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San Antonio Channel Improvement Project, General Re-evaluation Report and Environmental Assessment

Westside Creeks Ecosystem Restoration, San Antonio, Texas

Draft Report

July 2013

EXECUTIVE SUMMARY

The purpose of the San Antonio Channel Improvement Project (SACIP) General Re-evaluation Report (GRR) and Environmental Assessment (EA), Westside Creeks (WSC), Ecosystem Restoration, San Antonio, Texas, is to identify ecosystem restoration measures to restore the riverine ecosystem within the WSC that is severely degraded due to the construction and continuing maintenance of the authorized and constructed SACIP and identify recreation opportunities that are compatible with the ecosystem restoration objectives. The GRR and integrated EA describe the characteristics of the existing and future without project conditions, water related resource problems and opportunities, planning objectives and constraints, formulation, evaluation, and comparison of alternatives, and identifies a recommended plan.

The SACIP was authorized under the Flood Control Act of 1954, Section 203, as part of a comprehensive plan for Flood Risk Management (FRM) in the Guadalupe and San Antonio River Basins. The authorization was modified in the Water Resources Development Act (WRDA) of 1976, Section 103, and WRDA 2000, Section 335. The modifications added ecosystem restoration and recreation as authorized purposes. The SACIP, GRR and EA was initiated at the request of the San Antonio River Authority (SARA) to evaluate the addition of ecosystem restoration and recreation purposes to the WSC. The Feasibility Cost Sharing Agreement for the study was executed on February 25, 2012.

The WSC study area encompasses those portions of Martinez Creek, Alazán Creek, Apache Creek, and San Pedro Creek within the originally constructed SACIP footprint. These creeks, collectively known as the WSC, are located west of the San Antonio River on the west side of San Antonio (Figure ES1).

Changes in the hydraulic regime of the WSC over the last half-century are largely due to shifts in urbanization, the construction of the SACIP, and required operation and maintenance practices. Historic cross sections depict a more natural stream, consisting of a baseflow channel, a wider channel and a large floodplain. Straightening and channelization of the WSC yielded grass-lined trapezoidal channels, concrete banks, and an underground bypass tunnel (San Pedro). While the SACIP conveys flood flows more quickly out of the urban area, the channelization and required maintenance have resulted in unconsidered consequences for the riverine ecosystem along the 35 miles of the SACIP. Channelization has led to an increased bed slope and loss of sinuosity. The result is a system where the sediment transport is out of balance, few to none of the aquatic structures necessary to support and sustain the life cycle of aquatic organisms native to the system remain, and the required shading and allochthonous inputs from the riparian corridor have been removed, severely altering the function of the historic riverine habitat.

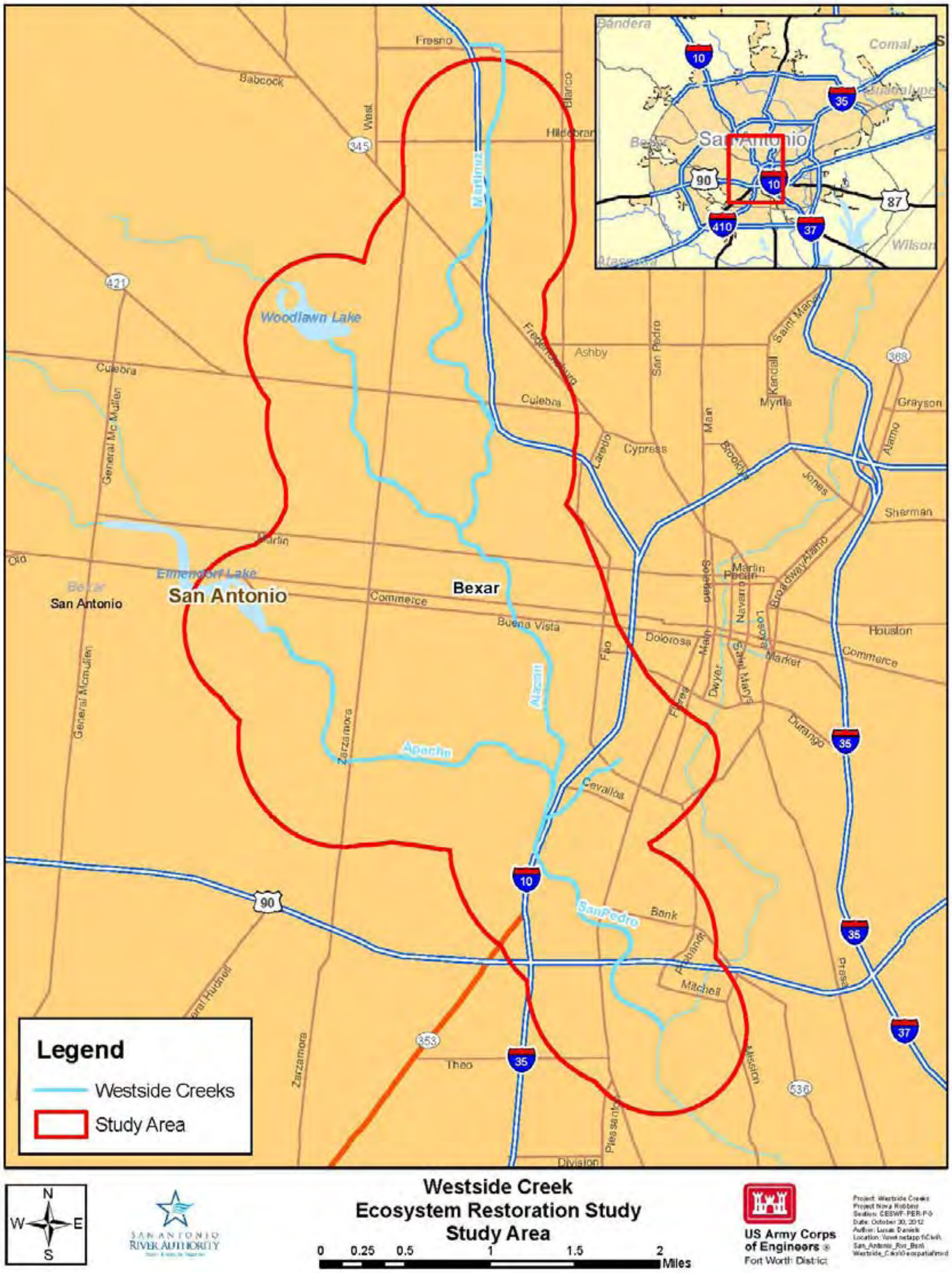

Figure ES1. Westside Creeks Study Area

The Resource of National Significance for the study has been identified as migratory birds using the Central Flyway. The study area lies in a critical portion of that flyway, providing stop over habitat, feeding and breeding grounds during crucial times of the migrations.

Measures identified for the ecosystem restoration of the WSC to a more natural condition include riparian meadow (RM) in all areas of the creek, pilot channel (PC) for the length of the creek (with the exception of Apache where only the lower 0.8 miles of pilot channel would be restored), riparian woody vegetation (RWV) at densities of 30- and 70-trees per acre depending on hydraulic constraints, slackwater (SW) areas for the length of the restored pilot channel, and wetlands (WL). Table ES1 lists the seven alternatives in the final array along with specific creeks and associated management measures that are included for each alternative.

Table ES1 Final array of alternatives for Westside Creeks study.

	San Pedro	Apache	Alazán	Martinez
Alt. 1	No Action	No Action	No Action	No Action
Alt. 2	RM, PC, SW, RWV	No Action	No Action	No Action
Alt. 3	RM, PC, SW, RWV	RM, PC, SW, RWV	No Action	No Action
Alt. 4	RM, PC, SW, RWV	RM, PC, SW, RWV	RM	No Action
Alt. 5	RM, PC, SW, RWV	RM, PC, SW, RWV	RM	RM
Alt. 6	RM, PC, SW, RWV	RM, PC, SW, RWV	RM, PC, SW, RWV	RM
Alt. 7	RM, PC, SW, RWV	RM, PC, SW, RWV	RM, PC, SW, RWV	RM, PC, SW, RWV,WL

RM = Riparian Meadow; PC=Pilot Channel; RWV=Riparian Woody Vegetation at 30 & 70 stems per acre; SW= Slackwater; WL=Wetland.

