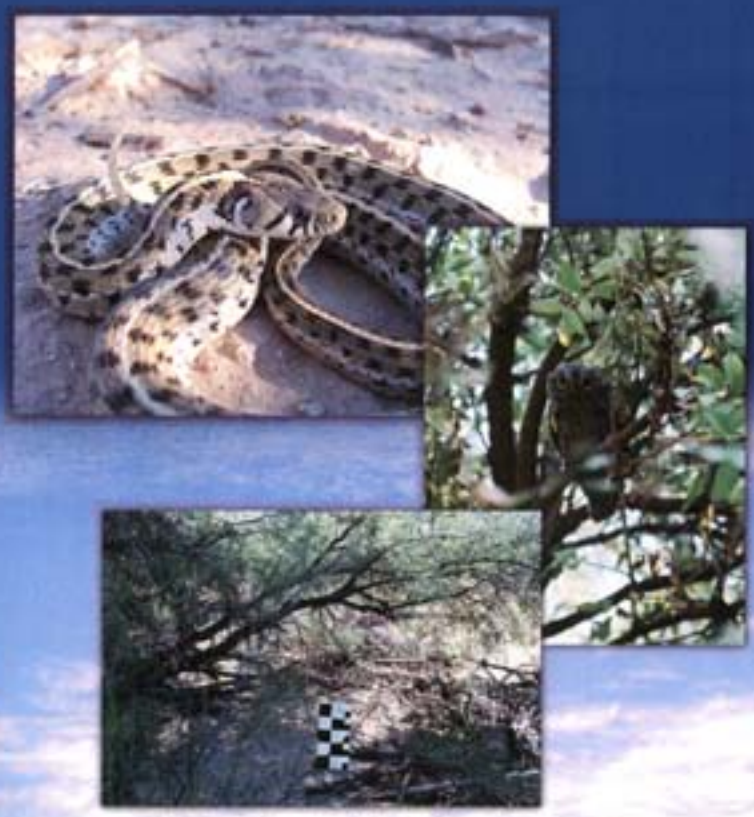
HIGH PLAINS EFFLUENT RECHARGE PROJECT

BIOLOGICAL MONITORING 2006



FOR:
Pima County Department of transportation and Flood Control District

DATE:
December 2006

PREPARED BY:

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HIGH PLAINS EFFLUENT RECHARGE PROJECT
BIOLOGICAL STUDIES
MONITORING REPORT - 2006

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1 INTRODUCTION

The Pima County Flood Control District (PCFCD) constructed an aquifer recharge demonstration project on an approximately 7.28 hectare (18-acre) site on the Santa Cruz River near Marana, Pima County, Arizona (Figure 1). Construction of the facility was completed in 2002, and the facility was operational beginning in February of 2003. The demonstration project provides floodplain aquifer recharge using treated effluent from the Santa Cruz River. Recharge is via infiltration from five shallow basins.

Prior to construction, a baseline description of the site was prepared by Entranco (1998) under contract to the PCFCD. That report included a brief history of the site with regard to human-caused changes in the surface flow, groundwater hydrology and land use of the region. The report also included baseline data collection and a description of the biological characteristics of the site.

In 2002 Environmental Planning Group (EPG) conducted initial monitoring of the biological characteristics of the site, and provided a report of the recently constructed, but then non-operational recharge project (EPG 2000). This initial report was the first of a planned long-term series of monitoring reports on the aquifer recharge site. A follow up report was produced in 2004 (EPG 2004), and contained analysis and comparison of data with the studies performed in 1998 and 2002. The present report (2006) follows the methodology established during the 2002 study season and continues with data accumulation at the established two year sampling interval. Data compiled for the 2006 season is compiled in the current report, and comparisons with the three previous studies are made.

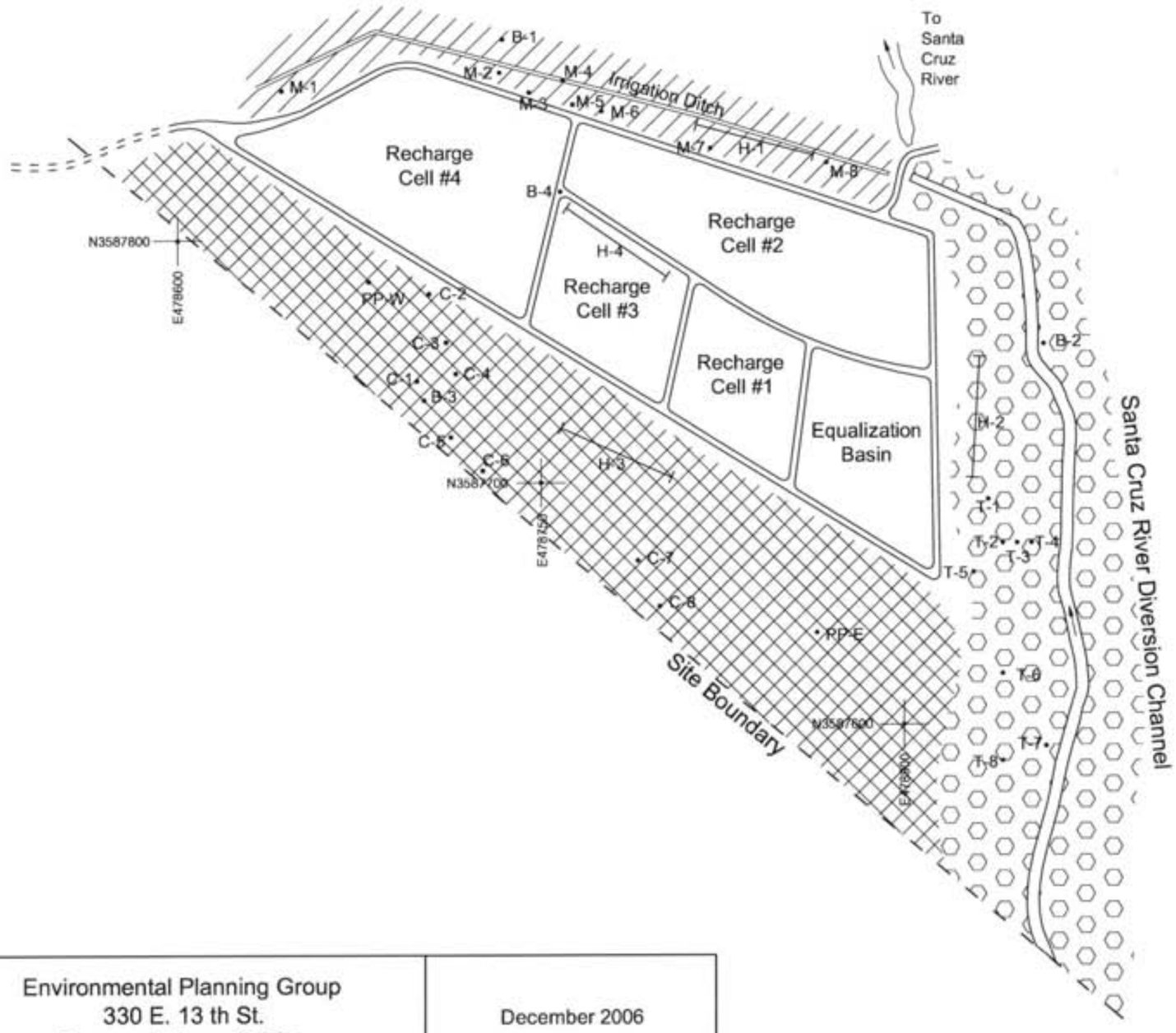
Figure 1. High Plains Effluent Recharge Project site location map.

2 METHODS

2.1 VEGETATION

Vegetation at the High Plains Effluent Recharge Site was originally established by Entranco (1998), and modified by EPG in 2002 (EPG 2002). Plant communities were identified on a large-scale aerial photograph of the site, and each community was treated as a separate stratum in the data collection. Plant communities were classified using the Brown, Lowe, Pase (1979) digitized plant community classification system. To randomize vegetation sample point locations within each community, a grid of points spaced at 6 m was placed on the aerial photograph. Within a community, random points were selected using random number generation software (Random.org. 1998). The location of each point was found in the field by reference to identifiable features such as trees, large shrubs, open areas, and drainage features.

Eight vegetation sample points were selected in each of the three habitats dominated by relatively undisturbed, natural vegetation (Figure 2). Each point selected in this random process was used as the center point of a 4 m by 4 m plot, with an area of 16 sq. m.



N

50 0 100

Approximate Scale, m

Legend

Plant Communities

Creosote Bush Association

Mesquite-Palo Verde Association

Tamarisk-Willow Association

Sample Points

Creosote Bush Association Plots = C
Mesquite-Palo Verde Association Plots = M
Tamarisk-Willow Association Plots = T

Bird Point Counts = B
Herptile Transects = H
Panorama Photo Points = PP

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Figure 2. Site Plan Sketch
High Plains Effluent Recharge Site
Pima County Floodwater District

These plots were oriented with the boundaries in north-south and east-west directions.

For each live perennial plant on a study plot, the following data were recorded:

- maximum height within the plot;
- canopy length and width at one meter intervals above ground level; and
- location of stem inside or outside plot.

For plants under 1 meter in height, the maximum canopy was measured. For most plants the maximum height was below 7 m, and canopy extent was measured at one-meter intervals up to that point with a graduated telescoping pole. However, in one of the plots (T1) in the Tamarisk-Willow habitat a single athel tree (*Tamarix aphylla*) that dominated the plot was in excess of the maximum height of the pole (7.62 meters). For this plot, above the 7-meter height, visual estimates of the canopy and maximum plant height were made. Annual plants were not measured, but the percent cover of annual plants was estimated on each plot. Annual plant cover is not a useful measurement for long-term monitoring because of the extreme variability in annual or seasonal rainfall patterns.

For plants that were entirely within the plot, the canopy area was calculated by assuming that the area could be approximated by the area of an ellipse, defined as area = πab, where "a" is half of the larger measurement and "b" is half of the smaller measurement. Where these measurements are equal, this equation reduces to the area of a circle. When the two measurements differ greatly, the ellipse is a much more accurate representation of the canopy area. For plants with stems outside the plot, but with branches overhanging the plot, the canopy area was approximated by the area of a triangle with a base measured along the plot boundary and a height measured in from the boundary.

Within each plot, the total canopy area was calculated for each species at each height interval by adding the areas for individual plants. The total density of plants was calculated by dividing the total number of stems within the plot by 16 sq. m and multiplying by 10,000 sq. m/ha.

Within each community type, the following values were calculated from the plot data:

- Species frequency (fraction of total plots with at least one individual of a species);
- Mean height and standard deviation for each species (based on all individuals measured within the community);
- Mean canopy cover area and standard deviation for each species at each height interval;
- Mean percent canopy cover and standard deviation for each species at each height interval;
- Mean density and standard deviation for each plant community.

For the comparison of two means, the *t*-test is an appropriate statistical test. Differences

can be considered significant when the probability that the means are equal is less than 0.05.

Four documentary photographs were taken at each of the vegetation plots. Two photos were taken from the center of the south boundary looking to the north, and two were taken from the center of the north boundary looking south. Each of these pairs of photos included one photo taken with a 35-mm lens and one photo taken with a 55-mm lens. Examples of these photos are given in Appendix E.

Panoramic sets of photographs were taken from the same two points used by Entranco (1998) and EPG (2002 and 2004). Stakes indicating these locations were still present on the site. At each point, the camera was mounted on a tripod and series of overlapping photos were taken with 35-mm and 55-mm lenses. These panoramic photos are shown in Appendix E.

A list of vascular plants present on the site was compiled from general observations made during vegetation plot data collection and from incidental observations made during site visits performed in 2002, 2004, and 2006. Eleven additional plant species were added to the list during 2006. Twenty-five plant species previously recorded were not observed during the five site visits performed in 2006. The plant, provide in Appendix D, list is not intended to be comprehensive.

2.2 AQUATIC ALGAE

Aquatic Consulting and Testing, Inc performed sampling for aquatic algae at the High Plains site on November 8, 2006. Two locations within the Santa Cruz River diversion channel, designated the upstream and downstream samples, were sampled for phytoplankton, periphyton, and aquatic macroinvertebrates.

During flooding associated with summer storms, the earthen diversion structure at the Santa Cruz River that supplies the effluent water to the High Plains site was lost. Repairs to the diversion structure were completed on October 19, 2006, and water was reintroduced to the diversion channel the following day. At the time of sampling for aquatic algae in November, the diversion channel at the site had apparently been reconfigured since the previous sampling in 2004, possibly from the 2006 event, or possibly from other events since 2004. The channel configuration in 2004 was V-shaped, while its profile in November of 2006 was a rectangular, nearly flat-bottomed channel. Water in the channel was moderately turbid. No riffle areas were observed to be present. Channel bottom composition was approximately 90 percent silts and clays, five percent sand, and less than five percent rock (½ inch).

Field temperature and oxygen measurement of the water were made using YSI Model 85 and YSI Model 58 temperature-oxygen meters. Water pH was measured with a YSI Model pH100 meter (Figure 3). Stream bed conditions were described and field measurements were made in accordance with Arizona Department of Environmental Quality guidelines described in "Biological Sampling Protocols: Reference Site Selection and Sampling Methods" (Meyerhoff and Spindler 1994).

Figure 3. Measuring pH in the diversion channel.

Periphyton samples were collected upstream and downstream using variable-depth Dura-sampler artificial substrate samplers (Figure 4). Each unit was fitted with five 25x75 mm glass slides as the colonization substrate. Hestor-Dendy samplers were also installed at upstream and downstream sites to serve as artificial substrate for both macroinvertebrates and periphyton (Figure 5). The units were exposed to the flowing water for one week. Collected material was prepared for microscopic examination using burn mount techniques. Periphyton species densities were computed using ocular micrometer surface area measurements.

Figure 4. Periphyton Dura-sampler apparatus installation.

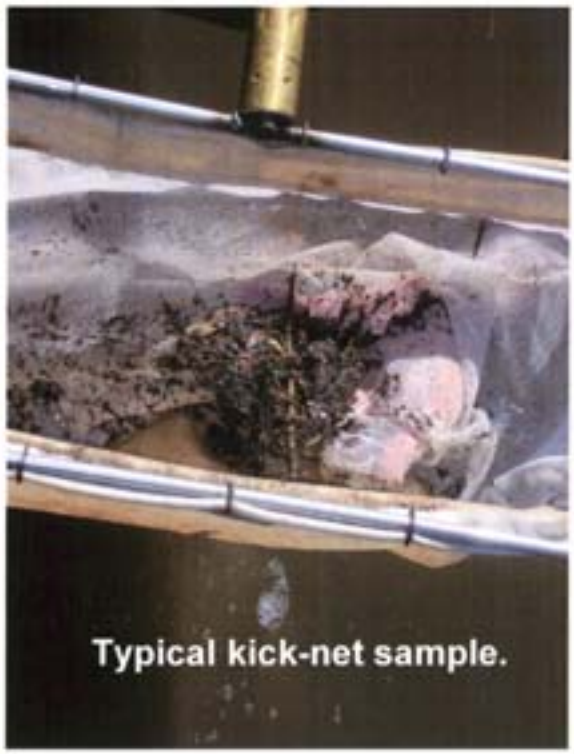
Figure 5. Hester-Dendy sampler for periphyton and macroinvertebrates.

Phytoplankton grab samples were collected at the upstream and downstream sites for suspended algae analysis. Representative aliquots were transferred to Utermohl settling chambers to concentrate cells. Observations were made using a Nikon phase-contrast inverted microscope. Species identifications were made using various taxonomic keys, which are listed in the references section. Species densities were computed using ocular micrometer surface area measurements, taking into account settling chamber concentration factors. Aquatic Consulting & Testing, Inc performed analysis of the algae samples.

2.3 AQUATIC MACROINVERTEBRATES

Aquatic Consulting and Testing, Inc. performed sampling for aquatic invertebrates on November 8, 2006. Stream macroinvertebrates were surveyed using bottom kick net (900-um mesh) collections (2x30-second duration) at each location (Figures 6 & 7). Samples were preserved with alcohol-formalin solution. Initial identifications were made using McCafferty (1998), Thorp and Covich (1991), and Arnett (1993).


Kick-net invertebrate sampling.


Typical kick-net sample.

Figures 6 and 7, kick-net sampling and sample.

2.4 BUTTERFLIES

Butterflies were observed and sampled primarily during three concentrated efforts on July 7 and 19, and September 28, 2006. Each of the three previously defined habitats surveyed in 2002 and 2004 was re-surveyed, and a new survey was instituted for the Recharge Basin area. Additional information was obtained as incidental records during two other site visits and was included in the determination of the BRQs for the appropriate habitat. Observations and sampling of butterflies were performed in general conformance with the procedure developed by Nelson and Andersen (1994). This method utilizes butterfly species composition and relative species disturbance

susceptibility to assign a measure of riparian habitat condition, or index of butterfly riparian quality (BRQ) for a given riparian site. This methodology was originally designed for use in riparian habitats, but is applicable to other habitats provided disturbance susceptibility scores (DSS) are established for non-riparian butterfly species. The Nelson and Andersen methodology has been applied to each of the plant communities being studied at the High Plains site.

Disturbance susceptibility scores are determined by assigning each butterfly species a weighted value in each of four ecologic categories. The four ecologic categories ranked for each species were: species mobility, larval host-plant form, larval food-plant specificity and riparian dependency. The original values assigned by Nelson and Andersen (1994) were based on a maximum weight of 5 representing the "idealized" riparian condition, 3 for values deviating somewhat from the ideal, and 0 for those deviating strongly from the idealized condition.

The value of the methodology developed by Nelson and Andersen (1994) is dependent on an accurate assessment of all species of butterflies present in a habitat. Susceptibility to disturbance varies in butterflies from species to species, and highly sensitive species, or those marginal for a habitat may be present in small numbers. Time constrained or cursory observations may not establish the presence of such species and could adversely affect the accuracy of the BRQ obtained. To minimize the chance of non-detection of species present in small numbers, efforts spent observing and sampling butterflies in each of the habitats were not time constrained.

