Final Mitigation Report for Riparian Habitat Compensatory Mitigation for Thurman I and II Sediment Basins

United States Section
International Boundary and Water Commission

February 2021

Title: # Final Mitigation Report for Riparian Habitat Compensatory Mitigation for Thurman I and II Sediment Basins

Date: **18 February 2021**

Prepared for:

United States Section
International Boundary and Water Commission
4171 N Mesa St., Suite C310
El Paso, TX 79902

Prepared by: IDEALS-AGEISS, LLC

848 W. Hadley Ave.
Las Cruces, NM 88005

Contract Number: IBM15D0006
Task Order Number: 191BWC18F0105

TABLE OF CONTENTS

Section **Page**

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix

LIST OF ABBREVIATIONS / ACRONYMS

CFR	*Code of Federal Regulations*
CMA	Channel Maintenance Alternative
GPS	Global Positioning System
NA	not applicable
PWS	Performance Work Statement
RGCP	Rio Grande Canalization Project
ROD	Record of Decision
U.S.	United States
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USIBWC	U.S. Section of the International Boundary and Water Commission
UTM	Universal Transverse Mercator

1.0 INTRODUCTION

The Rio Grande Canalization Project (RGCP) consists of a narrow river corridor that extends along the Rio Grande, for approximately 105 miles from below Percha Dam in New Mexico to American Dam in El Paso, TX. The project is designed to provide flood protection as well as ensure releases of irrigation water along the RGCP to downstream United States (U.S.) and Mexico users. In order to ensure both of these aspects are maintained, the U.S. Section of the International Boundary and Water Commission (USIBWC) prior to 2009, conducted channel maintenance activities including stabilizing banks; removing obstructions such as debris, sediment plugs, or gravel deposits; maintaining arroyos that act as flood conveyance; and dredging or excavating along the RGCP to control sediment below dam structures. With the signing of the 2009 *Record of Decision (ROD) for River Management Alternatives for the RGCP* (USIBWC 2004 and 2009), almost all channel maintenance activities ceased from 2009-2013. The ROD committed the USIBWC to implementing environmental measures in the long-term management of the river corridor and conducting studies and investigations to evaluate channel maintenance activities.

In 2015, a *Channel Maintenance Alternatives (CMAs) and Sediment Transport Study for the RGCP* (Tetra Tech 2015) analyzed sediment transport and sediment plugs in nine locations throughout the RGCP. Information from this study was incorporated into the 2016 River Management Plan as the Channel Maintenance Plan. As an alternative to excavating sediment from the main channel and a means to control sediment input, the CMA study recommended arroyo sediment traps be constructed in several northern locations. USIBWC chose Thurman I and II arroyos for implementing a pilot project for CMAs. The design included a deepening and widening of the Thurman I and II arroyos within the USIBWC floodplain, coupled with the construction of endwalls to create sediment basins that will allow the settling of sediment and rocks before entering the mainstem of the Rio Grande. Construction of the sediment basins requires compensatory mitigation. The mitigation plan notes that per the *Code of Federal Regulations* (CFR) Part 332.3 (a)(1), the fundamental objective of compensatory mitigation is to offset environmental losses resulting from unavoidable impacts to waters of the US. Furthermore, 33 CFR Part 332.3 (f)(1) states that the amount of required compensatory mitigation must be, to the extent practicable, sufficient to replace lost aquatic resource functions, and should be at least one-to-one acreage of linear foot compensation.

The USIBWC obtained a U.S. Army Corps of Engineers (USACE) Clean Water Act Section 404 permit under the Nationwide Permit #43 – Stormwater Management Facilities (Action No. SPA-2018-00084-LCO) for construction of the sediment basins (USACE 2018). Total habitat proposed for mitigation was approximately 2.62 acres, to offset the loss of riparian habitat and impacts below the ordinary high-water mark. USIBWC proposed three types of mitigation at each site and each type has its own mitigation ratio (USIBWC 2018).

- Establish onsite riparian areas along the banks of each new sediment basin by planting native willows. The sediment basins will create moister and more feasible conditions along the stream banks by pooling and slowing water. Sediment basin bank mitigation ratio is 4.56:1.
- Enhance existing riparian habitat along the embayment and river banks by removing nonnative vegetation such as saltcedar and planting native willows and cottonwoods. River bank mitigation ratio is 4.75:1.

- Create an embayment through construction of an endwall to create an aquatic habitat pool. Mitigation ratio is 0.75:1.

In conjunction with the construction of the sediment basins, USIBWC anticipated that it would: 1) conduct sediment removal within the Hatch Reach of the Rio Grande channel per the Long Excavation Plan, upstream and downstream of the Thurman I and II arroyos, and 2) conduct sediment removal further south at the Rincon Siphon/Garcia Arroyo (Figure 1). The sediment removal work required the removal of vegetated islands that have grown at the deltas of the Thurman I, Thurman II, and Garcia arroyos, and the vegetation on those islands was removed and transplanted to the Thurman and Rincon sites. This project is intended to not only improve conveyance efficiency of irrigation water through a reduction of sediment inflow from the arroyos and removal of island obstruction, but also to comply with the 2017 U.S. Fish and Wildlife Service (USFWS) biological opinion for moving suitable habitat on islands being removed from the channel to riparian habitat restoration sites to provide for flycatcher habitat.

This final report describes the current conditions, the restoration monitoring activities from saltcedar removal, island vegetation removal, and transplanting of willows, and the monitoring results from October 2018 to October 2020 for the Thurman I and II mitigation sites. Performance standards (success criteria), developed by USIBWC for the riparian habitat areas to ensure similar vegetation cover percentages, function, and hydrology through the recruitment of desirable vegetation and maintenance to remove undesirable species, are also discussed in this document. This report supports the monitoring requirements established by the USIBWC mitigation plan (USIBWC 2018) and the USACE Mitigation and Monitoring Guidelines for the South Pacific Division (USACE 2015).