The recommended plan is the combined National Ecosystem Restoration (NER)/National Economic Development (NED) plan. The NER plan, Alternative 6, would restore 67% of the lower trophic organism carrying capacity possible for the WSC riverine system and provide 114% improvement in habitat quality over the no action alternative for 11 miles along the WSC. At maturity (75 years), the NER plan would provide 222 acres of mixed riparian meadow and riparian woody vegetation. The 6.5 mile pilot channel network would incorporate 146 pool-riffle-run sections and 143 off-channel slackwater areas in the existing SACIP right of way contributing to the restoration of aquatic habitat. The implementation of the NER plan would provide a total migratory bird diversity benefit of 101 average annual avian community units, which represents 82% of the diversity benefits available in the system, at a first cost (October 2012 prices) of approximately $39.4 million. The National Economic Development (NED) plan for recreation would provide 44,600 linear feet of concrete walk, jog, and bike trails. In addition to trails, other components include shade structures (6), interpretive/directional signage (50), benches (15), water fountains (15), picnic tables with pads (23), and trash receptacles (23). The first cost for recreational facilities is approximately $5.1 million with an average annual cost of approximately $272 thousand. With visitor days per year estimated at 481 thousand, the annual benefit is $3.9 million. The resulting net annual benefits are $3.6 million, and the benefit to cost ratio is 14.25. Monitoring and adaptive management is estimated at $800,000. First cost of the combined NER/NED plan is estimated at $45.3 million.

Restoration of the WSC riverine system will add to a larger habitat complex of the San Antonio River. With implementation of Alternative 6, this complex of preserved and restored riverine and upland habitat would amount to 1,492 acres and approximately 20 miles. Restoration of the WSC system and of the larger San Antonio River complex will provide benefits for diverse communities of aquatic organisms and wildlife.

Taken as a whole, restoration of the WSC system represents a potential for a significant contribution of riverine habitat benefits in a region where such habitats are scarce and declining. In addition to helping to reverse the national trend of declining riverine habitat, restoration of the WSC in conjunction with the on-going restoration along the San Antonio River would provide much needed riverine habitat benefits for migratory birds utilizing the Central Flyway during their Spring and Fall migrations. The recommended plan would effectively provide approximately 20 miles of connected, restored riverine system along a critical stop-over corridor for the birds utilizing the Central Flyway.

The San Antonio Channel Improvement Project, Westside Creeks Ecosystem Restoration Recommended plan:

- fulfills the U.S. Army Corps of Engineers (USACE) restoration mission,
- is in accordance with the USACE Civil Works Strategic Plan,
- is in accordance with the USACE Environmental Operating Principles,
- is in compliance with USACE restoration and recreation policies,
- is sustainable though the application of geomorphologic principles for sediment transport, hydraulic modeling, native vegetation species survivability, and synergistic effects,
- restores biological and environmental resources that were present prior to the construction of the SACIP,
- restores limiting habitat for neotropical migratory bird species,
- complements other Federal, state, and local restoration programs and projects,
- demonstrates ecosystem restoration and recreation co-exists effectively with the existing SACIP purpose of flood risk management,
- provides connection to adjacent restored and preserved habitats within the San Antonio River watershed,
- restores the creeks to a more natural structure and function resulting in the greatest practicable sinuosity, slope gradient, velocity, and sediment transport while maintaining the current effectiveness of the flood risk management function of the SACIP, and
- is supported by U.S. Fish and Wildlife Service, and Texas Parks and Wildlife Department, as well as having widespread local support.

The San Antonio River Authority (SARA), on behalf of the City of San Antonio and Bexar County, is identified as the non-Federal sponsor. SARA, City of San Antonio, and Bexar County support the recommended plan and, should the plan be approved, intend to participate in its implementation.

The draft GRR and EA will be available for public review July 31 – August 30, 2013. Two public meetings are scheduled in the study area the week of June 24 – 28, 2013. The report is available in PDF on the Fort Worth District website, http://www.swf.usace.army.mil, and hard copies are available at the SARA office located at 100 E. Guenther St., San Antonio, Texas.

Comments or questions regarding the SACIP GRR and EA or the recommended plan should be addressed to Mr. Danny Allen, Environmental Planner, CESWF-PER-EC, U.S. Army Corps of Engineers, Fort Worth District, P.O. Box 17300, Fort Worth, Texas, 76102-0300, or call 817-886-1821, or use electronic mail at Daniel.Allen@usace.army.mil.

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CHAPTER 1: INTRODUCTION

The riverine habitat of the San Antonio River system within the boundaries of the San Antonio Channel Improvement Project (SACIP) in Bexar County has been severely degraded. The SACIP has successfully performed the single purpose of Flood Risk Management (FRM); however, construction and continued operations and maintenance have had severe ecological consequences for the riverine system along the 35 mile SACIP that were not considered at the time of design and construction. In 2000, the single purpose project authorization for SACIP was modified to allow ecosystem restoration and recreation to be added as project purposes, thereby providing an opportunity to consider the ecological losses to the riverine habitat and the impacts those losses may have to the Nation's natural resources including loss of stop-over habitat for migratory and nesting birds utilizing the Central Flyway. Restoration opportunities for the SACIP along nine miles of the San Antonio River have already been studied and are in the final stages of implementation. The remaining components of the SACIP under consideration for ecosystem restoration and recreation are the four tributaries along the western side of the San Antonio River mainstem. These four tributaries are Alazán Creek, Apache Creek, Martinez Creek, and San Pedro Creek, and are referred to collectively as the Westside Creeks (WSC).

STUDY PURPOSE AND NEED*

The purpose of the study is to identify and implement ecosystem restoration measures to restore the riverine ecosystem within the WSC that is severely degraded due to the construction and continuing maintenance of the original SACIP.

The quantity and quality of riverine habitat is degraded and no longer supports the historic level of organism diversity at all trophic levels. Degraded aquatic habitat fails to support the diversity of aquatic plants and macroinvertebrates that form the foundation of riverine (aquatic and riparian) biotic ecosystems. An increase in biomass and biotic diversity at the fundamental trophic levels is required to restore sustainable fish, amphibian, reptile, mammal, and avian communities.

SCOPE*

This General Re-evaluation Report (GRR) describes the existing and future without project conditions with regard to the water related resource problems and opportunities, planning objectives and constraints, development, analysis, and evaluation of measures and alternatives. A potential United States Army Corps of Engineers (USACE) project is identified with associated USACE and other Federal interests, and a recommended plan commensurate with USACE authorities and interests for an investment decision.

The Environmental Assessment (EA) integrated into the GRR has been prepared pursuant to Section 102 of the National Environmental Policy Act (NEPA) of 1969 as implemented by the regulations promulgated by the Council on Environmental Quality (40 CFR Parts 1500-1508 and ER 200-2-2). The objectives of NEPA are to ensure consideration of the environmental aspects of the Proposed Action in Federal decision-making processes and to disclose environmental information to the public and collect their input before decisions are made and actions are taken. The EA provides sufficient evidence for determining whether to prepare an Environmental Impact Statement (EIS) or Finding of No Significant Impact (FONSI). This EA evaluates the potential environmental impacts associated with seven alternatives, including the No Action alternative. The scope of the alternatives analyzed in this EA is limited to the SACIP boundaries of the WSC.

STUDY AUTHORITY

The GRR for the WSC is conducted under the SACIP authorization. The SACIP was authorized by Section 203 of the Flood Control Act (FCA) of 1954 as part of a comprehensive plan for flood protection on the Guadalupe and San Antonio Rivers.