Modifications to Methodology

Modifications to the Nelson and Anderson methodology were made by EPG during the 2002 monitoring season, but only for the values previously assigned for the larval host-plant form category. The original values assigned by Nelson and Anderson for this category were: trees = 5, grass = 3, herbs (forbs) = 2, and shrubs = 1. It was felt that a more appropriate assignment of values for this category would be: trees = 5, shrubs = 3, forbs = 2 and grass = 1. These adjustments to the larval host-plant form values do not greatly affect the calculated disturbance susceptibility scores. These reassigned values were applied to the species listed by Nelson and Andersen (1994), Entranco (1998), and additional species found at the High Plains Effluent Recharge Project site during the 2002, 2004, and 2006 studies. Additionally, the remaining ecological category values assigned each species by Nelson and Andersen (1994) and Entranco (1998) were reviewed and minor adjustments were made to some of the values based on species ecological information obtained from Stewart et al. (2001) and Opler et al. 2006. The parameter modifications implemented by EPG in 2002 have been retained for the 2004 and 2006 seasons. The only changes in 2006 were the addition of DSS values for 3 species of butterflies not previously encountered at the High Plains site. DSS values for these three species were established using the protocols of Nelson and Anderson (1994). A summary table of DSS scores is found in Appendix B as Table B-3f. Table B-3f includes all of the species originally listed by Nelson and Anderson (1994), and all additional species that have been recorded at the High Plains Recharge site.

Disturbance Susceptibility Score and the BRQ

The sum of the four values discussed above is the disturbance susceptibility score for each species. A higher DSS is indicative of greater species sensitivity to ecological disturbance. Mean DSS values were determined from the sum of the individual disturbance susceptibility scores for all the species documented within the project site. Separate mean DSS values were calculated for use in determining project composite (all years) and annual BRQ values for each plant association/habitat. A mean DSS (project composite DSS) was calculated as the composite of all data since project records were initiated in 1998. The BRQ for a plant association/habitat is calculated as the product of species richness (number of species) within the habitat and the proportion of species in the habitat with a DSS greater than the mean DSS (annual or composite) to the number of species at the project site with DSS scores greater than the mean DSS (annual or composite).

Since the last monitoring effort in 2004 there has been a large increase in density and size of vegetation in the recharge basins, particularly in Cell 4, which contains a different suite of plant species, primarily saltbush (*Atriplex* spp.), than is found in other areas of the project. Other cells contain a variety of primarily annual plants, most of which are grass species. Because of these recent changes in vegetation, butterflies documented in the recharge basin area were also recorded as occurring in a separate, though yet uncategorized, habitat.

BRQs were calculated for each of the three plant associations that were previously identified for the site, and the recharge basin area. Any BRQ value is relative, and it is a significant measure only when compared with other habitats. BRQ values obtained may be compared with each other and, to provide a regional perspective, with the values obtained by Nelson and Anderson (1994) for the Bill Williams Delta (BWD) site on the lower Colorado River near Parker, AZ. Because of its relatively low level of disturbance and non-channelized condition, the BWD site was used as the reference riparian site in their original study. Also, for comparison, annual BRQ values from 2002, 2004, and 2006 are shown in Appendix B, Tables B3-a, B3-b, B3-c, and B3-d. A composite list of butterfly species for the site has been updated to include the 2006 data (Appendix B, Table B-2a).

2.5 REPTILES AND AMPHIBIANS

Herpetofauna (amphibian and reptile) transects were walked within each of the three plant associations, and in the recharge basin area (Figure 2). Transects were walked, typically during mid-morning, after ambient air temperatures warmed sufficiently that herpetofauna would be active. Each transect is 50 meters long by 4 meters wide. Global Positioning System (GPS) data were obtained for each transect (Table A-5). Each transect was surveyed for at least five minutes. During these surveys, woody debris and rocks were moved to search for herpetofauna that could be hiding. These materials were replaced in their original location and orientation to minimize habitat disturbance.

A single random herpetofauna search of about two hours duration was conducted throughout the site on September 28, 2006, and additional observations were recorded during the course of other data collection activities on the site. Lists of all species

observed on the site were kept for each site visit and compiled for an overall species list for the site (Table 7).

2.6 BIRDS

Point counts for birds were conducted using the variable circular-plot method described by Reynolds et al. (1980). Counts were made at four locations on the property, with one point in each of the three vegetation communities, and one in the recharge basin habitat (Figure 2). During each survey, all birds observed (seen or heard) were recorded, with an estimated distance from the central point. For each individual, the habitat use was recorded as in the habitat of the central point, in an adjacent habitat, or flying over the site. Each point was surveyed twice, once during July, and once in August. From the combined results, it is possible to estimate the density of species observed within the habitat of the central point. Additional bird species are likely to use the High Plains site during different seasons, and surveys conducted during breeding and migration periods would certainly increase the knowledge of species using the site.

Other bird observations were recorded during the course of other data collection activities on the site. Lists of all species observed on the site were kept for each site visit and compiled for an overall species list for the site (Appendix C, Table C-1). Observations included the immediate vicinity of the project site, including the Santa Cruz River Diversion Channel and adjacent pastures and irrigated fields. Any unusual species, behaviors, and evidence of breeding were noted on the incidental observation data sheets.

2.7 MAMMALS

No specific mammal surveys were conducted on the site. However, incidental observations were recorded on incidental observation data sheets. Observations included direct sightings, tracks, scat, and burrows. A list of mammal species observed in 2002, 2004, and 2006 is shown in Table 9.

3 RESULTS AND DISCUSSION

3.1 VEGETATION

Species compositions of the defined plant communities present on the site in 2006 are essentially unchanged from 2004. The four recharge cells and equalization basin have been periodically filled with effluent water since February of 2003, but to date there has been no colonization by emergent vegetation. Recharge basin 4 currently supports a very dense population of saltbush species. The frequency and duration of water placed in the four recharge cells and equalization basin may not be sufficient at current levels to support emergent vegetation. The following plant associations are currently found on the site.

1. Creosote Bush Association. This association is present on the higher ground on the southwest side of the project site. The land surface is relatively flat, but it is dissected by shallow, eroded gullies. Creosote bush (*Larrea tridentata*) is the dominant species, with a few staghorn chollas (*Opuntia versicolor*) present. This

association is in the category 1,154.111 – *Larrea tridentata* (*divaricata*) association (Brown et al. 1979). It is a subcategory of the creosote bush-white bursage (*Ambrosia dumosa*) series of the Lower Colorado River Subdivision of Sonoran Desertscrub.

2. Mesquite-Paloverde Association. This association is found along the irrigation canal on the north edge of the site. Dominant species include velvet mesquite (*Prosopis velutina*), Mexican paloverde (*Parkinsonia aculeata*), and European elderberry (*Sambucus nigra*). Desert broom (*Baccharis sarothroides*) is a minor component of this association. Because this habitat is adjacent to the river channel and subject to infrequent but periodic submersion, it would fit the definition of a strandland (Brown et al. 1979). This association would fit into the category 1,254.71 – Sonoran Interior Strand, mixed shrub series, but no association has been defined with this set of species (Brown et al. 1979).

3. Tamarisk-Willow Association. This association is present adjacent to the Santa Cruz River Diversion Channel. Dominant species include athel, tamarisk (*Tamarix* sp.), Goodding willow (*Salix gooddingii*), and seep-willow (*Baccharis salicifolia*). Desert broom is a minor component of this association. Because this habitat is a river channel community subject to infrequent but periodic submersion, it would fit the definition of a strandland (Brown et al. 1979). This association would fit into the category 1,254.71 – Sonoran Interior Strand, mixed shrub series, but no association has been defined with this set of species (Brown et al. 1979).

4. Recharge Basins. The central portion of the site has been highly modified since the Entranco study in 1998. During construction of the recharge facility this area was cleared and graded, and berms were built to separate it into five individual basins, with pipes and gates to control water flow. Prior to modification, this area was mapped as a desert broom association by Entranco (1998). By May of 2002 (post-construction) the recharge basins supported no natural vegetation. Native tree and shrub species were planted by Pima County around the perimeter of the basins, and a drip irrigation system was installed to help support establishment of the plants. By the 2004 survey season the completed basins were periodically receiving reclaimed water pumped from the diversion channel, and whatever additional water input was provided by rainfall. The change in vegetation in the recharge basins, particularly in Recharge Cell number 4, from 2002 until 2006 is rather dramatic, with the size and density of plants having greatly increased (Figures 8-10). Here, species of saltbush up to two meters in height dominate the bottom of the recharge cell. This portion of the site is in transition, and we do not currently assign any plant association as defined in the Brown et al. (1979) classification system. Once emergent vegetation becomes established, the basins may be reclassified.

Figure 8. The east end of recharge cell 4, photographed on May 1, 2002. Note the perimeter plantings and the total lack of vegetation in the basin interior.

Figure 9. The east end of recharge cell 4 photographed on April 9, 2004. Note the establishment of saltbush species.

Figure 10. The east end of recharge cell 4, photographed on September 22, 2006. Note the almost total coverage of vegetation in cell, some saltbush plants are over two meters in height.

CREOSOTE BUSH ASSOCIATION

The creosote bush association, which is present on the southwest portion of the project site, southwest of the recharge basins, is dominated by creosote bush with only a handful of cane chollas scattered within the habitat. Results of vegetation sampling in this habitat are summarized in Appendix A. The habitat is elevated several a couple of meters above the remainder of the project site, and may represent an old embankment of the Santa Cruz River. This elevated section is currently being dissected from the northeast at its boundary with the site perimeter roadway.

Annual Ground Cover

Due to drought conditions, there was no annual ground cover present in creosote bush habitat at the time of the 2002 survey. In 2004 visually estimated ground cover was reported as approximately 6 percent, composed almost entirely of Arabian schismus (*Schismus arabicus*). The 2006 plots selected were effectively a repeat of the 2002 results, with no annual plants present. However, in the relatively flat bottoms of some of the erosion features at the north end of the creosote bush habitat (parallel with the recharge basin area), a patch of blooming fetid marigold (*Pectis* sp.) was present. By chance, none of the random plots in the creosote bush habitat included these small areas. The two permanent panoramic photo points are located in this habitat (Figure 2). Panoramic photos from these points are given in Appendix E, Figures E-1a & b, and E-2 a & b.

Data Summary

Creosote bush was present in all of the eight study plots in this habitat. No other woody plant species was present in any of the eight study plots. Average measured plant height for creosote bush was 1.17 m, which compares reasonably well with the 1.38 and 1.46 meter heights recorded in the 2002 and 2004 seasons respectively. A *t*-test of these values indicates no significant difference ($t = 0.253$, $df = 14$, $p > 0.8$ [2002] and $t = .015$, $df = 14$, $p > 0.9$ [2004]). The mean canopy cover for the study plots in 2006 is 12.56 percent at the one meter height. This compares with values of 35.4 in 2002 and 20.4 in 2004. *t*-tests of these values indicate a significant difference from 2002 ($t = 3.227$, $df = 14$, $p < .01$), but no significant difference with the 2004 value ($t = 1.265$, $df = 14$, $p > 0.2$). At a height of 2 m, the mean canopy cover for the study plots is 1.16 percent. This is similar to the 2.57 percent recorded for 2004, and is not considered to be a significant difference ($t = .641$, $df = 14$, $p > 0.5$). The highest value for the canopy at the 2 meter height (7.16 percent) was recorded in 2002, but was also not considered to be significantly different from the 2004 value ($t = 0.770$, $df = 14$, $p > 0.4$). A comparison of the 2006 (lowest value) and 2002 (highest value) is still not significant ($T = 1.065$, $df = 14$, $p > 0.3$). The overall plant density in this habitat in 2006 is 1,406 plants per hectare, which is slightly higher than the 1,250 plants/ha reported in 2004, and is slightly less than the density of 1,523 plants/ha reported in 2002. A *t*-test comparing the 2004 and 2002 values indicated no significant difference ($t = 0.071$, $df = 14$, $p > 0.9$). Since the 2006 value is less than the 2002 value, it also does not constitute a significant difference.

This essentially monotypic plant community provides a thin canopy where 90 percent (approximately 75 percent in 2004) of the plants are less than 2 m in height. Some desert broom and desertwillow (*Chilopsis linearis*) are present at the lower edge of this habitat, close to the recharge basins. Representative photos from this habitat are given in Appendix E, Figures E-3(a-d) and E-4(a-d).

MESQUITE-PALOVERDE ASSOCIATION

The mesquite-paloverde association is present along the northeast boundary of the project site along the existing irrigation ditch. This habitat continues northeast beyond the irrigation ditch and off the project site towards the Santa Cruz River. The density of the habitat north of the project site increases to the southeast where it intergrades with the tamarisk-willow habitat along the Santa Cruz River Diversion Channel.

Much of this habitat is quite open, with the dominant canopy elements being velvet mesquite and Mexican paloverde. Other woody plants found in the eight plots in 2006 were three species of saltbush, desert broom, seepwillow, European elderberry, cheeseweed burrobrush (*Hymenoclea monogyra*), tamarisk, burroweed (*Isocoma tenuisecta*), and creosote bush. Quail bush (*Atriplex lentiformis*), desert saltbush (*A. polycarpa*), seepwillow, tamarisk, and creosote bush had not occurred in plant plots in this habitat in previous years. Desertwillow occurs in the habitat, but was not present in any of the random study plots in 2006.

Annual Ground Cover

The average estimated percent annual ground cover of forbs and grasses for the eight

plots in 2006 is approximately 25 percent. Values were 42 percent in 2004 and 35 percent in 2002. The dominant annual plant species in 2006 is Bermuda grass (*Cynodon dactylon*). The somewhat lower annual ground cover may reflect the low quantity of rain that fell over the 2005/2006 winter season. A few buffalo bur (*Solanum rostratum*) (Figure 11) and silverleaf nightshade (*Solanum elaeagnifolium*) are present along the edges of the irrigation ditch, and based on visual observation, there is an apparent increase in density of these species since 2004. This may be due to increased use of the irrigation ditch and resultant increase of seed germination and plant recruitment. Density of milk thistle (*Silybum marianum*), an invasive species, along the irrigation ditch was visually similar to 2004. Most of the 2006 population of milk thistle is totally dead, and appears to have been sprayed with herbicide.

Figure 11. Buffalo-bur (*Solanum rostratum*) along the irrigation ditch in mesquite-paloverde habitat.

Data Summary

The total canopy cover measured for the mesquite-paloverde plant association in 2006, along with values for previous years (1998, 2002 & 2004) is shown in Table 1. In the 2002 report it was suggested that the lower canopy values obtained for that year might reflect the removal of trees during construction of the recharge basins and roads prior to the 2002 observations. The significant change in the values at the one and two meter heights is predominantly due to the rampant growth of saltbush plants in the habitat along the south edge of the habitat.

Table 1. Comparison of canopy cover measurements, mesquite-paloverde association.

Height above ground, m	Canopy Cover % Entranco (1998)	Canopy Cover % EPG (2002)	Canopy Cover % EPG (2004))	Canopy Cover % EPG (2006)	t-value Comparison EPG 2004/2006	Probability EPG 2004/2006
1	23.5	21.24	10.60	47.07	4.343	< .001
2	53.4	12.12	5.72	44.68	3.898	> .001
3	33.4	9.28	2.61	32.36	2.926	> 0.1
4	9.4	1.47	0.88	17.45	2.144	> 0.05
5	9.4	0.77	1.01	9.06	2.046	> 0.05
6	0.00*	0.00*	1.72	0.08	0.953	< 0.4

*No data at 6 meters from 1998 or 2002.

The measured average woody plant density for the mesquite-paloverde association in 2006 was found to be 2,812 plants/ha. While the difference between the reported values for 2002 (1,602 plants/ha) and 2004 (898 plants/ha) was not significant ($t = 1.132$, $df = 14$, $p > 0.2$), the difference between 2004 and 2006 is considered significant ($t = 2.917$, $df = 14$, $p > 0.01$. This can primarily be attributed to the increase in saltbush plants in the habitat since 2004. Growth of tree species, particularly velvet mesquite and Mexican paloverde, has also been a contributing factor to this increase. The change could also be partially due to randomness of sampling of plots. Five species of woody plants recorded in the mesquite-paloverde plots in 2006 had not previously been recorded in the plots for this habitat. These species are quail bush, desert saltbush, seepwillow, creosote bush, and tamarisk (*Tamarix* sp.) Representative photos from this habitat are given in Appendix E, Figures E-5(a-d) and E-6(a-d).

TAMARISK-WILLOW ASSOCIATION

The tamarisk-willow association is present on the project as a relatively narrow band of vegetation bordering the Santa Cruz River Diversion Channel. The boundary with the adjacent, more xeric, creosote bush habitat is generally well defined, and abrupt. The tamarisk-willow association indistinctly intergrades with the mesquite-paloverde habitat at the northeast corner of the site. The plant community is dominated by *Tamarix* spp. and Goodding willow. Other important woody plants present are desert broom, velvet mesquite, seepwillow, and European elderberry. Mature plants of Goodding willow, tamarisk, and athel form the overstory in this habitat. The mid-story is comprised primarily of tamarisk and velvet mesquite however; European elderberry and tree tobacco (*Nicotiana glauca*) are not uncommon, while other woody species, generally less than 3 m in height (Appendix A, Table A-3a), form the understory, resulting in a multi-tiered riparian habitat. Based on four years of data, rapid diminution of the total measured canopy cover for the tamarisk-willow association occurs somewhere within four to six meters above ground level.

Annual Ground Cover

The average estimated percent annual ground cover of forbs and grasses for the eight tamarisk-willow plots in 2006 was approximately 30 percent. Two of the plots had no annual ground cover due to being totally shaded out. One of these plots (T1) was totally shaded by a single large athel tree, and the other (plot T8) contained eight individual desert broom plants (some dead), which completely covered the plot. In places within this habitat tamarisk and desert broom exist either as monotypic stands or together at densities that are almost impenetrable. The 2006 value compares well with that from 2002 (20 percent), but is quite different from the less than two percent reported in 2004. The 2004 data included three plots dominated by three athel trees, which totally shaded out the plots, and in one other plot, European elderberry and tree tobacco produced the same effect. In general, the annual ground cover in this habitat was a little above average in 2006, primarily due to record summer rains this year.