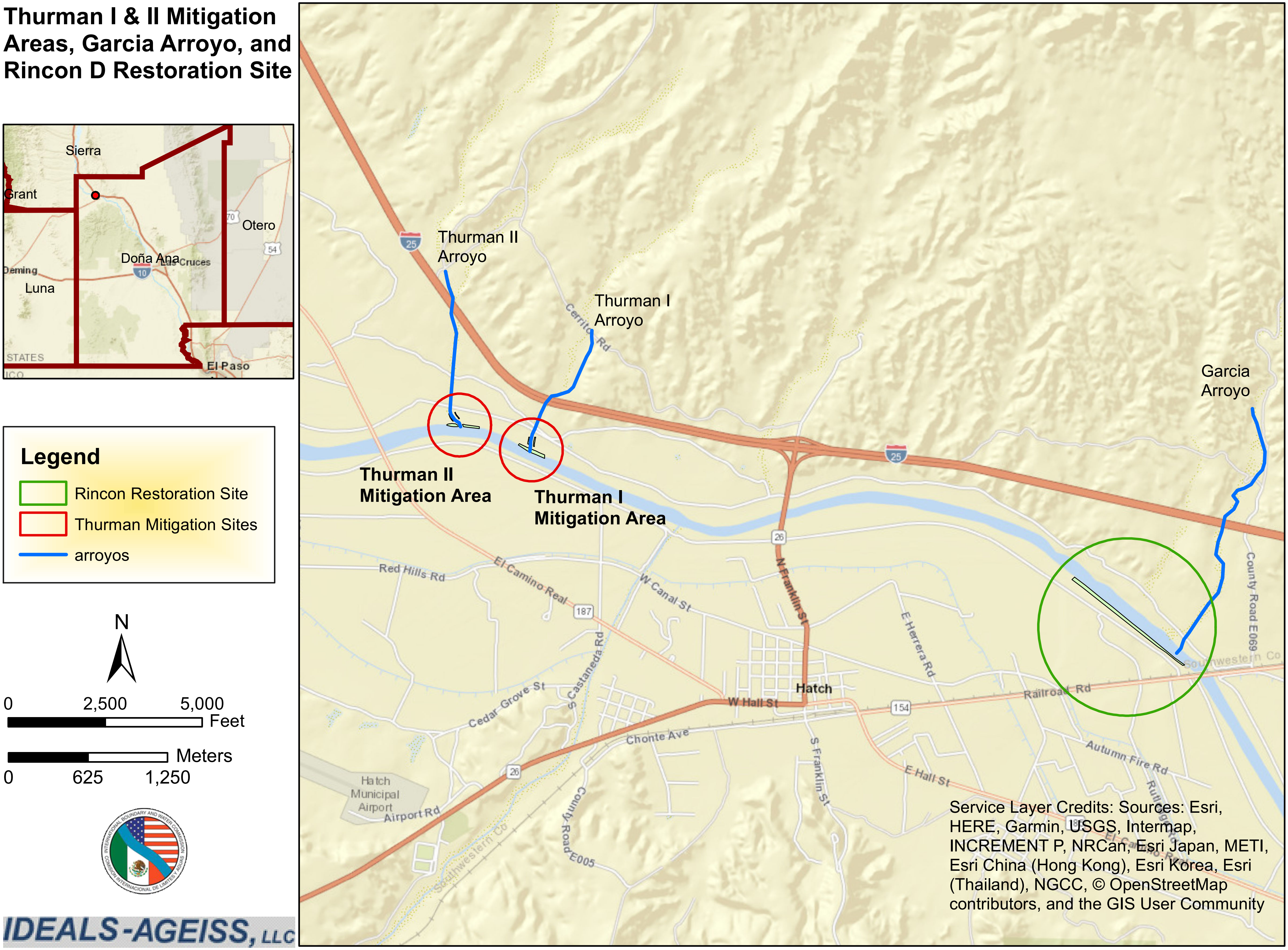


Figure 1. Overview of the Thurman I & II Mitigation Areas, Garcia Arroyo, and the Rincon D Restoration Site

2.0 METHODS

Prior to conducting any work, the field crew established three camera points for each mitigation site (Table 1). Each camera point has a Global Positioning System (GPS) location and is permanently marked for future reference. Three photo points for each camera point (where the camera is located) were established and permanently marked (fencepost or rebar). The azimuth was noted and an identification number was assigned to each photo and camera point. The points were given an adequate view of the site to document the anticipated growth of revegetated areas, and to monitor the stability of in-stream work. Photo point information was collected during eight periods of the project: pre-implementation monitoring, pre-mitigation monitoring, and six times during post-restoration monitoring. Additional photos were taken of any significant changes and points of interest. Photos were documented in accordance with Federal and National Archives and Records Administration regulations. Each photo met the USIBWC requirements for pixel array and was uniquely numbered and labeled for identification. Qualitative monitoring field sheets developed by USIBWC were used to document conditions at each site during each monitoring period.

After saltcedar removal occurred at the Thurman II site and transplanting began, it was determined that two of the photo points previously established may interfere with the restoration work. Thurman II photo points 2 and 3 were moved away from the construction area 20-50 feet; however, the angle of view was maintained. Updated locational information is included in Table 1.

Table 1. Established Photo Points for Each Restoration Site

Site	Photo Point 1			Photo Point 2			Photo Point 3		
	UTM E	UTM N	Bearing	UTM E	UTM N	Bearing	UTM E	UTM N	Bearing
Thurman I	296011	3618330	T1 – 340° T2 – 300° T3 – 255°	295896	3618282	T1 – 105° T2 – 150° T3 – 220°	295874	3618394	T1 – 125° T2 – 180° T3 – 205°
Thurman II	295357	3618549	T1 – 195° T2 – 210° T3 – 240°	295407	3618461	T1 – 130° T2 – 225° T3 – 295°	295246	3618532	T1 – 50° T2 – 110° T3 – 140°

UTM Universal Transverse Mercator, Zone 13S

2.1 Groundwater Monitoring

During each monitoring period and assessment, groundwater levels were collected and analyzed at the existing USIBWC shallow groundwater monitoring wells at the Rincon Siphon D restoration site and the information was used to supplement the groundwater monitoring data from the past several years. Groundwater measurements are taken to the top of the polyvinyl chloride casing inside the steel protector.

2.2 Pre-implementation Monitoring

A pre-implementation monitoring assessment was conducted on 15 October 2018, prior to any work at the sites in support of the mitigation and restoration plan. The field crew identified and mapped the distribution of native and riparian habitat (specifically the willow species of interest) to be protected during restoration efforts. Wildlife species and floral species observed on the sites were documented.

2.3 Pre-mitigation Monitoring

Once the noxious vegetation was removed from the Thurman I and II sites, the island vegetation transplantation initiated, and the site prepped for planting, a pre-mitigation assessment of the two sites was conducted. This assessment documents the remainder of the native vegetation on each site and the baseline habitat prior to planting. Pre-mitigation monitoring was conducted on 7 December 2018.

2.4 Post-restoration Monitoring

Six post-restoration assessments were conducted in May, July, and October 2019, and April, July, and October 2020. During post-restoration efforts, vegetation species and percent cover of created and restored areas before and after were compared. The comparison of these areas guided potential corrective actions and maintenance needs during the course of the monitoring period. The Team conducted a 100-percent count of all planted species during the monitoring efforts and recorded the status of each species (e.g., alive, stressed, or dead). Although through estimates it has been determined that approximate density of three willows per linear foot of trench are transplanted, once the clumps are in the ground, distinguishing clumps becomes difficult. The number of bucket loads transplanted was documented on the planting sheet and from this number the team can estimate the number of willows transplanted along the river bank for censusing. Percent cover and species composition were recorded on field monitoring datasheets. In addition, any changes in vegetation condition were noted on the field monitoring sheet, as well as stream bank conditions and any wildlife sightings.

3.0 RESULTS

3.1 Groundwater Monitoring

Groundwater levels fluctuate along the RGCP based on irrigation releases and time of year. Irrigation release occurred in June 2019 and June 2020. Groundwater levels were similar compared to historical data for the irrigation release period. Water was documented for the first time during this project at well RS-MW-6 in July 2019 (Appendix A). Well RS-MW-6 could not be opened during the October 2019 monitoring due to the presence of wasps in the well casing. Table 2 presents information tabulating current groundwater levels at the Rincon restoration area.

Table 2. Groundwater Monitoring Well Data

Site	Well ID	Site Visit Dates and Depth to Water from Surface in Feet							
		Pre-implementation	Pre-mitigation	Post-restoration					
		10/15/18	12/6/18	5/21/19	7/18/19	10/14/19	4/21/20	7/21/20	10/9/20
Rincon	RS-MW-4	3.55	3.35	5.72	0.43	3.09	1.9	0.95	4.73
	RS-MW-6	dry	dry	dry	2.33	N/A	3.84	1.28	3.05
	RS-MW-7	dry	5.9	dry	5.11	7.37	5.87	5.15	7.97

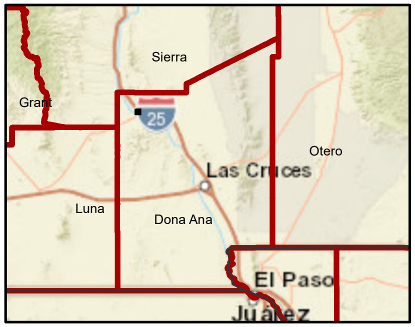
3.2 Pre-implementation Monitoring – Existing Conditions

Pre-implementation monitoring of the two sites was conducted on 15 October 2018. Results of this monitoring effort and data and photos are contained in Appendices B and C.

3.2.1 Thurman I

The Thurman I Arroyo lies just west of the city of Hatch, NM and the Placitas Arroyo restoration site (Figure 2). USIBWC mows the floodplain regularly in this area; therefore, most of the vegetation consists of short grasses and invasive species (Appendix B). Russian thistle (*Salsola tragus*) and kochia (*Kochia scoparia*) were found in moderate abundance throughout the mowed portion of the site. Mature saltcedar (*Tamarix ramosissima*) is found just behind the bank of coyote willows (*Salix exigua*) at the river bank. Cattails (*Typha spp*.) are interspersed with the coyote willows and form some of the dominant vegetation on the islands at the mouth of the arroyo. These islands are densely vegetated. Burrobrush (*Ambrosia dumosa*) patches occur along the arroyo with three cottonwood clumps (*Populus deltoids*) of about 12 mature cottonwoods. The mouth of the arroyo contains mixed vegetation restricting the arroyo at the confluence with the Rio Grande. Approximately 1.2 acres of Rio Grande island willows are to be removed and salvaged in this area.

Looking down the arroyo at the confluence and the Rio Grande River at Thurman I (15 October 2018).