> ***SEC. 203. SAN ANTONIO CHANNEL, SAN ANTONIO, TEXAS***
>
> *"The project for flood protection on the Guadalupe and San Antonio River, Texas is herby authorized substantially in accordance with the recommendation of the Chief of Engineers in the House Document Numbered 344, Eight-Third Congress at an estimated cost of $20,254,000."*

A modification to the original authorization was documented in Section 335 of WRDA 2000, which reads as follows:

> ***SEC. 335. SAN ANTONIO CHANNEL, SAN ANTONIO, TEXAS***
>
> *The project for flood control, San Antonio channel, Texas, authorized by section 203 of the Flood Control Act of 1954 (68 Stat. 1259) as part of the comprehensive plan for flood protection on the Guadalupe and San Antonio Rivers in Texas, and modified by section 103 of the Water Resources Development Act of 1976 (90 Stat. 2921), is further modified to include environmental restoration and recreation as project purposes.*

The above cited legislation defines the area of investigation known as the SACIP in San Antonio, Texas. The four creeks that make up the WSC are included in the SACIP. This study is therefore authorized under this legislation. The study fits into the overall concept of the SACIP authorization to conduct an integrated and coordinated approach to locating and implementing opportunities for FRM, ecosystem restoration, and recreation along the San Antonio River system. The goal of this study is to develop a recommendation whether or not to construct additional project purposes of ecosystem restoration and recreation in the San Antonio River watershed without compromising the functioning of the existing FRM project.

STUDY LOCATION*

While the SACIP footprint for the WSC represents a focal point for USACE actions and decisions, USACE recognizes that factors outside the SACIP footprint influence the feasibility and sustainability of any actions that might be undertaken. Likewise, any actions that might be undertaken in cooperation with USACE could have positive or negative impacts on the surrounding area. In order to identify those factors and consider them in the analysis and recommendations, the study area cannot be limited to the footprint of the authorized SACIP, even if any recommended measures are. Therefore, the study area (Figure 1) includes the WSC and one half mile on either side of each of the four creeks in the WSC.

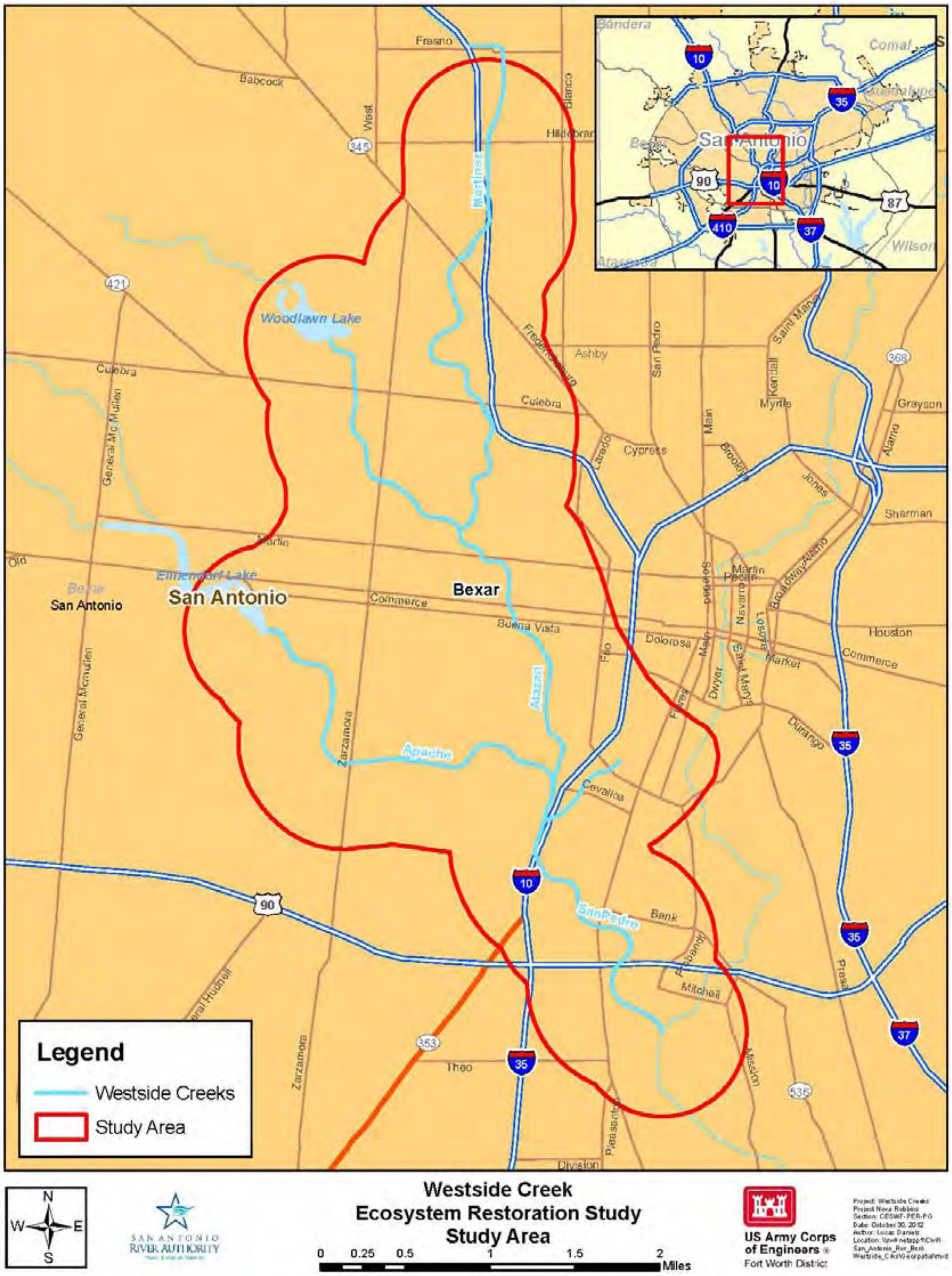


Figure 1. Westside Creeks General Re-evaluation Study Area

PREVIOUSLY CONSTRUCTED PROJECTS

SAN ANTONIO CHANNEL IMPROVEMENT PROJECT (SACIP)

Guadalupe and San Antonio Rivers, Texas – Chief of Engineers Report (February 1954). This USACE report served as the decision document for the authorized project (House Document Numbered 344, 83rd Congress, 2nd Session). The report concluded, in part, "that a serious flood problem exists within the city of San Antonio, an important military center and distribution point for a vast area in southwest Texas, and that a flood-protection project for this city to eliminate the flood menace is economically justified." Further, the report recommended "that a channel improvement project in San Antonio, Texas, be authorized at this time for construction by the Federal Government, substantially as outlined in this report, at an estimated first cost to the United States of $12,906,900…"

The project was constructed in increments beginning in 1957, and the FRM component was completed in 1998. The total length of the constructed project is 34.9 miles. Two flood diversion tunnels, each approximately 24 feet in diameter, were constructed beneath the downtown area. The authorized project cost was $20.3 million. This equates to $263.3 million in October 2012. Figure 2 shows the construction footprints of the previously constructed projects.

EAGLELAND, SECTION 1135

Eagleland Habitat Restoration, San Antonio, Texas – Section 1135 of the Water Resources Development Act (WRDA) of 1986, as amended. The Eagleland project is located in San Antonio along the portion of the SACIP from the Alamo Street dam downstream to the Lone Star Boulevard bridge. Clearing of the floodway and channel re-alignment for the SACIP destroyed the vast majority of the high quality riparian habitat. This project incorporated ecosystem restoration and recreation purposes into the existing FRM project while maintaining the existing FRM performance. The Eagleland project restored approximately one mile of the San Antonio River, relocating the base flow channel to meander primarily along the outside of the existing bends. Native grasses, trees, and shrubs were planted along channel side slopes, the top of the floodway bank, and within the flood control channel to restore riverine habitat. A riffle-pool complex was created in the base flow channel, and storm water outfall structures were naturalized through the use of native stone and wetland plantings. Construction was completed in 2006 with a total project cost of $2.8 million in 2006 (approximately $3.4 million in October 2012 dollars).