Data Summary

Results of total canopy cover measured in the tamarisk-willow habitat during four separate years are shown in Table 2. The corresponding values are generally comparable at each canopy height, and are statistically significantly different only at two and five meter heights between years 2004 and 2006.

Table 2. Comparison of canopy cover measurements, tamarisk-willow association.

Height above ground, m	Canopy Cover % Entranco 1998	Canopy Cover % EPG (2002)	Canopy Cover % EPG (2004)	Canopy Cover % EPG (2006)	t-value Comparison EPG 2004/2006	Probability EPG 2004/2006
1	53.0	42.19	32.44	25.88	0.604	< 0.6
2	44.2	32.02	39.90	15.59	2.391	> 0.02
3	22.4	20.62	36.64	16.05	0.775	< 0.5
4	11.9	15.20	28.71	9.59	1.598	> 0.1
5	6.8	11.75	24.62	2.46	2.177	< 0.05
6	4.7	3.05	20.55	1.29	1.843	< 0.1
7	2.9	2.03	17.26	0.99	1.518	< 0.2
8	*	1.02	16.77	0.27	1.537	< 0.2
9	*	1.12	16.16	0.19	1.473	< 0.2
10	*	0.76	16.07	*	*	*
11	*	*	16.07	*	*	*
12	*	*	15.82	*	*	*
13	*	*	15.10	*	*	*
14	*	*	11.16	*	*	*
15	*	*	6.25	*	*	*
16	*	*	6.25	*	*	*

Height above ground, m	Canopy Cover % Entranco 1998	Canopy Cover % EPG (2002)	Canopy Cover % EPG (2004)	Canopy Cover % EPG (2006)	t-value Comparison EPG 2004/2006	Probability EPG 2004/2006
17	*	*	6.25	*	*	*

*No data at these canopy heights.

A comparison of the average density of woody plants in the three habitats during the 2006 monitoring season shows the tamarisk-willow association with a density of 1,562 plants/ha, which is comparable to the 1,406 plants/ha for the creosote habitat ($t = 0.271$, $df = 14$, $p < 0.8$). The mesquite-paloverde habitat is considerably denser at 2,812 plants/ha, which is attributed primarily to the large increase in size and number of saltbush plants in the habitat. A t-test comparing the mesquite-paloverde habitat with the tamarisk-willow habitat data for 2006 shows that the plant density difference is not significant ($t = 1.966$, $df = 14$, $p > .05$). Representative photos from this habitat are given in Appendix E, Figures E-7(a-d) and E-8(a-d).

3.2 AQUATIC ALGAE

Basic physical properties of temperature, dissolved oxygen content, and pH of the diversion channel water were measured at the time algae samples were obtained. The results of these physical and chemical tests of the diversion channel water are summarized in Table 3, along with values from previous monitoring seasons. Water temperatures were considerably cooler during the November 2006 sampling when compared with samples taken in June of 2002 and 2004, but this would be expected. The dissolved oxygen content was double the 2002 value, and almost three times the 2004 value. Hydrogen ion concentration (pH) was consistent with previous years.

Table 3. Physical and chemical water parameters of the Santa Cruz River diversion channel.

Parameter	Upstream			Downstream		
	2002*	2004	2006	2002*	2004	2006
Temperature, C	30.4	24.3	17.2	30.4	24.5	17.3
Dissolved oxygen, mg/L	3.6	2.4	7.1	3.6	2.3	7.2
pH, SU	7.5	7.9	7.7	7.5	7.8	7.5

*2002 Data from one location only.

Five species of periphyton were found upstream, and six species were found downstream. Cell density was relatively low at both locations. Upstream and downstream samples were similar in 2006. Unicellular diatoms, *Cymbella, Gomphonema, Navicula*, and *Nitzschia* continue to be the dominant periphyton in the diversion channel from year to year. Because of the limited data recorded for 2006, the absence of species cannot be considered significant, but new species recorded in 2006 include *Achnanthes* sp., *Cymbella microcephala, Navicula cocconeiformis*, and *N. pupula*. Due to the late sampling date in 2006, compounded with the problem of the diversion channel being dry for a length of time precludes significant interpretation or comparison of data with

previous years. Calculated cell density and percent of total composition for each species are summarized in Tables 4a and 4b below.

Table 4a. Periphyton densities at the diversion channel upstream sampling site. Species not previously recorded on the site are highlighted in blue.

Species	Density (cells/sq m)			Composition, %		
	2002	2004	2006	2002	2004	2006
Cymbella amphicephala	580	1,180	0	3.5	21.9	0
Cymbella microcephala	0	0	111	0	0	24.4
Gomphonema parvulum	7,600	827	232	45.1	15.4	51.2
Navicula cocconeiformis	0	0	22	0	0	4.8
Navicula pupula	0	0	19	0	0	4.2
Navicula tripunctata.	580	1,560	0	3.5	29.0	0
Nitzschia accedans	3,740	0	70	22.2	0	15.4
Nitzschia sp.	2,100	0	0	12.5	0	0
Pinnularia substomatophora	580	0	0	3.5	0	0
Planothidium (Achnanthes) lanceolatum	0	1,750	0	0	32.5	0
Surirella ovalis	1,050	30	0	6.2	0.6	0
Synedra affinis	580	0	0	3.5	0	0
Synedra ulna	0	30	0	0	0.6	0
Total	**16,810**	**5,377**	**454**	**100.0**	**100.0**	**100.0**

Table 4b. Periphyton densities at the diversion channel downstream sampling site. Species not previously recorded on the site are highlighted in blue.

Species	Density (cells/sq m)			Composition, %		
	2002	2004	2006	2002	2004	2006
Achnanthes sp.	0	0	3	0	0	0.7
Cymbella amphicephala	0	1620	0	0	31.7	0
Cymbella microcephala	0	0	108	0	0	25.4
Gomphonema parvulum	6,430	1,780	162	33.1	34.8	38.1
Navicula cryptocephala	585	0	4	3.0	0	0.9
Navicula pupula	0	0	30	0	0	7.1
Navicula sp.	0	30	0	0	0.6	0
Navicula tripunctata	1,640	1020	0	8.4	20.0	0
Nitzschia accedans	9,120	30	118	47.1	0.6	27.8
Nitzschia sp.	585	0	0	3.0	0	0
Pinnularia substomatophora	1,050	0	0	5.4	0	0
Planothidium (Achnanthes) lanceolatum	0	570	0	0	11.1	0
Surirella ovalis	0	30	0	0	0.6	0
Synedra ulna	0	30	0	0	0.6	0
Total	**19,410**	**5,110**	**425**	**100.0**	**100.0**	**100.0**

A total of eight genera of phytoplankton were identified. Phytoplankton in both the upstream and downstream samples was dominated by *Navicula* sp. and *Oscillatoria* sp., with *Navicula* sp. greater downstream, and *Oscillatoria* sp. greater in the upstream sample. The only new phytoplankton species recorded in 2006 was the unicellular diatom *Synedra acus*, which was present in small number. Like the periphyton, the discussion of yearly changes in phytoplankton populations cannot be made with previous years due to the late sampling time. Algae species, division, form, density, and relative abundance are presented in Tables 5a and 5b.

Table 5a. Phytoplankton densities at the diversion channel upstream sampling site. Species not previously recorded on the site are highlighted in blue.

Species	Division & Form	Density (cells/mL)			Composition, %		
		2002*	2004	2006	2002*	2004	2006
Achnanthes affinis	Bacillariophyta Unicell	658	0	0	5.54	0	0
Achnanthes sp.	Bacillariophyta Unicell	60	0	0	0.51	0	0
Chlorella sp.	Chlorophyta Unicell	0	94	0	0	5.0	0
Cryptomonas sp.	Cryptophyta Flagellated unicell	0	102	38[2]	0	5.5	2.3[2]
Cymbella amphicephala	Bacillariophyta Unicell	0	188	0	0	10.1	0
Cymbella microcephala	Bacillariophyta Unicell	1,317	0	0	11.09	0	0
Cymbella sp.	Bacillariophyta Unicell	0	0	10	0	0	0.6
Euglena sp.	Euglenophyta Flagellated unicell	7	11	94	0.06	0.6	0.4
Gleothece sp.	Cyanophyta Colony	0	47	0	0	2.5	0
Gomphonema parvulum	Bacillariophyta Unicell	2,095	376	238	17.64	20.1	14.5
Navicula accomoda	Bacillariophyta Unicell	60	0	0	0.51	0	0
Navicula cryptocephala	Bacillariophyta Unicell	120	0	0	1.01	0	0
Navicula tripunctata	Bacillariophyta Unicell	0	188	0	0	10.1	0
Navicula sp.	Bacillariophyta Unicell	0	0	428	0	0	25.9
Nitzschia kutzingiana	Bacillariophyta Unicell	5,327	0	0	44.88	0	0
Nitzschia sp.	Bacillariiophyta Unicell	0	47	0	0	2.5	0

Species	Division & Form	Density (cells/mL)			Composition, %		
		2002*	2004	2006	2002*	2004	2006
Oscillatoria sp.	Cyanophyta Filament	2,166	189	912[1]	18.25	10.1	55.2[1]
Pinnularia divergentissima	Bacillariophyta Unicell	60	0	0	0.51	0	0
Planothidium (Achnanthes) lanceolatum	Bacillariophyta Unicell	0	235	0	0	12.6	0
Rhoicospenia curvata	Bacillariophyta Unicell	0	94	0	0	5.0	0
Scenedesmus quadricauda	Chlorophyta Colony	0	15	0	0	0.8	0
Surirella ovalis	Bacillariophyta Unicell	0	47	0	0	2.5	0
Synechococcus aeruginosus	Cyanophyta Colony	0	94	0	0	5.0	0
Synedra acus	Bacillariophyta Unicell	0	0	19	0	0	1.1
Synedra ulna	Bacillariophyta Unicell	0	141	0	0	7.6	0
Total		**11,870**	**1,868**	**1,739**	**100.0**	**100.0**	**100.0**

* The 2002 upstream and downstream phytoplankton grab samples were composited due to the rapid flow rate at the time of sampling.

[1] *Oscillatoria chalybea*

[2] *Cryptomonas erosa*

Table 5b. Phytoplankton densities at the diversion channel downstream sampling site. Species not previously recorded on the site are highlighted in blue.

Species	Division & Form	Density (cells/mL)			Composition, %		
		2002*	2004	2006	2002*	2004	2006
Ankistrodesmus falcatus	Chlorophyta Unicell	0	0	10	0	0	1.0
Achnanthes affinis	Bacillariophyta Unicell	658	0	0	5.54	0	0
Achnanthes sp.	Bacillariophyta Unicell	60	0	0	0.51	0	0
Cryptomonas sp.	Cryptophyta Flagellated unicell	0	95	19[1]	0	3.9	1.8[1]
Cymbella microcephala	Bacillariophyta Unicell	1,317	0	0	11.09	0	0
Euglena sp.	Euglenophyta Flagellated unicell	7	6	11	0.06	0.3	1.0
Gleothece sp.	Cyanophyta	0	564	0	0	22.8	0

Species	Division & Form	Density (cells/mL)			Composition, %		
		2002*	2004	2006	2002*	2004	2006
	Colony						
Gomphonema parvulum	Bacillariophyta Unicell	2,095	376	105	17.64	15.2	10.0
Navicula accomoda	Bacillariophyta Unicell	60	0	0	0.51	0	0
Navicula cryptocephala	Bacillariophyta Unicell	120	0	0	1.01	0	0
Navicula tripunctata	Bacillariophyta Unicell	0	235	0	0	9.5	0
Navicula sp.	Bacillariophyta Unicell	0	0	570	0	0	54.4
Nitzschia kutzingiana	Bacillariophyta Unicell	5,327	0	0	44.88	0	0
Oscillatoria sp.	Cyanophyta Filament	2,166	208	333[2]	18.25	8.4	31.8[2]
Pinnularia divergentissima	Bacillariophyta Unicell	60	0	0	0.51	0	0
Planothidium (Achnanthes) lanceolatum	Bacillariophyta Unicell	0	282	0	0	11.4	0
Rhoicospenia curvata	Bacillariophyta Unicell	0	94	0	0	3.8	0
Surirella ovalis	Bacillariophyta Unicell	0	47	0	0	1.9	0
Synechococcus aeruginosus	Cyanophyta Colony	0	470	0	0	19.0	0
Synedra ulna	Bacillariophyta Unicell	0	94	0	0	3.8	0
Total		**11,870**	**2,471**	**1,048**	**100.0**	**100.0**	**100.0**

* The 2002 upstream and downstream phytoplankton grab samples were composited due to the rapid flow rate at the time of sampling.

[1] *Cryptomonas erosa*

[2] *Oscillatoria chalybea*

3.3 AQUATIC INVERTEBRATES

Only a single taxon was observed in the samples; larvae of Chironomid midges (*Glyptotendipes* sp.). A total of 4 organisms were collected in the upstream sample and 28 at the downstream location. Chironomids, along with aquatic earthworms (Family Naididae), were the dominant macroinvertebrates present in the 2004 samples. No aquatic earthworms, nor any of the other taxa present in 2004 except the Chironomids, were found in the 2006 samples The presence of only a few individuals of a single taxon is certainly a result of the loss of the diversion structure, subsequent draining and drying of the diversion channel, and indicates a lack of sufficient time for re-colonization. Additionally, re-colonization is less likely to occur late in the season when temperatures

are cooler, resulting in less invertebrate activity. The reproductive seasons are also past for most species by this time of year. Table 6 provides a list of the taxa and the number found during the last three monitoring seasons.

Table 6. Aquatic macroinvertebrates found at the High Plains Effluent Recharge Site.

Taxon/Family	Species	Upstream			Downstream		
		2002	2004	2006	2002	2004	2006
Haplotaxida (Aquatic earthworms) Naididae	*Amphichaeta* sp.	168	1,200	0	40	4	0
Diptera (Flies) Chironomidae	*Bryophaenocladius* sp. *Glyptotendipes* sp.	2 1	524	0 4	0 0	268	0 28
Ephemeroptera (Mayflies)	Undetermined	0	38	0	0	0	0
Hemiptera (True bugs) Corixidae	Undetermined	0	6	0	0	0	0
Odonata (Dragonflies, damselflies) Coenagrionidae	Undetermined sp.	0	0	0	1	0	0
Hemiptera (True bugs) Naucoridae	*Ambrysus* sp.	0	0	0	1	0	0
Cladocera (Water fleas) Daphnidae	*Daphnia pulex*	0	0	0	1	0	0
Amphipoda (Scuds, sideswimmers) Talitridae	*Hyalella azteca*	83	0	0	138	0	0
Total		**254**	**1,768**	**4**	**181**	**272**	**28**

3.4 BUTTERFLIES

Butterfly observation and capture data for the 2006 monitoring effort, and calculated disturbance susceptibility scores for each species, are shown in Appendix B, Tables B-1a through B-1c.

The report provided by Entranco (1998) listed eight species of butterflies for the High Plains Effluent Recharge site (Table B-2a). Four of the species recorded in 1998 were positively confirmed to still be present at the site in 2002, 2004, and 2006. They included the Black Swallowtail (*Papilio polyxenes*), the Marine Blue (*Leptotes marina*), the Fatal Metalmark (*Calephelis nemesis*), and the Queen (*Danaus gilippus*). Three of the remaining four species have not been positively confirmed as present since 1998. These are the Cabbage White (*Pieris rapae*), the Cloudless Sulphur (*Phoebis sennae*), and the Viceroy (*Limenitus archippus*). The Fiery Skipper (*Hylephila phyleus*) was tentatively confirmed by a visual sighting in 2002, and confirmed as present this year based on a single collection. Based on larval food plant requirements and species range it is

reasonable that the remaining three species could be present, and the lack of sightings since 1998 may be coincidental.

The greatest number of butterfly species (19) was recorded in 2004. In 2006, eleven of those species were not observed. These include the Checkered White (*Pontia protodice*), Southern Dogface (*Colias cesonia*), Leda Ministreak (*Ministrymon leda*), Painted Lady (*Vanessa cardui*), Common Buckeye (*Junonia coenia*), Northern Cloudywing (*Thorybes pylades*), White Checkered-skipper (*Pyrgus albescens*), Orange Skipperling (*Copaeodes aurantiacus*), Eufala Skipper (*Lerodea eufala*), Arachne Checkerspot (*Polydryas arachne*), and Bordered Patch (*Chlosyne lacinia*). The last two species were unconfirmed visual observations in 2004. Five species, three of which were new site records in 2006, were not observed in 2004. These include the previously recorded Western Pygmy-blue (*Brephidium exile*) and Fiery Skipper, and new records including the Arizona Metalmark (*Calephelis arizonensis*) (Figure 12), Tiny Checkerspot (*Dymasia dymas*), and the Empress Leilia (*Asterocampa leilia*). The presence of the Empress Leilia was based on several visual observations but no captures, and the species could alternatively be the Hackberry Emperor (*Asterocampa celtis*), or both species may be present. The three new species recorded in 2006 have been added to the site list, and are highlighted in blue in Table B-2a.

Figure 12. Arizona Metalmark (*Calephelis arizonensis*) on Tamarisk blossom.

The Gray Hairstreak (*Strymon melinus*) was recorded from a single specimen in 2002 and has not been observed since. The apparent rarity at the project site of this typically common species is not understood. As of 2004, the Western Pygmy-blue was almost unknown at the project site, with only a single observation in 2002. By 2006 the species has become abundant on the project site, primarily associated with rampant growth of saltbush species in the recharge basin area.

BRQ values were calculated for each of the three habitat types identified at the project site, and for the recharge basin area. BRQ values were calculated using the disturbance susceptibility scores (values) assigned to each species (Tables B-3a – B3d, and B-3f). BRQ values were calculated using both annual data and a composite of all species data since the first monitoring effort in 1998.