Legend

- Island and Vegetation Removal
- OHWM
- Photo Point

0 100 200 300 Feet

0 30 60 90 Meters

IDEALS-AGEISS, LLC

Figure 2. Pre-implementation Existing Conditions at the Thurman I Sediment Basin Area

3.2.2 Thurman II

The Thurman II Arroyo site is located approximately 0.5 mile west of Thurman I. The floodplain through this area is also mowed regularly by USIBWC. Coyote willows and cattails are found at moderate abundance at the river bank and at the mouth of the arroyo. Mature saltcedar, sporadic in abundance, are located away from the river bank just behind the coyote willows. Kochia and Russian thistle dominate the floodplain area, and form a dense vegetative layer to the west of the arroyo. In addition to native vegetation occurring at the mouth of the arroyo, other smaller clumps of willows were noted along the arroyo (Figure 3). Vegetation, mainly coyote willows, have established on the accumulated sediment (sandbars) at the confluence of the Rio Grande. Approximately 1.8 acres of Rio Grande island willows are to be removed and salvaged.

3.3 Pre-mitigation Monitoring

Pre-mitigation monitoring for the sites occurred on 7 December 2018. Saltcedar extraction was completed by November 2018 prior to willow transplanting. Approximately 0.31 acre at Thurman I and 0.37 acre at Thurman II of saltcedar were removed. At the time of monitoring, coyote willows (*Salix exigua*) transplanting was complete at Thurman II and almost complete at Thurman I (Appendix B). All willow transplanting occurred outside the avian nesting season and best management practices in accordance with the USIBWC mitigation plan (USIBWC 2018) were implemented.

Vegetation at the confluence of Thurman II arroyo and the Rio Grande River, looking towards the river. Photo from USIBWC Thurman Mitigation Plan (February 2016).

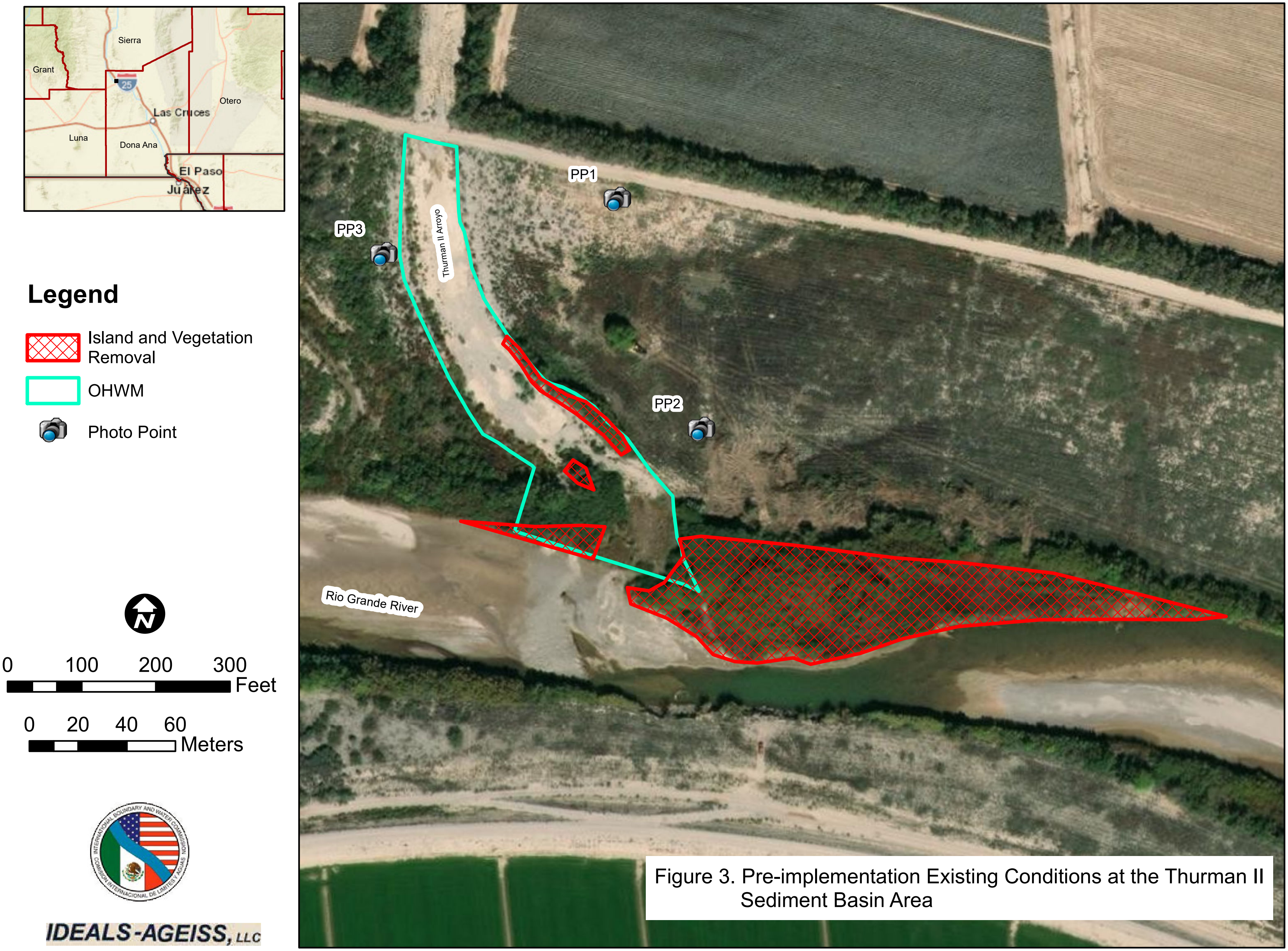


Figure 3. Pre-implementation Existing Conditions at the Thurman II Sediment Basin Area

3.3.1 Thurman I

A high level of bare ground (60 percent) occurs away from the river in the floodplain due to ground disturbance with Russian thistle found in high abundance throughout the floodplain. After site preparation, only small, sporadic individuals of saltcedar were documented away from the river. The island vegetation removal was partially complete with coyote willow transplantation occurring upstream of the arroyo. Approximately 3,140 linear feet of coyote willows were transplanted for an approximate total of 9,420 willows (Figure 4). Cattails are interspersed with the coyote willows and also form some of the dominant vegetation on the islands at the mouth of the arroyo. Scattered screwbean mesquite (*Prosopis pubescens*) occurs in low abundance near the river. The arroyo cottonwoods were removed and poles salvaged from the cottonwoods.

Transplanting coyote willows (14 November 2018).

Transplanted willows from the vegetated islands at Thurman I (7 December 2018).