MISSION REACH

San Antonio River, San Antonio, Texas, Channel Improvement Project, General Re-evaluation Report (GRR) (July 2006). The Mission Reach project continued the restoration downstream along the San Antonio River that began with the above mentioned Eagleland project. This project also incorporates ecosystem restoration and recreation while maintaining the existing FRM level of performance. This report concluded "the hydrologic regime of the San Antonio River within the Mission Reach has been severely altered by the construction, operation, and maintenance of the SACIP." In addition, "while conveying flood flows more quickly downstream, the geomorphic impact is erosion, scour, headcutting, and sediment accumulation. Together with the lack of vegetation, there is insufficient suitable aquatic feeding, breeding, and resting habitat for native fishes." The National Environmental Restoration (NER) plan recommended in the 2006 report is comprised of a series of pools-riffle-chute complexes, restored river remnants, nine embayments, four tributary mouths, a wetland, and riparian vegetation

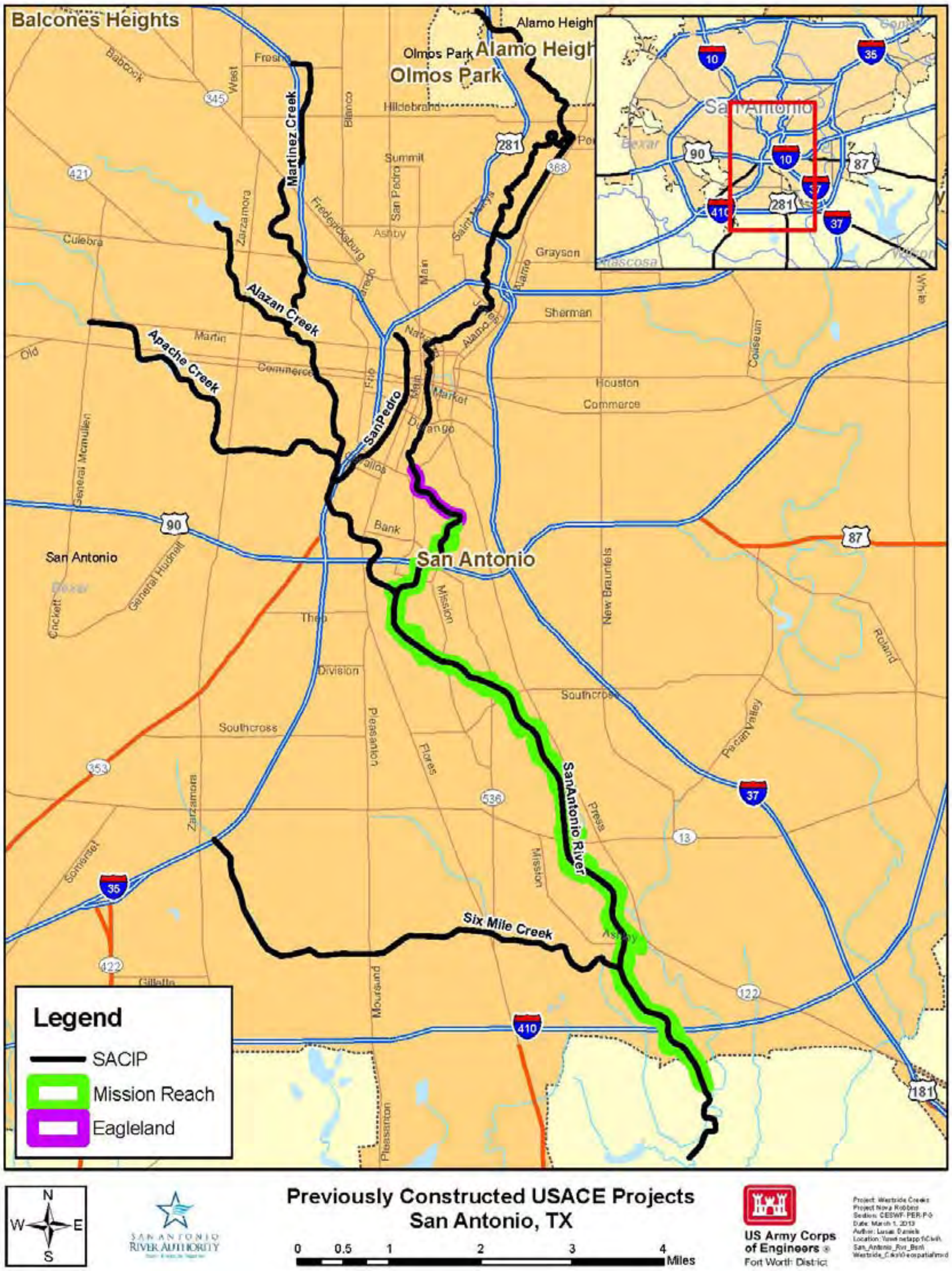


Figure 2. Previously Constructed Projects

resulting in 113 acres of restored aquatic habitat, and 320 acres of restored riparian habitat. The recommended plan in the 2006 report also includes the following recreation features: multi-purpose trails, shade shelters, picnic tables, water fountains, trash receptacles, benches, lighting and signage. The total estimated cost of this plan was $93.8 million in September 2004. When updated to October 2012, this cost is $134.8 million. Construction of the Mission Reach project began in 2008 and is scheduled to be completed in the winter of 2014.

PROBLEM IDENTIFICATION

The non-Federal sponsor, the San Antonio River Authority (SARA) requested the USACE re-evaluate the WSC area of the SACIP to determine if Federal interest exists for ecosystem restoration and recreation. SARA expressed interest in evaluating the potential to reverse to the extent possible the ecological losses to the riverine habitat, reduce the residual flood risk in the study area remaining following the construction of the SACIP, and provide recreation facilities.

ECOSYSTEM RESTORATION

Under natural river and stream morphological processes occurring during channel forming flow events, the longitudinal slope of the river bed is formed through the natural formation of curves (sinuosity) which lengthens the river and slows water velocities around the outer bends; subsequently, the slower velocities allow sediment to drop from the water column forming natural pools and riffles. As the channel forming flow continues through the river channel, the velocities increase around the inside bend of the river and in the straighter sections (runs), and additional sediment is picked up in the water column. The resulting habitat is sustained by the morphological processes repeating at each curve of the river creating a series of pool-riffle-run sequences. These pool-riffle-run sequences are the structural foundation of aquatic ecosystem habitat and in combination with the adjacent riparian corridor constitute the riverine ecosystem. Organic materials provided by both the riparian corridor and the aquatic environment are moved through the system largely through the flow of water where the diversity of water velocity along with subtle to dramatic changes in substrates, aquatic vegetation, and river banks cause the organic materials to become trapped and deposited. The process of organic movement, deposition, and decomposition is the foundation of a highly functional riverine ecosystem.

The riverine ecosystem within the WSC is severely degraded due to the construction and continuing maintenance of the original SACIP. Construction of the FRM measures for the SACIP included channelization which straightened the historically sinuous course of the San Antonio River and tributaries as well as removed the historic riparian woody vegetation and native herbaceous meadow vegetation. Continued maintenance of the FRM channel suppresses the re-establishment of a woody vegetation corridor and creates an environment which gives a competitive advantage to non-native and invasive herbaceous plants and non-native and tolerant aquatic organisms. The result is a riverine ecoysystem that no longer resembles the historically physically and faunistically distinctive riverine basin of the western Gulf Slope (Appendix C, Natural Resources).

The losses in riparian vegetation (with associated allochthonous inputs) and riffle-pool-run sequences (with associated habitat complexity) and the subsequent impact to organisms utilizing these habitats prompted this feasibility study to identify measures for restoration of riverine structure and function.

