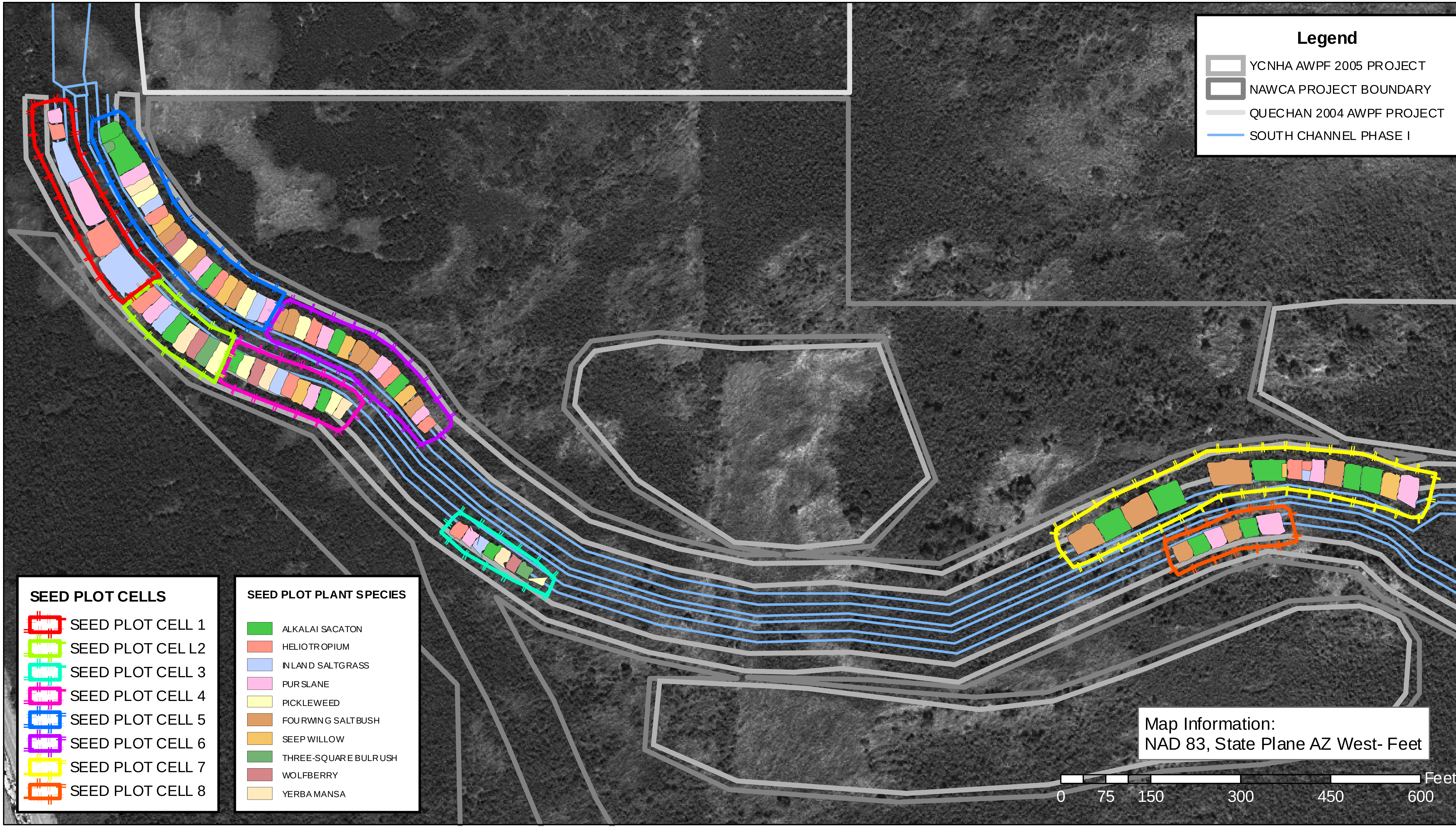
DATE: APRIL 3, 2007
JOB NO.:
DRAWN BY: AH
DESIGNED BY: FOP/AH
CHECKED BY: FOP
DESIGN SHEET 0 OF 11

SHEET NO.:
FIGURE 3

Yuma Crossing National Heritage Area
Yuma East Wetlands Restoration Project – Phase I

Appendix I.

Grant NO. 06-140WPF



Fred Phillips Consulting, LLC
928-773-1530

YUMA EAST WETLANDS
HA AWPF 25-ACRE EARLY ACTION REVEGETATION ACTIVITIES

DECEMBER 2006

SEED PLOT LOCATIONS

FIGURE 2.1.1

Yuma Crossing National Heritage Area
Yuma East Wetlands Restoration Project – Phase I

Appendix J.

Data Sheets on file in AWPF office

Grant NO. 06-140WPF

Yuma Crossing National Heritage Area
Yuma East Wetlands Restoration Project – Phase I

Appendix K.

Grant NO. 06-140WPF

HAAWPF Seedplot Photopoint #1. May 2007

HAAWPF Seedplot Photopoint #2. May 2007

HAAWPF Seedplot Photopoint #1. June 2008

HAAWPF Seedplot Photopoint #2. June 2008

HAAWPF Seedplot Photopoint #3. May 2007

HAAWPF Seedplot Photopoint #4. May 2007

HAAWPF Seedplot Photopoint #3. June 2008

HAAWPF Seedplot Photopoint #4. June 2008


HAAWPF Seedplot Photopoint #5. May 2007


HAAWPF Seedplot Photopoint #6. May 2007


HAAWPF Seedplot Photopoint #5. June 2008


HAAWPF Seedplot Photopoint #6. June 2008


HAAWPF Seedplot Photopoint #7. May 2007


HAAWPF Seedplot Photopoint #8. May 2007


HAAWPF Seedplot Photopoint #7. June 2008


HAAWPF Seedplot Photopoint #8. June 2008


HAAWPF Seedplot Photopoint #9a. May 2007


HAAWPF Seedplot Photopoint #9b. May 2007


HAAWPF Seedplot Photopoint #9a. June 2008


HAAWPF Seedplot Photopoint #9b. June 2008


HAAWPF Seedplot Photopoint #10. May 2007


HAAWPF Seedplot Photopoint #11. May 2007


HAAWPF Seedplot Photopoint #10 June 2008


HAAWPF Seedplot Photopoint #11. June 2008


HAAWPF Seedplot Photopoint #12. May 2007


HAAWPF Seedplot Photopoint #12. June 2008