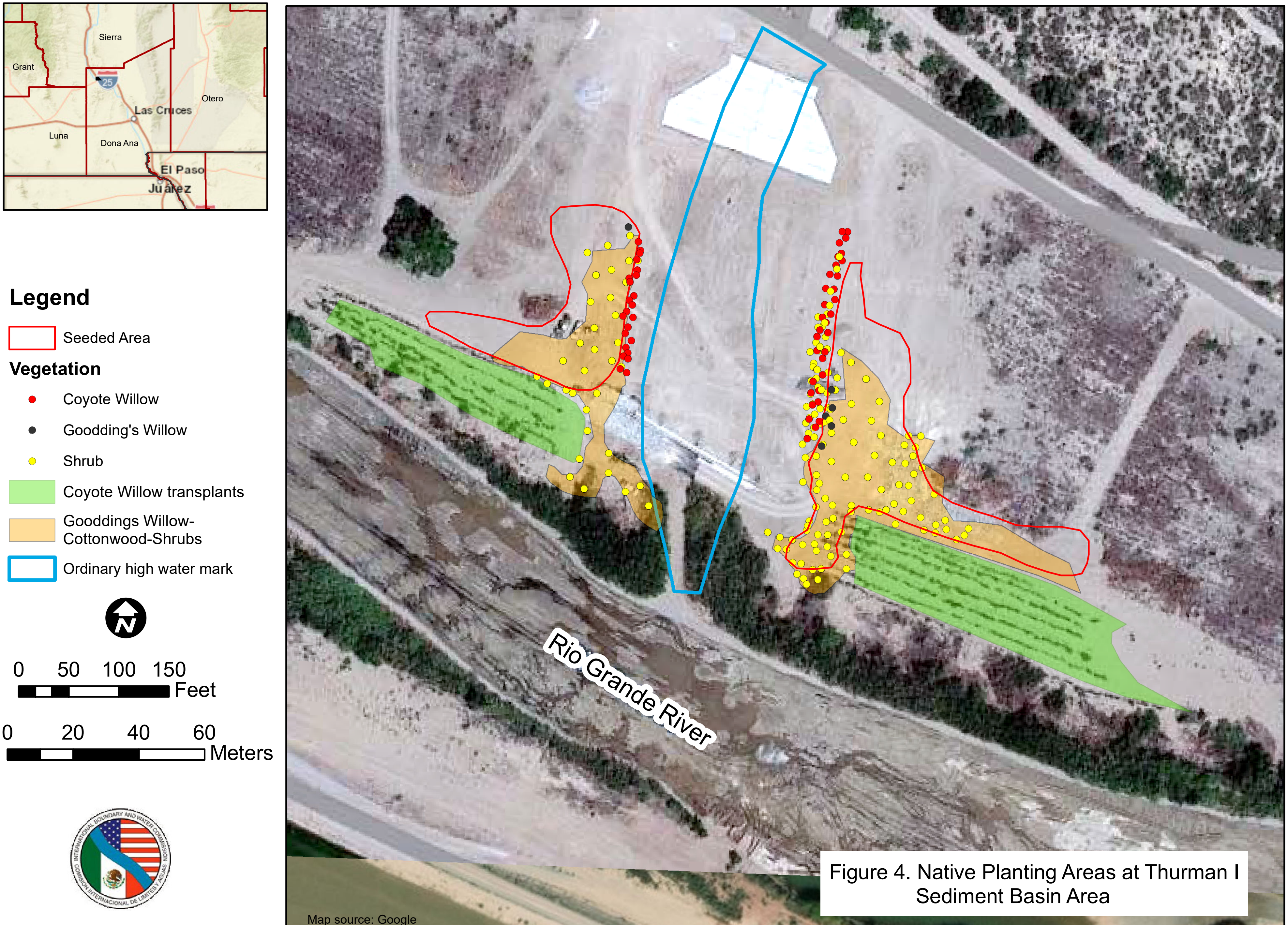


Figure 4. Native Planting Areas at Thurman I Sediment Basin Area

IDEALS-AGEISS, LLC

3.3.2 Thurman II

The floodplain through this area is also mowed regularly by USIBWC and along with site preparation has caused a high level of bare ground from disturbance (60-70 percent). Russian thistle and kochia continue to dominate the floodplain area between the river and the levee (Appendix B). Only small saltcedar individuals located away from the river remain after site preparation. The island vegetation removal was being completed at the time of monitoring with coyote willow transplantation occurring both upstream and downstream of the arroyo. Approximately 2,809 linear feet or 8,427 coyote willows were transplanted to Thurman II (Figure 5).

Saltcedar removal area in front of coyote willow transplants at Thurman II (7 December 2018).

Transplanted coyote willows at the Thurman II site (26 November 2018).

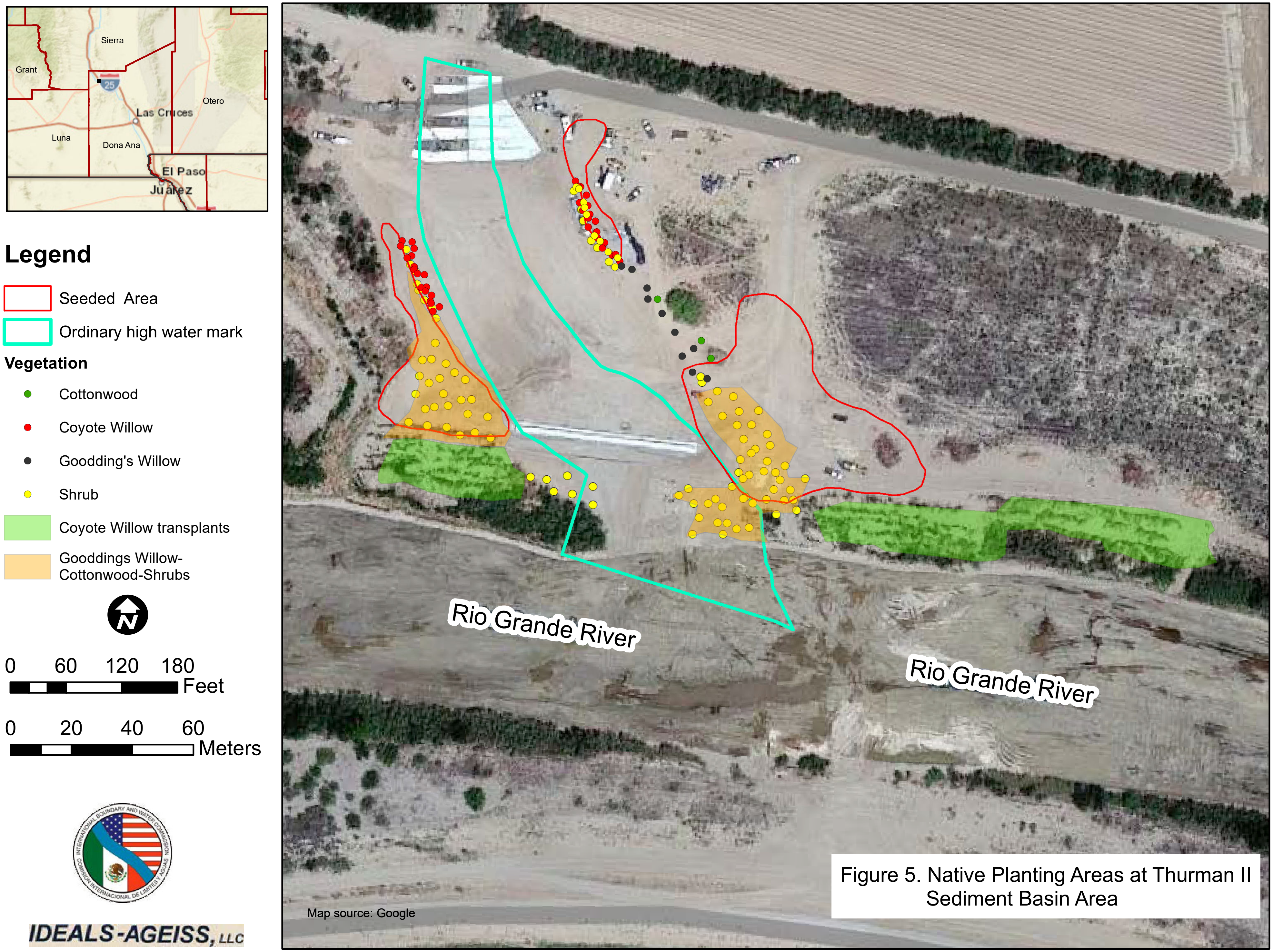


Figure 5. Native Planting Areas at Thurman II Sediment Basin Area

View of the Thurman II arroyo mouth from the upstream side
after saltcedar removal (7 December 2018).

3.4 Post-restoration Monitoring

On site mitigation for the project is 2.62 acres of planting at the sediment basin banks, the river banks, and the embayment area (USIBWC 2018); 1.48 acres at Thurman I and 1.14 acres at Thurman II. Only partial planting was completed at the sites by October 2019, which included the coyote willow transplantation at the river banks, since construction activities extended past the spring and the appropriate planting season. The remaining plantings along the sediment basin occurred during December 2019 and February 2020. Construction of the sediment basins was completed on 15 May 2019, and reseeding of the construction area was conducted after planting and then again by the construction contractor on 10-12 June 2019. Post-restoration monitoring was conducted on 21 May 2019, 18 July 2019, 14 October 2019, 21 April 2020, 21 July 2020, and 9 October 2020 (Appendices B and C).

3.4.1 Thurman I

Coyote willows, concentrated along the river bank, dominate the vegetation cover at the Thurman I site. The transplanted willows average approximately 3-7 feet and the willows further from the river are showing signs of stress. The willows downstream have a lower survivorship (70 percent) than the willows upstream (95 percent) which was consistent between the years. The mitigation plan called for approximately 1,070 willows to be transplanted to the mitigation area. During the October 2019 monitoring session, 10,500 poles in the transplant area were counted (original planting of 9,420 willows). During the October 2020 monitoring session, 10,050 poles in the transplant area were counted. The increase in number from the planting is due to recruitment in the area as well as the difficulty of distinguishing transplanted poles with previously established willows. With an average survival of 83 percent, approximately 8,341 coyote willows have established at the site. These transplanted willows cover approximately 0.85 acre. A low percentage of screwbean mesquite and isolated native cottonwoods can also be found on the site. Most of the site is bare ground with a scattered distribution of native forbs such as pigweed (*Amaranthus* sp.) and silverleaf nightshade (*Solanum elaeagnifolium*) throughout the site. A few scattered native individuals were found during the two-year monitoring sessions including buffalo gourd (*Cucubita foetidissima*), mulberry (*Morus sp*.), goldenrod (*Isocoma pluriflora*), and morning glory (*Ipomoea spp.*; Appendix B).