FLOOD RISK MANAGEMENT

The WSC study takes place within the footprint of an existing successful FRM project. The SACIP project was designed to contain the transposed 1946 storm event. Subsequent analysis indicates that the 1946 storm was an event slightly more frequent than a 1% Annual Chance Exceedance (ACE) probability, commonly known as the 100-year flood. Though the earlier channel modifications and subsequent removal of structures significantly reduced flood risk in San Antonio and the WSC community, residual damages remain within the 1% ACE floodplain delineation. Discussion with the non-Federal sponsor revealed that some structures in the study area experience recurring localized flooding. However, public safety is the more prevalent problem due to the loss of emergency access to neighborhoods when roads and bridges are covered in water. A preliminary analysis was performed to determine if the remaining flood risk would support Federal investment within USACE authorities prior to expending funds on formulation for FRM.

Building footprints, stream banks, contours, and the 1% ACE flood plain delineation based on Federal Emergency Management Agency (FEMA) Digitized Flood Insurance Rate Mapping (DFIRM) were identified in Geographic Information Systems (GIS). The depth of flooding was determined based on the difference between the water surface elevation and the top of bank elevation at cross sections along each of the creeks. Flooding was assumed to occur if the water surface elevation exceeded the top of bank elevation. The depths of flooding at structures were calculated using floor corrections ranging from 1.5 feet to 3 feet to obtain a range of finished floor elevations. Using contour shape files, a ground elevation, and stream station were assigned to each structure. The GIS analysis places water at floor elevation or higher for less than 50% of the structures remaining in the 1% ACE floodplain.

Based on Bexar County appraisal district information, the average age of homes in the WSC study community is 60 years, and the average valuation as of 2010 was $52 thousand. Since damages would accrue to less than 50% of the remaining structures, and the depreciated replacement value of these structures would be exceedingly low, the remaining damages would be insufficient to support any structural alternative. Furthermore, since non-structural measures have already been applied where desired through the Federal Emergency Management Agency Voluntary Acquisition Program (FEMA VAP), real estate acquisition costs would exceed the benefits for non-structural measures.

RECREATION

The availability of recreation facilities in the study area is disproportionately less than in other areas of the City of San Antonio (City), the State of Texas (State), and the nation. As a result, if ecosystem restoration is recommended, the study will assess the feasibility of incorporating recreation compatible in scale and type with ecosystem restoration.

STUDY FOCUS

The level of degradation to the riverine ecosystem and the potential ecosystems restoration benefit potential drive the scope and scale of the formulation for ecosystem restoration. Recreation is formulated and evaluated in a scope and scale consistent with the recommended NER plan and identified recreation problems and opportunities. Though some residual flood risk remains following construction of the SACIP, no formulation specifically for the purpose of FRM is performed. However, ecosystem restoration and recreation formulation are constrained by the existing water surface elevations so that the functionality of the existing FRM project remains intact.

CHAPTER 2: EXISTING CONDITIONS AND FUTURE WITHOUT PROJECT CONDITIONS

This chapter describes the existing conditions and expected conditions in the future that affect plan formulation and selection of a recommended plan. In addition, it includes discussion on the affected environment as it relates to NEPA. The affected environment is the natural and physical environment as well as the relationship of people with the environment.

Because the WSC study area is located within the existing SACIP project area, the future without-project condition for aquatic and riparian habitat would continue to be equivalent to the existing conditions. As continued mowing and maintenance of the floodway would continue to minimize the habitat value of the floodway, the Index of Human Disturbance and Avian IBI scores would fluctuate with yearly rainfall and management actions but on average remain the unchanged over the next 75 years. In order to maintain the existing flood protection, any woody vegetation invading the floodway would have to be removed and the invasive non-native Bermudagrass and Johnsongrass would continue to dominate the herbaceous vegetation. Sedimentation and erosion problems would also persist throughout the next 75 years, requiring frequent maintenance to keep flood conveyance within existing expected conditions.

CLIMATE*

San Antonio has a modified subtropical climate with more continental influence during winter and greater maritime influence from the Gulf of Mexico during summer. The mean annual temperature is 69°F. Mild weather prevails most of the winter, with freezing temperatures occurring approximately 20 days per year. Summers are usually long and hot with daily maximum temperatures over 90˚F occurring approximately 80% of the time. The mean annual precipitation is 29 inches per year. San Antonio is situated between more arid areas to the north and west, and more humid areas to the east. This results in large variations in monthly and annual precipitation, which can fluctuate between 10 and 50 inches annually.

In Texas, temperatures are expected to increase by 4° F by 2050 because of rising levels of carbon dioxide and other greenhouse gases in the atmosphere. The intensity of hurricanes and resulting precipitation is expected to increase; however, these pulsed periods of high precipitation are expected to be followed by increasingly long periods of drought (U.S. EPA 2013). Although temperatures are expected to increase according to the latest climate models, future changes to precipitation in Texas resulting from climate change are highly variable and continue to have a high level of uncertainty (Schmandt et al. 2011).

GEOLOGY AND TOPOGRAPHY*

Bexar County includes three physiographic provinces: the Edwards Plateau, Blackland Prairie, and Interior Coastal Plain. The Edwards Plateau is located to the northwest and the Interior Coastal Plain encompasses the southeastern part of Bexar County. The Balcones Escarpment and fault zone makes up the dividing line between the Edwards Plateau and the Blackland Prairie. The WSC study area is located downslope of the Balcones Fault Zone in the Blackland Prairie physiographic province, as is most of the city of San Antonio.

Geologic formations outcropping in the project study area are Cretaceous and Paleocene in age. In order of deposition from oldest to youngest, the Cretaceous age formations include the Austin

Chalk, Anacacho Limestone, Taylor Marl, and Navarro Group. The Wills Point formation of the Midway Group is Paleocene in age and outcrops at the southernmost extent of the study area.

Topography in the study area is typical of heavily urbanized areas. Beyond the SACIP, the terrain is gently sloped. Drainage swales effectively direct storm water and other run off into storm sewers or local creeks.

SOILS, INCLUDING PRIME FARMLANDS*

Within the WSC study area, historic soils were comprised of the Austin-Tarrant, Lewisville-Houston Black terrace, and Venus-Frio-Trinity associations. Today the overburden soils are composed of a mixture of the historic parent materials mixed with fill materials as a result of urban development and construction of the SACIP. Other historical soils in the study area include: Austin silty clay, Houston Black clay, Branyon clay, Houston Black gravelly clay, Lewisville silty clay, and Patrick soils.

Historically, the study area contained prime farmland soils; however, the area is urbanized and no longer falls under the jurisdiction of the Farmland Protection Policy Act (FPPA).

LAND USE*

Land in the study area is dominated by urban uses (Figure 3). The most abundant land use is residential followed by commercial, industrial, open space and municipal. Roads, sidewalks, buildings, parking lots, and other impervious surfaces are common. The San Antonio central business district adjoins the east side of the study area. The upper portion of San Pedro Creek is located within the downtown area, partly flowing underground through a manmade tunnel for several blocks in downtown San Antonio. The remainder of the creeks in the study area flow through combinations of residential, commercial, and industrial areas.

AIR QUALITY*

The study area is located in Bexar County which is currently in attainment or unclassifiable status for all National Ambient Air Quality Standards (NAAQS) criteria pollutants as established and monitored by the EPA.

NOISE*

Pursuant to Chapter 21, Article III of the City Municipal Code, maximum permissible noise levels depend on the land use of the property that contains the noise source (e.g., industrial, commercial, or residential) and the land use of the property receiving that noise. Maximum permissible noise levels range from the 63 A-frequency weighted decibels (dBA) in residential zoning districts to 85 dBA in the entertainment zoned districts. Baseline noise levels within the immediate vicinity are typical of urbanized areas.

TRANSPORTATION*

The main traffic arteries in the WSC study area include I-35 and I-10. Numerous two-lane roads form the primary transportation grid throughout the WSC neighborhoods. Four-lane collector roads such as Zarzamora, Brazos, Culebra, Guadalupe, Nogalitos, Buena Vista, Commerce, Probandt, and Flores Streets are interspersed at relatively equal distances throughout the WSC study area.

