ECOSYSTEM EVALUATION

INTRODUCTION

Leon Creek and its tributaries are primarily intermittent streams as they cross over the Edwards Plateau and associated Edwards Aquifer region of the study area and become perennial as they reach the Blackland Prairie region (Lower Leon Creek segment of the environmental study area). According to Zale et al. (1989) intermittent streams are unique habitats essential to the structure and function of ecosystems. Their presence is critical to fish and wildlife populations in the region, an area where perennial streams are rare and separated by great distances. Modification of intermittent streams by channelization, removal of riparian vegetation, grazing, construction of headwater impoundments, siltation, and domestic and industrial effluents is highly destructive to these sensitive habitats and their biota and significantly degrades the quality of adjacent terrestrial habitats. Enhanced protection of intermittent streams is an essential component of natural resource management, especially in light of the neglect of these critically important habitats in past and present land-use planning.

Terrestrial Resources

For central Texas, the wooded uplands, prairie uplands, and riparian corridors work in unison to provide the habitat needs for many species of wildlife. While some species are identified in this report, a more complete reference of species known to utilize the study area is available in project files. Upland areas in this part of the state are mostly prairie with some woodland consisting of legumes and other small and/or short-lived species. These wooded uplands do not typically progress to late successional woodlands, because the climate of the area is not favorable for late successional species except where associated with riparian corridors.

Therefore, many species of birds and other wildlife, which occupy upland habitats exclusively in other areas of the United States, occupy the riparian areas of central Texas exclusively or in conjunction with the upland habitats. Connection to upland woodlands is important to provide the full range of habitat requirements of a species. However, riparian areas of the region are small and less diverse than in areas to the east of this study area. Also, due to fragmentation of upland habitats, a riparian corridor serves as the only travel conduit for species to migrate to other habitats needed to complete their life requisites.

Riparian woodlands serve several important functions in this study area of Texas. According to the *Texas Environmental Almanac* (1995), 189 species of trees and shrubs, 42 woody vines, 75 grasses, and 802 herbaceous plants occur in Texas' bottomlands. They are also known to support 116 species of fish, 31 species of amphibians, 54 species of reptiles, 273 bird species, and 45 mammals. At least 74 species of threatened and endangered animals depend directly on bottomland hardwood systems, and over 50

percent of neotropical songbirds are associated with these systems. Besides providing important wildlife and bird habitat, riparian woodland systems contribute to the state's biodiversity.

They also:

- Serve as catchments and water retention areas in times of flooding,
- Help control erosion,
- Contribute to the nutrient cycle, and
- Play a vital role in maintaining water quality by serving as a depository for sediments, wastes, and pollutants from runoff.

Despite these important functions, riparian woodland ecosystems are one of the most endangered ecosystems in the United States (MacDonald et al., 1979). Prior to European settlement, Texas had approximately 16 million acres of bottomland hardwood riparian habitat. Today, the state has less than 5.9 million acres (Texas Center for Policy Studies, 1995). Riparian woodland systems are considered to be Texas' most diverse ecosystem, but ecosystem degradation has occurred in Leon Creek.

In addition to the direct loss of riparian woodland habitat, further degradation has occurred due to proliferation of invasive plant species such as ligustrum, Chinese tallow, and chinaberry. Non-native species typically occur in disturbed areas where native species take longer to reestablish. Once established, they proliferate and result in monotypic stands of vegetation, which leads to a decrease in diversity and richness.

Interior wetlands, which include bottomland hardwood forests, riparian vegetation, inland freshwater marshes, and the playa lakes of west Texas, account for 80 percent of the total wetland acreage in Texas. According to the *Texas Environmental Almanac* (1995), the vast majority of wetlands are located on private property. In the last 200 years, Texas has lost over 60 percent of these inland wetlands due to agriculture conversion, timber production, reservoir construction, and urban and industrial development. There is a need to restore as many of these wetlands—including riparian woodlands—as possible. This is especially true in urban areas where a large portion of the riparian zone has been lost, and only small, fragmented portions of low quality riparian zones exist today.

Aquatic Resources

A large amount of urban and rural development has occurred in the Leon Creek watersheds within the last fifty years. Much of the land within the study area has been highly disturbed by human activities that have altered the topography of the landscape, including construction of roads and in-stream sewer lines, mining of gravel by commercial business enterprises, and construction activities associated with industries, commercial businesses, residential neighborhoods, and parklands.

Development has reduced the overall width and quality of the riparian corridor in the watersheds, degrading wildlife habitat and aquatic resources. Riparian streambank vegetation improves the aquatic habitat and overall aquatic resources in a riverine system, in the following ways:

- Serve as buffer zones to help remove harmful pollutants and for nutrient loading of an aquatic system.

- Serve as depositories for sediments.
- Help stabilize the banks of creeks to prevent scour and erosion and to decrease sedimentation and turbidity of aquatic resources.
- Provide shade, which lowers water temperatures, which in turn helps keep dissolved oxygen levels higher.
- Serve as spawning and rearing habitat for fisheries.
- Serve as corridors for terrestrial wildlife resources.

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The quality and quantity of water that recharges the Edwards Aquifer has degraded over time. Leon Creek contributes recharge to the Edwards Aquifer and contains critical habitat for the nine listed karst invertebrates. Water quality is thought to be a major factor in the threat to the species. Because these species rely on high water quality to survive and are very sensitive to changes in water availability, water quality and space is the most degraded niche of their habitat.

Threatened and Endangered Species

Several species have been Federally listed as endangered or threatened in Bexar County, Texas. The Table B-1(a) provides the names, status and potential for these species to be within the Leon Creek study area. Most species listed are associated with karst topography within the extreme Upper Leon Creek study segment. In addition to the Federal list, the State of Texas has provided a list of species of concern for consideration evaluation of project impacts and for avoidance if possible. That list is maintained in project files.

Table B-1(a) Bexar County Federally-Listed Threatened and Endangered Species.

Common Name	Scientific Name	Listing Status	Potential to Occur within the Study Area
[Unnamed] Ground Beetle	*Rhadine infernalis*	Endangered	Yes
[Unnamed] Ground Beetle	*Rhadine exilis*	Endangered	Yes
Black-capped Vireo	*Vireo atricapilla*	Endangered	No
Braken Bat Cave Meshweaver	*Cicurina venii*	Endangered	Yes
Cokendolpher Cave Harvestman	*Texella cokendolpheri*	Endangered	Yes
Comal Springs Dryopid Beetle	*Stygoparnus comalensis*	Endangered	No
Comal Springs Riffle Beetle	*Heterelmis comalensis*	Endangered	No
Fountain Darter	*Etheostoma fonticola*	Endangered	No
Golden-cheeked Warbler	*Dendroica chrysoparia*	Endangered	Yes
Government Canyon Bat Cave Meshweaver	*Cicurina vespera*	Endangered	Yes
Government Canyon Bat Cave Spider	*Neoleptoneta microps*	Endangered	Yes
Helotes Mold Beetle	*Batrisodes venyivi*	Endangered	Yes
Madla's Cave Meshweaver	*Cicurina madla*	Endangered	Yes
Peck's Cave Amphipod	*Stygobromus pecki*	Endangered	Yes
Robber Baron Cave Meshweaver	*Cicurina baronia*	Endangered	Yes
San Marcos Salamander	*Eurycea nana*	Threatened	No
Texas Blind Salamander	*Typhlomolge rathbuni*	Endangered	No
Texas Wild Rice	*Zizania texana*	Endangered	No
Whooping Crane	*Grus americana*	Endangered and Experimental Population, Non-essential	Migrant only

Study Area

The Leon Creek study area was broken into five environmental study segments. Based on the vegetational areas of Texas and the overlapping areas of urbanization, the team defined the following environmental segments: Upper Leon Creek, Urban Leon Creek, Lower Leon Creek, Culebra Creek, and Helotes Creek, as shown in Figure B-1.

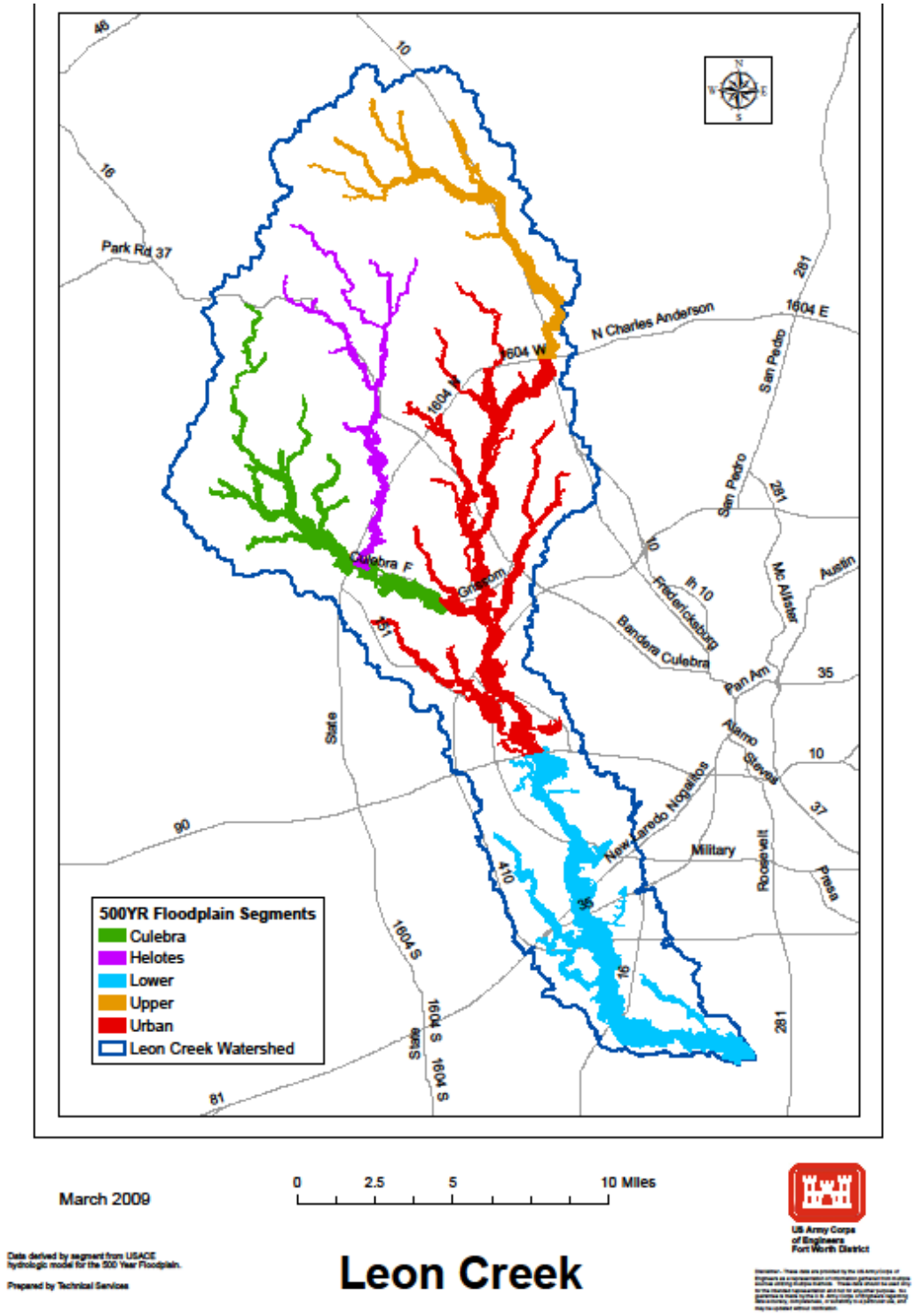

Figure B-1. Leon Creek Watershed Study Area

The Upper Leon Creek environmental segment of Leon Creek mainstem includes the area between its headwaters and Texas State Highway Loop 1604. The following economic reaches are included in this segment: Leon mainstem, Pecan Creek, Leon Tributaries J–N.

The Urban Leon Creek segment extends between Texas State Highway Loop 1604 to Texas State Highway 90 and includes Leon mainstem, Babcock Creek, Huesta Creek, French Creek, Huebner Creek, Slick Ranch Creek and Leon Tributaries G–I. The Lower Leon Creek environmental segment extends from Texas State Highway 90 to the confluence with the Medina River and includes Indian Creek, Comanche Creek, and Leon Tributaries A–E.

The Culebra Creek study segment runs from its confluence with Leon Creek mainstem to Government Canyon and includes Culebra Tributaries A–F. The Helotes segment extends from Helotes Creek mainstem's confluence with Culebra Creek to Helotes Creek headwaters and includes Los Reyes Creek, Chiminea Creek, and Helotes Tributaries A and B.

HABITAT EVALUATIONS

To evaluate terrestrial habitat, the team used the United States Fish and Wildlife Service (USFWS) Habitat Evaluation Procedure (HEP) (USFWS, 1980). Aquatic habitat was evaluated using the Rapid Bioassessment Protocols of the U.S. Environmental Protection Agency (EPA) Habitat Assessment model.

Terrestrial and Riparian Habitat

Procedures

To evaluate habitat conditions that would result from alternative plans, first a suitability index (SI) value is determined based on field measurements for existing conditions and on professional judgment for future conditions under alternative plans. The index ranges from 0 to 1.0, with 1.0 representing the highest habitat quality possible. The SI values are aggregated to derive a habitat suitability index (HSI) value for the indicator species.

A habitat unit (HU) is the product of the HSI value multiplied by an area (in acres) of available habitat. HSIs and HUs were developed for different times during the period of analysis (at years 1, 15, 25, and 50). The HUs were annualized to estimate an Average Annual Habitat Unit (AAHU).

This methodology allows future habitat conditions to be estimated for both baseline (without-project) and design (with-project) conditions. Projected long-term effects of a project can be predicted using AAHU values. Based on the AAHU outcomes, alternative designs can be formulated and trade-off analyses can be simulated to promote environmental optimization. As with HUs, AAHUs are determined utilizing the formulas provided by USFWS documentation. Thus, HEP provides information for three general types of wildlife habitat comparisons. The first is the relative value of different areas at the same point in time. The second is the relative value of the same area at future points in time. The use of annualized values allows for comparison of impacts of land and water use changes on wildlife habitat over time.

Evaluation

The USFWS, with assistance from the Texas Parks and Wildlife Department (TPWD) and the USACE Fort Worth District, completed the HEP for the without-project (existing and future) condition of riparian

natural resources on Leon Creek. Because the resource agencies are most concerned in the restoration of lost aquatic and riparian habitat functions, the focus was to use models that contain variables that measure important components of riparian corridor structure. The following species which represent guilds important to ecosystems within the Leon Creek watershed were used for terrestrial habitat evaluations.

- Riparian Woodlands: raccoon, barred owl, fox squirrel, green heron
- Grasslands: red-tailed hawk, meadowlark, scissor-tailed flycatcher, eastern cottontail

While these species are relatively common, their habitat suitability index (HSI) models, when averaged cumulatively, serve as good indicators of a healthy, functioning ecosystem and therefore provide a good basis for comparing outputs from alternative plans. However, they should not be used to judge the importance nor significance of these habitats.

Figure B-2 on the next page shows the sites where field surveys were done for the USFWS (HEP). The numbered sites are described according to the closest road or landmark and stream, as listed in Table B-1(b).