Upstream coyote willow transplants at Thurman I Arroyo with
some kochia established (14 October 2019).

Sediment basin after construction at Thurman I Arroyo (14 October 2019).

Seeding (approximately 1.3 acres) in areas disturbed by planting and areas where mastication was spread was conducted in April 2020 once planting was complete (Figure 4). The seed mixture included Indian ricegrass (*Oryzopsis hymenoides*), inland saltgrass (*Distichlis spicata*), plains bristlegrass (*Setaria leucopila*), sand dropseed (*Sporobolus cryptandrus*), and blue gama (*Bouteloua gracilis*). In addition, the contractor who constructed the sediment basins tilled and hydro mulched the site (over our seeding area) late June 2020. However, the equipment used for seeding and watering the grass damaged some of the trees and planting areas. Hydroseed was also found sprayed across some of the plantings.

Hydroseeding on planted species at Thurman I (26 June 2020).

Thurman I cottonwood potentially damaged by overspraying from adjacent area (14 August 2020).

In July 2020, large areas adjacent to the site had been mowed down and appeared to have been sprayed causing some drift into the planted area. Trash and vehicle activity on the site began in April 2020 and continued through September; in August damage from ATVs was noted on the site.

Saltcedar occurred sporadically as individuals scattered across the site and increased across the southern end of the site. Kochia was found scattered across the site in the disturbed areas and rebounded even after mowing. Russian thistle was the dominant invasive species on site, in the transplanted areas and away from the river, accounting for 50 percent cover across the site. A brush hog was used to mow weeds on site around the planted trees and shrubs in May 2020 and additional mowing and hand pulling was conducted around the planted species through the summer as needed. In addition, tree and shrub wells were weeded and repaired in May, June, and July to increase water retention and reduce competition. Weekly watering occurred from March through September unless the evaluation of soil moisture indicated no need. The basin appeared to provide some additional water to the plants located near the top of the basin (See Appendix C, Thurman I July and October 2020 Photopoint 2 Target 2).

Vegetative cover at the site, as of the October 2020 monitoring, was 30 percent. Dominant vegetation cover noted at Thurman I is listed in Table 3 and does not include the planted species. Nine additional longstem shrub species were planted along the north side of the basin area in August 2020 including false indigo (*Baptisia australis*), four-wing saltbush (*Atriplex canescens*), and New Mexico olive (*Forestiera pubescens*). Honeybees (several bee boxes were on the site) as well as other wildlife species observed at the site are listed in Table 4.

Table 3. Dominant Vegetation Cover Observed at Thurman I

Common Name	Scientific Name	Estimated Percent Cover						
		December 2018	May 2019	July 2019	October 2019	April 2020	July 2020	October 2020
Native Species								
Coyote willow	*Salix exigua*	30	10	50	50	50	50	50
Screwbean mesquite	*Prosopis pubescens*	5	5	2	2	2	2	2
Rio Grande cottonwood	*Populus fremontii*	<1	<1	<1	<1	<1	<1	<1
Willow baccharis	*Baccharis salicina*	-	<1	5	5	5	5	5
Cattail	*Typha latifolia*	5	<1	<1	<1	<1	<1	<1
Silverleaf nightshade	*Solanum elaeagnifolium*	1	1	5	5	5	5	5
Hoary aster	*Dieteria canescens*	-	1	1	1	1	1	-
Rio Grande greenthread	*Thelesperma megapoticum*	-	1	<1	<1	<1	<1	<1
Purslane	*Portulaca oleracea*	-	-	1	1	1	1	1
Honey Mesquite	*Prosopis glandulosa*	-	-	-	2	2	2	3
Pigweed	*Amaranthus spp.*	-	-	-	-	-	-	10
Non-Native Species								
Saltcedar	*Tamarix chinensis*	<1	1	20	10	10	10	10
Kochia	*Kochia scoparia*	-	-	5	5	5	5	5
Russian Thistle	*Salsola tragus*	50	5	5	50	50	50	50
Siberian elm	*Ulmus pumila*	-	-	2 individuals	2 individuals	2 individuals	2 individuals	2 individuals

Table 4. Wildlife Species Observed at Thurman I – October 2018-2020

Scientific Name	Common Name
Accipiter cooperii	Cooper's Hawk
Agelaius phoeniceus	Red-winged Blackbird
Anas clypeata	Northern Shoveler
Anas discors	Blue-winged Teal
Anas platyrhynchos	Mallard
Anas strepera	Gadwall
Ardea herodias	Great Blue Heron
Aspidoscelis spp.	Whiptail Lizard
Auriparus flaviceps	Verdin
Buteo jamaicensis	Red-tailed Hawk
Callipepla gambelii	Gamble's Quail
Carpodacus mexicanus	House Finch
Cathartes aura	Turkey Vulture
Charadrius vociferus	Killdeer
Circus hudsonius	Northern Harrier
Contopus sordidulus	Western Wood Pewee
Corvus cryptoleucus	Chihuahuan Raven
Dendroica petechia	American Yellow Warbler
Euphagus cyanocephalus	Brewer's Blackbird
Euptoieta claudia	Variegated Fritillary
Falco sparverius	American Kestrel
Geothlypis trichas	Common Yellowthroat
Grus canadensis	Sandhill Crane
Hirundo rustica	Barn Swallow
Icteria virens	Yellow-breasted Chat
Mephitis mephitis	Striped Skunk
Mergus merganser	Common Merganser
Molothrus ater	Brown-headed Cowbird
Myiarchus cinerascens	Ash-throated Flycatcher
Passerina ciris	Painted Bunting
Petrochelidon pyrrhonota	Cliff Swallow
Picoides scalaris	Ladder-backed Woodpecker
Pipilo maculatus	Spotted Towhee
Porzana carolina	Sora
Regulus calendula	Ruby-crowned Kinglet
Sayornis nigricans	Black Phoebe
Setophaga coronata	Yellow-rumped Warbler
Setophaga petechia	American Yellow Warbler
Spizella passerina	Chipping Sparrow
Sylvilagus audubonii	Desert Cottontail
Thomomys bottae	Botta's Pocket Gopher
Thryomanes bewickii	Bewick's Wren
Wilsonia pusilla	Wilson's Warbler

Scientific Name	Common Name
Xanthocephalus xanthocephalus	Yellow-headed Blackbird
Zenaida asiatica	White-winged Dove
Zenaida macroura	Mourning Dove
Zerene cesonia	Southern Dogface Butterfly
Zonotrichia leucophrys	White-crowned Sparrow

3.4.2 Thurman II

A high percentage (approximately 65 percent) of bare ground occurs at the Thurman II site away from the river. Coyote willows and cattails occur along the river bank with alkali sacaton (*Sporobolus airoides*) occurring near the northern part of the arroyo. Muhly grass (*Muhlenbergia spp.*) occurs near the river bank. Species diversity increased throughout the growing season (Table 5). The transplanted willows are surviving along the river but some appear stressed away from the river edge. According to the mitigation plan, approximately 730 willows were to be transplanted along the river bank mitigation area (actual plantings numbered 8,427). After the October 2019 monitoring, approximately 6,476 coyote willows were alive along the river banks in an area of approximately 0.59 acre. The increase in number from the planting is due to recruitment in the area as well as the difficulty of distinguishing transplanted poles with previously established willows. In October 2020, 8,025 were counted with 83 percent survivorship downstream (1,556 willows) and 80 percent survivorship upstream (4,920 willows).

Sediment basin after construction at Thurman II Arroyo (28 August 2019).