Creosote Bush Association

Butterfly species diversity and density in the creosote bush habitat has been low during all three of the last monitoring efforts, with a total of only five species recorded in the habitat. BRQ values based on annual data for the creosote bush habitat were 0.0, 0.3, and 0.0, in 2002, 2004, and 2006 respectively. Project composite BRQ values for the creosote bush habitat were 0.0, 0.2, and 1.0 for the same three year sequence, with an average of 0.4. A comparison of these data with the original results of Nelson and Anderson (1994) shows the creosote bush association at the High Plains site to be depauperate of butterfly species, not unlike a portion of the No Name Lake (NNL) site of Nelson and Anderson, which was dominated by tamarisk (BRQ 0.3). Plant associations exhibiting low species diversity and lacking variability in plant form tend to have a corresponding low BRQ.

Mesquite-Paloverde Association

Four species of butterflies were found in the mesquite-paloverde association in 2002, 11 in 2004, and 7 in 2006. The BRQ based on annual data for the mesquite-paloverde association was 2.0 in 2002, 7.3 in 2004, and 3.5 in 2006. The higher BRQ in 2004 is a function of the presence of three species of butterflies with high DSS values: the Fatal Metalmark, the American Snout (*Libytheana carinenta*), and the Common Buckeye.

The Fatal Metalmark was present as a single specimen taken on salt heliotrope (*Heliotropium curassavicum*) that was in blossom along the west end of the irrigation canal. The larval food plant for the Fatal Metalmark is seepwillow. This plant is uncommon along the irrigation canal, but is common along the diversion channel, where this species has been regularly observed during previous surveys. The Fatal Metalmark evidently does not wander far from its larval food plant, and its presence in the mesquite-paloverde habitat would be associated primarily with utilization of nectar sources present there.

The American Snout was observed as a single butterfly perched on European elderberry along the irrigation canal. None of its larval food plants (*Celtis* spp.) are recorded from the High Plains site, but may occur along the main channel of the Santa Cruz River, which is adjacent to the project, or upstream along the diversion channel. The American Snout is apparently uncommon at the High Plains site, probably due to the lack of the larval food plants.

The Common Buckeye is probably a regular resident at the High Plains site in low numbers. One of its larval food plants, speedwell (*Veronica* sp.) is present along the diversion channel, and other larval food plant species such as owl's clover (*Orthocarpus purpurascens*) and plantains (*Plantago* spp.) are likely to be present. The single record of the Common Buckeye at High Plains (2004) may due to the short life of the adult, which is usually about 10 days (Stewart et al. 2001), and the limited sampling performed at the

site. The value of non-time-constrained sampling in determining species richness utilized in the calculation of BRQ values becomes evident with the documentation of species with low populations or a brief presence as adults such as the Common Buckeye.

Because of the somewhat incidental presence of these three species, the real BRQ value for the mesquite-paloverde association is probably lower than that calculated for 2004. Project composite BRQ values for the mesquite-paloverde association were 1.2, 0.7, 5.5, and 2.3 for 1998, 2002, 2004, and 2006 respectively. The average project composite BRQ for the mesquite-paloverde association, based on the four years of data is 2.4.

Tamarisk-Willow Association

Eight species of butterflies were found in the tamarisk-willow association in 2002, 11 in 2004, and five in 2006. BRQs based on annual data were 8.0, 5.5, and 2.5 respectively. The decrease in the BRQ for the tamarisk-willow association in 2004 reflected the addition of four species with low DSS values. These species were the Orange Sulphur (*Colias eurytheme*), Dainty Sulphur (*Nathalis iole*), Bordered Patch, and Eufala Skipper. Based on four years of observations it is apparent that none of these species is common at High Plains on a regular basis. Larval food plants for these species are either known or likely to be present on the High Plains site, or are likely available in adjacent agricultural lands. Therefore, these species are not considered accidental, but are likely to be regular residents whose populations may be at a low level seasonally, or may fluctuate from year to year depending on abundance of larval food plants. The average composite BRQ for the tamarisk-willow association, based on four years of data is 1.8.

Variables Affecting BRQ Values

Total butterflies observed at the High Plains site were 41 in 1998, 89 in 2002, 142 in 2004, and 93 in 2006. Due to several factors, caution should be exercised in the interpretation and comparison of the BRQ values obtained between years. The 1998 data set was based on observations that were both time constrained and more limited in extent. The total butterflies recorded in 1998 was less than half of the three successive monitoring efforts, and may not be representative of the full range of species that were present during that year. Fluctuation in annual rainfall and subsequent development of available food sources for butterflies are important considerations when comparisons are made between years. Both larval food plants and adult nectar sources are affected by variability in the timing and quantity of rainfall. Either or both of these parameters may affect annual butterfly populations. Timing of sampling efforts can also affect species diversity results, and subsequent comparative interpretations. In Arizona, most butterfly species are active sometime between May and September (Stewart et al. 2001).

Observations and sampling of butterflies at High Plains has generally not been seasonally consistent for each of the sampling efforts. The 1998 observations were made in August and September, compared with observation times in May and September in 2002, April and May in 2004, and July and September in 2006. Because sampling time is limited, and adult emergence times may shift annually due to rainfall patterns, selection of appropriate survey periods for each monitoring effort is important. Many species have short activity periods that may be missed by using a narrow sampling window. Restricting butterfly observations to spring (March and/or April) or the late summer and fall months eliminates the possibility of recording species that are present at other times,

may affect the completeness of species diversity present, and the subsequent accuracy of the BRQ value determined for any given habitat. Ideally observations should be conducted early in the season (late April or May), in July after the onset of the summer monsoon rains, and again in early fall (September) such that seasonally constrained species are included when determining site diversity (species richness).

Annual BRQ values are of interpretive value in showing variability between years, so long as variables that can affect individual years are considered. However, any of several variables may potentially affect seasonal or annual BRQ values, a more useful number for evaluating plant associations/habitats, individual sites, or when comparing sites is probably a composite BRQ value. A composite BRQ value includes all species that have been recorded in (i.e. can be supported by or occur in) the plant association/habitat. By including all butterfly species, annual fluctuations due to variability of rainfall and associated plant diversity and density can be minimized. The mean DSS score based on a composite of all 28 butterfly species recorded at the High Plains site over the four years of monitoring is 8.9. Composite BRQ values using all four years of data and the multi-year mean DSS are; 0.8, 9.3, and 7.5 for the creosote bush, mesquite-paloverde, and tamarisk-willow plant communities respectively. Project composite Riparian Environmental Quality values (expressed as a BRQ value) by habitat, using the four-year DSS (8.9) and annual data are shown in Appendix B, Table B-3e. While the composite BRQ numbers appear "lower" when compared to annual values, due to the buffering effects of species with low disturbance susceptibility scores, they are probably a more real reflection of the butterfly riparian quality. Differences of a couple of tenths of the value are more significant than for BRQs based on annual data.

None of the three plant associations present at the High Plains site currently has a high BRQ. Nelson and Anderson (1994) reported a BRQ of 14.2 (based on an annual sampling) for the Bill Williams Delta site. This site was not a pristine riparian site; however it was relatively undisturbed, and contained a greater species diversity of grasses and herbaceous plants. A multi-year effort of sampling for butterflies at the BWD site would likely reduce its composite BRQ value due to dilution by species with low DSS values.

The BRQ values for the creosote bush habitat at the High Plains site have so far remained consistent, and it is unlikely that this will change. Because of poor plant species diversity in this habitat, there is little potential for these areas to become more supportive of greater butterfly species diversity. The three year average BRQ of 0.4 for this habitat can probably be considered representative. Currently, the butterfly species diversity recorded at the High Plains site is equal for the mesquite-paloverde and tamarisk-willow associations, with 19 species recorded for each habitat. The suite of species recorded from the mesquite-paloverde association contains several species with high DSS values and because of this, the average composite BRQ value is the higher of the two plant associations at 2.4. The tamarisk-willow association may have greater potential value as butterfly habitat due to a greater volume of water available to support larger tree species such as cottonwood (*Populus* sp.), willow, and walnut (*Juglans major*) that would provide a valuable component of a multi-tiered habitat. Currently, only a few Goodding willows are present on the site, but the possibility of other large native tree species becoming established over time is reasonably good. The two species of *Tamarix* at the High Plains site provide little value to butterflies except a moderate quantity of nectar. Thick stands of *Tamarix* tend to prevent the growth of native understory plants. This

results in loss of plant species diversity and use of a large portion of the available water resource. The overall health of this habitat, and its value for butterflies and other species could be enhanced by the removal and regular abatement of *Tamarix* spp.

3.5 REPTILES AND AMPHIBIANS

Transects for herpetofauna were walked on July 7 and 19, 2006. Surveys were conducted between 0935 and 1027 on July 7th, and between 0905 and 0957 on July 19th. Sightings included the presence of the Western Whiptail (*Cnemidophorus tigris*) in each of the three plant habitats and also, for the first time, in the recharge basin area. The Common Side-blotched Lizard (*Uta stansburiana*) was observed in the Tamarisk-willow habitat, and for the first time, in the recharge basin area (as an incidental record). An incidental observation of about 100 larvae and two juveniles of an unidentified *Bufo* sp. was made on July 19th, in a small area of ponded water and adjacent muddy substrate in the creosote bush habitat (at E478750/N3587729, NAD 27). An American Bullfrog (*Rana catesbeiana*) was heard calling from the recharge basin area on July 7, 2006. A two-hour search for herpetofauna in areas not covered by transects, but that were thought might harbor additional species, was conducted on September 28, 2006. This effort yielded only one additional species, the Checkered Gartersnake (*Thamnophis marcianus*) (Figure 13), which was found among grasses along the bank of one of the recharge basins. This is only the second snake species located on the project site in the four seasons of monitoring since 1998, and each record is represented by a single individual. No other herpetofauna were recorded on the site in 2006. Three species of reptiles previously recorded at the site, the Desert Iguana (*Dipsosaurus dorsalis*), Ornate Tree Lizard (*Urosaurus ornatus*), and the Western Diamond-backed Rattlesnake (*Crotalus atrox*) were not observed during the 2006 monitoring. The most common lizard observed on the site in 2006, as in previous years, was the Western Whiptail. The scarcity and low species diversity of herpetofauna on the project site are surprising. This is particularly unusual for reptile species. It is possible that surveys at night might have located some snake species that tend to be more nocturnal. The 2006 herpetofauna results are quite similar to those reported for earlier monitoring efforts.

Figure 13. Checkered Gartersnake (*Thamnophis marcianus*) located at the edge of the recharge basin area. Photographed on September 28, 2006.

Table 7. Reptile and amphibian species observed at the High Plains Effluent Recharge Facility. New site records for 2006 are shown in blue.

Latin Name	2002				2004				2006			
	Habitat Type				Habitat Type				Habitat Type			
	CBA	MPV	TW	RB	CBA	MPV	TW	RB	CBA	MPV	TW	RB
Bufo sp.									✓			
Rana catesbeiana		✓	✓				✓					✓
Cnemidophorus tigris	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓
Dipsosaurus dorsalis	✓											
Urosaurus ornatus					✓							
Uta stansburiana	✓	✓					✓				✓	✓
Thamnophis marcianus												✓
Crotalus atrox						✓						

Habitat Types:
CBA – Creosote Bush Association
MPV – Mesquite/Paloverde Association
TW – Tamarisk/Willow Association
RB – Recharge Basin

3.6 BIRDS

Birds were counted in each of the four habitats present on the site at point locations selected as representative of each habitat (Figure 2). Each bird survey point was counted twice on separate days. Survey dates were July 7 and 19, 2006, and September 28, 2006. The bird survey points used in 2004 were initially reoccupied on July 7, 2006. After surveys were completed on that day, it was decided to relocate bird points in the

mesquite-paloverde and tamarisk-willow plant communities. This was due to an increase in density of vegetation since 2004, which was impacting visibility at the original points. The point locations for the creosote bush association and recharge basin area were retained. Results of these observations are given in Tables 8-a through 8-d. Because of the small sample sizes and limits on the time of year sampled, densities for bird species were not calculated. In order to obtain meaningful density estimates, multiple points in each habitat should be counted on several days. For common species, a reasonable estimate could be obtained with four to six replicate points in each habitat, and each point should be counted at least six times. For uncommon species, these efforts would need to be increased to get adequate sample sizes.

Table 8a. Bird Point Count Results, Creosote Bush Association. Combined results for two observation periods: July 7, 2006 from 0830-0845, and July 19, 2006 from 0834-0849.

Species Observed	Number of Observations		
	Within Habitat	Adjacent Habitat	Fly-over
Mallard	1		
Turkey Vulture		1	1
Gambel's Quail	2	4	
Killdeer		15	
Black-necked Stilt		11	5
Mourning Dove	3	18	81
White-winged Dove	1	16	31
Gila Woodpecker		1	
Western Kingbird		1	
Bell's Vireo		1	
Common Raven	2	1	1
Violet-green Swallow		1	
Cliff Swallow		3	3
Northern Rough-winged Swallow			3
Verdin	1		
Cactus Wren	1		
Black-tailed Gnatcatcher	1	1	
Northern Mockingbird		1	
Curve-billed Thrasher		1	
European Starling		30	40
Phainopepla	3	3	20
Song Sparrow		6	
Northern Cardinal		1	
Red-winged Blackbird		10	2
Great-tailed Grackle		3	1
House Finch	1	1	6

Table 8b. Bird Point Count Results, Mesquite - Paloverde Association. Combined results for two observation periods: July 19, 2006 from 0724-0739, and September 28, 2006 from 0713-0728.

Species Observed	Number of Observations		
	Within Habitat	Adjacent Habitat	Fly-over
Cooper's Hawk	1		
Gambel's Quail	6	1	
Killdeer		5	
Black-necked Stilt		2	
Mourning Dove	1	7	18
White-winged Dove		3	50
Gila Woodpecker		5	3
Black Phoebe		1	
Say's Phoebe	1		
Bell's Vireo	5		
Violet-green Swallow			20
Barn Swallow	5		2
Verdin	2		
Black-tailed Gnatcatcher	1		
Curve-billed Thrasher	1		
European Starling	4		
Phainopepla	2	2	
Yellow Warbler	4		
Northern Cardinal	1		
Red-winged Blackbird		6	28
Great-tailed Grackle		3	2
Brown-headed Cowbird	2		
House Finch	7	1	3
Lesser Goldfinch			15

Table 8c. Bird Point Count Results, Tamarisk-Willow Association. Combined results for two observation periods: July 19, 2006 from 0751-0806, and September 28, 2006 from 0736-0751.

Species Observed	Number of Observations		
	Within Habitat	Adjacent Habitat	Fly-over
Turkey Vulture	1		
Gambel's Quail		2	
American Coot		1	
Killdeer		5	
Black-necked Stilt		2	
Rock Dove			50

Species Observed	Number of Observations		
	Within Habitat	Adjacent Habitat	Fly-over
Mourning Dove	2		56
White-winged Dove		5	22
Black Phoebe	4	4	
Say's Phoebe	2		
Bell's Vireo	1		
Vireo sp.	1		
Violet-green Swallow			1
Cliff Swallow	2		25
Northern Rough-winged Swallow			1
Barn Swallow			2
Verdin	6		
Bewick's Wren	2		
Northern Mockingbird			1
Phainopepla	2		
Abert's Towhee	1		
Song Sparrow	6	3	
Northern Cardinal	2		
Pyrrhuloxia	2		1
Lazuli Bunting	2		
Red-winged Blackbird		2	31
House Finch	1		6

Table 8d. Bird Point Count Results, Recharge Basin. Combined results for two observation periods: July 7, 2006, 0653-0708 and July 19, 2006, 0654-0709.

Species Observed	Number of Observations		
	Within Habitat	Adjacent Habitat	Fly-over
Mallard	3	5	6
Red-tailed Hawk		1	
Gambel's Quail	1	8	
American Coot	3		
Killdeer	9		
Black-necked Stilt	14		
Spotted Sandpiper	10		
Wilson's Phalarope	7		
Mourning Dove		2	64
White-winged Dove		3	7
Gila Woodpecker		2	1
Black Phoebe	1		

Species Observed	Number of Observations		
	Within Habitat	Adjacent Habitat	Fly-over
Bell's Vireo		3	
Violet-green Swallow			11
Cliff Swallow			1
Northern Rough-winged Swallow	5		
Phainopepla		5	
Song Sparrow	14		
Northern Cardinal		1	
Red-winged Blackbird	11	2	
Great-tailed Grackle	2	1	2
Brown-headed Cowbird		1	
Bronzed Cowbird		2	
House Finch		7	

In addition to the point counts, incidental records of bird species observed on the site were kept during each site visit. The combined species list for the four site visits in 2006, along with the data from the 2002 and 2004 seasons for comparison, is given in Appendix C, Table C-1. Table C-1 includes data on the habitats used by each of the species. To aid in visual comparison between years, habitat totals have been color coordinated.

During the 2002 season EPG identified 56 species of birds on or near the High Plains Effluent Recharge Facility. During the 2004 site visits 48 species of birds were observed, including 14 that were new for the site. During the 2006 season 54 bird species were observed, of which ten were new. These additions for 2006 are the Great Blue Heron (*Ardea herodias*), Cooper's Hawk (*Accipiter cooperi*), Greater Yellowlegs (*Tringa melanoleuca*), Wilson's Phalarope (*Phalaropus tricolor*), Western Screech-owl (*Otus kennicottii*)(Figure 14), Say's Phoebe (*Sayornis saya*), Vermilion Flycatcher (*Pyrocephalus rubinus*), an undetermined *Vireo* sp., Violet-green Swallow (*Tachycineta thalassina*), Pyrrhuloxia (*Cardinalis sinuatus*), and Lazuli Bunting (*Passerina amoena*). The average of the three years is 53 bird species observed.

Figure 14. Western Screech-owl (*Otus kennicottii*) in European elderberry in the mesquite-paloverde plant association, photographed on August 23, 2006.