Table B-1(b). HEP Map Legend by Segment

HEP Site	Road	Stream
Upper Leon Creek		
1	Huntress Lane	Leon Creek
2	Scenic Loop Road	Tributary M
3	Flint/Buck Road	Leon Creek
4	Stonewall Fire Station	Tributary J
5	Leon Creek Drive	Leon Creek
Urban Leon Creek		
25	Prue Road	Leon Creek
24	Pinn Road	Leon Creek
15	Via Station	Huebner Creek
16	Piper Trail	Leon Creek
17	Mystic Park	French Creek
7	Dime Street	Huesta Creek
6	UTSA Blvd.	Babcock Creek
Culebra Creek		
12	Westwood Park	Culebra Creek
13	Kalison Road	Culebra Creek
14	Easterling Road	Culebra Creek
Helotes Creek		
8	Old Scenic Loop Road	Helotes Creek
9	Scenic Loop Road	Chiminea Creek
10	Dent Lane	Los Reyes Creek
11	Leslie Road	Helotes Creek
Lower Leon Creek		
18	Pleasanton Road	Leon Creek
19	Maurmann Road	Comanche Creek
20	Applewhite Road	Leon Creek
21	5 Palm Drive	Indian Creek
22	Military Road	Leon Creek
23	Quintana Road	Leon Creek

Note: The sites are listed in the order in which the survey team visited them.

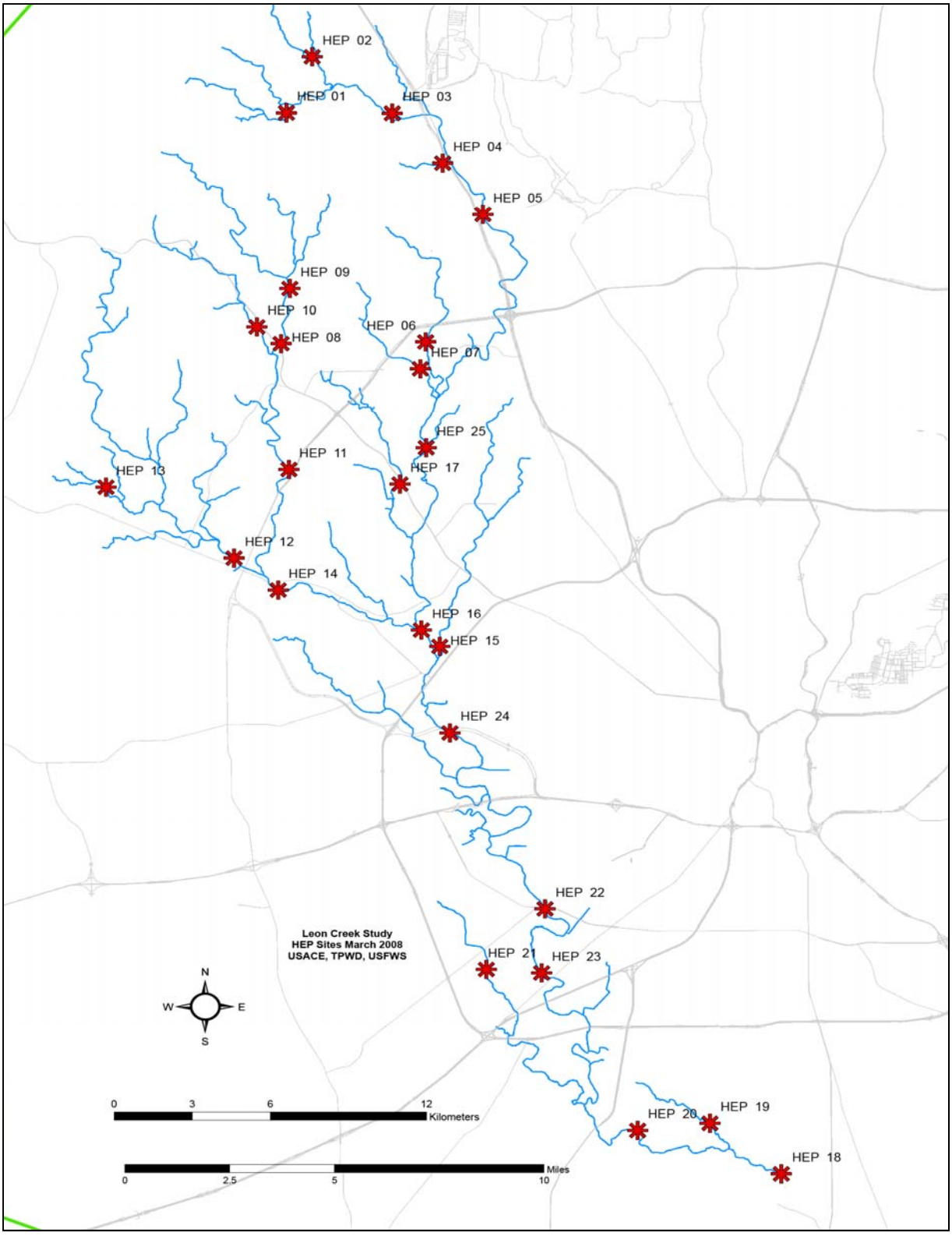

Figure B-2. Survey Sites for HEP Assessment

Table B-2 shows the results of the habitat evaluation for each environmental segment. The overall indices were of average quality except in certain segments where substantial degradation of the riparian zone has occurred due to existing development.

Table B-2. Existing Conditions Wildlife Habitat Values

Habitat / Species	Upper Leon	Urban Leon	Culebra	Helotes	Lower Leon
Riparian Woodlands					
Raccoon	0.62	0.43	0.45	0.49	0.46
Barred Owl	0.43	0.30	0.16	0.10	0.12
Fox Squirrel	0.49	0.24	0.01	0.11	0.12
Green Heron	0.32	0.35	0.59	0.49	0.58
Overall HSI	0.47	0.33	0.30	0.30	0.32
Grasslands					
Red-tailed Hawk	0.75	0.65	0.65	NA	0.65
Meadowlark	0.43	0.57	0.27	NA	0.71
Scissor-tailed Flycatcher	1.0	1.0	1.0	NA	1.0
Eastern Cottontail	1.0	1.0	1.0	NA	0.04
Overall HSI	0.80	0.81	0.72	NA	0.60

The Corps used ESRI ArcMap to develop a vegetation classification of the 500-year floodplain and to determine acreages by vegetative cover within each segment. These acreages were used, along with the Overall HSI values from the habitat evaluation (Table B-2), to determine the existing habitat units within each cover type (Acreage * HSI value = HU), as shown in Table B-3.

Table B-3. Existing Conditions Habitat Units by Vegetative Cover

Cover Type / Study Zone	Riparian Woodlands			Grasslands		
	Acres	HSI	HU	Acres	HSI	HU
Upper Leon	878	.47	413	408	.80	326
Urban Leon	2,730	.33	901	945	.81	765
Culebra Creek	1,680	.30	504	229	.72	167
Helotes Creek	928	.30	278	117	NA	NA
Lower Leon	2,822	.32	903	346	.60	208
Total	9,038		2,999	2,045		1,466

Aquatic Habitat

Procedures

To establish a baseline for project evaluation, the study team quantified the existing value of the aquatic resources. The team analyzed several sites within each environmental segment of the study area. When

specific project areas are identified, additional assessments may be needed to more accurately assess the habitat value in those particular areas.

The EPA developed a Habitat Assessment model using Rapid Bioassessment Protocols to analyze the physical characteristics of habitat types. For the aquatic habitat assessments, a portion of the EPA Habitat Assessment was used instead of HEP, because HEP provides quality information for aquatic conditions when water is present, but gives low scores (sometimes zero) when water is not present.

The EPA Habitat Assessment is described in detail in *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers*: *Periphyton, Benthic Macroinvertebrates, and Fish*, Second Edition (Manuel Barbour, 1999). Several protocols can be used to complete an in-depth analysis, but only the Habitat Assessment Field Data Sheet was completed for this habitat analysis. Two data sheet survey forms, with slightly different parameters, were used depending on whether the stream was high or low gradient. The analysis measures ten parameters:

- Epifaunal substrate/available cover
- Embeddedness (high-gradient stream) or pool substrate (low-gradient stream) characterization
- Velocity/depth combinations (high-gradient) or pool variability (low gradient)
- Sediment Deposition
- Channel flow status
- Channel alteration
- Frequency of riffles (high-gradient) or channel sinuosity (low gradient)
- Bank stability
- Bank vegetative protection
- Riparian vegetational zone width

Each of the parameters is given a score from 1 to 20 for a possible total score of 200 points for each survey location within a segment. These scores are then averaged to derive a value for the existing conditions per segment.

Evaluation

The team used the same survey sites for the EPA assessment as those for HEP, shown in Figure B-2. Table B-4 provides the results of the field survey for each study segment.

Table B-4. Existing Conditions Aquatic Habitat EPA Survey Scores

Habitat Parameter		Upper Leon	Urban Leon	Culebra	Helotes	Lower Leon
Epifaunal Substrate		14	8	16	14	18
Embeddedness / Pool Substrate		15	8	12	12	17
Velocity/Depth Regime / Pool Variability		12	10	14	13	15
Sediment Deposition		13	12	16	14	16
Channel Flow Status		2	2	6	5	16
Channel Alteration		16	9	13	16	14
Frequency of Riffles / Channel Sinuosity		18	12	15	16	16
Bank Stability	Left Bank	7	6	7	7	5
	Right Bank	8	5	7	9	5
Vegetative Protection	Left Bank	8	5	8	9	6
	Right Bank	9	6	7	8	6
Riparian Zone Width	Left Bank	8	5	8	10	7
	Right Bank	8	6	6	8	7
Habitat Total Score		138	94	135	141	148
RBPI		.69	.47	.68	.70	.74

To project future without-project conditions, the team predicted the expected changes for years 1, 15, 25, and 50 and completed additional sets of field data sheets to document those expected changes. This process will be repeated to obtain future with-project projections after project features are developed.

- Each segment's score was normalized (converted from the 0–200 scale to a scale where scores range from 0 to 1.0) to produce a Rapid Bioassessment Protocol Index (RBPI). The RBPI is similar to the HSI using HEP.
- The RBPI was multiplied by acres of stream to obtain aquatic RBPUs.
- The remaining runs of the model were accomplished similar to HEP, to produce the Average Annual Rapid Bioassessment Protocol Unit (AARBPU) values.

Using the Ultimate Land Use data provided by the sponsor, San Antonio River Authority (SARA), our projections hold true, in that the remaining segments will experience a similar degradation pattern as the Urban Leon Creek segment has.

EXISTING HABITAT CONDITIONS

This section details the existing environmental setting for each segment of the study area and describes how the vegetative cover types were refined for analysis.

- Because grasslands have a woody component, areas having only low-density shrubland, these areas and their acreages are included in the grasslands discussion.
- Similarly, young or first successional woodland acreages are included in the discussion of riparian woodlands.
- Due to lack of access, inadequate survey locations were available for true shrublands. However, the team felt it was important to keep the shrubland acreages separate for discussion purposes and leave the topic open for future study if necessary.
- Commercial, residential, and road acreages were combined into the urban classification.
- The entire watershed, with the exception of the Lower Leon Creek segment, is ephemeral to intermittent; therefore, *streambed* is used as a description for stream channels that would normally be classified as water.

Although USACE normally would not restore nor mitigate for grasslands, the team felt it important to include assessment of these habitats for mitigation purposes by conversion to riparian forests.

The historic vegetation within the Upper and Urban Leon Creek, Culebra Creek, and Helotes Creek segments is described as savanna that was rich in tall and mid grasses with interspersed clumps of live oak and shin oak. However, overgrazing by livestock and the desire to suppress naturally occurring range fires have promoted a tremendous increase in the abundance of woody species. Such species include Ashe juniper, honey mesquite, huisache, and others that were historically restricted to the steep slopes of canyons, ridges, and ravines where fires could not reach them (Buechner, 1944).

Much of the watershed is still being used for agricultural purposes, such as grazing, row cropping, and hay production. However, a recent increase in population has promoted residential growth throughout the area. This development has resulted in clearing of large tracts of land for homes, businesses, and utility lines. The City of San Antonio has established ordinances to reduce development in the 100-year floodplain. A common practice is the clearing of brush and understory and leaving stands of oak species. The implications of increased impervious cover and the conversion to Ashe juniper and other prolific hydrophytes (“water loving” species) from native grasslands or savannas is that there is less water infiltration into the soils and more runoff. This results in shorter durations of flow in the creeks, which in turn results in less recharge into the aquifers. In addition, if hydrophytic vegetation gets established, their roots may extend to the aquifer and influence water quantities within shallow aquifers.

The historic vegetation of the Lower Leon Creek segment is rolling to nearly level plains of the Northern Blackland Prairie ecoregion, with mostly fine-textured, dark, calcareous, and productive Vertisol soils. Historical vegetation was dominated by little bluestem, big bluestem, yellow Indian grass, and tall dropseed. Common forbs included asters, prairie bluet, prairie clovers, and black-eyed susan. Stream

bottoms were often wooded with bur oak, Shumard oak, sugar hackberry, elm, ash, eastern cottonwood, and pecan. Most of the prairie has been converted to cropland, non-native pasture, and expanding urban uses around San Antonio.

Aquatic habitat in the Leon Creek watershed is diverse. The headwater originates from spring flow, and the stream is classified as an ephemeral stream through this segment with varying levels of available water depending on the location above or upon the Edwards Aquifer Recharge Zone. This segment provides riverine riparian habitat for fisheries and other aquatic species for most of the zone. The substrate is rocky with cobble. The creek has clear water with a diversity of aquatic in-stream vegetation and structure that provide aquatic habitat.

As the creek moves south into a transition zone, it becomes less diverse and closely surrounded by an urban environment. This area is composed of very rocky substrate with boulder-size particles and a bedrock channel. Fractures in limestone outcrops are common and serve to recharge the aquifer. The creek is intermittent and only flows during large rain events of more than a couple of inches. The creeks are sometimes dry for several years, except for a small amount of flow attributed to urban lawn irrigation and a few persistent pools. The decrease in persistent water is attributed to several things, including groundwater pumping, growth of hydrophytic plants in the contributing watershed, and increases in impervious cover.

As the stream passes out of the aquifer recharge and transition zone and beyond the urban area, it transitions into a perennial stream that provides riverine aquatic habitat, and the adjacent riparian areas become wider. In addition to spring flow, reuse water from the Lackland Air Force Base Test Cell Facility and a San Antonio Water System (SAWS) wastewater recycling facility are discharged in this zone. While water is more permanent in this reach, water quality is impaired due to bacteria and to PCBs in edible tissue of fish, according to the State of Texas 303(d) 2010 List.

In-stream vegetation observed during site visits included: buttonbush (*Cephalanthus occidentalis*), water willow (*Justicia Americana*), duckweed (*Spirodela polyrhiza*), fern, pennywort (*Hydrocotyle sp*.), pondweed (*Potamogeton illinoensis*), sedge (*Carex sp*.), smartweed (*Polygonum hydropiperiodes*), spadderdock (*Nuphar luteum*), needle spikerush (*Eleocharis acicularis*), switchgrass (*Panicum virgatum*), and water star grass (*Heternanthera dubia*).

Upper Leon Creek

The upper segment of Leon Creek mainstem runs from its headwaters to Texas State Highway Loop 1604 and includes the economic reaches: Leon mainstem, Pecan Creek, Leon Tributaries J–N. This segment has experienced a great deal of urban sprawl. Very little forest cover exists except along the riparian zone of Leon Creek. This segment has rocky soils typical of the Edwards Plateau ecoregion and a large deciduous canopy where it has been left alone. Along several sections of this stream, grazing has left virtually no riparian zone. In other areas, the riparian zone is more than 200 meters wide, dense, and intact. Like the rest of Leon Creek, the grasslands have relatively high HSIs, but are composed mostly of non-native invader species. In general, this segment is highly degraded from urban sprawl and grazing activities and appears to have areas susceptible to erosion due to a non-continuous and low-quality riparian zone.