Table 5. Dominant Vegetation Cover Observed at Thurman II

Common Name	Scientific Name	Estimated Percent Cover						
		December 2018	May 2019	July 2019	October 2019	April 2020	July 2020	October 2020
Native Species								
Coyote willow	*Salix exigua*	10	20	30	20	20	20	20
Screwbean mesquite	*Prosopis pubescens*	1	1	5	5	5	5	5
Salt grass	*Distichlis spicata*	1	-	-	1	-	-	-
Willow baccharis	*Baccharis salicina*	<1	-	5	5	5	5	5
Alkali sacaton	*Sporobolus airoides*	<3	5	5	5	5	5	5
Cattail	*Typha latifolia*	<5	1	1	1	1	1	1
Muhly grass	*Muhlenbergia spp.*	5	1	5	5	5	5	5
Goldenrod	*Isocoma pluriflora*	-	-	20	20	20	20	20
Pigweed	*Amaranthus spp.*	<3	5	-	5	5	5	40
Silverleaf nightshade	*Solanum elaeagnifolium*	<5	-	5	5	5	5	5
Goodding's willow	*Salix gooddingii*	<1	-	-	<1	<1	<1	<1
Sand dropseed	*Sporobolus cryptandrus*	1	-	-	-	-	-	-
Dakota mock vervain	*Glandularia bipenetifida*	-	-	1	1	1	1	1
Buffalo gourd	*Cucubita foetidissima*	-	-	1	1	1	1	1
Wolfberry	*Lycium spp.*	-	-	-	2	2	2	-
Honey mesquite	*Prosopis glandulosa*	-	-	-	5	5	5	5
Non-Native Species								
Bermuda grass	*Cynodon dactylon*	-	-	1	1	1	1	1
Saltcedar	*Tamarix chinensis*	<1	<1	25	10	10	10	10
Kochia	*Kochia scoparia*	20	1	10	30	30	20	20
Russian Thistle	*Salsola tragus*	30	1	1	10	10	10	10
Goathead	*Tribulus terrestris*	-	-	-	2	2	2	2

Damage from hydroseed watering (26 June 2020).

Seeding (approximately 1.2 acres) in areas disturbed by planting and areas where mastication was spread was conducted in April 2020 once planting was complete (Figure 5). In addition, the contractor who constructed the sediment basins tilled and hydro mulched the site (over our seeding area) late June 2020. Some damage to planting was noted from the construction contractor watering the hydroseed.

A brush hog was used to mow weeds on site around the planted trees and shrubs in May 2020 and additionally through the summer as needed. Invasive species rebounded quickly on Thurman II so this site required more maintenance especially in August. Weekly watering occurred from March through September unless the evaluation of soil moisture indicated no need. During late July and August supplemental watering occurred at Thurman II. Nine longstem shrub species including false indigo, New Mexico olive, and four-wing saltbush were added to the north side of the channel in August 2020.

Dominant groundcover species varied by year from goldenrod (*Isocoma pluriflora*) early in the project to pigweed (*Amaranthus spp.*). Saltcedar recruitment is occurring throughout the site but remains in low abundance (Table 5). Russian thistle and kochia are the dominant invasive species throughout the disturbed areas and are intermixed with the transplants. Invasive species cover was reduced in the planting areas from the monthly maintenance activities. Wildlife species observed at the site throughout the study period are listed in Table 6.

Thurman II willow and cottonwood plantings (25 September 2020).

Northern transplants looking south at Thurman II (14 October 2019).

Table 6. Wildlife Species Observed at Thurman II – October 2018-2020

Scientific Name	Common Name
Accipiter cooperii	Copper's Hawk
Actitis macularius	Spotted Sandpiper
Agelaius phoeniceus	Red-winged Blackbird
Anas clypeata	Northern Shoveler
Anas discors	Blue-winged Teal
Anas platyrhynchos	Mallard
Anthus rubescens	American Pipit
Aspidoscelis spp.	Whiptail Lizard
Auriparus flaviceps	Verdin
Battus philenor	Pipevine Swallowtail
Buteo jamaicensis	Red-tailed Hawk
Callipepla gambelii	Gamble's Quail
Carpodacus mexicanus	House Finch
Charadrius vociferus	Killdeer
Circus hudsonius	Northern Harrier
Colias philodice	Clouded Sulfur Butterfly
Corvus cryptoleucus	Chihuahuan Raven
Dendroica coronata	Yellow-rumped Warbler
Eremophila alpestris	Horned Lark
Geococcyx californianus	Greater Roadrunner
Grus canadensis	Sandhill Crane
Hirundo rustica	Barn Swallow
Icteria virens	Yellow-breasted Chat
Melospiza lincolnii	Lincoln's Sparrow
Mimus polyglottos	Northern Mockingbird
Petrochelidon pyrrhonota	Cliff Swallow
Pipilo maculatus	Spotted Towhee
Rana catesbeiana	American Bullfrog
Sayornis nigricans	Black Phoebe
Sayornis saya	Say's Phoebe
Selasphorus platycercus	Broad-tailed Hummingbird
Setophaga coronata	Yellow-rumped Warbler
Setophaga petechia	American Yellow Warbler
Spizella passerina	Chipping Sparrow
Sturnus vulgaris	European Starling
Toxostoma crissale	Crissal Thrasher
Tringa solitaria	Solitary Sandpiper
Troglodytes aedon	House Wren
Xanthocephalus xanthocephalus	Yellow-headed Blackbird
Zenaida asiatica	White-winged Dove
Zenaida macroura	Mourning Dove
Zonotrichia leucophrys	White-crowned Sparrow

3.5 Native Planting Survivorship

Nursery stock for planting both poles and shrubs was purchased and planted by Hydra Aquatic Albuquerque, NM. Cottonwood poles and Goodding's willows were 12- to 16-feet long and approximately 2- to 3-inches in diameter. An auger was used to plant cuttings after the cuttings soaked for approximately two weeks. Coyote willows, other than the transplants, were planted in groups. Shrubs were planted in December and pole planting was conducted in late winter 2020 (February) with some additional shrub plantings. Approximate areas covered by plantings and seeding can be found in Figures 4 and 5.

Thurman II additional watering of plantings (15 May 2020).

Watering and invasive species maintenance around the plantings (15 May 2020).

During the 2019-2020 monitoring events, IDEALS-AGEISS' Team biologist inspected plantings, in addition to the transplants previously discussed, to document survival and evaluate their overall health status. The majority of the species planted were alive and thriving (Table 7) in large part due to the rigorous watering schedule implemented (watering at least twice per month). Coyote willows (not the transplants) were initially miscounted in April and July as one plant instead of the total number of species within a large clump. Some discrepancies in planted numbers were noted through the year and are likely due to already established native species on the site (not all flagging remained on planted species), individuals that resprouted after the tops died (sprouted from the base of the plant), or plants that were without leaves and identification was difficult to determine during a monitoring period. The additional nine plants added at each site in August were accounted for in the October 2020 monitoring. Sixty-seven longstem riparian shrubs were required at Thurman I and 58 at Thurman II; 91 and 77 were planted respectively. Seepwillows (*Baccharis salicifolia*) on the Thurman I site were the only longstem riparian shrub that did not have a high survivorship (37 percent). The mortality occurred between the July 2020 (81 percent survivorship) and the October 2020 monitoring. However, overall shrub survivorship was high at both sites: 90 percent at Thurman I and 95 percent at Thurman II (Tables 8 and 9).

Table 7. Overall Native Plant Survivorship

Species	Thurman I				Thurman II			
	PWS require-ment	Number Planted	Alive	Survival (%)	PWS require-ment	Number Planted	Alive	Survival (%)
Goodding's willow	134	134	136	100	91	100	94	94
Cottonwood	27	27	23	85	24	26	27	100
Coyote willow	270	278	280	100	180	180	180	100
Total longstem shrubs	67	91*	82	90	58	77**	73	95
Seepwillow	NA	27	17	37	NA	18	17	94
New Mexico olive	NA	13	11	85	NA	27	22	82
False indigo	NA	31	30	97	NA	11	12	100
Four-wing salt bush	NA	11	12	100	NA	12	11	92
Three-leaf sumac	NA	9	12	100	NA	9	11	100

* 82 original plantings and 9 additional shrubs in August 2020
** 68 original plantings and 9 additional shrubs in August 2020
NA not applicable
PWS Performance Work Statement

Re-sprouting of cottonwoods (12 June 2020).

Water retention at the pole plantings (11 September 2020).

Clumped plantings of coyote willows (25 September 2020).

Table 8. Native Plant Survivorship through 2020 for Thurman I

Species	Planted	April 2020		July 2020		October 2020	
		Alive	Survival %	Alive	Survival %	Alive	Survival %
Goodding's willow	134	124	93	118	88	136	100
Cottonwood	27	22	81	25	93	23	85
Coyote willow	278	46[a]	17	58[a]	21	280	100
Seepwillow	27	28	100	22	81	17	37
New Mexico olive	10 (13)[b]	11	100	9	90	11	85
False indigo	28 (31)[b]	33	100	30	100	30	97
Four-wing salt bush	8 (11)[b]	11	100	10	100	12	100
Three-leaf sumac	9	4	44	9	100	12	100

a Not all coyote willows were relocated.
b Includes three additional plantings in August that only affect the October 2020 survivorship numbers.