The site total observed by EPG is currently 81 species of birds. The additional 11 species recorded in 1998 by Entranco (Table C-2) would bring the site bird list to 92 species. However, the presence of the Chihuahuan Raven (*Corvus cryptoleucus*) recorded at the High Plains site by Entranco is highly unlikely, and EPG biologists consider the current site total to be 91 species.

Forty-seven of these 91 species are permanent residents in this vicinity, 43 are Neotropical migrants, and an unidentified species of *Vireo* is of indeterminate status. During the 2006 site visits only the Gambel's Quail (*Callipepla gambelii*) was observed in all habitats. No bird species was observed in all habitats in 2004, and in 2002, two species, the Mourning Dove (*Zenaida macroura*) and White-winged Dove (*Z. asiatica*) were seen in all available habitats. During the 2006 monitoring six species of birds; Rock Dove (*Columba livia*), Vermilion Flycatcher, Violet-green Swallow, Northern Mockingbird (*Mimus polyglottos*), Yellow-headed Blackbird (*X. xanthocephalus*), and Lesser Goldfinch (*Carduelis psaltria*) were only observed flying over the site.

Ten bird species were recorded in the creosote bush habitat in 2006. This is slightly less than in previous years (13 species in 2004, and 16 in 2002), but since the habitat has not changed in character, the numbers probably represent variability due to small sampling size and/or year to year variability in birds utilizing or migrating through the habitat.

Nine of these species are permanent residents, and one (White-winged Dove) is a Neotropical migrant. Because the creosote bush habitat has very low vegetative species diversity, and the shrubs provide limited structural diversity and cover, the average of 13 species for the 2002-2006 surveys will probably remain similar as subsequent surveys are conducted.

As was the case in 2002 and 2004, the mesquite-paloverde and the tamarisk-willow habitats had similar bird species diversity. The 2006 surveys had 23 species recorded in the mesquite-paloverde habitat and 24 species recorded for the tamarisk-willow habitat. These compare with 39 and 37 species recorded in 2002, and 16 and 15 species in 2004 respectively. In 2002, there was a high degree of overlap in species between these two habitats, with 32 species (84%) observed in both habitats. However, in 2004, the species overlap was not as evident (45%), and the 2006 value (47%) has not changed significantly. There is no obvious reason for the decrease in habitat overlap when comparing the 2002 value with the 2004 and 2006 values. This could indicate the difficulty inherent in attempting to make comparisons between habitats that are so small that edge effects may overshadow any real differences. In 2002, approximately 62% of the birds in each of these two habitats were represented by permanent resident species. In 2004, these values were 75% for the mesquite-paloverde habitat, and 67% for the tamarisk-willow habitat. The 2006 percentages are 70% for the mesquite-paloverde habitat and 62% for the tamarisk-willow habitat. The similarity in avian diversity in these two habitats is not surprising. The habitats are similar in their vegetative species diversity and vegetative structural diversity, and they have an equal proximity to water.

Six species of birds were observed in the recharge basins during the 2002 season. The low avian diversity in this habitat at that time was due to a lack of vegetation or open water, and the extensive areas of bare soil present. At that time the recharge basins were recently constructed, and had not received water. During the 2004 season twelve bird species were recorded at the recharge basins, twice as many as in 2002. Seventeen bird species were observed associated with the recharge basin habitat in 2006, with the addition of eight new records in this habitat, including the Great Blue Heron, Cooper's Hawk, Greater Yellowlegs, Wilson's Phalarope, Black Phoebe (*Sayornis nigricans*), Bell's Vireo (*Vireo bellii*), and Song Sparrow (*Melospiza melodia*). This is not a large increase in species, but is probably indicative of the occasional presence of water in the basins and the increase in vegetation in recharge cell 4, which is providing cover for species such as Bells' Vireo, Abert's Towhee (*Pipilo aberti*), and the Song Sparrow. The presence of passerine birds in the vegetation in recharge cell 4, and along the perimeter of the basins has attracted predators, such as the Cooper's Hawk.

3.7 MAMMALS

No specific surveys were conducted for mammal species on the High Plains Effluent Recharge Facility site. However, notes were kept on incidental observations of any evidence of mammals using the site. During the 2002 season only two mammal species, Black-tailed Jackrabbit (*Lepus californicus*) and Round-tailed Ground Squirrel (*Spermophilus tereticaudus*) were actually seen on the site. The presence of other species on the site was confirmed by the presence of bones, tracks, or scat. In 2002 the diversion channel was a good location for observing tracks as it was drying out, leaving a soft muddy surface that preserved tracks of several species. This condition of the diversion channel was not available during any of the site visits in 2004 or 2006. Three additional

mammal species were added to the site list in 2004. The only mammal added to the site list in 2006 was the Cotton Rat (*Sigmodon* sp.), which was observed on one of the roadways between the recharge cells. It is likely that other mammal species are using this site, and more observation time, particularly at night, would probably confirm several other species. To identify small mammals on the site, live-trapping in different habitats would be necessary.

Table 9. Mammal species observed (including indirect evidence) at the High Plains Effluent Recharge Facility. New animal records for the site in 2006 are highlighted in blue.

Latin Name	Common Name	Notes	2002	2004	2006
Sylvilagus audubonii	Desert Cottontail	Observed in creosote bush habitat.		✓	✓
Lepus californicus	Black-tailed Jack Rabbit	Observed in recharge basin cells.	✓		
Ammospermophilus harrisii	Harris' Antelope Squirrel	Observed in creosote bush habitat.		✓	
Spermophilus variegatus	Rock Squirrel	Observed in creosote bush habitat.		✓	
Spermophilus tereticaudus	Round-tailed Ground Squirrel	Observed in adjacent habitat, just west of site.	✓	✓	✓
Dipodomys sp.	Kangaroo Rat	Tracks in fine sand in recharge basin.	✓		
Sigmodon sp.	Cotton Rat	Between recharge basin ponds.			✓
Neotoma albigula	White-throated Woodrat	Midden in Mesquite-Paloverde Habitat at base of elderberry tree.		✓	✓
Canis latrans	Coyote	Scat and tracks in numerous locations.	✓		✓
Procyon lotor	Raccoon	Tracks in diversion channel.	✓		
Felis rufus	Bobcat	Tracks in diversion channel.	✓		
Pecari tajacu	Collared Peccary	Jaw bone in tamarisk/willow habitat.	✓		

3.8 DISCUSSION OF CHANGES AND TRENDS

Vegetation

The greatest change at the High Plains Recharge Facility since 2004 has been the increase in vegetation in the recharge basin area. Recharge cell 4 has become choked with shrubby vegetation, mostly species of saltbush, some as tall as two meters in height (Figure 10). This vegetation currently provides nesting and cover habitat for certain passerine bird species, and has attracted predators such as the Cooper's Hawk, which was observed hunting in recharge cell 4 on September 28, 2006. There is a significant difference in the level of development of the vegetation in the ponds, which probably reflects the water input and holding schedule of each pond. To date, the other three recharge cells and the equalization basin have received and held water for long enough periods such that the establishment of woody vegetation has not occurred. The embankments of these remaining basins are covered with grasses (Figure 15), and when the basins remain dry for some time, grass species are the first plants to colonize, and occasionally cover the entire bottom of the basin. In late September of 2006, recharge cell 2 was dominated by various species of grasses, to about one half meter in height, and

there was very little water in recharge cells 1, 3, and the equalization basin. There is no evidence of the establishment of any emergent plant species in the recharge ponds at this time; however, the increased activity of aquatic bird species at the site is likely to provide a method of introduction of emergent vegetation seed. Many of the trees planted on the pond berms appear to be established, although a few have died since being planted in 2002.

Figure 15. Equalization basin photographed on July 19, 2006, showing grasses on embankments, and initial colonization of the bottom.

Along with the increase in vegetation and the presence of seasonally dependable lentic waters in the recharge basins, there has been a continued increase in bird species utilizing this habitat. In 2002, when the basins were dry, only six bird species were recorded in the recharge basin area. In 2004 the number of birds associated with the active recharge basin habitat was 12 species, seven of which are aquatic-associates, including Mallard (*Anas platyrhynchos*), Cinnamon Teal (*A. cyanoptera*), American Coot (*Fulica americana*), Black-necked Stilt (*Himantopus mexicanus*), Spotted Sandpiper (*Actitis macularia*), and Red-winged (*Agelaius phoeniceus*) and Yellow-headed Blackbirds. In 2006, an additional eight species of birds, including three species of aquatic associates were observed. The new aquatic species are the Great Blue Heron, Greater Yellowlegs, and Wilson's Phalarope.

The increase in vegetation along with the associated lentic waters also attracts a variety of animals, including birds, small mammals, and insect species to the site. This in turn provides a food resource for birds, bats, and other vertebrate species. Total butterfly species recorded at the High Plains Recharge Facility increased from 11 species in 2002 to 25 species in 2004, and 28 in 2006. Increases in bird and butterfly species are at least partially attributable to the presence of the lentic aquatic habitat and associated vegetation.

Woody plant density in the creosote bush and the tamarisk-willow habitats have not appreciably changed since 2004. Woody plant density in the mesquite-paloverde association is significantly higher than in 2004 (2,812 plants/ha in 2006 and 898 plants/ha in 2004; $p > 0.01$). This is attributable in part to recruitment and continued maturation of the larger tree species such as Mexican paloverde, and particularly the more abundant velvet mesquite. Additionally, there has been a very large increase in size and density of saltbush plants along the south bank of the irrigation ditch that parallels the boundary between the mesquite-paloverde association and the recharge basin habitat.

Site Plant List

An additional 10 species of plants were added to the site plant list in 2006, including a single night-blooming cereus (*Peniocereus greggii*) in the creosote bush habitat (Figure 16). Some of these species are likely to have been present on the site previous to 2006, but since formal plant surveys are not a component of the project studies, they may have been overlooked. A couple of these species screwbean mesquite (*Prosopis pubescens*) and Wislizenus senna (*Senna wislizenii*) had obviously been planted during the original site landscaping. Some of the newly recorded grass species, mostly from the recharge basin area, have probably been recently introduced. Buffelgrass (*Pennisetum ciliare*), a recently listed Arizona Department of Agriculture prohibited noxious weed species is just beginning to appear on the project site as a few small, isolated clusters. Active control of this species is recommended to preclude it from taking over portions of the site.

Figure 16. Night blooming cereus (*Peniocereus greggii*) in the creosote bush habitat on the site. The inset is a close-up of the mature fruit.

Aquatic Algae and Macroinvertebrates

Due to the loss of the control structure for the diversion channel, sampling for aquatic algae and macroinvertebrates was conducted late in the year. The cooler temperatures and loss of aquatic populations present when the diversion channel dried out precluded representative sampling of these groups for the 2006 monitoring effort. Four new species of periphyton and a single additional species of phytoplankton were recorded in 2006.

Butterflies

Sampling of butterflies at the High Plains site since 1998 has gradually revealed the presence of a variety of species using the site. Since butterflies are dependent on plants both to support the development of their larvae, and as nectar sources for adults, they are closely tied to the plant species present on the site at any given time. The butterfly species present on the site has varied from year to year, with some species appearing only in years when the presence or an abundance of suitable annual food plants occurs. Changes in butterfly diversity on an annual basis are directly correlated to variability of rainfall quantity and timing, and the resultant annual plants that are present on the site at any given time. Annual variability in butterfly species present on the site does not necessarily represent changes in the suite of species that the site will support, except for that year, and may or may not reflect permanent changes in the species complex that will be supported by vegetation on the site over time.

Changes in vegetation on the site are mostly the result of maturation and recruitment of individuals of existing species, and for the most part there have been no dramatic changes in plant communities. The most significant vegetative changes at the site that have, or that are likely to affect butterflies, are the proliferation of saltbush species and grasses associated with the recharge basins. These changes are direct results of the availability of water pumped into the basins, and have resulted in increases in butterflies and bird life associated with their presence. The population of the Western Pygmy-blue butterfly on the project site has exploded from a single individual recorded in 2002, to a presence where they are abundant on the site wherever the saltbushes have become established.

Reptiles and Amphibians

Data collected since 2002 indicates low numbers of reptile and amphibian species at the High Plains site. Incidental observations in 2006 added one unidentified species of toad (*Bufo* sp.) in a low, wet area within the creosote bush habitat. Identification was uncertain since the individuals observed were immature, but they may represent the Great Plains toad (*Bufo cognatus*). Since so few herpetofauna had previously been encountered, an approximately two-hour long, concerted effort was made on September 28, 2006 to locate other species on the site. This effort did turn up the checkered garter snake as a new record for the site. Nocturnal surveys during warm summer evenings could reveal the presence of addition species.

Birds

The presence of water in the structures at the High Plains site continues to attract additional bird species. Three of the ten new site records for 2006 were aquatic dependent species. Fourteen of the 91 species of birds, representing fifteen percent of the total, recorded at the site are aquatic dependent species. Most of these species had probably

already been using aquatic resources available along the adjacent Santa Cruz River, but at least the Red-winged Blackbird, Yellow-headed Blackbird, and Wilson's Phalarope have been attracted to the ponded habit provided by the recharge basins. Additionally, the increase in plant density in the mesquite-paloverde habitats, and in recharge cell number four has attracted additional bird species.

Mammals

Twelve species of mammals have been recorded at the High Plains site to date. Because surveys for mammals are not part of the current scope of work for the monitoring at the site, all observations are incidental. Nocturnal site visits, mist netting for bats, or live trapping for small mammals would be likely to uncover other mammal species that are present at the site.

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APPENDIX A. VEGETATION SAMPLE PLOT RESULTS AND LOCATIONS.

Table A-1a. Frequency (%) and average height by species in the Creosote Bush Association. (Based on eight sample plots).

Species	Frequency	Plant Height (S.D.), m	Number of Individuals
Larrea tridentata	100.0	1.17 (0.30)	34

Table A-1b. Average percent canopy cover in the Creosote Bush Association (Based on eight sample plots).

Species	Mean % Canopy Cover (S.D.) at Height Interval	
	1m	2m
Larrea tridentata	13.2 (10.0)	1.16 (2.1)
Total Plant Canopy, %	**13.2**	**1.16**

Average density of all plants: **1,406 plants/ha (S.D. = 1145).**

Table A-2a. Frequency and average height by species in the Mesquite-Paloverde Association (Based on eight sample plots).

Species	Frequency	Plant Height (S.D.), m	Number of Individuals
Atriplex canescens	37.5	2.00 (1.05)	8
Atriplex lentiformis	87.5	1.80 (1.17)	21
Atriplex polycarpa	25	0.57 (0.30)	3
Baccharis salicifolia	12.5	1.52 (0.70)	3
Baccharis sarothroides	25	1.83 (1.74)	3
Hymenoclea monogyra	12.5	2.92 (*)	1
Isocoma tenuisecta	25	0.66 (0..40)	3
Larrea tridentata	12.5	0.30 (*)	1
Parkinsonia aculeata	12.5	5.51 (*)	1
Prosopis velutina	75	4.90 (0.42)	10
Sambucus nigra	50	3.39 (1.76)	6
Tamarix sp.	12.5	2.70 (*)	1

*Only one individual observed.

Table A-2b. Average percent canopy cover in the Mesquite-Paloverde Association (Based on eight sample plots).

Species	Mean % Canopy Cover (S.D.) at Height Interval					
	1m	2m	3m	4m	5m	6m
Atriplex canescens	5.50 (12.37)	0.30 (0.86)	0.62 (1.77)			
Atriplex lentiformis	18.50 (20.22)	15.70 (29.86)	5.87 (14.39)			
Atriplex polycarpa	1.19 (3.23)					
Baccharis salicifolia	1.03 (*)	2.72 (*)				
Baccharis sarothroides	1.40 (3.50)	0.74 (2.10)	0.01 (0.02)			
Hymenoclea monogyra	2.96 (*)	1.88 (*)				
Isocoma tenuisecta	2.09 (5.50)					
Larrea tridentata	0.05 (0.13)					
Parkinsonia aculeata				0.45 (1.28)	0.03 (0.09)	
Prosopis velutina	7.54 (11.05)	15.36 (24.11)	18.25 (25.18)	12.29 (15.63)	8.08 (10.11)	0.08 (0.22)
Sambucus nigra	7.26 (10.55)	9.98 (20.84)	7.61 (21.52)	4.71 (13.32)	0.94 (2.67)	
Tamarix sp. (tamarisk)	0.22 (0.62)	0.26 (0.73)				
Total Plant Canopy, %	**47.07 (20.30)**	**44.68 (27.18)**	**32.36 (28.30)**	**17.45 (21.71)**	**9.06 (10.76)**	**0.08 (0.22)**

*Species represented in only one plot.

Average density of all plants: **2812 plants/ha (S.D. = 1377).**

Table A-3a. Frequency and average height by species in the Tamarisk-Willow Association. (Based on eight sample plots)

Species	Frequency	Plant Height (S.D.), m	Number of Individuals
Baccharis salicifolia	12.5	2.10 (0.25)	2
Baccharis sarothroides	75	1.66 (0.89)	14
Hymenoclea monogyra	12.5	2.35 (0.37)	5
Isocoma tenuisecta	12.5	0.33 (0.05)	3
Larrea tridentata	12.5	1.00 (0.08)	2
Prosopis velutina	62.5	4.08 (2.52)	11
Sambucus nigra	12.5	3.98 (1.76)	3
Tamarix aphylla	12.5	9.22 (*)	1

*Only one individual observed.

Table A-3b. Average percent canopy cover in the Tamarisk-Willow Association (Based on eight sample plots).