Figure B-3 shows the vegetative cover types along the Upper Leon Creek segment.

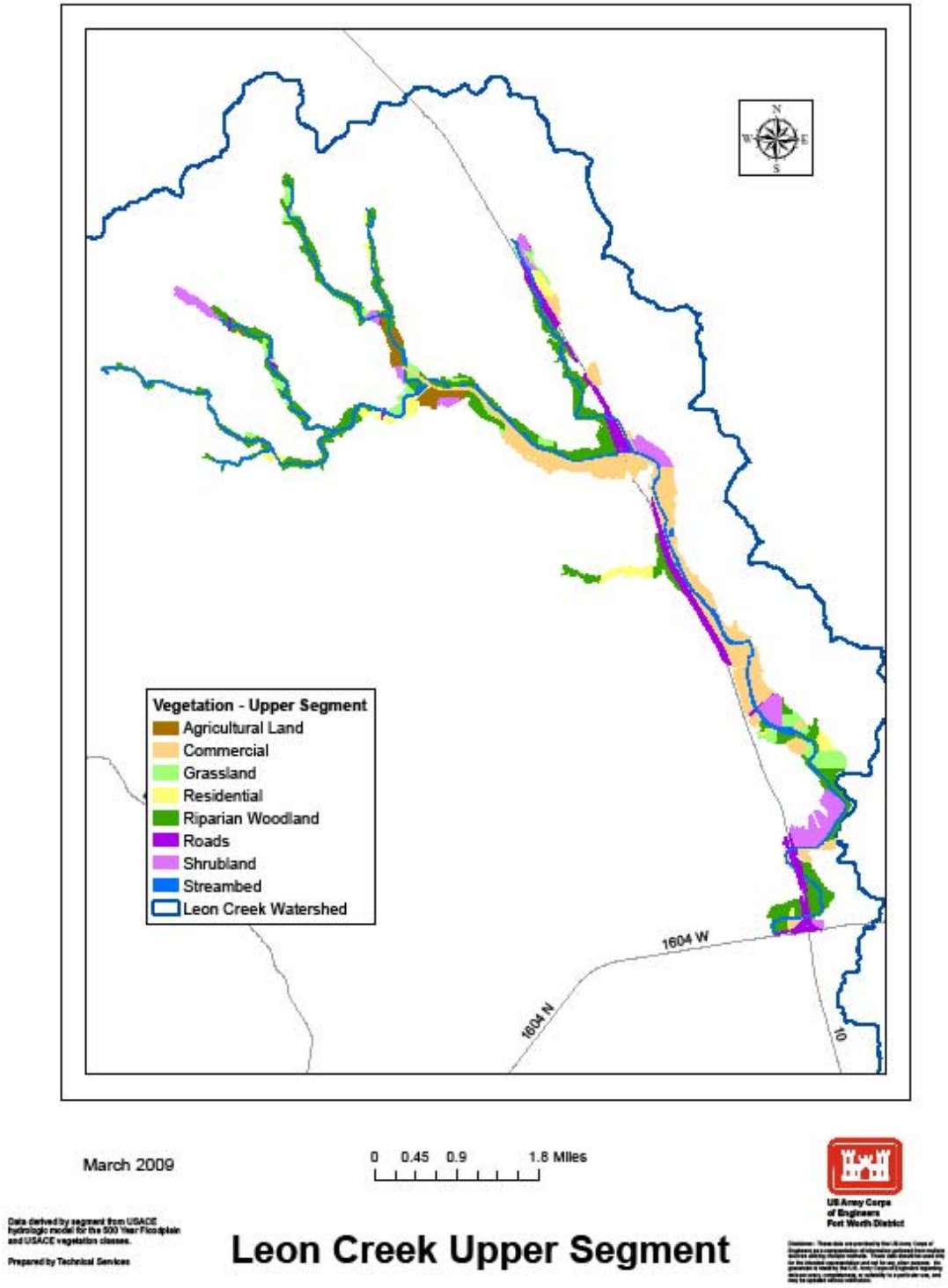

Figure B-3. Upper Leon Creek Segment Vegetation

Terrestrial and Riparian Habitat

The Upper Leon Creek segment covers about 2,456 acres within the 500-year floodplain and contains the following vegetative cover types:

Cover Type	Acreage
Riparian Woodlands	878
Grasslands	408
Agricultural	83
Urban	967
Streambed	120
Total	2,456

The riparian zones in this segment consist of pole-size stands of Live oak, Ashe juniper, and Cedar elm trees. The canopy has an average of 40% closure with 25% shrub understory. As shown in Table B-2 "Existing Conditions Wildlife Habitat Values", the overall riparian woodland HSI value for the Upper Leon Creek segment is 0.47 which is considered fair quality habitat, providing 412 habitat units.

- The majority of the sites in these riparian areas had more than four trees greater than twenty inches in diameter, which improved the overall habitat rating for raccoon cover and reproduction (0.62).
- Barred owl habitat was fair, though the average diameter at breast height (dbh) of less than 10 inches for overstory trees reduces the cover and reproductive values (0.43).
- Fox squirrel habitat value was reduced by the relatively young overstory and lack of available winter food (0.49).
- The green heron had only a fair score (0.32) because of the rocky substrate and lack of emergent herbaceous cover.

Most of the grassland along Leon Creek has high HSI values with an overall HSI of 0.80, with 326 existing habitat units.

- The grasslands generally had dense ground cover and a mixture of grasses and forbs. The grasslands were adjacent to wooded riparian areas providing good red-tailed hawk nesting and perching. (0.75)
- Because of the lower percentage of grass present, meadowlark habitat value was average (0.43).
- The habitat scored perfect (1.0) for scissor-tailed flycatcher and eastern cottontail at all three sites. There was good ground cover and a good mixture of forbs and grasses. Removing some of the nonnative invasive species and restoring native vegetation to the area could improve the overall diversity of the area.

Aquatic Habitat

The aquatic habitat in the Upper Leon Creek segment is considered diverse. The headwater originates from spring flow and the stream is classified as an ephemeral stream through this segment, with varying levels of available water depending on its location above or upon the Edwards Aquifer Recharge Zone. This segment provides riverine riparian habitat for fisheries and other aquatic species. The substrate is rocky with cobble. Although many small, man-made check dams hold water and fill with cobble, the creek has clear water with a diversity of aquatic in-stream vegetation and structure that provide fair aquatic habitat. There are a variety of flows, pools, and riffle complexes.

For the most part, the upper segment is in good or excellent condition with the exception of the man-made check dams, which are not natural to riverine areas, but it would not be practical to restore these areas. However, the area of Leon Creek main stem that runs along Interstate Highway 10 is degraded and could be restored by increasing the riparian zone along the creek.

These areas had very little running water, but numerous persistent pools. The aquatic habitat RBPI is 0.69 providing 302 RBPUs for excellent to good aquatic habitat. The site locations on Upper Leon Creek scored high: 141 at Huntress, 155 at Flint, and 118 at Leon Creek Drive. The entire area scored a little low due to water availability. If the score had been taken during a high-flow event, it would have been higher. To provide a more accurate assessment, the field experts decided to view streams as if they had water and according to how the flows would traverse the segment for the Velocity/Depth Regime parameter.

The Huntress and Flint sites are relatively pristine with the major loss of points due to the Channel Alteration parameter. Huntress had a man-made check dam located just upstream, and Flint was adjacent to a road.

The Leon Creek Drive site scored a little lower than the first two, but much of that can be attributed to Leon Creek crossing under Interstate 10 and into a more urban environment. There was no water present at the site and the creek bed comprised mostly bedrock. The riparian zone was reduced to 6–12 meters on either side with a moderate amount of non-native vegetation. This site would be vastly improved by replacing the non-native streambank vegetation with native species and increasing the riparian vegetative zone where space permits.

Tributaries M and J scored 139 and 133 respectively and can be categorized together, as their aquatic habitats are similar. These tributaries consist of only small residual pools and are flashy in nature during high-water events. They lack Epifaunal Cover for fisheries and consist of only two of the four Velocity/Depth Regimes. Considering the nature of these tributaries, this is to be expected. The Riparian Zones, Bank Stability, and Vegetative Protection parameters all scored high. The aquatic habitat in these streams is good.

Ecosystem Restoration Opportunities

The Upper Leon Creek segment is unlimited in the number of opportunities for restoration.

Urban Leon Creek

The Urban Leon Creek segment extends between Texas State Highway Loop 1604 to Texas State Highway 90 and includes the economic reaches described as Leon main stem, Babcock Creek, Huesta Creek, French Creek, Huebner Creek, Slick Ranch Creek, and Leon Tributaries G–I. This area has experienced high-density residential and commercial development within the 500-, 100-, and 25-year floodplains, which has reduced the width of the riparian corridor. However, this segment of Leon Creek has average quality riparian areas with pockets of high quality habitat.

Invasive species within the segment, such as Chinese Tallow, ligustrum, and chinaberry, indicate an opportunity for improvement for fish and wildlife species. This area is experiencing erosion due to the vegetation being removed from the tops of the banks, channelization projects, and impervious cover. Reestablishing vegetation on these banks would help stabilize the banks and would benefit the overall habitat in the area. Figure B-4 shows the types of vegetative cover along the Urban Leon Creek segment.

Terrestrial and Riparian Habitat

The Urban Leon Creek segment covers about 6,591 acres within the 500-year floodplain and contains the following vegetative cover types:

Cover Type	Acreage
Riparian Woodlands	2,730
Grasslands	945
Agricultural	340
Urban	2,274
Streambed	302
Total	6,591

The overall HSI value for riparian woodlands in Urban Leon Creek is 0.33 with 901 Habitat Units providing fair habitat.

- The majority of the trees in these riparian areas were less than ten inches in diameter, which lowered the overall habitat rating (0.43) for raccoon cover and reproduction.
- The barred owl habitat was poor (0.30). The relatively thick understory, in conjunction with the lack of overstory trees greater than 20 inches and the dbh of overstory trees being of the pole class, significantly limited the cover and reproductive values.

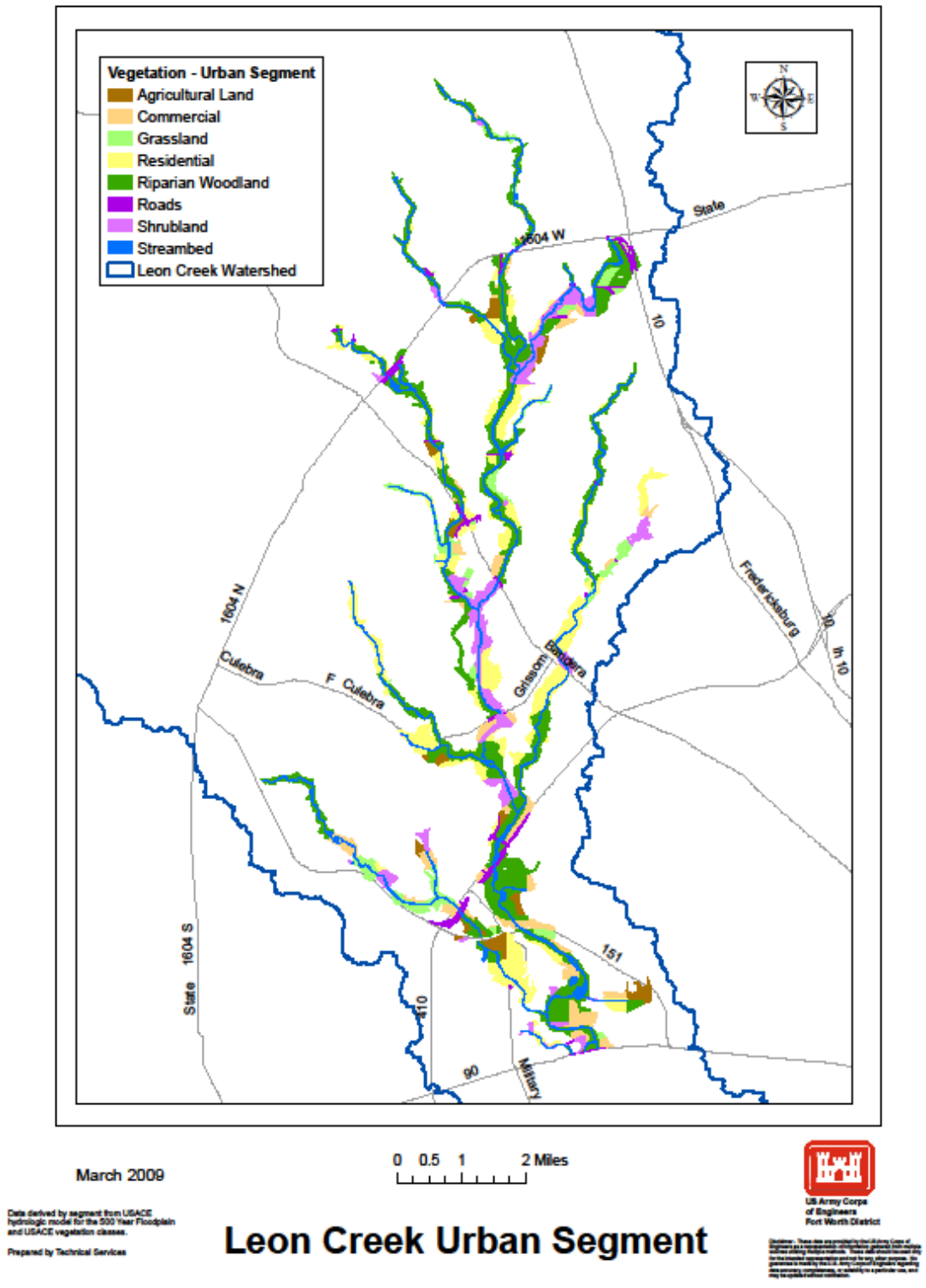

Figure B-4. Urban Leon Creek Segment Vegetation

- Similarly, fox squirrel habitat value (0.24) for cover and reproduction was reduced by the relatively thick understory. Barred owls and fox squirrels require a more open understory.
- Mast producers greater than or equal to six inches dbh were fairly uncommon throughout the woodlands producing low food value for fox squirrels.

The grasslands along Urban Leon Creek are in good condition with an overall HSI value of 0.81, and 765 habitat units.

- The grasslands are adjacent to wooded riparian areas providing good red-tailed hawk nesting and perching habitat. However, the close proximity of residential housing depresses red-tailed nesting success. Therefore, these areas only provide average (0.65) habitat for red-tailed hawks.
- Meadowlark habitat value was similarly lower (0.57) because of the taller herbaceous cover of grass present in the areas.
- The area scored perfect (1.0) scissor-tailed flycatcher and eastern cottontail habitat.

Habitat diversity in these areas could be improved by establishing a few native tall grassland areas along the floodway grassland boundary with scattered shrubs and scattered brush piles.

Aquatic Habitat

The Urban Leon Creek segment is not as diverse as the Upper Leon Creek segment. This area is composed of very rocky substrate with boulder-size particles and a bedrock channel. Fractures in limestone outcrops are common and serve to recharge the aquifer. The creek is intermittent and only flows during large rain events of more than a couple of inches. The creek is sometimes dry for several years, except for limited flow attributed to urban lawn irrigation and a few persistent pools. These permanent pools are essential in ephemeral and intermittent streams, as they provide niche space for the abundance of macroinvertebrates and fishes that inhabit these streams, while providing water for wildlife species that inhabit the riparian corridors. Manipulations that decrease the size or frequency of permanent pools decrease habitat availability and stability and deleteriously affect macroinvertebrate and fish assemblages in intermittent streams (Zale et al., 1989). The decrease in persistent water is attributed to several things, including groundwater pumping, growth of hydrophytic plants in the contributing watershed, and increases in impervious cover. The main degradation to this segment is due to the decrease in water within the creeks, damage from channelization projects, and narrowing of the riparian corridor within this urban environment.