Broken coyote willows at Thurman (21 August 2020).


Cottonwood damaged by activity at the Thurman sites
(15 May 2020).

Table 9. Native Plant Survivorship through 2020 for Thurman II

Species	Planted	April 2020		July 2020		October 2020	
		Alive	Survival %	Alive	Survival %	Alive	Survival %
Goodding's willow	100	110	100	93	93	94	100
Cottonwood	26	29	100	33	100	27	100
Coyote willow	180	35[a]	19	39[a]	22	180	100
Seepwillow	18	27	100	19	100	17	94
New Mexico olive	24 (27)[b]	16	67	18	75	22	82
False indigo	8 (11)[b]	8	100	9	100	12	100
Four-wing salt bush	9 (12)[b]	9	100	9	100	11	92
Three-leaf sumac	9	12	100	13	100	11	100

a Not all planted coyote willows were relocated.
b Includes three additional plantings in August that only affect the October 2020 survivorship numbers.

4.0 CONCLUSIONS

USIBWC selected onsite mitigation to recreate the riparian zone to provide a direct and reliable means to compensate for riparian habitat impacts caused by the project. Placing the mitigation along the river edge establishes connectivity with adjacent river habitats and the overall ecosystem. The design of in-kind mitigation provides the best means of directly compensating for the project impacts while also providing additional threatened and endangered species habitat (USIBWC 2018). The objectives of the mitigation were to:

- Establish 2.62 acres of total onsite aquatic and riparian habitat;
- Reestablish ecological functions on the river corridor such as wildlife habitat, water quality improvement, and nutrient cycling; and
- Develop restoration that achieves sustainability and limits the amount of maintenance required by establishing natural processes.

Per the USIBWC mitigation plan, biannual monitoring (May and October) and the establishment of a minimum of three photo points for the onsite mitigation areas were required. Parameters analyzed during the monitoring include species inventory, percent survival of recruited vegetation, groundwater data from the groundwater monitoring wells, and percent coverage of desirable and undesirable vegetation along the riparian zones of the river (USIBWC 2018). This final report covers both biannual monitoring periods from 2019-2020, as well as, provides baseline data to compare the mitigation efforts.

4.1 Project Performance Measures

In order to determine if the mitigation efforts are successful, the USIBWC has set performance standards for the riparian zones to achieve vegetative cover similar to existing desirable conditions on the Rio Grande (USIBWC 2018).

Sediment basin at the Thurman I arroyo (21 August 2020).

These performance standards include:

1. Willows are planted at 1,000 plants /acre.
2. Survival rate of re-established and enhanced mitigation areas will be 65 percent over 5 years.
3. Planted willows and underbrush should achieve cover percentages that increase from 35 percent the first year to 70 percent by year 5.
4. No more than 20 percent of observed plants from measured plots can be nuisance species in any monitoring year.
5. By year 4, at least 10 percent of the habitat should be species other than coyote willows.

By the end of year two, the project exceeds permit performance goals and meets terms and conditions authorized in the USACE Nationwide Permit 43 (Table 10; Appendices D and E). Transplanted willows at both sites readily established along the banks and by the end of the second growing season in some places were indistinguishable from the already established vegetation. More willows were salvaged and transplanted from the in-channel islands that were removed than were required by the mitigation plan. Transplanting willows not only allowed for a quicker establishment of the onsite riparian habitat along the banks where saltcedar were removed, but also provided habitat for listed species in accordance with the USFWS biological opinion. Although the planting schedule for the both sediment basins was delayed due to construction, planted native cover has increased at the sites as observed in the photos during seven months of the first growing season (estimated approximately 29 percent canopy cover).

Table 10. Performance Standards for the Thurman I and II Mitigation Areas

Performance Standard	Goal	Results	
		Year 1 (2019)	Year 2 (2020)
Willows transplanted at 1,000 willows/acre	1,000 willows/acre	Approximately 9,420 willows planted in 0.85 acre at Thurman I and 8,427 willows planted in 0.59 acre at Thurman II.	Within the Thurman I planted willow area 8,341 willows have survived. At Thurman II, 6,476 willows are alive within the 0.59-acre area planted.
Transplanted willow survival	65%	Thurman I – 83% Thurman II – 80%	Thurman I – 83% Thurman II – 82%
No more than 20% of observed plants from measured plots can be nuisance species	< 20%	Range of invasive species distribution dependent on the species and the numbers are for the entire site (10-50%)[1]. The main species of concern, saltcedar, only represented 10% cover in the monitored transplanted willows.	Range of invasive species distribution dependent on the species and the numbers are for the entire site (5-50%)[2]. Invasive species cover within the planted pole and shrub area was less than the overall site as it was maintained throughout 2020. The main species of concern, saltcedar, only represented 10% cover in the monitored transplanted willows.
Planted willows and underbrush should achieve cover percentages that increase from 35 percent the first year to 70 percent by year 5.	35%	NA	This measure should actually be conducted in the spring of 2021, one full year after planting. However, as observed at the photos points (such as Thurman I- Photo Point 2-1, 2-2, 2-3 and Thurman II- 2-3) native species cover has increased since initial planting at both sites. Average canopy cover increase was approximately 29 percent in first 7 months.

1 Invasive species cover was noted throughout the site and not just in the transplanted willow areas. The higher percentage of cover of kochia noted in October 2019 is due to invasion into the disturbed tilled areas of the sites.

2 Invasive species cover was noted throughout the site and not just in the transplanted willow and planting areas. At Thurman I, 50% of the area not planted contained Russian thistle and kochia only accounted for 5 percent cover of the entire area. At the Thurman II site, outside the planted areas had 20 percent kochia and 10 percent Russian thistle.

4.2 Expected and Observed Benefits

The sediment traps called for deepening and widening the arroyo channels to construct basins for sediment collection (USIBWC 2018). The basins would provide sufficient time for sediment to settle out of arroyo flows and to be deposited at the bottom of the channel. USIBWC has determined that the sediment banks mitigation area will have a functional gain from the impact site because the impact site has no vegetation within the floodplain, and the mitigated site will create moist conditions for riparian vegetation to grow (USIBWC 2018). An increase in soil moisture in the root zone adjacent to the unlined retention basins was expected during times of arroyo flow. While this project did not include any direct measurement of this parameter, field crews did observe that plantings adjacent to the Thurman I basin did require less supplemental water than would be expected without the presence of the nearby impounded water.

Prior to the mitigation effort, some riparian vegetation existed at the confluence of the Thurman I and II arroyos and the Rio Grande. Mixed native (willows, cottonwood, and seepwillow) and nonnative vegetation (saltcedar) exists along the mouth of the arroyos. Along the banks of the Rio Grande adjacent to the arroyos, riparian vegetation consists mainly of exotic saltcedar mixed with some native coyote willows. Sediment delivery from the arroyos can have a significant local impact on the mainstem of the Rio Grande where channel blockage occurs by coarse-grains tributary fans, causing upstream backwater, overbank flows, and flow conveyance losses (USIBWC 2017). The mouth of the Thurman I and II arroyos continually fill with sediment and provide an additional area for saltcedar habitat. Through this project, the riverside of the endwall created an embayment area that can act as a small backwater area for aquatic habitat, provide slight energy dissipation, and provide short-term water storage (USIBWC 2018). The removal of the invasive saltcedar, additional willow plantings along the embayment, and the construction of the sediment basins to reduce sediment load are all beneficial to the establishment of aquatic habitat. Aquatic habitat at the confluence of the arroyo with the river seemed to retain water longer than in the basin and the river.

Species diversity contributes to ecosystem health and provides for a more sustainable and stable ecosystem. Diversity is based not only on the number of different species (richness) but also the number of individuals of each species (abundance or evenness). Species richness at the site increased from pre-implementation to the final monitoring in October 2020 even without incorporation of our supplemental plantings. Prior to restoration efforts, native species included coyote willows, cattails, cottonwoods, screwbean mesquite, and silverleaf nightshade and three invasive species saltcedar, kochia, and Russian thistle (Table 3). Similar invasive species were noted at Thurman II; however, native species richness was greater with several more herbaceous species in the understory (Table 3). Exclusive of the invasive species and our additional planted species, species richness increased at both sites: five additional species were observed at Thurman I and four at Thurman II although sand dropseed was no longer documented at the site.