LIGHT*

Existing artificial light sources within the WSC study area can be attributed to streetlights, traffic at bridge crossings, and fugitive light from parks, neighborhoods, businesses, and industries adjacent to the floodway. The existing Apache Creek Park hike and bike trail follows both sides of Apache Creek from Elmendorf Lake downstream to the intersection of Tampico and Hidalgo Streets. The existing trail is illuminated by overhead lighting dedicated to the trail. Because of the urban landscape, sky glow (diffuse light escaping from urban sources) is potentially the greatest source of artificial light for the remainder of the study area.

HYDROLOGY & HYDRAULICS

*WATERSHED DESCRIPTION**

San Pedro Creek is classified as a perennial stream while the remaining three creeks in WSC are classified as ephemeral. However, site visits show that even in drought conditions there is generally water in all four creeks, and the few life-sustaining pools remaining in the system continue to have water at depths of 4 to 6 feet.

Flood potential is evaluated by the FEMA, which determines the floodplain for 1% ACE and 0.2% ACE flood events. Federal, state, and local regulations often limit floodplain development to passive uses such as recreational and preservation activities in order to reduce the risks to human health and safety. The SACIP improvements were designed to convey flood flows for the storm of record that occurred in 1946 as transposed over the San Antonio River Basin. Flood elevations during the 1946 flood did not approach the 1% ACE flood elevation; therefore, the 1% ACE floodplain extends beyond the SACIP boundary (Figure 4).

FLOOD HISTORY

High intensity precipitation coupled with urbanized rocky terrain makes the WSC prone to flash floods which rise and fall in rapid response to storms. The National Climatic Data Center (NCDC) storm event data base (www.ncdc.noaa.gov/stormevents, accessed May 23, 2013) reports 33 flood events and 142 flash flood events in Bexar County between January 2000 and February 2013. The June 30 – July 4, 2002 flash flood event affected the study area and precipitated the FEMA VAP grant used by the City to permanently evacuate and demolish flood prone residences between 2002 and 2004.