This segment's water regimes are characteristic of the Upper Leon Creek segment, but are located in an urban environment, on or just below the recharge zone, and range from minimal to a complete lack of water. The RBPI value in this segment is .47 and contains 509 RBPUs providing fair aquatic habitat. The urban site locations on Leon Creek scored low, with 63 at Huntress and 97 at Piper Trail. However, the Prue Road site (144) provides an example of the benefits that could be accomplished at poor quality sites..

The Prue Road site had a minimal amount of water and was lacking in epifaunal cover and embeddedness. This is not a major concern because it is located over the aquifer recharge zone and will

typically only carry flows during rain events. Although within an urban environment, the area consisted of a good mix of mature trees and shrubs in the riparian area that provides quality aquatic habitat. The Pinn Road site was a channelized segment of Leon Creek, which provides few if any aquatic benefits. It is a mowed channel that has eroded to a bedrock surface. It received a few points for the adjacent riparian grassland and lack of levee erosion. Planting native riparian species along the channel would vastly improve this section. However, any plantings would have to be done in a manner to not adversely impact channel hydraulic performance.

Although scoring low, the Piper Trail site represents a good area for restoration. This site does not have a prominent stream channel and has eroded at multiple locations throughout scrub-shrub brushland. This area has an extensive corridor for project features. Huebner Creek (110), French Creek (55 channelized), Huesta Creek (71), and Babcock Creek (113) all scored low due to limited water, and on all other factors due to their urban nature. A major reason for the low scores is the areas are dry most of the time, with exception of some persistent pools.

The areas are in the Edwards Aquifer Recharge Zone and typical of central Texas recharge streams. The substrate moves during each rain event and is unstable. The substrate compositions have a lot of sediment deposition. Riffles were dry. The Velocity/Depth Regime and Channel Flow were also rated poor because of all four regimes not being present. Stream width was also a limiting factor; the streams appeared to be widening and the streambanks had signs of erosion. The adjacent riparian vegetation width was insufficient and composed of more plant species that do not provide adequate streambank protection. Although this area scored low on the EPA assessment method, there is little room for improvement due to the type of stream and aquatic habitat available. It would be possible in some areas to increase riparian areas to improve stream functions and habitat values.

Ecosystem Restoration Opportunities

Ecosystem restoration opportunities in this area include: grassland restoration, riparian woodland restoration, channel restoration/creation, and buyout of flood prone residential subdivisions and implementation of regulations to prevent development within the 25-year floodplain to prevent additional riparian habitat losses and provide base for riparian corridor restoration.

Culebra Creek

This stretch of the Leon Creek watershed study identified as the Culebra Creek segment runs from its confluence with Leon Creek Main stem to Government Canyon and includes Culebra Tribs A–F economic reaches. The Culebra Creek segment emerges from spring flow at its headwaters and traverses through the Edwards Aquifer Recharge Zone until its confluence with Leon Creek. Two tributaries in this segment begin in Government Canyon State Natural Area, which covers approximately 8,622 acres in Bexar County, just west of San Antonio. This area is a pristine, highly sensitive ecosystem due to the karst features and critical habitat identified for several endangered species. Figure B-5 shows the vegetative cover types along the Culebra Creek segment.

Terrestrial and Riparian Habitat

The Culebra Creek segment covers about 3,397 acres within the 500-year floodplain and contains the following vegetative cover types:

Cover Type	Acreage
Riparian Woodlands	1,680
Grasslands	229
Agricultural	527
Urban	806
Streambed	155
Total	3,397

The Culebra Creek segment is dominated by low-quality riparian woodlands, residential, and agricultural land use. The riparian zone is continuous, but ranges from less than 30 meters to greater than 200 meters, with some areas that are mowed and/or cleared up to one bank of the stream. Because there is dense residential development within the riparian zone, this directly contributes to erosion and sedimentation from the steep rocky banks where riparian vegetation has been removed. In general, the riparian zone is poor to fair with many areas that are dominated by first successional species with some higher quality older communities interspersed.

The overall HSI value for the riparian woodlands on Culebra Creek is 0.30, with 504 habitat units providing fair habitat.

- The raccoon and barred owl require large diameter trees, which were fairly uncommon throughout the woodlands. The trees in these riparian areas were less than 20 inches dbh, which reduced the overall habitat rating for raccoon cover and reproduction (0.45) and barred owl habitat (0.16).
- Mast producing trees greater than or equal to six inches dbh were lacking throughout the woodlands producing poor food value for fox squirrels (0.01).
- Green heron habitat rated average with an overall 0.59 HSI.

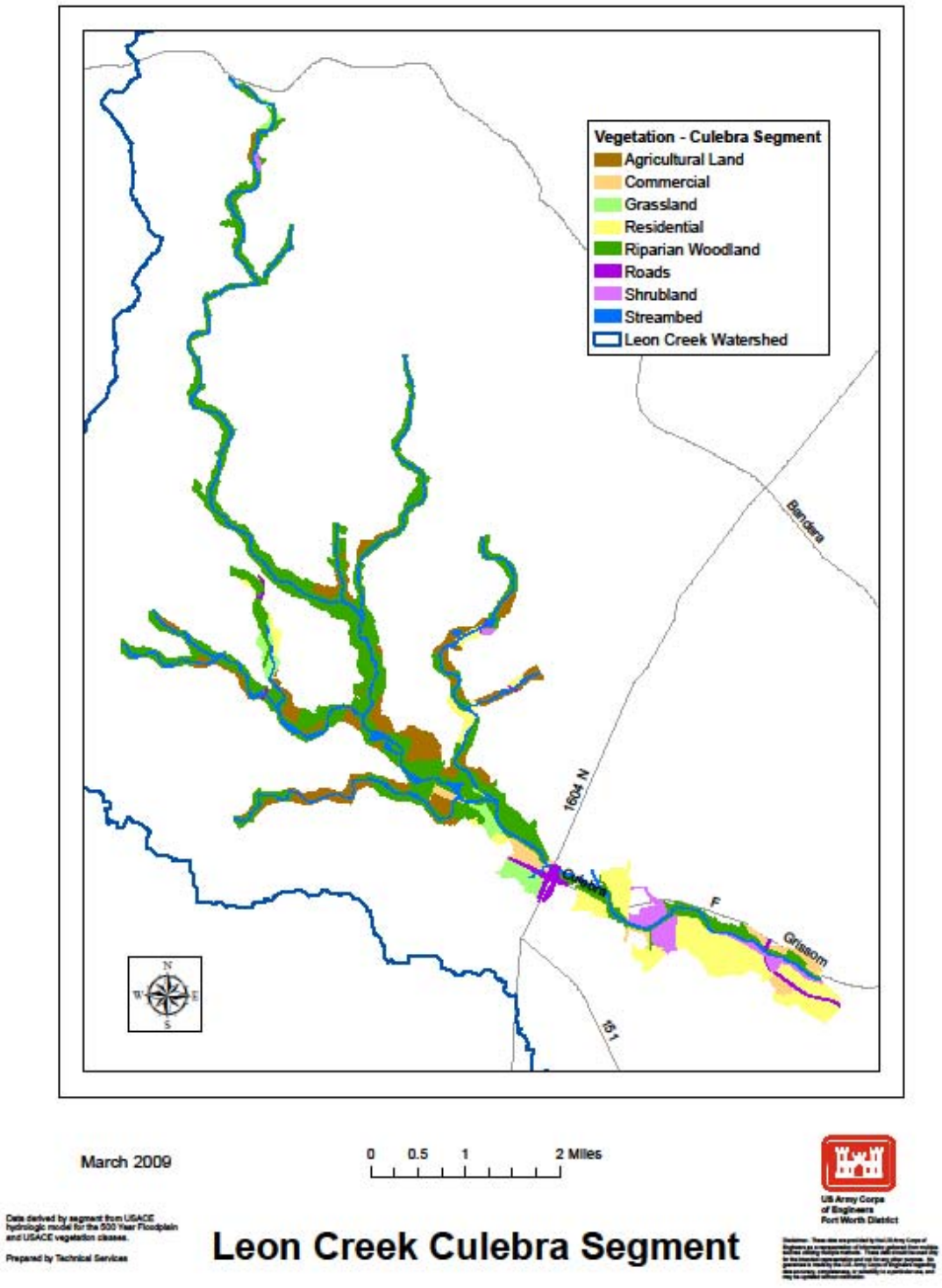

Figure B-5. Culebra Creek Segment Vegetation

The few areas of established riparian woodlands are of high quality. However, there are several areas along the creek where the riparian zone has been reduced due to residential growth. The fish and wildlife habitat would benefit from extending the riparian zone and creating a larger buffer zone.

The grasslands along Culebra Creek are in good condition with an overall HSI value of 0.73, with 167 habitat units.

- The grasslands were adjacent to wooded riparian areas providing good red-tailed hawk nesting and perching habitat. However, the close proximity of residential housing within the sample areas depresses red-tailed nesting success, and therefore these areas provide only fair habitat for red-tailed hawks (0.65).
- Meadowlark habitat value was fair (0.27) because of the lower herbaceous cover of grass present in the areas.
- The area was considered perfect (1.0) scissor-tailed flycatcher and eastern cottontail habitat.

Habitat diversity in these areas could be improved by establishing a few native tall grassland areas along the floodway grassland boundary with scattered shrubs and scattered brush piles.

Aquatic Habitat

The Culebra Creek segment is consistent with the Upper Leon Creek segment in available water, riparian zones, substrate, and aquatic habitat. As the stream flows through the Edwards Aquifer Recharge Zone, available water remains only in persistent pools, and the riparian areas become narrower as it moves through the urban areas until its confluence with Leon Creek. A housing development is currently being built in the headwaters with a storm drain channeled into a culvert, which will add water to the small stream during rain events. By adding impervious cover to the headwater of streams as suburbs grow away from metropolitan areas, this urban sprawl is a major contributor to the flooding of San Antonio. This segment could be improved by protecting stream corridors from urbanization. From the confluence with Helotes Creek to the confluence with Leon Creek, Culebra Creek is surrounded by development on both sides. Stream functions in this area are greatly altered and degraded.

The Culebra Creek segment was assessed at three locations: Kallison Road (135), midpoint at Westwood Park (150) and below the confluence with Helotes Creek at Easterling Road (126). Aquatic resources in this segment consist of good quality aquatic habitat with an RBPI of 0.68 and contain 398 RBPH units.

At the Kallison Road site, Culebra Creek is a low-gradient, spring-fed, slowly meandering, persistent stream. The stream's limiting factors include its lack of pool variability due to its size, disturbances from the housing development, and vehicle tracks. This area of the stream will change greatly in the future, as the development has constructed a concrete drainage ditch, with a culvert directly into this small stream. The riparian area is first successional grassland converting to shrubland, which provides bank stability and vegetative protection. To slow further degradation, purchase or protection of this area is advisable.

The Westwood Park site is considered quality aquatic habitat with limitations based only on the lack of flow. It does contain persistent pools, which are occupied by several fish species.

The site at Easterling Road was just downstream from a concrete diversion channel project and adjacent to a cement plant on the right bank. The low-flow channel contains fair aquatic habitat in the persistent pools, although the velocity and amount of water during high-water events are widening and moving the channel, which causes the lower score. This site could be improved by creating additional riparian features along the left bank.

Ecosystem Restoration Opportunities

The Culebra Creek segment has low quality existing habitat, as much of the riparian woodlands are first successional and/or converted to residential housing. Riparian woodlands could be restored.

Helotes Creek

The stretch of the Leon Creek watershed study identified as the Helotes Creek segment extends from Helotes Creek mainstem's confluence with Culebra Creek to Helotes Creek headwaters and includes Los Reyes Creek, Chiminea Creek, and Helotes Tributaries A and B economic reaches. The Helotes Creek segment is categorized as an ephemeral stream and similar in nature to Upper Leon and Culebra Creek segments. The headwaters of Los Reyes, Chiminea, and Helotes Creeks are spring fed and converge to create Helotes Creek, which has varying amounts of water depending on the location as it crosses the Edwards Aquifer Recharge Zone. This segment's evaluation included two locations on Helotes Creek and one each on Los Reyes Creek and Chiminea Creek. Figure B-6 shows the types of vegetative cover that exist along the Helotes Creek segment.

Terrestrial and Riparian Habitat

Helotes Creek covers about 1,621 acres within the 500-year floodplain and contains the following vegetative cover types:

Cover Type	Acreage
Riparian Woodlands	928
Grasslands	117
Agricultural	29
Urban	417
Streambed	130
Total	1,621

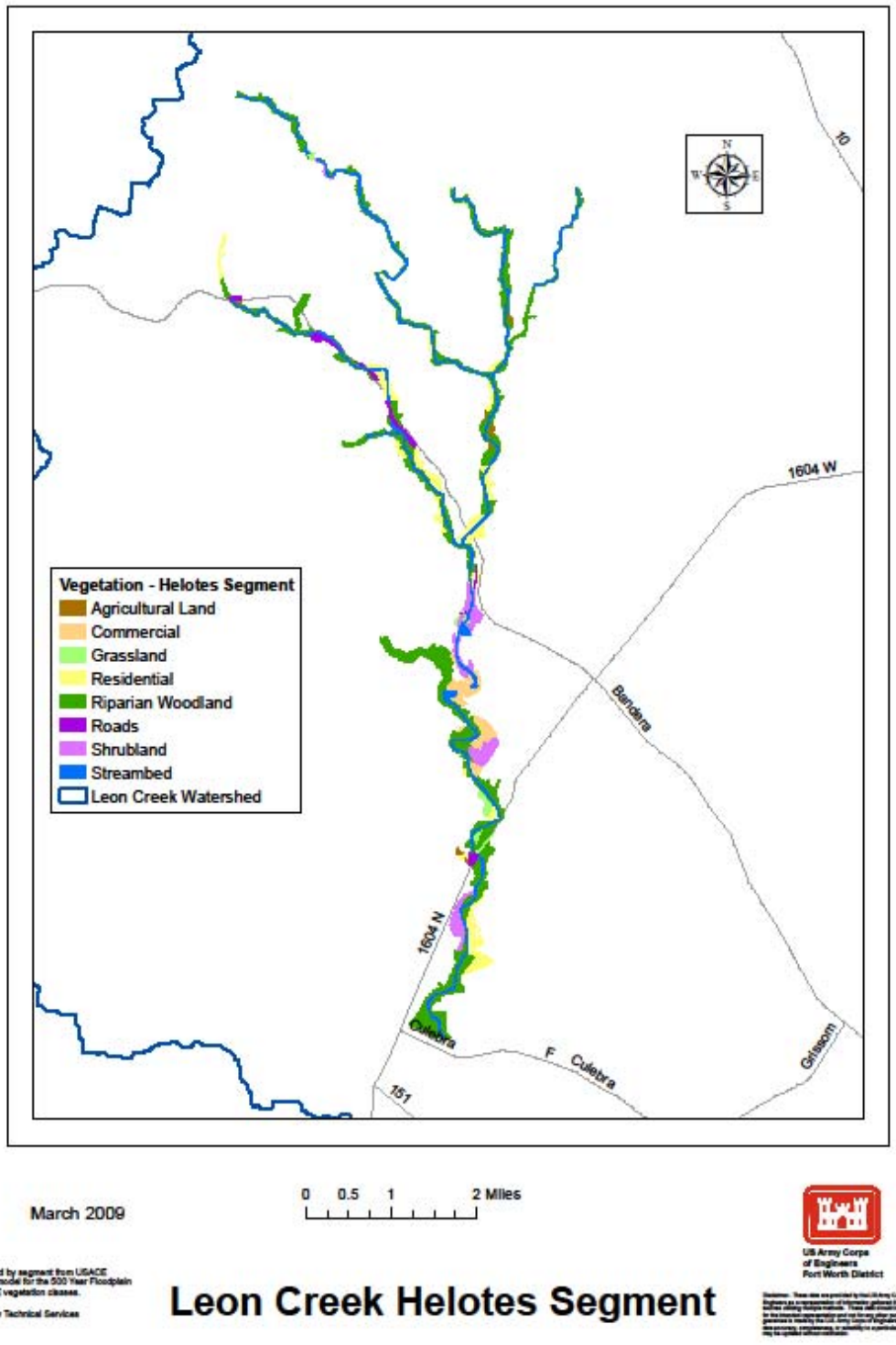

Figure B-6. Helotes Creek Segment Vegetation

The Helotes Creek segment is dominated by average quality riparian woodlands, residential, and agricultural land use. The riparian zone ranges from less than 30 meters to greater than 200 meters, with some areas that are mowed and/or cleared up to one bank of the stream. Riparian habitat is intact in the upper part of the Helotes Creek segment, but the habitat becomes less functional as the segment moves downstream due to dense residential development within the riparian zone. In general, the riparian zone in this area is good, but continued urban sprawl is taxing this segment.