Species	1m	2m	3m	4m	5m	6m	7m	8m	9m
Baccharis salicifolia	3.07 (8.46)	0.27 (0.77)							
Baccharis sarothroides	11.91 (17.5)	2.91 (7.63)	1.57 (4.03)						
Hymenoclea monogyra	1.98 (3.78)	1.12 (2.87)	0.02 (0.07)						
Isocoma tenuisecta	0.07 (0.17)								
Larrea tridentata	0.80 (2.28)								
Prosopis velutina	4.83 (9.86)	6.06 (11.4)	9.12 (16.6)	2.55 (4.38)	0.59 (1.14)	0.02 (0.05)	0.01 (0.02)		
Sambucus nigra	0.01 (0.02)	2.21 (6.25)	2.74 (7.76)	5.98 (16.9)	0.57 (1.61)				
Tamarix aphylla	3.28 (9.28)	3.08 (8.70)	3.26 (9.23)	1.34 (3.78)	1.30 (3.67)	1.27 (3.60)	0.98 (2.79)	0.26 (0.75)	0.19 (0.53)
Total Plant Canopy, %	**25.88 (14.3)**	**15.59 (11.1)**	**16.05 (16.1)**	**9.59 (16.3)**	**2.46 (3.8)**	**1.29 (3.6)**	**0.99 (2.8)**	**0.27 (0.8)**	**0.19 (0.5)**

Average density of all plants: **1562 plants/ha (S.D. = 1157).**

Table A-4. Sample Plot Locations. GPS - UTM coordinates, referenced to NAD27, Zone 12S (estimated error ±5 m)

Plot Number	Easting	Northing
C-1	478699	3587742
C-2	478704	3587778
C-3	478711	3587758
C-4	478715	3587745
C-5	478704	3587718
C-6	478726	3587705
C-7	478790	3587668
C-8	478799	3587649
M-1	478644	3587869
M-2	478732	3587856
M-3	478745	3587861
M-4	478759	3587866
M-5	478763	3587856
M-6	478775	3587849
M-7	478820	3587838
M-8	478868	3587832
T-1	478935	3587693
T-2	478941	3587675
T-3	478947	3587675
T-4	478953	3587675
T-5	478929	3587663
T-6	478941	3587621
T-7	478959	6587591
T-8	478941	3587585
West Photo Point	478679	3587783
East Photo Point	478864	3587638

Table A-5. Other Sample Locations. Centers of bird point counts and endpoints of herpetofauna transects. GPS - UTM coordinates, referenced to NAD27, Zone 12S (estimated error ±5 m).

Sample Point	Easting	Northing
B-1. Bird Count – Mesquite-Paloverde	478734	3587883
B-2. Bird Count – Tamarisk-Willow	478954	3587757
B-3. Bird Count – Creosote Bush	478702	3587734
B-4. Bird Count – Recharge Basin	478762	3587814
H-1. Herpetofauna Transect – Mesquite-Paloverde – West End	478815	3587851
H-1. Herpetofauna Transect – Mesquite-Paloverde – East End	478863	3587837
H-2. Herpetofauna Transect – Tamarisk-Willow – North End	478931	3587748
H-2. Herpetofauna Transect – Tamarisk-Willow – South End	478931	3587698
H-3. Herpetofauna Transect – Creosote Bush – West End	478707	3587749
H-3. Herpetofauna Transect – Creosote Bush – East End	478751	3587725
H-4. Herpetofauna Transect – Recharge Basin – West End	478762	3587812
H-4. Herpetofauna Transect – Recharge Basin – East End	478806	3587701

APPENDIX B. BUTTERFLY SURVEY RESULTS.

Table B-1a. Butterflies observed and/or sampled on July 7, 2006, 0906-1021.

Species	No. Observed/ Captured	Habitat	DSS*
Calephelis nemesis (Fatal Metalmark)	1/0	Tamarisk-Willow	18
Danaus gilippus (Queen)	1/0	Mesquite-Paloverde	12
Hemiargus ceraunus (Ceraunus Blue)	4/2	Mesquite-Paloverde	7
Hylephila phyleus (Fiery Skipper)	3/1	Mesquite-Paloverde	14
Leptotes marina (Marine Blue)	2/1	Mesquite-Paloverde	8
Papilio polyxenes (Black Swallowtail)	1/0	Recharge Basin	6
Total Number	**12/4**		

*Disturbance susceptibility score.

Table B-1b. Butterflies observed and/or sampled on July 19, 2006, 0712 to 1000. A question mark attached to a species reference indicates an unconfirmed (by capture) identification.

Species	No. Observed/ Captured	Habitat	DSS*
Brephidium exile (Western Pygmy-blue)	29/0	Mesquite-Paloverde	9
Brephidium exile (Western Pygmy-blue)	3/0	Tamarisk-Willow	9
Calephelis arizonensis (Arizona Metalmark)	2/1	Mesquite-Paloverde	8
Calephelis nemesis ? (Fatal Metalmark)	1/0	Tamarisk-Willow	18
Calephelis nemesis ? (Fatal Metalmark)	1/0	Recharge basin	18
Danaus gilippus (Queen)	6/0	Mesquite-Paloverde	12
Dymasia dymas (Tiny Checkerspot)	1/1	Recharge basin	11
Hylephila phyleus ? (Fiery Skipper)	2/0	Mesquite-Paloverde	14
Leptotes marina ? (Marine Blue)	3/0	Mesquite-Paloverde	8
Total Number	**48/2**		

*Disturbance susceptibility score. ?=Species not confirmed.

Table B-1c. Butterflies observed and/or sampled on September 28, 2006, 0755 to 0952.

Species	No. Observed/ Captured	Habitat	DSS*
Asterocampa (leilia ?) (Empress Leilia)	1/0	Mesquite-Paloverde	15
Asterocampa (leilia ?) (Empress Leilia)	1/0	Tamarisk-Willow	15
Asterocampa (leilia ?) (Empress Leilia)	3/0	Recharge Basin	15
Brephidium exile (Western Pygmy-blue)	1/0	Creosote Bush	9
Brephidium exile (Western Pygmy-blue)	20/0	Tamarisk-Willow	9
Brephidium exile (Western Pygmy-blue)	2/0	Recharge Basin	9
Libytheana carinenta (American Snout)	1/0	Tamarisk-Willow	14
Libytheana carinenta (American Snout)	1/0	Recharge Basin	14
Nathalis iole (Dainty Sulphur)	1/0	Creosote Bush	6
Nathalis iole (Dainty Sulphur)	2/1	Tamarisk-Willow	6
Total Number	**33/1**		

*Disturbance susceptibility score. ?=Species not confirmed.

Table B-2a. Butterfly species recorded at High Plains Effluent Recharge Project site, Marana, AZ. Species records added in 2006 are highlighted in blue. A question mark attached to a species reference indicates an unconfirmed (by capture) identification.

Latin Name	Common Name	1998 (Entranco)	2002 (EPG)	2004 (EPG)	2006 (EPG)
Papilio polyxenes	Black Swallowtail	✓	✓	✓	✓
Pieris rapae	Cabbage White	✓			
Pontia protodice	Checkered White		✓	✓	
Colias eurytheme	Orange Sulphur			✓	✓
Colias cesonia ?	Southern Dogface			✓	
Phoebis sennae	Cloudless Sulphur	✓			
Nathalis iole	Dainty Sulphur			✓	✓
Strymon melinus	Gray Hairstreak		✓		
Ministrymon leda	Leda Ministreak			✓	
Brephidium exile	Western Pygmy-blue		✓		✓
Leptotes marina	Marine Blue	✓	✓	✓	✓
Hemiargus ceraunus	Ceraunus Blue			✓	✓
Calephelis arizonensis	Arizona Metalmark				✓
Calephelis nemesis	Fatal Metalmark	✓	✓	✓	✓
Libytheana carinenta	American Snout			✓	✓
Polydryas arachne ?	Arachne Checkerspot			✓	
Chlosyne lacinia ?	Bordered Patch			✓	
Dymasia dymas	Tiny Checkerspot				✓

Latin Name	Common Name	1998 (Entranco)	2002 (EPG)	2004 (EPG)	2006 (EPG)
Vanessa cardui	Painted Lady			✓	
Junonia coenia	Common Buckeye			✓	
Danaus gilippus	Queen	✓	✓	✓	✓
Limenitus archippus	Viceroy	✓			
Asterocampa (leilia?)	Empress Leilia				✓
Thorybes pylades	Northern Cloudywing			✓	
Hylephila phyleus	Fiery Skipper	✓	✓?		✓
Pyrgus albescens	White Checkered-Skipper		✓	✓	
Copaeodes aurantiacus	Orange Skipperling			✓	
Lerodea eufala	Eufala Skipper			✓	
Totals by Year		**8**	**9**	**19**	**13**
Cumulative Project Total		**8**	**11**	**25**	**28**

?=Species unconfirmed

Table B-2b. Butterfly species recorded at High Plains Effluent Recharge Project site, by habitat.

Latin Name	Common Name	Creosote Bush	Mesquite - Paloverde	Tamarisk - Willow	Recharge Basin
Papilio polyxenes	Black Swallowtail	✓	✓	✓	✓
Pieris rapae	Cabbage White			✓	✓
Pontia protodice	Checkered White	✓	✓	✓	
Colias eurytheme	Orange Sulphur			✓	
Colias cesonia ?	Southern Dogface		✓		
Phoebis sennae	Cloudless Sulphur		✓	✓	
Nathalis iole	Dainty Sulphur	✓		✓	
Strymon melinus	Gray Hairstreak			✓	
Ministrymon leda	Leda Ministreak		✓		
Brephidium exile	Western Pygmy-blue	✓	✓	✓	✓
Leptotes marina	Marine Blue		✓	✓	
Hemiargus ceraunus	Ceraunus Blue		✓		
Calephelis	Arizona			✓	

Latin Name	Common Name	Creosote Bush	Mesquite - Paloverde	Tamarisk - Willow	Recharge Basin
arizonensis	Metalmark				
Calephelis nemesis	Fatal Metalmark		✓	✓	✓
Libytheana carinenta	American Snout		✓	✓	✓
Polydryas arachne?	Arachne Checkerspot				✓
Chlosyne lacinia ?	Bordered Patch		✓	✓	
Dymasia dymas	Tiny Checkerspot				✓
Vanessa cardui	Painted Lady		✓		
Junonia coenia	Buckeye		✓		
Danaus gilippus	Queen	✓	✓	✓	
Thorybes pylades	Northern Cloudywing		✓		
Hylephila phyleus	Fiery Skipper		✓	✓	
Limenitus archippus	Viceroy		✓		
Asterocampa (leilia?)	Empress Leilia		✓	✓	✓
Pyrgus albescens	White Checkered-skipper			✓	
Copaeodes aurantiacus	Orange Skipperling			✓	
Lerodea eufala	Eufala Skipper		✓	✓	
Total Species		**5**	**19**	**19**	**8**

?=Unconfirmed species

Table B-3a. Riparian Environmental Quality Assessment for the Creosote Bush Association, based on annual data.

Latin Name	DSS*	2002	2004	2006
		Relative Abundance	**Relative Abundance**	**Relative Abundance**
Brephidium exile	9	No Record	No Record	Uncommon
Danaus gilippus	12	No Record	Uncommon	No Record
Nathalis iole	6	No Record	No Record	Uncommon
Papilio polyxenes	6	Rare	No Record	No Record
Pontia protodice	8	No Record	Uncommon	No Record
Total number of species		1	2	2
Butterfly Riparian Quality **(BRQ)**		**0.0**	**0.3**	**0.0**

*DSS – Disturbance susceptibility score.

Table B-3b. Riparian Environmental Quality Assessment for the Mesquite-Paloverde Association, based on annual data.

Latin Name	DSS*	2002	2004	2006
		Relative Abundance	**Relative Abundance**	**Relative Abundance**
Asterocampa (leilia?)	15	No Record	No Record	Uncommon
Brephidium exile	9	Uncommon	No Record	Abundant
Calephelis arizonensis	8	No Record	No Record	Uncommon
Calephelis nemesis	18	No Record	Uncommon	No Record
Chlosyne lacinia?	6	No Record	Uncommon	No Record
Colias cesonia?	7	No Record	Uncommon	No Record
Danaus gilippus	12	Uncommon	Common	Common
Hemiargus ceraunus	7	No Record	No Record	Common
Hylephila phyleus	14	No Record	No Record	Common
Junonia coenia	9	No Record	Uncommon	No Record
Leptotes marina	8	Abundant	Common	Common
Lerodea eufala	5	No Record	Uncommon	No Record
Libytheana carinenta	14	No Record	Uncommon	No Record
Papilio polyxenes	6	No Record	Common	No Record
Pontia protodice	8	Abundant	Abundant	No Record
Vanessa cardui	4	No Record	Uncommon	No Record
Total number of species		4	11	7
Butterfly Riparian Quality **(BRQ)**		**2.0**	**7.3**	**3.5**

*DSS – Disturbance susceptibility score. ?=Unconfirmed species

Table B-3c. Riparian Environmental Quality Assessment for the Tamarisk-Willow Association, based on annual data. A question mark attached to a species reference indicates an unconfirmed (by capture) identification.

Latin Name	DSS*	2002	2004	2006
		Relative Abundance	**Relative Abundance**	**Relative Abundance**
Asterocampa (leilia?)	15	No Record	No Record	Uncommon
Brephidium exile	9	No Record	No Record	Common
Calephelis nemesis	18	Common	Common	Common
Chlosyne lacinia?	6	No Record	Uncommon	No Record
Colias eurytheme	6	No Record	Uncommon	No Record
Danaus gilippus	12	Uncommon	Common	No Record
Hylephila phyleus?	9	Rare	Uncommon	No Record
Leptotes marina	8	Abundant	Common	No Record
Lerodea eufala	5	No Record	Uncommon	No Record
Libytheana carinenta	14	No Record	No Record	Uncommon
Nathalis iole	6	No Record	Rare	Uncommon
Papilio polyxenes	6	Uncommon	Uncommon	No Record
Pontia protodice	8	Abundant	Common	No Record
Pyrgus albescens	8	Uncommon	Uncommon	No Record
Strymon melinus	4	Uncommon	No Record	No Record
Total number of species		8	11	5
Butterfly Riparian Quality **(BRQ)**		**8.0**	**5.5**	**2.5**

*DSS – Disturbance susceptibility score. ?=Unconfirmed species.

Table B-3d. Riparian Environmental Quality Assessment for the recharge basin area, based on annual data. A question mark attached to a species reference indicates an unconfirmed (by capture) identification.

Latin Name	DSS*	2002	2004	2006
		Relative Abundance	**Relative Abundance**	**Relative Abundance**
Asterocampa (leilia?)	15	No Record	No Record	Common
Brephidium exile	9	No Record	No Record	Common
Calephelis nemesis ?	18	No Record	No Record	Rare
Dymasia dymas	11	No Record	No Record	Uncommon
Libytheana carinenta	14	No Record	No Record	Uncommon
Papilio polyxenes	6	No Record	No Record	Uncommon
Polydryas arachne	6	No Record	Uncommon	No Record
Pontia protodice	8	No Record	Common	No Record
Total number of species		0	2	6
Butterfly Riparian Quality **(BRQ)**		**0.0**	**0.0**	**4.0**

*DSS – Disturbance susceptibility score. ?=Unconfirmed species.

Table B-3e. Project composite Riparian Environmental Quality Assessment expressed as the BRQ index by habitat for each monitoring year.

Habitat	1998	2002	2004	2006	Average
Creosote Bush	No Data	0.0	0.2	1.0	0.4
Mesquite-paloverde	1.2	0.7	5.5	2.3	2.4
Tamarisk-Willow	1.2	1.3	2.8	1.7	1.8
Recharge Basin	No Data	No Data	0.0	2.5	0.8

Table B-3f. Disturbance Susceptibility Scores (DSS) of butterfly species.

Latin Name	Common Name	Categories*				DSS	Source
		1	2	3	4		
Papilionidae							
Papilio cresphontes	Giant Swallowtail	3	5	3	2	13	Pape/EPG
Papilio polyxenes	Black Swallowtail	1	2	3	0	6	Pape/EPG
Pieridae							
Colias eurytheme	Orange Sulphur	1	2	1	2	6	Nelson & Anderson
Colias cesonia	Southern Dogface	1	3	3	0	7	Pape/EPG
Eurema nicippe	Sleepy Orange	3	2	5	2	12	Pape/EPG
Nathalis iole	Dainty Sulphur	1	2	3	0	6	Nelson & Anderson
Phoebis sennae	Cloudless Sulphur	1	2	5	2	10	Nelson & Anderson
Pieris rapae	Cabbage White	1	2	1	0	4	Pape/EPG
Pontia protodice	Checkered White	3	2	3	0	8	Pape/EPG
Lycaenidae							
Brephidium exile	Western Pygmy-blue	3	3	3	0	9	Pape/EPG
Hemiargus ceraunus	Ceraunus Blue	1	3	3	0	7	Pape/EPG
Hemiargus isola	Reakirt's Blue	1	2	1	2	6	Nelson & Anderson
Leptotes marina	Marine Blue	3	2	1	2	8	Pape/EPG
Ministrymon leda	Leda Hairstreak	3	5	5	0	13	Pape/EPG
Strymon melinus	Gray Hairstreak	1	2	1	0	4	Nelson & Anderson
Riodinidae							
Apodemia mormo	Mormon Metalmark	3	2	3	2	10	Pape/EPG
Apodemia palmeri	Mesquite Metalmark	5	3	5	2	15	Pape/EPG
Calephelis arizonensis	Arizona Metalmark	3	2	3	0	8	Pape/EPG
Calephelis nemesis	Fatal Metalmark	5	3	5	5	18	Pape/EPG
Nymphalidae							
Chlosyne lacinia	Bordered Patch	1	2	1	2	6	Pape/EPG
Dymasia dymas	Tiny Checkerspot	4	2	5	0	11	Pape/EPG
Danaus gilippus	Queen	3	2	5	2	12	Nelson & Anderson
Danaus plexippus	Monarch	1	2	5	2	10	Pape/EPG
Junonia coenia	Buckeye	1	2	3	3	9	Pape/EPG
Libytheana carinenta	American Snout	3	3	5	3	14	Pape/EPG
Limenitus archippus	Viceroy	3	5	3	5	16	Nelson & Anderson
Asterocampa leilia	Empress Leilia	2	5	5	3	15	Pape/EPG
Nymphalis antiopa	Mourning Cloak	3	5	1	3	12	Nelson & Anderson
Polydryas arachne	Arachne Checkerspot	1	2	3	0	6	Pape/EPG
Vanessa cardui	Painted Lady	1	2	1	0	4	Nelson & Anderson

Latin Name	Common Name	Categories*				DSS	Source
		1	2	3	4		
Hesperiidae							
Celotes nessus	Common Streaky-skipper	1	2	5	0	8	Pape/EPG
Copaeodes aurantiacus	Orange Skipperling	3	1	3	2	9	Pape/EPG
Hylephila phyleus	Fiery Skipper	1	1	3	2	7	Pape/EPG
Lerodea eufala	Eufala (gray) Skipper	1	1	3	0	5	Pape/EPG
Pyrgus albescens	White Checkered skipper	1	2	3	2	8	Pape/EPG
Pyrgus communis	Common Checkered Skipper	3	2	1	2	8	Nelson & Anderson
Thorybes pylades	Northern Cloudywing	3	2	3	2	10	Pape/EPG

*Categories: 1 - Species mobility
2 - Larval host plant form
3 - Larval food-plant specificity
4 - Riparian dependency

APPENDIX C. BIRD SPECIES LISTS.