4.3 Unanticipated Issues

During the life time of the project there were a few issues that arose that had minor impacts to the survivorship of the plantings and the success of the monitoring efforts. Photo points for the project were established during the pre-implementation monitoring of the project. At this time there was no site layout or construction area defined at the site. We had to move two photo points during the monitoring process since they were placed too close to the construction site, but this was unknown until the site was actually laid out. Developing the site layout prior to mitigation efforts will also ensure that transplanted species do not interfere with the construction site.

The restoration sites along the RGCP have always been subject to impacts from human activities. Adding large expanses of concrete areas with the sediment basins provided a very attractive area for ATV users. Increased traffic at the sites resulted in damage to some plantings as well as increased trash deposited at the sites.

Timing of planting and hydro seeding is vital to the survival of the species. We initiated planting and seeding at the sediment basin area after what we thought was the completion of the construction portion of the project. Unfortunately due to the need to improve the stabilization of the sediment basins, the construction contractors returned to the site after the planting was completed to do additional work such as additional hydro seeding. Even though the plants were flagged, damage to the plants occurred from the trucks hydro seeding (running over the trees and over spraying of the shrubs).

4.4 Recommendations for Future Project Designs

The goal of this project was to ensure compensatory mitigation for unavoidable impact to waters of the U.S. from construction of two sediment basins. Overall the construction of the sediment basins and the mitigation efforts for riparian habitat restoration were successful. The maintenance plan outlined by USIBWC (USIBWC 2018) will continue to assist in the re-establishment of riparian vegetation and the function of the sediment basins at both Thurman sites. These activities include:

- Implementation of the operations and maintenance plan for the sediment basins.
- Suspension of mowing over the river embankment areas which will support establishment of the riparian zone.
- Biannual maintenance of the mitigation areas, river embankment, coupled with the monitoring plan, to include herbicide spraying, cutting and/or hand-removal of non-native and invasive species vegetation.
- Installation of signs indicating these areas are environmental stewardship areas and restricting public access.

Coordination with construction activities plays a vital role in not only the success of the restoration efforts, but also the ability to monitor the restoration progress. Having the construction area well defined on the ground prior to any transplanting or planting will prevent interference with the construction activities. In addition we recommend that plantings should be initiated after the construction activities are complete.

Establishing photo points is an important component to monitoring the success of the restoration effort. Although photo points that provide a view of the entire site can provide documentation of the site as a whole, they may not provide adequate representation of site specific areas of interest. These Thurman sites were very open with little topographic relief often making it difficult to determine site succession. In addition, the site dynamic changed once the sediment basin was constructed often obscuring the intending original view of the point. We recommend for future construction and restoration project such as this that additional photo points be established after construction activities are complete from a higher advantage (e.g. top of the sediment basin look out on the site).

As noted at several restoration sites, including the Thurman sites, human activity can often have detrimental effects on plant survivorship. Damage at the Thurman I site included: three Goodding's willows, four coyote willows, one cottonwood, and two New Mexico olives. Less damage was noted at Thurman II where two Goodding's willows and one false indigo were damaged along with several shrubs that were run over but not snapped. Although a few signs were posted at each restoration site, they did not deter activity in the area. If possible, large signs, or more of them, posted along the restoration area noting the activity in the area may better inform the public and prevent future disturbance.

During the first growing season, and just after saltcedar removal, estimating vegetation cover is relatively easy as the plants are still small. Unfortunately with the delayed planting the project ended before a full year after planting was completed. Estimating percent vegetation cover can be done many ways and during our monitoring periods, we used the same biologist who estimated cover of native and invasive species throughout the planted areas. We have had issues at other restoration sites trying to maintain permanent plots, but this can be alleviated using GPS location or even an application called ecological canopy survey that estimates cover from photos. Even though a full year had not passed, we used photos from several photos points in the native planting areas to estimate canopy cover for seven months (April to October) of 2020 after initial planting (averaged approximately 29 percent cover). We recommend in April 2021 (after a full year of planting) establishing four areas on each site, two on either side of the basin, to estimate percent cover using approximately a 3-meter radius plot.

The USIBWC should continue to conduct willow transplants when possible at restoration sites although no additional willows are required at either Thurman site. Transplantation of mature coyote willows with their established root balls provides high survivorship at the sites. In addition, the habitat is well on its way to establishment using these mature trees. Although coyote willows further away from the river edges had a lower survivorship then those at the river edges in this project, these areas may benefit from additional watering after transplanting and prior to irrigation release and/or appropriate distances from the river banks for willow transplants in relation to groundwater levels should be considered. These areas also had increased stress due to competition with invasive species.

Coyote willows transplant survivorship and additional shrub and tree survivorship were high after the first growing season. The success of planted species is highly dependent upon water availability and planting plans should take into account the local hydrology of the site. For a better understanding of the hydrology in the area, groundwater depth should be assessed on the site prior to restoration work to facilitate planting area location. Unfortunately there were no groundwater wells located at the Thurman site but measurements came from the Rincon site located within 2 miles of the mitigation sites. Using piezometers (measures groundwater pressure) located at different areas across the restoration site could help with documenting the variability of groundwater depths before and during restoration allowing the plantings to occur in areas with good groundwater connection (USIBWC 2015).

The aggressive water schedule we implemented (weekly once planted) provided the new plantings with the ability to establish at both sites and should be considered for future restoration projects. Additional watering during the second growing season (2021) prior to irrigation release would benefit the newly established plants. The use of a tensiometer to measure soil tension (measures the water availability in the soil) may be employed to determine when the sites need supplemental water. Tensiometers at varying depth of 6 to 24 inches on a line extending out from the basin should provide information on the water content and the need for supplemental watering. To promote water retention future planting designs may consider the use of swales. In addition, removing competition from invasive species has also allowed for native plant establishment. Maintaining weed-free planting wells (where soil moisture is retained) along the planted shrubs and trees will further promote survivorship in future restoration projects. As has been noted on other restored sites, once the pole plantings become established they provide enough shade to impede the establishment of invasive species like kochia. Ensuring the native plant survivorship and establishment through the second growing season will also assist in controlling the invasive species. We recommend clearing around the longstem planted species again in spring 2021, much like we did through 2020, to reduce competition if invasive species are present. Future restoration efforts should also consider incorporating landscape grade mulch (or mulch made from the vegetation previously removed) in/around the planting holes to increase water retention and provide supportive nutrients to the transplants to increase survival. The plantings in this project had soil amendments added to improve root establishment during planting.

5.0 REFERENCES

Tetra Tech. 2015. Channel Maintenance Alternatives (CMAs) and Sediment Transport Study for the RGCP. Final Report to USIBWC.

USACE (U.S. Army Corps of Engineers). 2015. *Final 2015 Regional Compensatory Mitigation and Monitoring Guidelines for South Pacific Division USACE*. Available at: https://www.spd.usace.army.mil/Portals/13/docs/regulatory/mitigation/MitMon.pdf. Accessed 7 November 2019.

USACE. 2018. Nationwide Permit (NWP) Verification – Action No. SPA-2018-00084-LCO, Construction of Sediment Basins at Thurman I and II Arroyos in the Rio Grande Canalization Project. May 30, 2018.

USIBWC (U.S. Section of the International Boundary and Water Commission). 2004. Final Environmental Impact Statement: River Management Alternatives for the Rio Grande Canalization Project. Available at: http://www.ibwc.gov/EMD/documents/Final_EIS.pdf. Accessed 5 November 2018.

USIBWC. 2009. Record of Decision River Management Alternatives for the Rio Grande Canalization Project. United States Section of the International Boundary and Water Commission, El Paso, Texas. Available at: https://www.ibwc.gov/EMD/reports_studies.html#EIS. Accessed 5 November 2018.

USIBWC. 2015. Berino East and West Site Restoration Final Monitoring Report. June 2015.

USIBWC. 2017. Final Environmental Assessment and Finding of No Significant Impact: Channel Maintenance Alternatives at Thurman I and II Arroyos in Hatch, New Mexico, Rio Grande Canalization Project.

USIBWC. 2018. Riparian Habitat Compensatory Mitigation Plan for Sediment Basins at Thurman I and II Arroyos, Doña Ana County, New Mexico.

APPENDIX A

Well Monitoring Data

APPENDIX B

Planting and Monitoring Datasheets

APPENDIX C

Photo Points

APPENDIX D

2019 USACE Mitigation Monitoring Report

APPENDIX E

2020 USACE Mitigation Monitoring Report