The overall HSI value for the riparian woodlands on Helotes Creek is 0.30, with 278 habitat units providing fair habitat.

- The raccoon and barred owl require large diameter trees, which were fairly uncommon throughout the woodlands. The trees in these riparian areas were less than 20 inches dbh, which reduced the overall habitat rating for raccoon cover and reproduction (0.49) and barred owl habitat (0.10).
- Mast producing trees greater than or equal to six inches dbh were lacking throughout the woodlands, producing poor food value for fox squirrels (0.11).
- Green heron habitat rated average with an overall 0.49 HSI, due to a low food value from the rocky substrate.

The fish and wildlife habitat would benefit from extending the riparian zone and creating a larger buffer zone, although the lower portion of the stream is bottlenecked due to residential neighborhoods.

Aquatic Habitat

The Helotes Creek segment is categorized as an ephemeral stream and is similar in nature to Upper Leon and Culebra Creek segments. The headwaters of Los Reyes, Chiminea, and Helotes Creeks are spring fed and converge to create Helotes Creek, which has varying amounts of water depending on the location as it crosses the Edwards Aquifer Recharge Zone.

Along much of this segment, the riparian corridor remains intact and should be protected. North of the confluence of the three creeks, a great deal of this zone is listed as in or closely adjacent to Karst Habitat Zone 1 or 2, and any proposed project would have to be closely monitored to ensure these areas are avoided. Additionally, Final Critical Habitat models for the nine Bexar County Endangered Invertebrate Species show three karst features that hold the invertebrates; the Helotes Mold Beetle (*Batrisodes venyvivi*) is only located in the three karst regions on the Helotes Creek channel from Scenic Loop Road to approximately one-half mile upstream (Federal Register, 2000). This area should be avoided when planning proposed project features.

The Helotes Creek segment contains 298 RBPUs with an RBPI of 0.70, providing good to excellent aquatic habitat.

- Helotes Creek at Old Scenic Road scored 106 due to lack of water, lack of Epifaunal Substrate, Embeddedness (streambed was primarily rock and boulder sized materials), and Velocity/Depth Regime provided no deep water. On both sides of the stream, residences with mowed yards cause poor bank stability. This site location makes improvements difficult.

- The site at Leslie Road scored 149 and is considered excellent aquatic habitat. Water was present in persistent pools with favorable epifaunal habitat. However, with the stream's ephemeral nature, it scored low. A moderate amount of sediment deposition also contributed to a lower score.
- Chiminea Creek at the confluence with Helotes Creek is a spring-fed stream with permanent, clear channel flow, bass and sunfish present at the site along Scenic Loop Road, and a score of 159. The site would score higher, but a man-made check dam located just upstream from the site slows the natural flow of the stream. Additionally, a small amount of streambank erosion has occurred on the right bank due to the cutting action off of the dam.
- Los Reyes Creek along Dent Lane scored 124. However, the aquatic habitat at this location is favorable except for lack of permanent water.

This stream is also flashy in nature and lacks Epifaunal Substrate and Embeddedness. Only two of the four Velocity/Depth Regimes are present, and sediment deposition is prevalent. It is evident that high water events routinely shift and move sediments through this area. A possible improvement could be to add roughness in this stretch to ease the impact on the natural features of this stream.

Ecosystem Restoration Opportunities

The Helotes Creek segment has several karst features that contain, or have a high probability of containing, the nine karst invertebrates. Critical habitat for several species has been designated within the Helotes Creek basin above Scenic Loop Road (Federal Register, Vol. 77 No. 30, Tuesday February 14, 2012). Helotes Creek offers the opportunity to increase the riparian zones to improve water quality and create features designed to increase water quantity to the aquifer. Heavily disturbed limestone rock mining areas adjacent to the creek downstream of Scenic Loop Road could be considered for opportunities to improve overall ecological conditions in Helotes Creek.

Lower Leon Creek

The Lower Leon Creek segment extends from Texas State Highway 90 to the confluence with the Medina River and includes the Indian Creek, Comanche Creek, and Leon Tributaries A–E economic reaches. The lower segment of Leon Creek returns to a perennial stream that provides riverine aquatic habitat. Aquatic vegetation species are the same species reflected in the other four segments, and the adjacent riparian areas again become wider with more bottomland hardwood species. Agricultural lands become more prevalent, as this segment is listed as Blackland Prairie in the vegetational zones of Texas. The surrounding riparian areas are clay, silt, and sand. The survey sites for the lower segment on Leon Creek included Military Road, Quintana Road, Applewhite Road, and Pleasanton Road locations. Figure B-7 shows the vegetative cover types along the Lower Leon Creek segment.

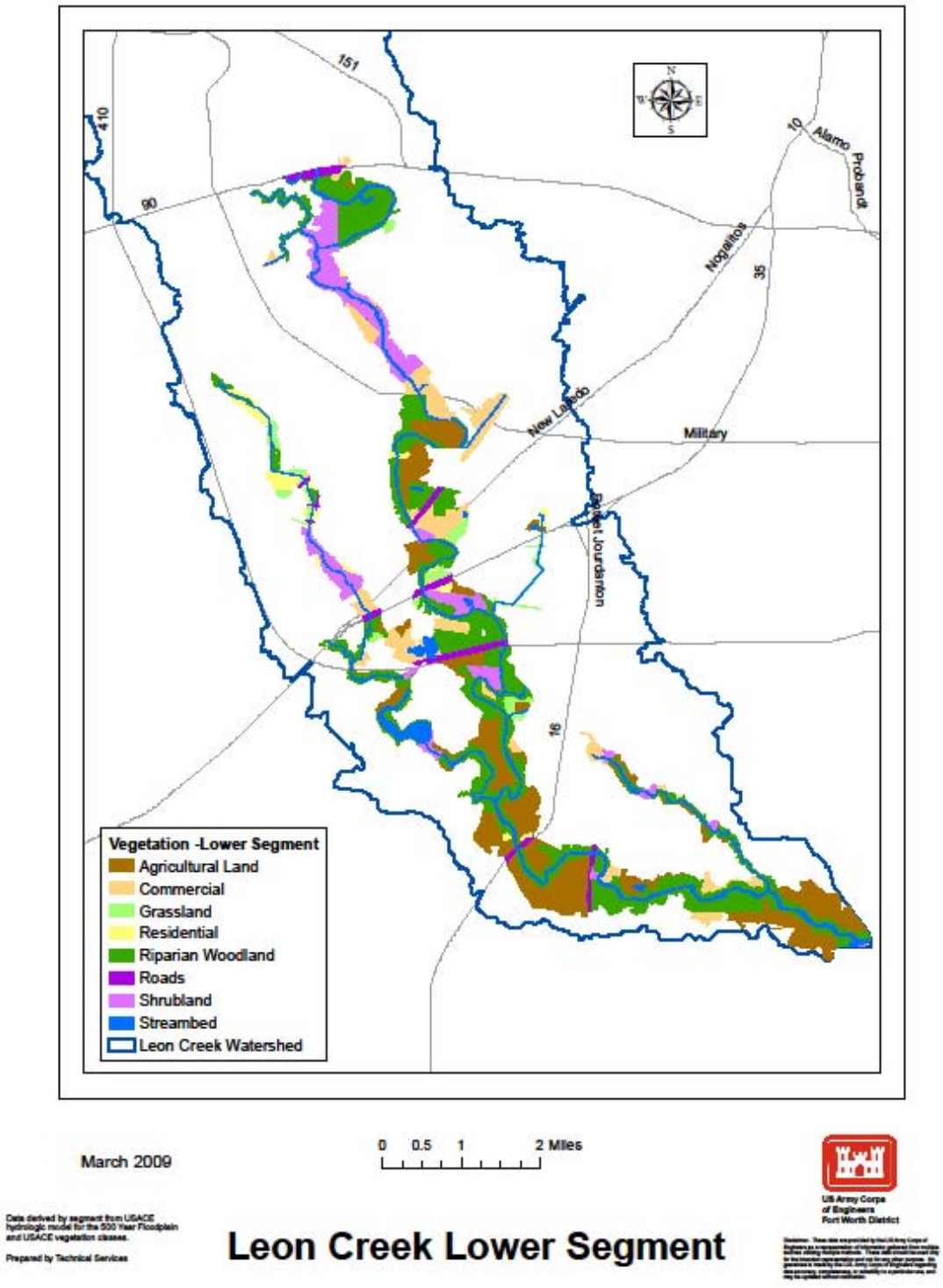

Figure B-7. Lower Leon Creek Segment Vegetation

Terrestrial and Riparian Habitat

The Lower Leon Creek segment covers 6,406 acres within the 500-year floodplain and contains the following types of vegetative cover:

Cover Type	Acreage
Riparian Woodlands	2,822
Grasslands	346
Agricultural	1,748
Urban	1,136
Streambed	354
Total	6,406

The riparian zones in this segment are diverse and range from mature stands of bottomland hardwood species to the south to pole-size stands of green ash, black willow, and cedar elm trees in the upper portions of the segment. The overall riparian woodland HSI value for the Lower Leon Creek segment is 0.32 with 903 habitat units providing fair habitat.

- The majority of the sites in these riparian areas had less than four trees greater than twenty inches in diameter, which reduced the overall habitat rating for raccoon cover and reproduction (0.46).
- Barred owl habitat was poor (0.12), due to the low average dbh of overstory trees less than 10 inches, which reduces cover and reproductive values.
- Fox squirrel habitat value (0.12) was reduced by the lack of mast producing trees for available food.
- The green heron had only a fair score (0.58) because of the lack of emergent herbaceous cover.

The grasslands in Lower Leon Creek have average HSI values with an overall HSI of 0.60, and 208 habitat units. The grasslands generally had dense ground cover and a mixture of grasses and forbs.

- The grasslands were adjacent to wooded riparian areas providing good red-tailed hawk nesting and perching (0.65).
- Meadowlark habitat value was good (0.71) because of the lower percentage of shrub crown cover and high presence of grasses present in the areas.
- Scissor-tailed flycatcher habitat was perfect (1.0) at the sites.
- However, the cottontail habitat was poor (0.04) due to the lack of canopy closure.

Habitat diversity in this area was average due to the non-native invasive plant species. Bermuda grass, used in this area as improved pasture for grazing livestock, dominates the grassland area and limits the habitat potential of these sites. Removing some of the non-native invasive species and restoring native vegetation to the area could improve the overall diversity of the area.

Aquatic Habitat

The Lower Leon Creek segment becomes a perennial stream that provides riverine aquatic habitat, as this segment is below the aquifer recharge zone. Aquatic vegetation species are the same species reflected in the other four segments, and the adjacent riparian areas become wider with more bottomland hardwood species. In addition to spring flow, reuse water from the Lackland Air Force Base Test Cell Facility and a San Antonio Water System (SAWS) wastewater recycling facility are discharged in this zone. This provides for higher levels of base flow, but water quality is slightly impaired because of these facilities. In addition to water quality problems from the treatment plant, much of the area is agricultural lands that affect the water quality due to herbicide and pesticide runoff into this Leon Creek segment.

Because riparian zones link the stream with its terrestrial catchment, they can modify, incorporate, dilute, or concentrate substances before they enter a lotic system. In small to mid-size streams, forested riparian zones can moderate temperatures, reduce sediment inputs, provide important sources of organic matter, and stabilize streambanks (Osborne, 2007). For the most part, the Lower Leon Creek segment is in good or excellent condition, but could be improved by widening the riparian zones to protect the stream from agricultural runoff.

The survey sites for the lower segment on Leon Creek were Military Road, Quintana Road, Applewhite Road, and Pleasanton Road locations, which scored 156, 151, 145, and 142, respectively. These areas consist of excellent aquatic resources with an overall RBPI of .74 containing 655 RBPUs. In each case, the sites lost points for bank stability due to the Blackland Prairie soils' erosive nature and the extreme velocity of water coming from the impervious cover of urban San Antonio, which causes much of this area to have a vertical bank.

Although stream erosion under these parameters can cause problems, the creek would naturally cut and meander over time. However, under the circumstances listed above, it is expected to happen within the project life instead of in geological time. An overbank swale either grass-lined or developed as a complex of wetlands dynamic could be a solution at one of the oxbow regions between Military Road and Interstate 35 to help reduce velocities and in the latter example restore wetland functions in this region.

In addition to the four Leon Creek assessment sites in this segment, two additional sites were surveyed on Comanche Creek at Maurmann Road and Indian Creek on 5 Palm Drive.

- The Indian Creek site was fully channelized, mowed, and provided little to no aquatic benefits with a score of 60. Establishing vegetation along the banks would improve this segment by as much as 40 points.
- Comanche Creek had a score of 147 and lost 40 points due to erosion and a lack of vegetative protection. This area would improve over time, as the vegetation on site was first succession and will mature if left alone.

Ecosystem Restoration Opportunities

The Lower Leon Creek segment is unlimited in the number of opportunities that exist, due to the abundance of space for riparian woodland plantings. Native grassland restoration could be implemented

in place of improved pastures. Additionally, the possibilities exist for a chain of wetlands to help reduce peak flows without channelization, while adding valley storage.

FUTURE WITHOUT PROJECT CONDITIONS

To effectively evaluate changes to the environment of Leon Creek if proposed projects were implemented, it is necessary to forecast the likely future environmental conditions if they were not.

Assumptions for Analysis

In the absence of any type of flood damage reduction project, the problems experienced in some Bexar County neighborhoods as a result of Leon Creek flooding would continue. It is anticipated that growth and development in the watersheds would continue. As a result, there would be additional construction and increased amounts of impervious surfaces such as roads, parking lots, and structures. According to information provided by SARA, future impervious cover would increase 45% for Leon Creek over the project life. These factors would add to the runoff within the creeks and would typically increase the severity and/or frequency of the flood problems within neighborhoods that are currently affected by flooding problems and possibly adds to the number of structures inundated. This would lead to continued degradation of the aquatic resources of Leon Creek.