Table C-1. Bird species observed in various habitats at High Plains Recharge Site. New site records added in 2006 are highlighted in blue.

Latin Name	Common Name	Status	2002 Habitat Type						2004 Habitat Type						2006 Habitat Type					
			CBA	MPV	TW	RB	FO	AA	CBA	MPV	TW	RB	FO	AA	CBA	MPV	TW	RB	FO	AA
Egretta thula	Snowy Egret	T (S)											✓							
Ardea herodias	Great Blue Heron	P																✓	✓	
Plegadis chihi	White-faced Ibis	T											✓							
Cathartes aura	Turkey Vulture	S					✓	✓						✓			✓		✓	✓
Accipiter cooperii	Cooper's Hawk	P													✓	✓		✓		
Dendrocygna autumnalis	Black-bellied Whistling-duck	S					✓													
Anas platyrhynchos	Mallard	P			✓		✓					✓				✓		✓	✓	
Anas cyanoptera	Cinnamon Teal	T										✓								
Buteo jamaicensis	Red-tailed Hawk	P	✓				✓	✓												✓
Falco sparverius	American Kestrel	P		✓	✓				✓				✓							✓
Falco mexicanus	Prairie Falcon	P		✓																
Callipepla gambelii	Gambel's Quail	P	✓	✓	✓	✓		✓	✓	✓	✓				✓	✓	✓	✓		
Fulica americana	American Coot	P										✓						✓		
Charadrius vociferus	Killdeer	P		✓	✓	✓		✓	✓	✓		✓		✓				✓	✓	✓
Himantopus mexicanus	Black-necked Stilt	P										✓						✓	✓	
Tringa melanoleuca	Greater Yellowlegs	T																✓		
Actitis macularia	Spotted Sandpiper	T										✓						✓		
Phalaropus tricolor	Wilson's Phalarope	T																✓		
Columba livia	Rock Dove	P					✓	✓					✓						✓	
Zenaida asiatica	White-winged Dove	S	✓	✓	✓	✓	✓	✓	✓				✓		✓				✓	
Zenaida macroura	Mourning Dove	P	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓		✓	✓
Columbina passerina	Common Ground-Dove	P	✓																	
Geococcyx californianus	Greater Roadrunner	P							✓	✓				✓						
Bubo virginianus	Great Horned Owl	P		✓																
Otus kennicottii	Western Screech-owl	P														✓				
Archilochus alexandri	Black-chinned Hummingbird	S	✓	✓	✓					✓	✓					✓				
Calypte costae	Costa's Hummingbird	P		✓							✓									
Melanerpes uropygialis	Gila Woodpecker	P		✓	✓					✓						✓			✓	
Picoides scalaris	Ladder-backed Woodpecker	P	✓	✓	✓															
Colaptes chrysoides	Gilded Flicker	P			✓															
Empidonax sp.	Empidonax Flycatcher	T			✓															
Sayornis nigricans	Black Phoebe	P		✓	✓												✓	✓		
Sayornis saya	Say's Phoebe	P														✓	✓			✓
Pyrocephalus rubinus	Vermilion Flycatcher	P																	✓	
Myiarchus cinerascens	Ash-throated Flycatcher	S	✓	✓	✓						✓						✓			
Tyrannus verticalis	Western Kingbird	S	✓	✓	✓	✓			✓	✓	✓						✓			
Lanius ludovicianus	Loggerhead Shrike	P	✓					✓												
Vireo bellii	Bell's Vireo	S		✓	✓						✓					✓	✓	✓		
Vireo gilvus	Warbling Vireo	T		✓	✓															
Vireo sp.	Vireo species	*															✓			
Corvus corax	Common Raven	P					✓						✓		✓				✓	
Eremophila alpestris	Horned Lark	P						✓						✓						
Progne subis	Purple Martin	S					✓													
Tachycineta thalassina	Violet-green Swallow	T																	✓	

Latin Name	Common Name	Status	2002						2004						2006					
			Habitat Type						Habitat Type						Habitat Type					
			CBA	MPV	TW	RB	FO	AA	CBA	MPV	TW	RB	FO	AA	CBA	MPV	TW	RB	FO	AA
Stelgidopteryx serripennis	Northern Rough-winged Swallow	S					✓					✓	✓				✓	✓	✓	
Petrochelidon pyrrhonota	Cliff Swallow	T (S)											✓				✓		✓	
Hirundo rustica	Barn Swallow	S					✓									✓			✓	
Auriparus flaviceps	Verdin	P	✓	✓	✓				✓	✓	✓				✓	✓	✓			
Campylorhynchus brunneicapillus	Cactus Wren	P	✓	✓	✓				✓	✓					✓					
Thryomanes bewickii	Bewick's Wren	P		✓	✓					✓						✓	✓			
Polioptila melanura	Black-tailed Gnatcatcher	P		✓	✓										✓	✓				
Mimus ployglottos	Northern Mockingbird	P								✓	✓								✓	
Toxostoma curvirostre	Curve-billed Thrasher	P	✓	✓	✓			✓	✓							✓	✓			
Toxostoma crissale	Crissal Thrasher	P									✓									
Sturnus vulgaris	European Starling	P											✓			✓			✓	
Phainopepla nitens	Phainopepla	P	✓	✓	✓			✓		✓			✓		✓	✓	✓		✓	
Vermivora luciae	Lucy's Warbler	S		✓	✓															
Dendroica petechia	Yellow Warbler	T		✓	✓											✓				
Dendroica townsendi	Townsend's Warbler	T			✓															
Geothlypis trichas	Common Yellowthroat	S		✓	✓							✓								
Wilsonia pusilla	Wilson's Warbler	T		✓						✓						✓				
Icteria virens	Yellow-breasted Chat	S		✓	✓						✓						✓			
Pipilo fuscus	Canyon Towhee	P							✓											
Pipilo aberti	Abert's Towhee	P		✓	✓					✓	✓						✓	✓		
Chondestes grammacus	Lark Sparrow	P	✓	✓	✓			✓												
Melospiza melodia	Song Sparrow	P		✓	✓												✓	✓		
Zonotrichia leucophrys	White-crowned Sparrow	T (W)		✓	✓			✓	✓											
Cardinalis cardinalis	Northern Cardinal	P		✓	✓						✓					✓	✓			
Cardinalis sinuatus	Pyrrhuloxia	P															✓		✓	
Guiraca caerulea	Blue Grosbeak	S		✓																
Passerina amoena	Lazuli Bunting	T															✓			
Agelaius phoeniceus	Red-winged Blackbird	P					✓	✓		✓		✓	✓					✓	✓	
Sturnella neglecta	Western Meadowlark	P										✓								
Xanthocephalus xanthocephalus	Yellow-headed Blackbird	T (W)										✓							✓	
Quiscalus mexicanus	Great-tailed Grackle	P		✓	✓	✓	✓	✓				✓	✓			✓		✓	✓	
Molothrus aeneus	Bronzed Cowbird	S			✓		✓	✓								✓				
Molothrus ater	Brown-headed Cowbird	P		✓	✓		✓	✓					✓			✓	✓			
Icterus cucullatus	Hooded Oriole	S		✓																
Icterus bullockii	Bullock's Oriole	T		✓						✓										
Carpodacus mexicanus	House Finch	P	✓	✓	✓		✓				✓				✓	✓	✓		✓	
Carduelis psaltria	Lesser Goldfinch	P		✓	✓				✓		✓						✓		✓	
Total Number of Species			16	39	37	6	16	17	13	16	15	12	14	4	10	22	24*	17	24	6
Permanent Residents			12	24	23	4	9	13	10	12	10	7	9	3	9	16	15	12	17	5
Summer Residents			4	10	9	2	7	3	2	2	5	2	2	1	1	4	6	2	5	1
Winter Residents			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transients			0	5	5	0	0	1	1	2	0	3	3	0	0	2	2	3	2	0

* Species and status indeterminate; this also affects total species in habitat for 2006. Taxonomy from AOU, 1998.

Habitat Types:

CBA - Creosote Bush Association
MPV - Mesquite/Paloverde Association
TW - Tamarisk/Willow Association
RB - Recharge Basin
FO - Fly-over
AA - Adjacent Agricultural Area

Status:

P - Permanent Resident
S - Summer Resident
W - Winter Resident
T - Transient; T(S) = Transient in summer; T (W) - Transient in winter

Table C-2. Additional Bird Species Reported by Entranco (1998), that have not been observed since that time.

Latin Name	Common Name	Status
Nycticorax nycticorax	Black-crowned Night-Heron	T (W)
Parabuteo unicinctus	Harris's Hawk	P
Aeronautes saxatalis	White-throated Swift	T (S)
Contopus sordidulus	Western Wood-Pewee	T
Myiarchus tyrannulus	Brown-crested Flycatcher	S
Vireo plumbeus	Plumbeous (Solitary) Vireo	T
Corvus cryptoleucus	Chihuahuan Raven	*
Regulus calendula	Ruby-crowned Kinglet	T (W)
Piranga rubra	Summer Tanager	S
Piranga ludoviciana	Western Tanager	T
Icterus parisorum	Scott's Oriole	S

Status:
P – Permanent Resident
S – Summer Resident
W – Winter Resident
T–Transient; T (S) = Transient in summer; T (W) = Transient in winter

* Unlikely record.

APPENDIX D. PLANT SPECIES.

Table D-1. High Plains Effluent Recharge Project – Plant Species Observed on Project Site. Species highlighted in blue are new records during the 2006 season. Common names are from the Integrated Taxonomic Information System website (ITIS 2006).

Family	Latin Name	Common Name	2002	2004	2006
Amaranthaceae	*Amaranthus palmeri*	Palmer amaranth	✓		✓
	Tidestromia lanuginosa	Wooly tidestromia		✓	✓
Asteraceae	*Baccharis salicifolia*	Seepwillow	✓	✓	✓
	Baccharis sarothroides	Desert broom	✓	✓	✓
	Chrysothamnus (viscidiflorus?)	Green Rabbitbrush			✓
	Cirsium sp.	Thistle	✓	✓	
	Heterotheca subaxillaris	Camphorweed	✓		
	Hymenoclea monogyra	Cheeseweed burrobrush	✓	✓	✓
	Isocoma tenuisecta	Burroweed	✓	✓	✓
	Pectis sp.	Fetid-marigold	✓		✓
	Silybum marianum	Milk thistle	✓	✓	✓
	Sonchus (oleraceus?)	Common sowthistle	✓	✓	
	Xanthium strumarium	Cocklebur	✓	✓	✓
Bignoniaceae	*Chilopsis linearis*	Desertwillow	✓	✓	✓
Boraginaceae	*Amsinckia* sp.	Fiddleneck	✓		
	Cryptantha sp.	Cryptantha	✓		
	Heliotropium curassavicum	Salt heliotrope	✓	✓	✓
Brassicaceae	*Descurainia* sp.	Tansy mustard	✓		
	Sisymbrium irio	London rocket		✓	
Cactaceae	*Opuntia versicolor*	Staghorn cholla	✓	✓	✓
	Peniocereus greggii	Nightblooming cereus			✓
Caprifoliaceae	*Sambucus nigra*	European elderberry	✓	✓	✓
Chenopodiaceae	*Atriplex canescens*	Fourwing saltbush	✓	✓	✓
	Atriplex lentiformis	Quailbush		✓	✓
	Atriplex polycarpa	Desert saltbush		✓	✓
	Salsola tragus	Prickly Russian thistle	✓	✓	✓
Cyperaceae	*Scirpus* sp.	Bulrush	✓	✓	✓
Ephedraceae	*Ephedra trifurca*	Longleaf ephedra	✓	✓	
Fabaceae	*Medicago* sp.	Alfalfa	✓		
	**Olneya tesota*	Ironwood	✓	✓	
	**Parkinsonia florida*	Blue paloverde	✓	✓	✓
	Parkinsonia aculeata	Mexican paloverde	✓	✓	✓

Family	Latin Name	Common Name	2002	2004	2006
	Prosopis pubescens	Screwbean mesquite			✓
	Prosopis velutina	Velvet mesquite	✓	✓	✓
	**Senna wislizenii*	Wislizenus senna			✓
Geraniaceae	*Erodium cicutarium*	Filaree	✓		
Hydrophyllaceae	*Nama hispidum*	Bristly nama		✓	
Lamiaceae	*Marrubium vulgare*	Horehound	✓	✓	
Loasaceae	*Mentzelia (pumila?)*	Dwarf blazingstar	✓	✓	
Malvaceae	*Sphaeralcea (ambigua?)*	Globemallow		✓	
Martyniaceae	*Proboscidea parviflora*	Devil's claw		✓	✓
Oleaceae	**Fraxinus* sp.	Ash	✓	✓	✓
Poaceae	*Bouteloua barbata*	Sixweeks grama			✓
	Bouteloua rothrockii	Rothrock grama			✓
	Bromus catharticus	Rescue grass		✓	
	Bromus rubens	Red brome		✓	
	Cynodon dactylon	Bermudagrass	✓	✓	✓
	Echinochloa crus-galli	Barnyard grass			✓
	Hordeum jubadum	Foxtail barley		✓	
	Hordeum murinum	Mouse barley		✓	
	Leptochloa fusca ssp. *uninervia*	Mexican sprangletop			✓
	Pennisetum ciliare	Buffelgrass			✓
	Polypogon monspeliensis	Annual rabbit's-foot grass		✓	
	Schismus arabicus	Arabian schismus		✓	
	Sorghum halepense	Johnson grass	✓		✓
Polygonaceae	*Polygonum* sp.	Knotweed	✓		
	Rumex (hymenosepalus?)	Dock	✓	✓	✓
Portulacaceae	*Portulaca (oleracea?)*	Purslane	✓		✓
Ranunculaceae	*Ranunculus sceleratus*	Cursed buttercup		✓	
Salicaceae	*Salix gooddingii*	Goodding willow	✓	✓	✓
Solanaceae	*Datura* sp.	Datura	✓	✓	✓
	Lycium berlandieri	Berlandier wolfberry			✓
	Nicotiana glauca	Tree tobacco	✓	✓	✓
	Nicotiana obtusifolia	Desert tobacco		✓	
	Solanum elaeagnifolium	Silverleaf nightshade	✓	✓	✓
	Solanum rostratum	Buffalobur	✓	✓	✓
Tamaricaceae	*Tamarix aphylla*	Athel	✓	✓	✓
	Tamarix sp.	Tamarisk	✓	✓	✓

Family	Latin Name	Common Name	2002	2004	2006
Scrophulariaceae	**Leucophyllum frutescens*	Cenizo	✓	✓	
	Veronica sp.	Speedwell	✓	✓	✓
Zygophyllaceae	*Larrea tridentata*	Creosote bush	✓	✓	✓
	Tribulus terrestris	Puncture vine			✓
Total Species Observed by Year			**45**	**49**	**47**
Total Species Recorded at High Plains Recharge Facility				**72**	

*Planted species.