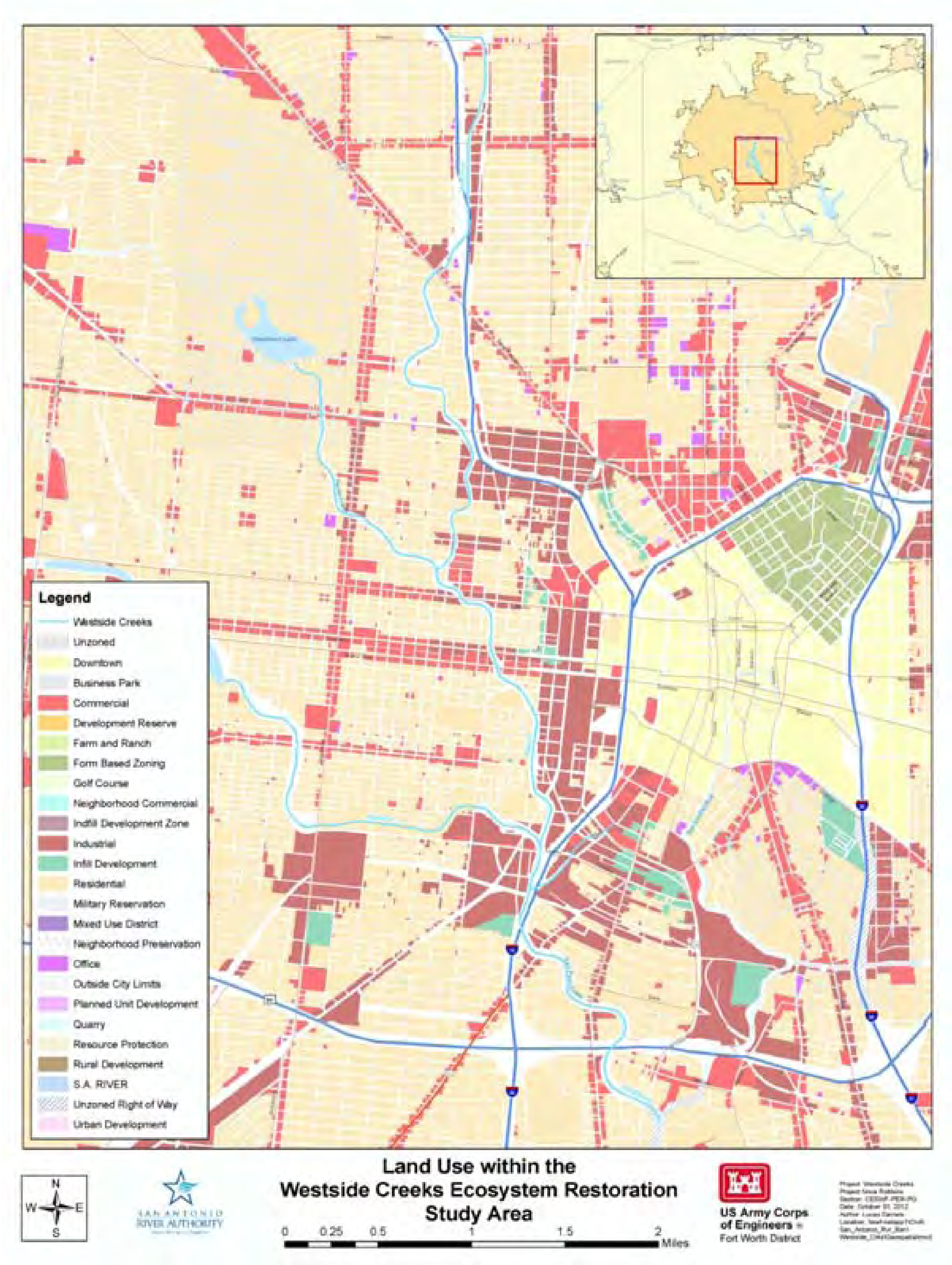


Figure 3. Land Use within the Westside Creeks Study Area

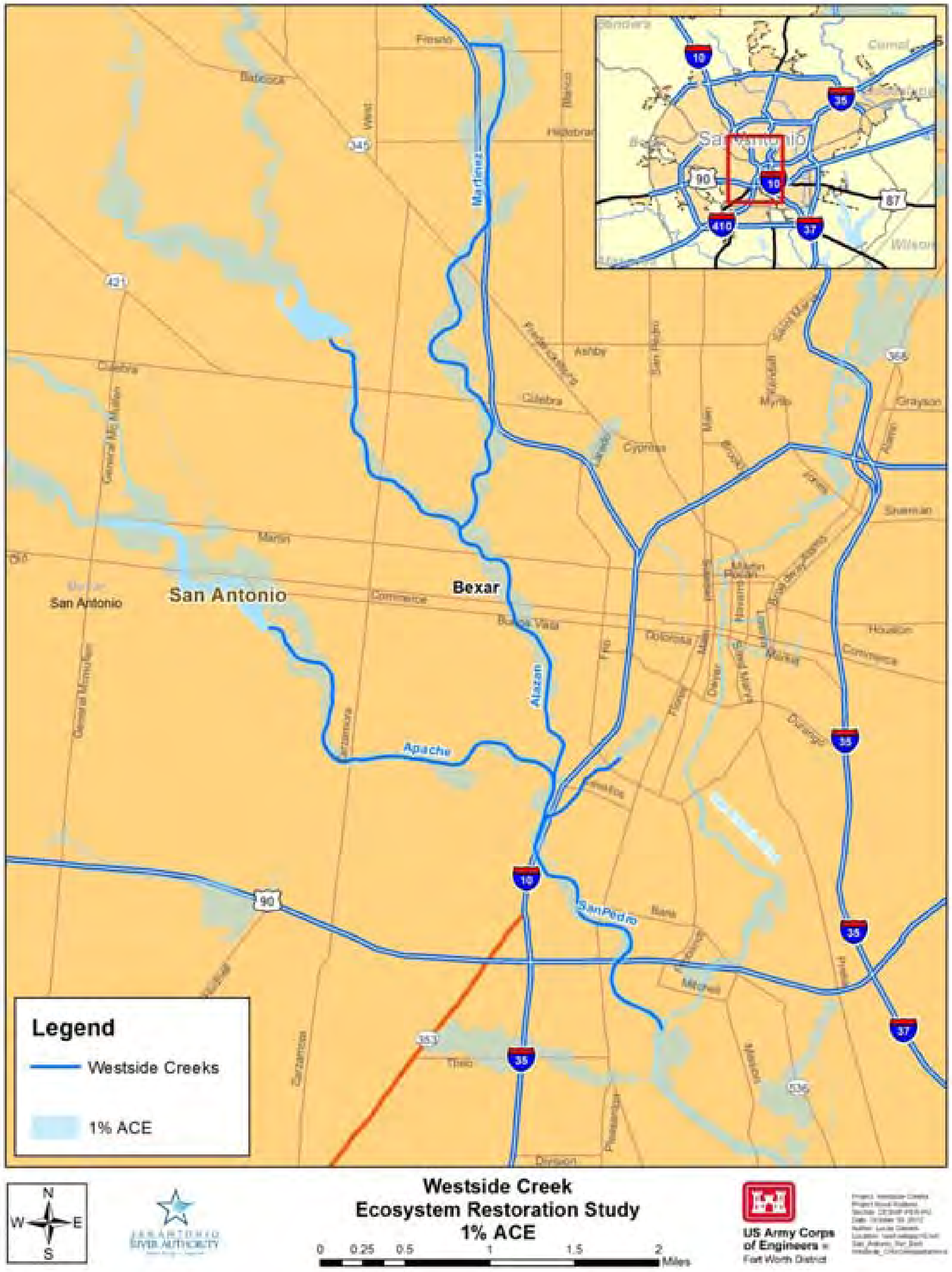


Figure 4. Limits of the 1% Annual Chance Exceedance Floodplain for the Westside Creeks Study Area

The October 16-18, 1998 flood event is reflective of the performance of the SACIP. The October 1998 storm broke rainfall records across South Central Texas, producing 18 floods of record in South Central Texas streams over seven river basins. Rainfall for a 24-hour period was approximately 13 inches at the San Antonio International Airport. All rivers, creeks and streams along and east of a San Antonio to Austin line remained at or above flood stage from Saturday, October 17th through Sunday, October 18th, with a majority continuing to flood through Monday, October 19th. On Tuesday, October 20th and Wednesday, October 21st, flooding was confined to rivers, streams and creeks in the southeastern portion of the basin. Of the $750 million ($1.2 billion in October 2012 dollars) in reported damages resulting from this storm, $8 million ($12.9 million in October 2012 dollars) occurred in Bexar County; however, SACIP reportedly prevented an estimated $296 million in damages (equivalent to $478 million in October 2012 dollars). Eleven of the 31 deaths associated with this event occurred in Bexar County. All eleven Bexar County drownings resulted from vehicles driven into water or swept away by rapidly rising water, and none took place in the WSC study area.

HYDROLOGY

The contributing watershed for the WSC is highly developed, with extensive residential areas, and some retail and industrial zoning. The ground cover is typical of highly urbanized areas and predominantly impervious. The areas of contributing watersheds for WSC are:

- Alazán Creek, 17.5 square miles,
- Apache Creek, 40.3 square miles,
- Martinez Creek, 7.2 square miles, and
- San Pedro Creek, 44.9 square miles.

Following the 1946 flood, Federal and community efforts were undertaken to manage flood risk in the area. The efforts included the comprehensive SACIP which converted the natural creeks to efficient drainage channels for the purposes of conveying flood waters out of the neighborhoods as quickly as possible. The channelization is effective and for many years has provided reduction in flood risk for the area.

HYDRAULICS

Changes in the WSC over the last half-century are largely due to shifts in urbanization and in flood risk management and maintenance practices. Historic cross sections depict a more natural stream, consisting of a baseflow channel, a wider channel and a large floodplain. Straightening and channelization of the creeks has resulted in grass-lined trapezoidal channels, concrete banks, and an underground bypass tunnel on San Pedro Creek.

No gauge data is available to accurately determine the current base flow category for the WSC. The bankfull discharge is the event that drives the natural formation of the stream channel. This is the discharge at which the channel is most effective with regard to maintaining sediment transport. Studies have found that the bankfull discharge is typically associated with a 67% ACE or 1.5-year return period flow (USACE, 2001); however, this can vary greatly given differing hydrologic and geologic parameters.

SOCIOECONOMICS*

San Antonio is the 7th largest city in the U.S, with a total population of 1.3 million in 2010. Approximately 6% of the population of San Antonio lives within the WSC communities, equating to 78,000 persons. The population is predominantly of Hispanic Origin (89%), and 72% of the population considered themselves as White on the 2010 census. With regards to age, the two largest age groups are 20-34 (23%) and 45-64 (23%). The population under nine years of age is 16%, and 11% are 65 years or older. The median age is 32.3 years.

Households are predominantly made up of two or more persons (72%), family households (66%) and have a higher multi-generational makeup (11%) than the state (5%), county (7%) and city (7%). With regards to housing, 89% of available housing units are occupied, and 50% are owner occupied, though the ownership rate is 3% less than the city of San Antonio and 9% less than Bexar County.

The population residing in the study area has attained less education in comparison to the populations of San Antonio, Bexar County, and Texas. Almost 50% of the WSC population 25 years of age and older does not have a high school diploma, 29% have a high school diploma, and 9% completed some type of formal education beyond high school.

Similarly, the residents of the WSC study area tend to be economically depressed in comparison to city, county, and state populations. With a median household income of $23 thousand, the income is about half of what is experienced in the other geographical areas. Per capita income ($13 thousand) is also about half of per capita incomes in the other geographical areas. Table 1 shows the 2010 median household and per capita incomes within the state, county, city, and study area.

Table 1. 2010 Median Household and Per Capita Incomes for the WSC Study Area.

Geographical Area	Median Household Income	Per Capita Income
Texas	$47,753	$24,332
Bexar County	45,689	23,545
San Antonio city	42,612	22,457
Westside Creeks Study Area	22,739	12,813

Source: ESRI Community Analyst citing U.S Bureau of the Census, 2010 Census of Population and Housing

Service sector and retail establishments make up the largest number of employers in the study area; however, most people working in the study area are in either public administration, educational services, or health care. The unemployment in the area is around 6.0%.

CULTURAL RESOURCES

Section 106 (16 U.S.C. 470*f*) of the National Historic Preservation Act of 1966, as amended, (NHPA) requires that Federal agencies consider their undertakings, or projects, and the potential of those undertakings to impact significant cultural resources through the procedures found in 36 Code of Federal Regulations(CFR) Part 800 (*Protection of Historic Properties*). To fully consider the effects of a proposed project on cultural resources, USACE must consult with the Texas State Historic Preservation Office (SHPO) and federally recognized Native American tribes who have traditionally or historically used the area affected by the proposed action. USACE initiated consultation with the SHPO and appropriate Native American tribes in 2011.

The potential cultural resources within the WSC study area are expected to be archeological, consisting primarily of evidence of the presence of prehistoric and historic peoples. Cultural resources are evaluated for eligibility or listing in the National Register of Historic Places (NRHP). The Area of Potential Effects (APE) for archeological resources lies within the existing right of way of the SACIP. The limits of the APE for above ground and architectural properties and associated view sheds is half a mile from the limits of the SACIP since proposed construction activities are unlikely to be perceived beyond this point. The view shed of WSC is primarily a built environment, which was highly modified by residential and other developments in the mid-20th Century.

*ARCHEOLOGICAL RESOURCES**

A review of the Texas Historical Commission (THC) data files was conducted to identify any cultural resources investigations that have been conducted within the WSC APE and the results of those investigations. The THC records search revealed that no archeological surveys have been conducted within the WSC study area and no known cultural resources have been recorded within the APE. Construction activities along portions of the San Antonio River from 2006 to present uncovered several archeological sites. However, given the rapid rate at which alluvial soils are deposited, the sites encountered along the SACIP to date have been deeply buried.