The increase in peak flows, increased construction, and increase of impervious cover would also contribute to increases in sediment transport and turbidity from construction activities. These increases are not expected to affect the existing riparian zone to the point that riparian woodland restoration activities would not be sustainable. To the contrary, riparian woodland restoration would help offset some of these impacts from future impervious cover. Riparian woodlands serve as buffer zones to construction sites to help filter pollutants that enter the waterways.

It is expected that without restoration measures, and probably even with restoration measures to a certain extent, water quality in Leon Creek would degrade slightly to moderately in the future as Bexar County continues to develop. The construction phase of new residences and businesses would produce additional sediment load from runoff from construction sites. After completion, the increases in impervious surface area, traffic, lawn fertilizing, and other human activities would have an adverse impact on the creeks. Degradation of the water quality would reduce the number of aquatic biota in the creeks. The overall diversity of fishes and other aquatic species is already low according to USFWS; further loss of aquatic biota would be damaging to the aquatic ecosystem.

Encroaching urban and rural development activities (projected to go from 5,300 acres of urban use to 10,400 acres) would also be expected to negatively impact the watershed's existing vegetation. The existing forested riparian vegetation zone within much of the watershed is already very narrow with several grass and shrub openings. The number and size of the openings would continue to increase, and there would be fewer acres of forest in the future. The loss of habitat, particularly the riparian woodlands would reduce the number of wildlife and bird species within the watershed. This is especially true for migratory songbirds listed in the TPWD *Annotated County Lists of Rare Species* (see project files), which

are particularly susceptible to the loss of habitat along their migration routes. Furthermore, without additional protective measures as the urban sprawl continues out from the city limits of San Antonio, more critical habitat will be lost for the endangered golden-cheeked warbler and black-capped vireo.

The increased impervious cover and increased residential subdivisions will continue to impact the Edwards Aquifer. Increased impervious cover limits infiltration into the aquifer and reduces storage capacity of the watershed. Leon Creek would see increased peak flows, which would limit aquifer recharge. In addition, water quality would be reduced, and therefore, the quality of water in the aquifer would continue to degrade. Degraded water quality and quantity are major factors that affect the nine endangered karst invertebrates. There are impervious cover regulations over the recharge zone to help reduce these impacts, but continued degradation over time is still projected.

TPWD and USFWS participated in the projection of future without-project conditions for this study. From their opinions as experts, USFWS, TPWD, and USACE agreed on certain assumptions regarding the parameters used in the EPA habitat assessment model. This section presents the assumptions used during analysis and discussion.

Terrestrial and Riparian Habitat

- For future without-project projections, Ultimate Land Use data provided by SARA was used to calculate future acreages in the areas between the boundaries of the 500-year floodplain and the 100-year floodplain. Urban land uses will increase 45% outside of the 100-year floodplain, with a 20% reduction inside the 100-year floodplain for the future without-project.
- The progression from existing conditions to ultimate projections is linear over time, because there is no data to indicate otherwise. However, for the Urban Leon Creek segment, the projections indicate that it will be built out in 25 years.
- Riparian Habitat HSIs that remain will continue to degrade measurably over time. City of San Antonio floodplain ordinances do not specifically protect habitats, only against a rise in the floodplain. However, protection against development *will* suppress the effect of fragmentation.
- First successional woodland is included in the discussion of riparian woodland.
- Savanna habitat is included in the grasslands discussion.
- Losses of grassland habitat will be linear over time.

Aquatic Habitat

- Progression of future without-project conditions will be linear over time, as no data exists to suggest otherwise.
- Using professional judgment, USFWS, TPWD, and USACE personnel estimated future without-project conditions. Using the Urban Leon Creek segment as a reference segment, our estimates appear valid. According to our Ultimate Land Use data, future without-project conditions of other segments will degrade at the rate and fashion that the Urban Leon Creek segment has already incurred in the absence of project, as urbanization moves toward these segments. The Urban Leon Creek segment

will be fully built out in 25 years, and other segments will decline linearly toward Urban Leon until the 50-year project life.

- As defined for this study, the aquatic habitat includes the adjacent riparian zone. Although not all inclusive, the approximate 25-year floodplain is described with the aquatic habitat. As the parameters show, riparian vegetation plays an important role in the habitat quality of the aquatic environment, thus it is included in the aquatic resource discussion.
- The habitat model was created for perennial streams, and all segments with the exception of Lower Leon Creek are predominantly ephemeral with pockets of perennial pools. In sections where only standing pools were located, for the parameters of Velocity/Depth Regime and Frequency of Riffles, the stream was analyzed as if water was moving across the system and the score was adjusted.

Upper Leon Creek

This segment has already experienced a great deal of urban sprawl, and very little forest cover exists except along the riparian zone of Leon Creek. Projections from SARA indicate that this will continue as populations move away from San Antonio proper.

Terrestrial and Riparian Habitat

The Upper Leon Creek segment covers about 2,456 acres within the 500-year floodplain. According to Ultimate Land Use data provided by SARA, the existing land use acreages are expected to change as shown in Table B-5. Over the project life, the Upper Leon Creek segment is expected to withstand an increase in urban land use from 39 to 56 percent of the total acreage.

Table B-5. Expected Change in Upper Leon Creek Land Use Acreages

Land Use	Existing (acres)	Ultimate (acres)
Woodlands	878	602
Agricultural	83	59
Grasslands	408	289
Streambed	120	120
Urban	967 (39%)	1,386 (56%)
Total	2,456	2,456

Table B-6 shows the calculation of habitat units (HU) and average annual habitat units (AAHU) for the Upper Leon Creek segment.

Table B-6. Upper Leon Creek Future Without-Project Terrestrial and Riparian Habitat

	Target Year	0	1	15	25	50	Cumulative	
	Interval (years)	0	0	14	10	25	HU	AAHU
Woodlands	HSI	0.47	0.47	0.44	0.41	0.38		
	Acres	878	878	790	711	602		
	Target Year HU	412.7	412.7	347.7	291.6	229.2		
	Interval HU		275.1	5,316.3	3,192.4	6,495.9	15,279.7	**305.6**
Grasslands	HSI	0.80	0.80	0.77	0.74	0.71		
	Acres	408	408	367	330	289		
	Target Year HU	326.4	326.4	282.7	244.6	205.3		
	Interval HU		326.4	4,261.2	2,634.7	5,618.2	12,840.4	**256.8**

The overall riparian woodland HSI value for the Upper Leon Creek segment is 0.47 with 412 HUs providing fair habitat. Due to fragmentation and a lack of recruitment of the existing vegetation, the quality of the woodlands is expected to reduce the overall HSI values over time. The segment will also decline by the loss of 276 acres of woodland habitat to urbanization over the project life. The habitat will contribute 229 HUs in project year 50, with an AAHU value of 305.

Most of the grassland in the Upper Leon Creek segment currently has very high HSI values with an overall value of 0.80 and 326 habitat units. The remaining grassland HSI will decrease in value from overgrazing of livestock, mowing, and infestation of non-native plants. Habitat units will be reduced from the loss of 119 available acres of grassland. Project year 50 will total 205 HUs with an AAHU value of 256.

Aquatic Habitat

As shown in Table B-4. Existing Conditions Aquatic Habitat EPA Survey Scores" on page 11, the existing aquatic habitat RBPI of the Upper Leon Creek segment is 0.69 providing 302 RBPUs, which indicates excellent to good aquatic habitat. Urban expansion will cause reduction to the parameter of Channel Alteration, due to the addition of bridges, storm drains, and additional check dams. Channel Flow Status value will decrease due to expected channelization projects, increasing the frequency and shortening the duration of water in the channel. This will also cause the stream to be much flashier in nature, creating reductions in the parameter for Epifaunal Substrate, as the ultimate removal of riparian area will reduce the amount of debris in the channel. Embeddedness parameter will be reduced, as the rocky/gravel substrate will be washed away and eventually be eroded to bedrock. Sediment Deposition would increase with added construction. Bank Stability will decrease, as the flashy nature of the stream will increase. Vegetative Protection and Vegetative Cover are reduced with the narrowing of the riparian zone width. The parameters of Velocity/Depth Regime/Pool Variability and Frequency of Riffles/ Channel Sinuosity will remain unchanged over time.

As determined by the PDT, these parameter changes are expected to continue throughout the planning period. Rate of reductions will decrease as buildout nears the 50-year project life; much of the

degradation will have already taken place. The RBPI at 50 years is expected to be .48, as shown in Table B-7.

Table B-7. Upper Leon Creek Future Without-Project Aquatic Habitat RBPI

	Target Year	0	1	15	25	50
	Interval (years)	0	0	14	10	25
Epifaunal Substrate		14	13.8	11.7	10.0	8.5
Embeddedness / Pool Substrate		15	14.8	12.6	10.7	9.1
Velocity/Depth Regime / Pool Variability		12	12.0	12.0	12.0	12.0
Sediment Deposition		13	12.8	10.9	9.2	7.9
Channel Flow Status		2	1.9	1.6	1.4	1.2
Channel Alteration		16	15.8	13.4	11.4	9.7
Frequency of Riffles / Channel Sinuosity		18	18.0	18.0	18.0	18.0
Bank Stability	Left	7	6.9	5.8	5.0	4.2
	Right	8	7.9	6.7	5.7	4.8
Vegetative Protection	Left	8	7.9	6.7	5.7	4.8
	Right	9	8.9	7.5	6.4	5.4
Riparian Zone Width	Left	8	7.9	6.7	5.7	4.8
	Right	8	7.9	6.7	5.7	4.8
Habitat Total Score		138	136.9	120.8	107.2	95.6
RBPI		**.69**	**.68**	**.60**	**.54**	**.48**

The habitat total scores were normalized to determine the RBPI values shown in the table. The RBPIs were used to calculate the RBPU and AARBPU values shown in Table B-8. At 50 years, the segment's AARBPU is expected to be 246.1.

Table B-8. Upper Leon Creek Future Without-Project Aquatic Habitat RBPU and AARBPU

Target Year	0	1	15	25	50	Cumulative	
Interval (years)	0	0	14	10	25	RBPU	AARBPU
RBPI	0.69	0.68	0.60	0.54	0.48		
Acres	438	438	438	438	438		
Target Year RBPU	302.2	297.8	262.8	236.5	210.2		
Interval RBPU		300.0	3,924.5	2,496.6	5,584.5	12,305.6	**246.1**

Urban Leon Creek

This area has already experienced a high density of residential and commercial development within the 500-, 100-, and 25-year floodplains, which has reduced the width of the riparian corridor and is expected to be totally built out within 25 years. This segment's existing condition provides a snapshot of the future without-project conditions of the other segments if no project is authorized.

Terrestrial and Riparian Habitat

The Urban Leon Creek segment covers about 6,591 acres within the 500-year floodplain. According to Ultimate Land Use data provided by SARA, the existing land use acreages are expected to change as shown in Table B-9. The Urban Leon Creek segment is expected to withstand a change in land use from 34 to 55 percent urban.

Table B-9. Expected Change in Urban Leon Creek Land Use Acreages

Land Use	Existing (acres)	Ultimate (acres)
Woodlands	2,730	1,926
Agriculture	340	174
Grasslands	945	578
Streambed	302	302
Urban	2,274 (34%)	3,611 (55%)
Total	6,591	6,591

Table B-10 shows the calculation of HUs and AAHUs for the Urban Leon Creek segment.

Table B-10. Urban Leon Creek Future Without-Project Terrestrial and Riparian Habitat

	Target Year	0	1	15	25	50	Cumulative HU	AAHU
	Interval (years)	0	0	14	10	25		
Woodlands	HSI	0.33	0.33	0.29	0.24	0.22		
	Acres	2,730	2,730	2,457	2,088	1,928		
	Target Year HU	900.9	900.9	712.5	501.2	424.1		
	Interval HU		900.9	11,268.5	6,038.1	1,155.9	29,760.5	**595.2**
Grasslands	HSI	0.81	0.81	0.77	0.72	0.70		
	Acres	945	945	803	643	578		
	Target Year HU	765.5	765.5	618.5	462.7	404.8		
	Interval HU		765.4	9,674.4	5,392.5	10,838.5	26,670.9	**533.4**

The overall riparian woodland HSI value for the Urban Leon Creek segment is 0.33, with 901 habitat units providing fair habitat. Due to fragmentation and a lack of recruitment of the existing vegetation, the quality of the woodlands is expected to reduce the overall HSI values through year 25, until buildout has occurred. The segment will also decline by the loss of 804 acres of woodland habitat to urbanization over the project life. The habitat will contribute 424 HUs in project year 50 with an AAHU value of 595.

Most of the grassland on Urban Leon Creek has high HSI values with an overall value of 0.81, with 765 habitat units. The remaining grassland HSI will decrease in value primarily due to mowing and infestation of non-native plants. Habitat units will be reduced by the loss of 119 available acres of grassland. Project year 50 will provide 404 HUs with an AAHU value of 533.

Aquatic Habitat

These areas are characteristic of the Upper Leon Creek segment, but are located in an urban environment, on or just below the recharge zone, and range from minimal to a complete lack of water. The existing condition RBPI value in this segment is 0.47 and contains 509 RBPUs, providing fair aquatic habitat. The signs of urbanization have already been seen in this segment from several channelization projects, which will continue. A portion of the segment does not have a prominent stream channel and is subject to erosion at multiple locations, as the stream's flashiness becomes more prominent due to the buildout of sites upstream. The substrate compositions have a lot of sediment deposition, and the riffles were dry. The substrate moves during each rain event and is unstable, which will increase in the future. The Velocity/Depth Regime and Channel Flow were rated poor, because of all four regimes not being present. The width of the streams was also a limiting factor. The streams in this area appeared to be widening and the stream banks will continue to erode. The adjacent riparian vegetation width was insufficient and composed of more upland species that do not provide adequate streambank protection.

At the rate of urban expansion, this segment is expected to reach total buildout in 25 years, as opposed to the other areas that will build out in 50 years. This segment gives researchers good insight into what the future without-project conditions will be on the other segments, because it is already at year 25 of the 50-year project life. Table B-11 shows that the RBPI at 50 years is expected to be .42.

Table B-11. Urban Leon Creek Future Without-Project Aquatic Habitat RBPI

		Target Year	0	1	15	25	50
		Interval (years)	0	0	14	10	25
Epifaunal Substrate			8	7.8	7.4	7.0	7.0
Embeddedness / Pool Substrate			8	7.8	7.4	7.0	7.0
Velocity/Depth Regime / Pool Variability			10	10.0	10.0	10.0	10.0
Sediment Deposition			12	11.7	11.1	10.6	10.5
Channel Flow Status			2	1.9	1.8	1.7	1.7
Channel Alteration			9	8.8	8.3	7.9	7.8
Frequency of Riffles / Channel Sinuosity			12	12.0	12.0	12.0	12.0
Bank Stability	Left		6	5.8	5.5	5.3	5.2
	Right		5	4.9	4.6	4.4	4.3
Vegetative Protection	Left		5	4.9	4.6	4.4	4.3
	Right		6	5.8	5.5	5.3	5.2
Riparian Zone Width	Left		5	4.9	4.6	4.4	4.3
	Right		6	5.8	5.5	5.3	5.2
Habitat Total Score			94	92.5	89.0	85.6	85.4
RBPI			**.47**	**.46**	**.44**	**.43**	**.42**

Table B-12 shows an AARBPU of 470.9 calculated from these RBPI values.

Table B-12. Urban Leon Creek Future Without-Project Aquatic Habitat RBPU and AARBPU

Target Year	0	1	15	25	50	Cumulative	
Interval (years)	0	0	14	10	25	RBPU	AARBPU
RBPI	0.47	0.46	0.44	0.43	0.42		
Acres	1,083	1,083	1,083	1,083	1,083		
Target Year RBPU	509.0	498.2	476.5	465.7	454.9		
Interval RBPU		503.6	6,822.9	4,711.1	11,506.9	23,544.4	**470.9**

Culebra Creek

The Culebra Creek segment is already dominated by low-quality riparian woodlands, residential, and agricultural land use. Terrestrial and riparian habitats will continue to degrade over the project life in absence of a project.