APPENDIX E. DOCUMENTARY PHOTOGRAPHS

Edge Match A ▶

◀Edge Match A

Figure E-1a. Panoramic photograph, 35 mm lens, September 28, 2006, from west photo point (referenced on Figure 2)

Edge Match B ▶

◀Edge Match B

Figure E-1b. Panoramic photograph, 55 mm lens, September 28, 2006, from west photo point (referenced on Figure 2)

Edge Match C ▶

◀Edge Match C

Figure E-2a. Panoramic photograph, 35 mm lens, September 28, 2006, from east photo point (referenced on Figure 2)

Edge Match D▶

◀Edge Match D

Figure E-2b. Panoramic photograph, 55 mm lens, September 28, 2006, from east photo point (referenced on Figure 2)

Figure E-3a. Vegetation Plot C-3, Creosote Bush Association, view north, July 7, 2006, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

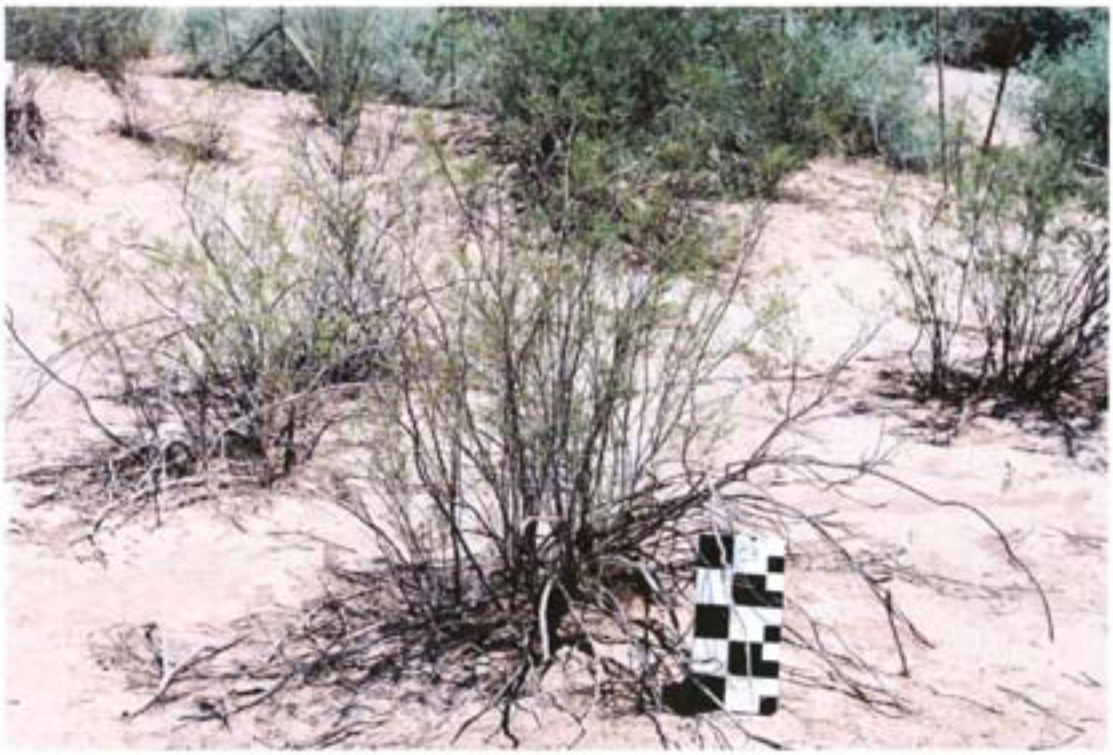

Figure E-3b. Vegetation Plot C-3, Creosote Bush Association, view north, July 7, 2006, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-3c. Vegetation Plot C-3, Creosote Bush Association, view south, July 7, 2006, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-3d. Vegetation Plot C-3, Creosote Bush Association, view south, July 7, 2006, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

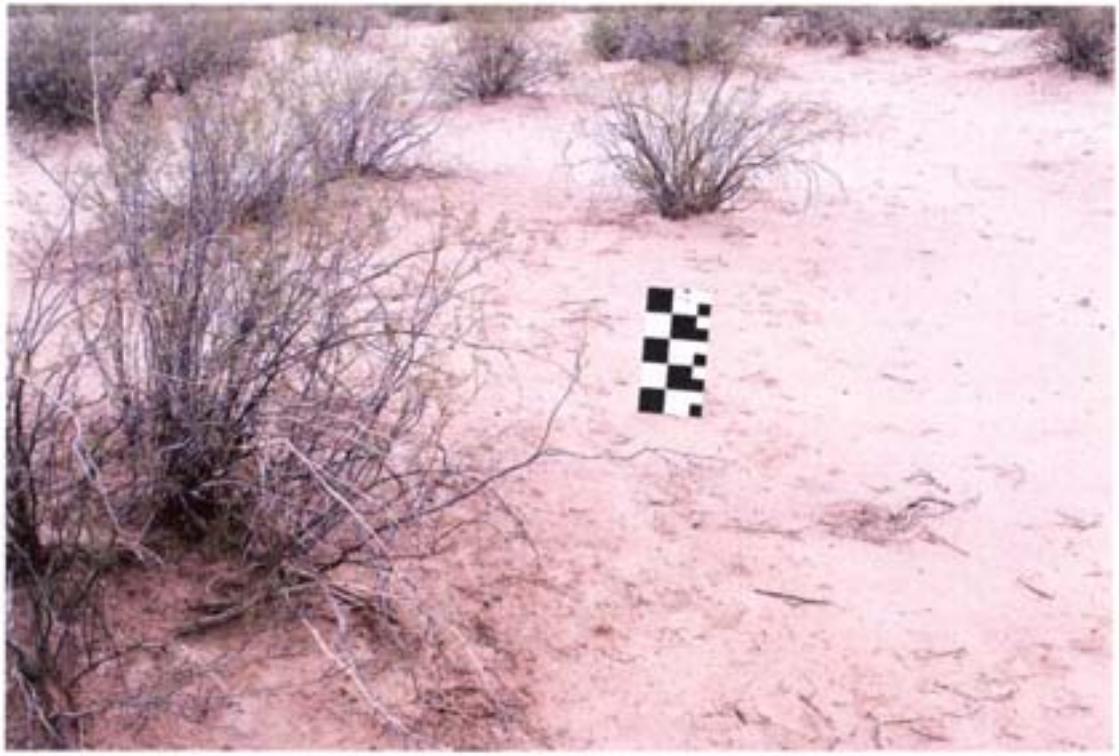

Figure E-4a. Vegetation Plot C-8, Creosote Bush Association, view north, July 7, 2006, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

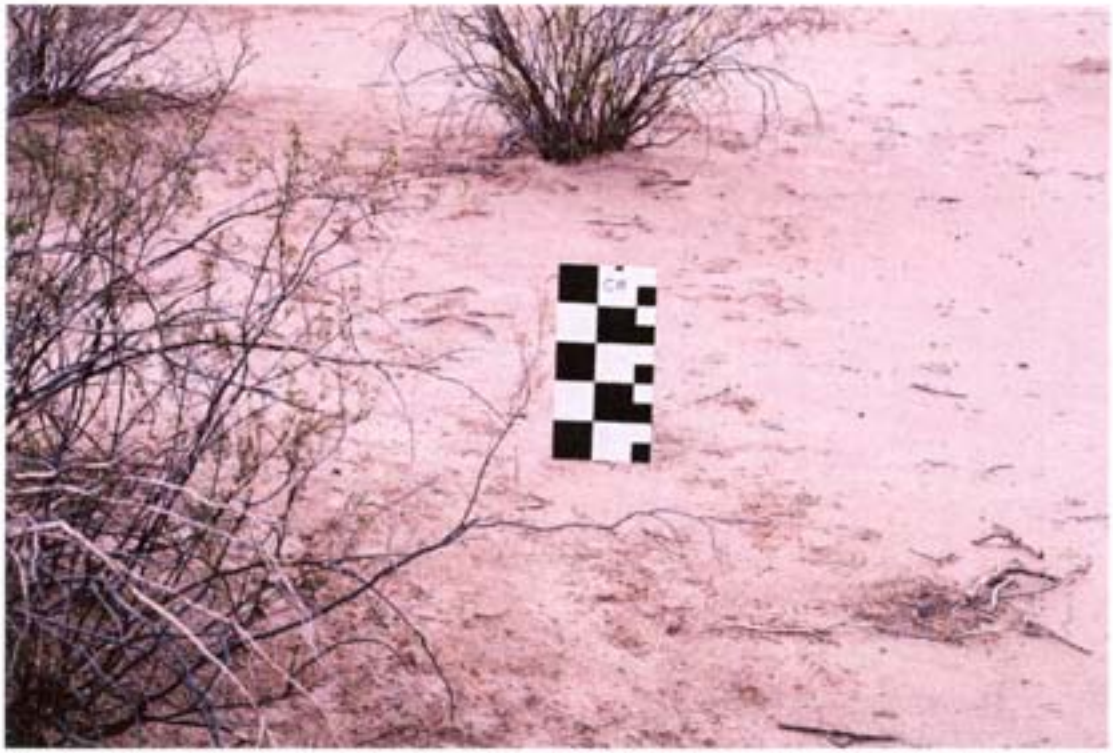

Figure E-4b. Vegetation Plot C-8, Creosote Bush Association, view north, July 7, 2006, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

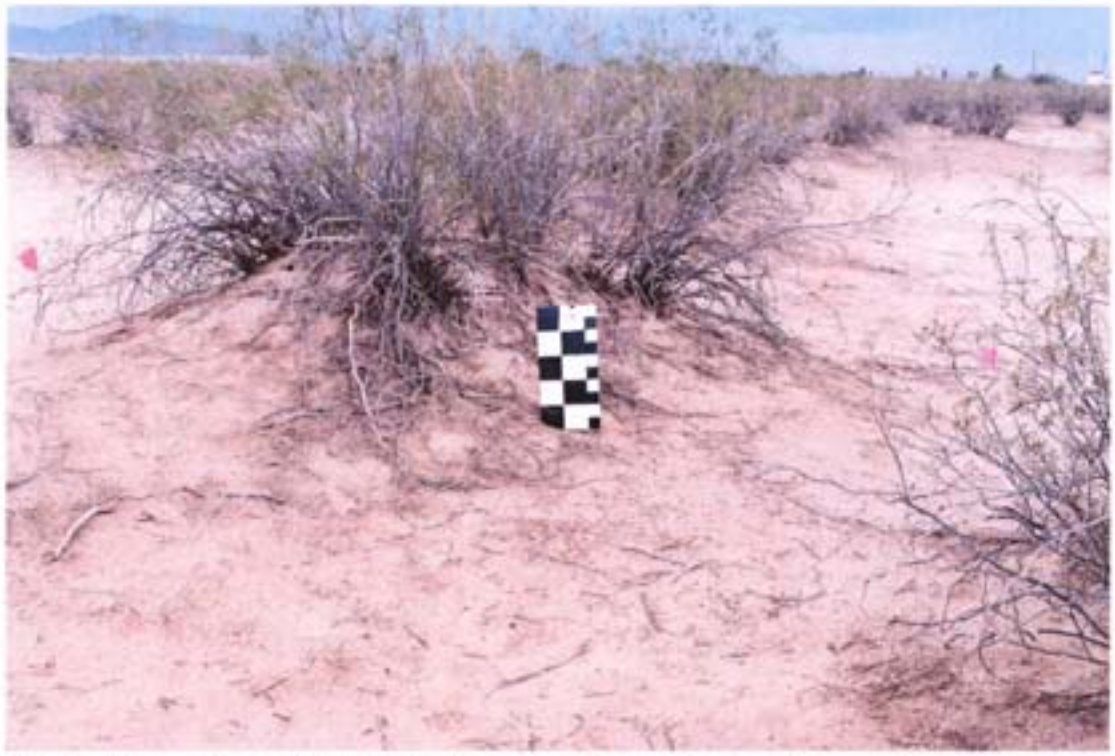

Figure E-4c. Vegetation Plot C-8, Creosote Bush Association, view south, July 7, 2006, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-4d. Vegetation Plot C-8, Creosote Bush Association, view south, July 7, 2006, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-5a. Vegetation Plot M-3, Mesquite-Palo Verde Association, view north, July 19, 2006, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-5b. Vegetation Plot M-3, Mesquite-Palo Verde Association, view north, July 19, 2006, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-5c. Vegetation Plot M-3, Mesquite-Palo Verde Association, view south, July 19, 2006, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-5d. Vegetation Plot M-3, Mesquite-Palo Verde Association, view south, July 19, 2006, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-6a. Vegetation Plot M-4, Mesquite-Palo Verde Association, view north, July 23, 2006, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-6b. Vegetation Plot M-4, Mesquite-Palo Verde Association, view north, July 23, 2006, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-6c. Vegetation Plot M-4, Mesquite-Palo Verde Association, view south, July 23, 2006, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-6d. Vegetation Plot M-4, Mesquite-Palo Verde Association, view south, July 23, 2006, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-7a. Vegetation Plot T-3, Tamarisk-Willow Association, view north, September 22, 2006, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-7b. Vegetation Plot T-3, Tamarisk-Willow Association, view north, September 22, 2006, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-7c. Vegetation Plot T-3, Tamarisk-Willow Association, view south, September 22, 2006, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-7d. Vegetation Plot T-3, Tamarisk-Willow Association, view south, September 22, 2006, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-8a. Vegetation Plot T-4, Tamarisk-Willow Association, view north, September 22, 2006, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-8b. Vegetation Plot T-4, Tamarisk-Willow Association, view north, September 22, 2006, 55-m lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-8c. Vegetation Plot T-4, Tamarisk-Willow Association, view south, September 22, 2006, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

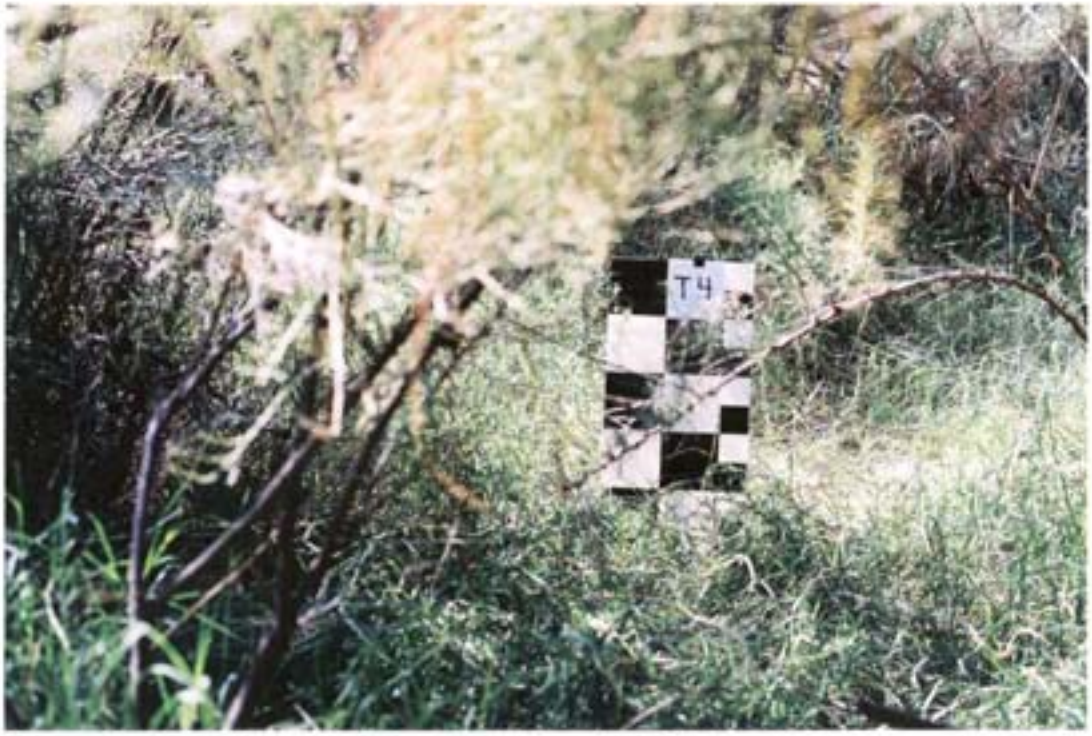

Figure E-8d. Vegetation Plot T-4, Tamarisk-Willow Association, view south, September 22, 2006, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

APPENDIX F

PROJECT AEREAL IMAGERY – VEGETATION REVEIW

Three aerial images of the project site are provided in this appendix (Figures F1-F3). Figure F1 shows the site in 1996 prior to construction related ground disturbing activity that was initiated in 2002. Prior to construction, the site consisted of mature riparian vegetation along the Santa Cruz River diversion channel at the east side of the property, where a few mature Goodding willows and tamarisk trees, along with desert broom, seepwillow, and velvet mesquite were dominant. Both the high density and large size of trees along the diversion channel contrasts significantly with the area east of the diversion channel, which supports mostly mesquite trees that are considerably smaller in size. The periodic presence of additional water available in the diversion channel supports larger trees. These trees may be of similar age as the smaller trees to the east that receive water only during rainfall events. The water table in the project area prior to development of the recharge facility was probably well below the reach of trees in the area, and only those near enough to the diversion channel and irrigation ditch have shown significant change during the last ten years.

The irrigation ditch along the north side of the property provides diverted water from the diversion to private agricultural fields to the west, and prior to 2002 (Figure F-1) supported moderate-sized velvet mesquite, Mexican elderberry, desert broom, and Mexican paloverde along its banks. At that time, the interior of the site (Figure F-1) consisted of a strand area where vegetation was mostly limited to desert broom and flood-borne debris. The south portion of the site, south of the area to be developed consisted of an almost pure stand of creosote bushes.

By 2002, when construction of the recharge basins was completed, there were no significant changes in vegetation on the site. The trees along the diversion channel and irrigation ditch had increased some in size (Figure F-2) during the intervening seven years, making the canopy somewhat denser. There is some recruitment of trees during this period, mostly mesquites, that is most evident north of the irrigation ditch. Some of the trees along the south side of the irrigation ditch were removed during the construction of the recharge basins. New trees were planted along the perimeter of some of the recharge basins, and can be readily seen at Recharge Cell 4 (Figures 8 and F-2) at the west side of the project site. Irrigation was initially provided for these trees until they became established. The dark areas in Recharge Cells 1-4 in Figure F-2 are areas of damp soil, and the Equalization Basin is flooded. The presence of some annual vegetation in the Recharge Cells, supported by periodic filling of the ponds, was minimal in 2002, and was probably not significant until some time in 2003.

There are no significant changes evident on the aerials in the creosote bush habitat on the south portion of the site between 1996 and 2006. The plant community is probably stable with little recruitment. The visually less robust appearance of the creosote in the 2002 image (Figure F-2), compared with the 1996 and 2006 images, is likely a result of

drought conditions, which resulted in the plants temporarily being less full. A comparison of the three aerials shows no significant change in creosote density.

By 2006 (Figure F-3) significant changes in vegetation are apparent on the project site since initiation of operation of the facility in 2002. Recharge basin 4 has become densely filled with vegetation, primarily saltbush plants (Figures 10 and F3). There are crops of annual grasses and other plants around the perimeter of the other recharge basins and the equalization basin (Figures 15 and F-3), and that seasonally fill the bottom of the structures in times between recharge events. The trees planted around the perimeter of basins are larger although there was a loss of some of the plantings. Vegetation along the diversion channel and the irrigation ditch has also visibly increased in size and density with some recruitment evident.

High Plains Effluent Recharge Project

Appendix F
Figure F-1
Aerial Photograph 1996

N

0 30 60 120

Meters

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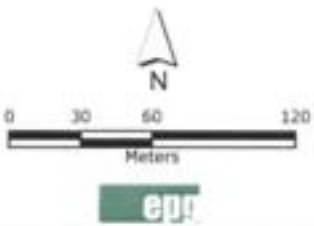
Appendix F
Figure F-2
Aerial Photograph 2002



High Plains Effluent Recharge Project

Appendix F
Figure F-3
Aerial Photograph 2006