Terrestrial and Riparian Habitat

Culebra Creek covers about 3,397 acres within the 500-year floodplain. According to Ultimate Land Use data provided by SARA, the existing land use acreages are expected to change as shown in Table B-13. This segment is expected to withstand a change in urban land use from 23 to 47 percent.

Table B-13. Expected Change in Culebra Creek Land Use Acreages

Land Use	Existing (acres)	Ultimate (acres)
Woodlands	1,680	1,178
Agriculture	527	338
Grasslands	229	138
Streambed	155	155
Urban	806 (23%)	1,587 (47%)
Total	3,397	3,397

Table B-14 shows the calculation of HUs and AAHUs for the Culebra Creek segment.

Table B-14. Culebra Creek Future Without-Project Terrestrial and Riparian Habitat

	Target Year	0	1	15	25	50	Cumulative	
	Interval (years)	0	0	14	10	25	HU	AAHU
Woodlands	HSI	0.30	0.30	0.27	0.24	0.21		
	Acres	1,680	1,680	1,512	1,361	1,177		
	Target Year HU	504.0	504.0	408.2	326.6	247.2		
	Interval HU		504.0	6,373.9	3,666.6	7,149.3	17,693.8	**353.9**

	Target Year	0	1	15	25	50	Cumulative HU	AAHU
	Interval (years)	0	0	14	10	25		
Grasslands	HSI	0.73	0.73	0.70	0.67	0.64		
	Acres	229	229	197	169	138		
	Target Year HU	167.2	167.2	137.9	113.5	88.6		
	Interval HU		167.2	2,132.9	1,255.3	2,521.6	6,077.0	**121.5**

The overall riparian woodland HSI value for the Culebra Creek segment is 0.30, with 504 habitat units providing fair habitat. Due to fragmentation and a lack of recruitment from the existing vegetation, the quality of the woodlands is predicted to reduce the overall HSI values throughout the project life. The segment will also decline in habitat units by the loss of 502 acres of woodland habitat to urbanization over the project life. This loss of acreage could be more extreme if not for the Government Canyon State Natural Area. The habitat will contribute 247 HUs in project year 50 with an AAHU value of 353.

Most of the grassland along the Culebra Creek segment currently has good HSI values with an overall HSI of 0.73 and 167 habitat units. The remaining grassland HSI will decrease in value from overgrazing of livestock, mowing, and infestation of non-native plants. Habitat units will be reduced by 91 available acres. Project year 50 will provide 88 HUs with an AAHU value of 122.

Aquatic Habitat

The Culebra Creek segment consists of good quality aquatic habitat with an RBPI of .68 and contributes 398 RBPUs. The upper portions of this segment are and will continue to be protected as part of Government Canyon State Natural Area. However, build out is occurring just below the natural area and will continue. From the confluence of Helotes Creek to the confluence with Leon Creek, Culebra is already surrounded by urbanization. The urbanization predicted to continue toward the headwaters will continue to impair this segment. The factors used to estimate future conditions in the Upper Leon Creek segment are also applicable here.

Table B-15 shows that the RBPI at 50 years is expected to be .47.

Table B-15. Culebra Creek Future Without-Project Aquatic Habitat RBPI

Target Year	0	1	15	25	50
Interval (years)	0	0	14	10	25
Epifaunal Substrate	16	15.8	13.4	11.4	9.7
Embeddedness / Pool Substrate	12	11.8	10.0	8.5	7.2
Velocity/Depth Regime / Pool Variability	14	14.0	14.0	14.0	14.0
Sediment Deposition	16	15.8	13.4	11.4	9.7
Channel Flow Status	6	5.9	5.0	4.2	3.6
Channel Alteration	13	12.8	10.9	9.2	7.9
Frequency of Riffles / Channel Sinuosity	15	15.0	15.0	15.0	15.0
Bank Stability Left	7	6.9	5.8	5.0	4.2

	Target Year	0	1	15	25	50
	Interval (years)	0	0	14	10	25
	Right	7	6.9	5.8	5.0	4.2
Vegetative Protection	Left	8	7.9	6.7	5.7	4.8
	Right	7	6.9	5.8	5.0	4.2
Riparian Zone Width	Left	8	7.9	6.7	5.7	4.8
	Right	6	5.9	5.0	4.2	3.6
Habitat Total Score		135	133.9	118.1	104.8	93.4
RBPI		**.68**	**.67**	**.59**	**.52**	**.47**

Table B-16 shows an AARBPU of 321.4 calculated from these RBPI values.

Table B-16. Culebra Creek Future Without-Project Aquatic Habitat RBPU and AARBPU

Target Year	0	1	15	25	50	Cumulative	
Interval (years)	0	0	14	10	25	RBPHU	AARBPHU
RBPI	0.68	0.67	0.59	0.52	0.47		
Acres	586	586	586	586	586		
Target Year RBPU	398.5	392.6	345.7	304.7	275.4		
Interval RBPU		395.6	5,168.5	3,252.3	7,251.8	16,068.1	**321.4**

Helotes Creek

This stretch of the Leon Creek watershed study identified as the Helotes Creek segment is already dominated by average quality riparian woodlands, residential, and agricultural land use.

Terrestrial and Riparian Habitat

Helotes Creek covers about 1,620 acres within the 500-year floodplain. According to Ultimate Land Use data provided by SARA, the existing land use acreages are expected to change as shown in Table B-17. The Helotes Creek segment is expected to be subjected to a change in urban land use from 26 to 48 percent.

Table B-17. Expected Change in Helotes Creek Land Use Acreages

Land Use	Existing (acres)	Ultimate (acres)
Woodlands	928	620
Agriculture	29	15
Grasslands	117	75
Streambed	130	130
Urban	417 (26%)	781 (48%)
Total	1,620	1,620

Table B-18 shows the calculation of HUs and AAHUs for the Helotes Creek segment.

Table B-18. Helotes Creek Future Without-Project Terrestrial and Riparian Habitat

	Target Year	0	1	15	25	50	Cumulative HU	AAHU
	Interval (years)	0	0	14	10	25		
Woodlands	HSI	0.30	0.30	0.27	0.24	0.21		
	Acres	928	928	835	752	620		
	Target Year HU	278.4	278.4	225.5	180.4	130.2		
	Interval HU		278.4	3,520.8	2025.34	3,866.5	9,691.1	**193.8**

The overall riparian woodland HSI value for this segment is 0.30, with 279 habitat units providing fair habitat. Due to fragmentation and a lack of recruitment from the existing vegetation, the quality of the woodlands is predicted to reduce the overall HSI values throughout the project life. The segment will also decline in habitat units by the loss of 308 acres of habitat to urbanization over the project life. The habitat will contribute 130 HUs in project year 50 with an AAHU value of 193.

Aquatic Habitat

The Helotes Creek segment is categorized as an ephemeral stream and is similar in nature to Upper Leon and Culebra Creek segments. The headwaters of Los Reyes, Chiminea, and Helotes Creeks converge to create Helotes Creek. Like Culebra Creek, the upper portion is relatively pristine in nature and, as it moves toward its confluence with Culebra Creek, it becomes highly urbanized. As the predicted urbanization moves upstream, the effects will create the same conditions, so the same criteria for future without-project conditions as in the Culebra Creek segment were used for Helotes Creek. The Helotes Creek segment currently contains 298 RBPUs with a RBPI of 0.70, providing good to excellent aquatic habitat. Table B-19 shows that the RBPI at 50 years is expected to be 0.48.

Table B-19. Helotes Creek Future Without-Project Aquatic Habitat RBPI

		Target Year	0	1	15	25	50
		Interval (years)	0	0	14	10	25
Epifaunal Substrate			14	13.8	11.7	10.0	8.5
Embeddedness / Pool Substrate			12	11.8	10.0	8.5	7.2
Velocity/Depth Regime / Pool Variability			13	13.0	13.0	13.0	13.0
Sediment Deposition			14	13.8	11.7	11.4	9.7
Channel Flow Status			5	4.9	4.2	3.5	3.0
Channel Alteration			16	15.8	13.4	9.2	7.9
Frequency of Riffles / Channel Sinuosity			16	16.0	16.0	16.0	16.0
Bank Stability	Left		7	6.9	5.8	5.0	4.2
	Right		9	8.9	7.5	6.4	5.4
Vegetative Protection	Left		9	8.9	7.5	6.4	5.4
	Right		8	7.9	6.7	5.7	4.8
Riparian Zone Width	Left		10	9.9	8.4	7.1	6.0
	Right		8	7.9	6.7	5.7	4.8
Habitat Total Score			141	139.8	123.2	109.1	97.0
RBPI			**.70**	**.69**	**.62**	**.55**	**.48**

Table B-20 shows an AARBPU of 243.6 calculated from these RBPI values.

Table B-20. Helotes Creek Future Without-Project Aquatic Habitat RBPU and AARBPU

Target Year	0	1	15	25	50	Cumulative	
Interval (years)	0	0	14	10	25	RBPHU	AARBPHU
RBPI	0.7	0.69	0.62	0.55	0.48		
Acres	426	426	426	426	426		
Target Year RBPU	298.2	293.9	264.1	234.3	204.5		
Interval RBPU		296.1	3,906.4	2,492.1	5,484.8	12,179.3	**243.6**

Lower Leon Creek

Under existing conditions, the lower segment of Leon Creek returns to a perennial stream that provides riverine aquatic habitat. Aquatic vegetation species are the same species reflected in the other four segments, and the adjacent riparian areas again become wider with more bottomland hardwood species. Agricultural lands are more prevalent, as this segment is Blackland Prairie in the vegetational zones of

Texas. Urbanization is expected to double in this area over the project life thus resulting in conversion of woodlands, agriculture lands and grasslands.

Terrestrial and Riparian Habitat

The Lower Leon Creek segment covers about 6,450 acres within the 500-year floodplain. According to SARA's Ultimate Land Use data, the existing land use acreages are expected to change as shown in Table B-21. The Lower Leon Creek segment is expected to withstand a change in urban land use from 17 to 47 percent.

Table B-21. Expected Change in Lower Leon Creek Land Use Acreages

Land Use	Existing (acres)	Ultimate (acres)
Woodlands	2,822	1,912
Agriculture	1,748	926
Grasslands	346	229
Streambed	354	354
Urban	1,136 (17%)	2,985 (47%)
Total	6,406	6,406

Table B-22 shows the calculation of Hus and AAHUs for the Lower Leon Creek segment.

Table B-22. Lower Leon Creek Future Without-Project Terrestrial and Riparian Habitat

	Target Year	0	1	15	25	50	Cumulative HU	AAHU
	Interval (years)	0	0	14	10	25		
Woodlands	HSI	0.32	0.32	0.29	0.26	0.23		
	Acres	2,822	2,822	2,540	2,235	1,911		
	Target Year HU	903.0	903.0	736.5	581.1	439.5		
	Interval HU		903.0	11,457.3	6,573.0	12,717.3	31,650.7	**633.0**
Grasslands	HSI	0.60	0.60	0.57	0.54	0.51		
	Acres	346	346	298	259	229		
	Target Year HU	207.6	207.6	169.6	139.8	116.8		
	Interval HU		207.6	2,637.1	1,545.1	3,204.3	7,594.0	**151.9**

The riparian zones in this segment are diverse and range from mature stands of bottomland hardwood species to the south to pole-size stands of green ash, black willow, and cedar elm trees in the upper portions. The overall riparian woodland HSI value for the Lower Leon Creek segment is 0.32 with 903 habitat units providing fair habitat. Due to fragmentation and a lack of recruitment from the existing vegetation, the quality of the woodlands is predicted to reduce the overall HSI values throughout the project life. The segment will also decline in habitat units by the loss of 910 acres of woodland habitat to urbanization over the project life. The habitat will contribute 439 HUs in project year 50 with an AAHU value of 633.

The grasslands in Lower Leon Creek have average HSI values with an overall HSI of 0.60, with 208 habitat units. The remaining grassland HSI will decrease in value from overgrazing of livestock, mowing, and infestation of non-native plants. Habitat units will be reduced by 117 available acres. Project year 50 will provide 116 HUs with an AAHU value of 151.

Aquatic Habitat

The lower segment of Leon Creek returns to a perennial stream that provides riverine aquatic habitat, as this segment is below the aquifer recharge zone. This segment consists of excellent aquatic resources with an overall RBPI of 0.74 and 655 RBPUs. This area is expected to feel the most impact from land use change. The channel already shows signs of meandering and incising due to the Blackland soils that occupy the segment. This problem is expected to continue and worsen as urbanization moves south along its banks with resultant channelization projects and road construction into the current riparian areas. As the water is expedited out of San Antonio, the channel will deepen until it reaches bedrock. Due to channel improvement projects, it will no longer be allowed to meander, which will increase flooding.

Water quality will continue to be an issue, as field crop herbicide and pesticide will be replaced with urban contaminants, and the riparian width which acts as a filter to lateral movement of contaminants is reduced in width. All of the habitat parameters, except Velocity/Depth Regime and Frequency of Riffles, are expected to experience decreases in RBPI values from these changes in land use. Table B-23 shows that the RBPI at 50 years is expected to be 0.46.

Table B-23. Lower Leon Creek Future Without-Project Aquatic Habitat RBPI

	Target Year	0	1	15	25	50
	Interval (years)	0	0	14	10	25
Epifaunal Substrate		18	17.8	15.1	12.8	10.9
Embeddedness / Pool Substrate		17	16.8	14.3	12.2	10.3
Velocity/Depth Regime / Pool Variability		15	15.0	15.0	15.0	15.0
Sediment Deposition		16	15.8	13.4	11.4	9.7
Channel Flow Status		16	15.8	3.4	11.4	9.7
Channel Alteration		14	13.8	11.7	10.0	8.5
Frequency of Riffles / Channel Sinuosity		16	13.0	13.0	13.0	13.0
Bank Stability	Left	5	4.9	4.2	3.5	3.0
	Right	5	4.9	4.2	3.5	3.0
Vegetative Protection	Left	6	5.9	5.0	4.2	3.6
	Right	6	5.9	5.0	4.2	3.6
Riparian Zone Width	Left	7	6.9	5.8	5.0	4.6
	Right	7	6.9	5.8	5.0	4.6
Habitat Total Score		148	143	126	112	99
RBPI		**.74**	**.71**	**.63**	**.55**	**.49**

Table B-24 shows an AARBPU of 514.0 calculated from these RBPI values.

Table B-24. Lower Leon Creek Future Without-Project Aquatic Habitat RBPU and AARBPU

Target Year	0	1	15	25	50	Cumulative	
Interval (years)	0	0	14	10	25	RBPU	AARBPU
RBPI	0.74	0.71	0.63	0.55	0.49		
Acres	886	886	886	886	886		
Target Year RBPU	655.6	629.1	558.2	487.3	434.1		
Interval RBPU		642.4	8,310.7	5,227.4	11,518.0	25,698.4	**514.0**

FUTURE WITH PROJECT CONDITIONS

During the planning for Leon Creek many preliminary alternatives for flood risk management were evaluated. In addition environmental investigations were conducted to establish baseline conditions for impact assessment of project alternatives and for possible consideration of ecosystem restoration. However, only three flood risk management alternatives were developed

and presented at the AFB. One plan, the Helotes Creek detention measure located within the Upper Leon Creek Segment, is no longer included in the Recommended Alternative as additional investigations determined that the proposed detention facility was not prudent. The remaining two alternatives, the jet engine test facility (AOI-2) and the buyout of existing homes and townhouses (AOI-4), comprise the Recommended Alternatives for Leon Creek.

Non Structural Buy-out at AOI-4

The buy-out measure proposed for inclusion in the project plan is located in the Babcock Creek floodplain and lies at the intersection of Babcock Road and Old Cedar Blvd. This measure includes only buy-out of townhouses and residential structures and would result in only minimal temporary adverse impacts to the natural environment. Trees adjacent to the structures would be preserved to extent possible, and following demolition and removal of debris, the disturbed areas would be replanted with grasses to stabilize the soil against erosion. Approximately 3.85 acres of floodplain lands would be available for use by the sponsor as open space. This measure would not require environmental mitigation other than compliance with best management practices during demolition to control dust emissions and surface erosion into the aquatic environment.

No negative impacts to waters of the United States, riparian forest nor threatened or endangered species would occur with implementation of this measure.

Given that only 3.85 acres of residential lands would be impacted by implementation of the non-structural buyout, it was determined that the Future With Project Terrestrial, Riparian, and Aquatic Habitat projections would be the same as those identified under the Future Without Project analysis for the Urban Leon Creek segment shown on pages B-36, B-37, and the top of B-38 of this appendix.

Test Cell 100-year Levee and Channel Modification

The 100-year levee at the Test Cell would impact only manicured grasslands and no environmental mitigation would be required. However, hydraulic and hydrology analyses subsequent analysis has indicated that hydraulic mitigation is required to prevent induced damages. To achieve that goal, channelization of Leon Creek for approximately 2,850 linear feet upstream and adjacent to the levee would be required. Hydraulic design indicates that the revised channel width would vary from 50 feet to 120 feet with a channel bottom width between 15 and 50 feet. USFWS has concurred with that analysis. Sufficient information from the baseline environmental analysis exists to clearly indicate that environmental impacts associated with the channel modifications would require environmental mitigation. Important riparian resources and aquatic resources within Leon Creek channel proper would be significantly degraded within the footprint of the modification.

Leon Creek channel has been identified as ‘waters of the United States” and therefore, project modification proposals require compliance with Section 404 of the Clean Water Act. The channel modification would result in a direct impact of greater than three acres of waters of the state or 1,500 linear feet of streams and would not fulfill Tier I criteria for the project. Therefore, Texas Commission on Environmental Quality (TCEQ) Water Quality certification is required.

Concurrent with public review of the project report, TCEQ will review application under Section 401 of the Clean Water Act, and Title 30, Texas Administrative Code Section 279.1-13 to determine if the work would comply with State water quality standards. By virtue of an agreement between the USACE and the TCEQ, a public notice will also be issued for the purpose of advising all known interested persons that there is pending before the TCEQ a decision on water quality certification. A Section 404(b)(1) analysis has been prepared and is included as an addendum to this appendix for agency and public review.

Preliminary analysis indicates that potential for polychlorinated biphenyls exist in channel sediments within the proposed modification reach. Depending upon extent and magnitude of these contaminants, cleanup by project sponsor may be required, or special handling during construction may be required to protect against spread of contaminants within the natural environment.

Mitigation of Impacts

Leon Creek is subject to regulation under Section 404 of the Clean Water Act. Because the extent of stream impacts (approximately 2900 linear feet) is above the limit allowed for compliance with any of the authorized Nationwide Permits, mitigation for stream impacts would be required to offset the adverse impacts associated with the channelization required for hydraulic mitigation and flood risk management benefits. In addition, impacts to riparian woodland habitat resulting from channel modification would also require mitigation.

The study team evaluated four mitigation alternative for stream and riparian woodland mitigation options: onsite mitigation, offsite mitigation within the Leon Creek watershed, the use of a regional Mitigation Bank, and mitigation along a degraded segment of Martinez Creek in the San Antonio River watershed.

Option 1 – Onsite Natural Stream Design Channel. Over the last decade, several FRM projects in the City of San Antonio such as the Mission Reach and Eagleland segments of the San Antonio River have been reconstructed to restore the aquatic and riparian ecological function to the channelized streams. This mitigation alternative would utilize the same Natural Channel Design (NCD) concepts used for Mission Reach and the Westside Creeks studies to "self mitigate" impacts to waters of the U.S. The NCD methods utilize vertical and horizontal structures in the form of cross vanes, rock weirs, J-hooks, or other natural material structures to maintain a neutral sediment transport balance for the creek. The NCD structures also recreate pool and riffle habitats with proper substrate to support a diverse community of aquatic organisms. The NCD methodology develops a functional, self-sustaining system providing valuable hydraulic transport, geomorphic functions, and ecological functions. Costs for this option were initially estimated to be $672,354.

In order to mitigate for the impacts to riparian woodlands, additional channel excavation would be required to accommodate the placement of native riparian woodland vegetation along the riparian corridor of Leon Creek. Additional native riparian plantings would occur in the existing grassland habitats along the southern edge of the lower portion of the constructed NCD channel and downstream of the lower limits of the NCD channel to mitigate for all riparian woodland

impacts. Using the Mission Reach and Westside Creek studies as planning level guide, it is anticipated that and additional 10 acres of riparian woodland would be removed for the channel excavation required to accommodate a density of 70 stems of site-specific, native, woody vegetation per acre.

Option 2 – within Leon Creek Watershed. Since the area of impact for channelization is at the upper end of the Lower Leon Creek segment, the only segment of the Creek considered a perennial stream, the mitigation for stream impacts within the Leon Creek watershed would be limited to the area downstream of the channelization site to the Creek's confluence with the Medina River. Two factors make this area problematic for use as stream mitigation. First, the existing aquatic habitat quality in this entire segment is considered high with an overall RBPI of 0.74 (the highest value within the watershed), so to further increase the functional value to an even higher value would require mitigation for a length at least 3 to 5 times greater than the area of impact (8,700-14,500 linear feet). The second limiting factor in this segment is the projected expansion of development and urbanization of areas adjacent to the Lower Leon Creek segment in the future that would preclude being able to realize the functional lift in habitat value needed to mitigate the impacts during the 50-year life of the project. Due these issues no cost estimates were pursued.

Option 3 – Mitigation Bank. The Straus Medina Mitigation Bank is the only stream/wetland mitigation bank proposed within the study area. The mitigation bank prospectus was submitted to CESWF on 1 June 2011, the Draft Mitigation Bank Instrument was submitted on 20 July 2012, and the Final Mitigation Bank Instrument was submitted on 28 January 2013. Since then, the mitigation bank sponsor has put the project on hold as a result of new mitigation bank permitting guidelines limiting the designation of in-stream mitigation credits established by CESWF in September 2013. Based on these new guidelines, it is possible that the sponsor may revise or withdraw the mitigation bank proposal.

If the sponsor decides to proceed with the mitigation bank proposal, there are still several uncertainties about the applicability of the use of the bank for the mitigation of stream impacts to Leon Creek. The Straus Medina Mitigation Bank is located on one side of the Medina River and does not have the authority to control land use activities along the opposite bank. As current CESWF guidance requires the sponsor to have control of both sides of a stream, creek, or river to be able to generate stream credits for perennial waters, the mitigation bank may not be able to provide compensation for the stream impacts for Leon Creek. Should these issues be resolved and the mitigation bank is able to provide stream credits, a high level of uncertainty remains regarding mitigation credit costs as there are no other established or proposed mitigation banks in the region and no competition to keep the costs of the mitigation credits in check. However, the highest level of uncertainty regarding the use of the mitigation bank centers on when and if the mitigation bank completes the application process. Based on input from Regulatory, the estimated mitigation cost for this option was $2.2 million. However, the availability of this option is very uncertain.

Option 4 – Martinez Creek. Initially, the Martinez Creek segment was eliminated from the suite of viable alternatives due to the cost of utility relocations required to construct the natural

stream channel Of the four WSC, Martinez Creek was the only creek where the restoration of the stream channel was not justified by the CE/ICA and alternative selection process.

Martinez Creek provides 2.8 miles of potential stream channel restoration opportunities from the headwaters to the confluence with Alazan Creek. The restoration of the natural stream channel design for Martinez Creek provides the hydraulic capacity to include the restoration of riparian woodlands within portions of the 50 acres of Martinez Creek riparian corridor.

The primary the reason the Martinez Creek segment of was eliminated from the suite of alternatives was due to the cost of utility relocations required to construct the natural stream channel. However, the San Antonio Water System (SAWS) agreed to Consent Decree with the U.S. EPA to address waste water infrastructure and maintenance. The Consent Decree would result in SAWS investing an additional $492 million (compared to a 10 year average of $600 million) over the next 10 years to rehabilitate and maintain its sewer infrastructure. The cost of the Martinez Creek restoration without the utility costs would be approximately $3.3 million.

Preferred Mitigation Alternative

Because the Alternative 1 – Onsite Natural Stream Design Channel results in a self mitigating project and would restore the aquatic and riparian ecological functions of Leon Creek impacted by the proposed levee on-site, it is the preferred mitigation alternative. Furthermore, as the mitigation would occur at the proposed construction site, costs associated with mobilization, site preparation, and maintenance would be much less than the other alternatives, with the exception of the mitigation bank. However, the high uncertainties, potential costs, and risks associated with the mitigation bank preclude consideration of Alternative 3 as a viable mitigation alternative.

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Tier II 401 Certification Questionnaire and Alternatives Analysis Checklist

I. Impacts to surface water in the State, including wetlands

a. What is the area of surface water in the State, including wetlands, that will be disturbed, altered or destroyed by the proposed activity? The proposed action would temporarily disturb approximately 2,850 linear feet of Leon Creek.

b. Is compensatory mitigation proposed? If yes, submit a copy of the mitigation plan. If no, explain why not. The channelization of Leon Creek within the study area will be designed utilizing natural channel design concepts. In addition, the channel will be excavated beyond the capacity required for the hydraulic mitigation required due to the construction of the adjacent levee. The additional excavation will allow native riparian vegetation to be included within the riparian corridor to restore the ecological and hydraulic functions the creek.

c. Please complete the attached Alternatives Analysis Checklist. See attached

II. Disposal of waste materials

a. Describe the methods for disposing of materials recovered from the removal or destruction of existing structures. Suitable materials excavated from the site will be used in the construction of the adjacent levee, the constructed channel banks, and in the establishment of habitat restoration features. Materials not suitable for construction activities will be removed from the site and disposed of at a licensed disposal facility.

b. Describe the methods for disposing of sewage generated during construction. If the proposed work establishes a business or a subdivision, describe the method for disposing of sewage after completing the project. No sewage will be generated by or because of the proposed actions.

c. For marinas, describe plans for collecting and disposing of sewage from marine sanitation devices. Also, discuss provisions for the disposing of sewage generated from day-to-day activities. Proposed action does not involve marinas.

III. Water quality impacts

a. Describe the methods to minimize the short-term and long-term turbidity and suspended solids in the waters being dredged and/or filled. Also, describe the type of sediment (sand, clay, etc.) that will be dredged or used for fill. Turbidity and sedimentation resulting from temporary construction impacts will be minimized utilizing established Best Management Practices (BMPs) such as silt fence and temporary stream diversion. Because the creek will be restored utilizing natural channel design and native riparian vegetation, long-term turbidity and sedimentation is not anticipated.

b. Describe measures that will be used to stabilize disturbed soil areas, including: dredge material mounds, new levee or berms, building sites, and construction work areas. The description should address both short-term (construction related) and long-term (normal operation or maintenance) measures. Typical measures might include

containment structures, drainage modifications, sediment fences, or vegetative cover. Special construction techniques intended to minimize soil or sediment disruption should also be described. Soil erosion and sedimentation to adjacent waters resulting from temporary construction impacts will be minimized utilizing established Best Management Practices (BMPs) such as silt fence and vegetative cover. Disturbed areas would be revegetated with native riparian vegetation and the adjacent levee would be vegetated with sod forming grass species such as Bermudagrass (*Cynodon dactylon*). anticipated.

c. Discuss how hydraulically dredge materials will be handled to ensure maximum settling of solids before discharging the decant water. Plans should include a calculation of minimum settling times with supporting data (Reference: Technical Report, DS-7810, Dredge Material Research Program, GUIDELINES FOR DESIGNING, OPERATING, AND MAINTAINING DREDGE MATERIAL CONTAINMENT AREAS). If future maintenance dredging will be required, the disposal site should be designed to accommodate additional dredged materials. If not, please include plans for periodically removing the dried sediments from the disposal area. The proposed action does not involve hydraulic dredging.

d. Describe any methods used to test the sediments for contamination, especially when dredging in an area known or likely to be contaminated, such as downstream of municipal or industrial wastewater discharges. Soil and sediments within the study area will be tested prior to construction of the proposed action. USACE policy requires that the project site be free of contamination prior to construction. If required, the project sponsor is responsible for remediation of the site and ensuring that the site is free of contamination prior to initiation of construction.

Texas Commission on Environmental Quality

Tier II
Alternatives Analysis Checklist

I. Alternatives
   a. How could you satisfy your needs in ways which do not affect surface water in the State? Structural and non-structural alternatives were evaluated during Plan Formulation (see Interim Feasibility Study and Integrated Environmental Assessment). The Recommended Alternative minimizes impacts to Leon Creek and employs "self-mitigating" measures to mitigate for impacts to waters of the U.S.
   b. How could the project be re-designed to fit the site without affecting surface water in the State? The project was originally designed with a longer channelized section that included constructing a flood bypass that would convey floodwaters across the bend in Leon Creek. These measures were reduced to minimize impacts to Leon Creek to the greatest extent possible while still providing the hydraulic capacity required due to the construction of the levee.
   c. How could the project be made smaller and still fit your needs? As stated in Ib., the impacts to Leon Creek were minimized during Plan Formulation resulting in a recommended alternative that minimizes impacts to Leon Creek.
   d. What other sites were considered? No other sites were considered as the proposed levee has to be built between Leon Creek and the Jet Engine Test Cell Facility.
   e. What are the consequences of not building the project? Consequences of not building the project include the potential flooding of the Jet Engine Test Cell Facility adjacent to Leon Creek. Quantification and risk of damages are documented in the Interim Feasibility Study and Integrated Environmental Assessment (IFS-IEA).

II. Comparison of Alternatives
   a. How do the costs compare for the alternatives considered above? Quantification of costs and benefits of the alternatives are documented in the Interim Feasibility Study and Integrated Environmental Assessment (IFS-IEA).
   b. Are there logistical (location, access, transportation, etc.) reasons that limit the alternatives considered? No
   c. Are there technological limitations for the alternatives considered? No
   d. Are there other reasons certain alternatives are not feasible? USACE considers alternatives that have a positive benefit to cost ratio; therefore alternatives where the costs exceed benefits of the action are not considered feasible.

III. If you have not chosen an alternative which would avoid impacts to surface water in the State, please explain:
   a. Why your alternative was selected. The recommended alternative was selected because it provided flood risk benefits to areas of interest, has a positive benefit to cost ratio, and minimizes impacts to Leon Creek.

b. What you plan to do to minimize adverse effects on the surface water in the State impacted. Impacts to Leon Creek were minimized by employing natural channel design concepts into the design of the channel improvements and over-excavating the channel to accommodate the native riparian vegetation within the channel while maintaining the required hydraulic capacity to ensure the flood risk management benefits for the project.

IV. Please provide a comparison of each criteria (from Part II) for each site evaluation in the alternatives analysis. Comparison of alternatives is documented in the Interim Feasibility Study and Integrated Environmental Assessment (IFS-IEA).