*ARCHITECTURAL RESOURCES**

As part of the WSC communities' Conceptual Plan, SARA conducted a reconnaissance level survey of known and potential NRHP - eligible architectural resources within the APE. The THC records search indicated that no known NRHP eligible architectural resources have been recorded within the WSC APE for above ground resources.

HAZARDOUS, TOXIC AND RADIOACTIVE WASTE*

In accordance with American Society of Testing and Materials (ASTM) E1527-05 requirements, a Phase I Environmental Site Assessment (ESA) was completed for the WSC study area. As part of the ESA, an Environmental Data Resources, Incorporated (EDR) database report identifies areas having reported spills, past activities, or current activities which could result in contaminated areas within the study area. The EDR report identifies one site of environmental concern along San Pedro Creek at an abandoned railroad yard, Sloan Market Yard site, located within a quarter mile of San Pedro Creek. During the ESA field investigations conducted in 2012, recognized environmental conditions were visually observed on the identified property. No other concerns are identified on the remaining extent of the WSC study area.

VISUAL ESTHETICS*

The study area consists of a somewhat straightened, engineered grass-lined trapezoidal channel, devoid of trees or woody understory plant species. This type of channel is frequently ecologically impoverished and perceived as aesthetically displeasing because it lacks the local instream and riparian heterogeneity and complexity found in naturally meandering rivers.

OTHER SOCIAL EFFECTS*

During public workshops spearheaded by SARA, the communities reflected on the unique, rich history of WSC prior to the channelization when the creeks were known for swimming, fishing, a source for community gathering, enjoyment, and relaxation. The current condition of the channelized WSC causes the community to be physically and psychologically disconnected from other communities and community amenities as well as from the creeks. The outcome of multiple impediments that prevent individuals or groups from participating fully in the social and environmental life of the society in which they live is key to the communities' perspective of their social exclusion. This concept characterizes a form of social disadvantage or obstruction from environmental resources.

After extensive public outreach, SARA established Other Social Effects (OSE) goals which are documented in the Westside Creeks Restoration Project Conceptual Plan (June 2011). Ecosystem restoration and recreation development could assist the local community in addressing some of the issues identified in the 2011 Conceptual Plan such as:

- a high rate of bicycle related crashes and fatalities in comparison to national, state, and local rates,
- the highest rating in child obesity for the city of San Antonio,
- loss of social connectedness and social identity, and
- safety.

REAL ESTATE

The real estate interests in the WSC are owned by SARA and the City. SARA ownership is reported to be within the floodway and City ownership is reportedly at the street closure points along the creeks. The SARA website indicates they are the title holder for the entire beds and banks of the San Antonio River and its creeks and tributaries. The operation and maintenance of the SACIP and included WSC is the responsibility of the City.

Public utilities are located within the SACIP ROW. Water and sanitary sewer lines are owned by San Antonio Water Systems, gas and electrical lines are owned by CPS Energy, cable and communication lines, including fiber optic cables within Apache Creek and Martinez Creek, are owned by Time Warner, Grande Communications, and WilTel Communications. Any proposed utility relocations in the WSC project ROW will require an Attorney's Opinion of Compensability Report prepared by USACE or SARA's Office of Counsel.

RECREATION RESOURCES*

Recreation facilities within one half mile of the WSC include seven Downtown Runs and Walks and Bike Rides, bike racks, roads with designated bike lanes, and numerous small parks. Approximately 20 parks and greenways maintained by the City and Bexar County lie in the WSC study area. All of the parks are open to the public free of charge; however, several community centers charge rental fees.

The San Antonio Park and Recreation System Strategic Plan (SAPRSSP) 2006 identifies recreation deficits and acreages for general park needs. The SAPRSSP 2006 quotes the national average for parklands as 16 acres per 1,000 residents. In June 2005, the City owned 602.26 acres of park land, 2.84 acres per 1,000 residents, in the West Subarea, which includes the WSC study area. Based on the national average quoted in the SAPRSSP 2006, there is a shortage of 2,787 acres of parklands for the WSC community.

Existing recreation opportunities along Apache Creek include Elmendorf Lake near the campus of Our Lady of the Lake University at the upper extent of the study area. Apache Creek runs southeast near Avenida Guadalupe and several schools including Lanier High School. Several parks bound Apache Creek including Amistad Park, Escobar Field, Cassiano Park, Apache Creek Park, Elmendorf Lake Park, and Rosedale Park. Apache Creek Park, a linear park along the creek, contains 17 picnic units, one multipurpose field, one basketball court, and a 3.8-mile hike and bike trail that loops a portion of Apache Creek.

Existing Alazán Creek community and recreation opportunities include Woodlawn Lake Park, the Josephine Tobin Recreation Center, and the National Basilica of the Little Flower. Alazán Creek also flows past the housing authority's Alazán Courts. Alazán Creek continues south of Avenida Guadalupe near San Fernando Cemetery until it merges with Martinez Creek at Mario Farias Park. Other adjacent parks to this creek are John Tobin and Smith Parks. Five roads with designated bike lanes cross Alazán Creek.

The Beacon Hill Neighborhood Association is in the process of implementing a conceptual design for a linear park and a community garden along the northern extent of Martinez Creek in the heart of the neighborhood. The starting point of the VIA Metropolitan's proposed Bus Rapid Transit Line is located near Martinez Creek at Fredericksburg Road and continues downtown to the medical center. This area is also the beginning of the revitalized Deco District commercial strip on Fredericksburg Road, and home to the Jefferson Woodlawn Community Development Corporation and several active neighborhood associations. Willie Ojeda Park bounds a portion of Martinez Creek. Two designated bike lanes cross Martinez Creek.

Of the WSC, only San Pedro Creek flows within the boundaries of downtown San Antonio. The confluence of San Pedro Creek with the San Antonio River is marked with Concepcion Park which provides access to one of the San Antonio Missions National Historic Parks, the Pro Vida Academy Charter High school, and Knox Early Childhood Center.

RIVERINE RESOURCES

AQUATIC RESOURCES

Havard (1885) describes an extremely rich and diverse aquatic ecosystem within the San Antonio River watershed during the late 19th century. Historically, San Antonio aquatic habitats supported a diverse array of high quality emergent aquatic plant species. Beckham (1887) provides further insight into the historic morphology of the San Antonio River and its tributaries writing "These [San Antonio] springs or fountains unite to form a river, which, after winding through the town in a very tortuous course, is joined some distance below by the San Pedro, a large creek having a source of supply similar to that of the river." Menger (1913) described San Pedro Creek as once "broader in most places than our present riverbed; and it was studded all along the serpentine course from San Pedro Springs to its communication with the San Antonio River, with man-high reeds, or tule, with wide open places where we caught eels and catfish weighing over 30 pounds and shot ducks close to the Salinas Street bridge."

Not only has the WSC aquatic ecosystem been affected by increased urbanization and its associated encroachment on riparian habitats throughout the 20th century, construction of the SACIP project between 1957 and 1998 eradicated any semblance of the historical streams that Havard and Beckham described almost 130 years ago. The SACIP straightened approximately 35 miles of the San Antonio River and its tributaries in the San Antonio area and converted the aquatic and riparian habitats to maintained grass-lined FRM channels (Figure 5). By straightening the once winding watercourses, water velocities increased, disrupting the substrate composition of the aquatic habitats resulting in increased erosion and sedimentation downstream. The homogeneous, shallow pilot channel that replaced the sinuous natural pool-riffle-run habitats severely degraded the quality of the aquatic habitat. Additionally, the loss of overstory vegetation provided by shrubs and trees, and to a limited extent herbaceous vegetation has led to increased water temperatures, lower dissolved oxygen concentrations, and limited organic inputs into the aquatic system.

Figure 5. Current Appearance of Westside Creeks

Aquatic habitat surveys were conducted in April 2012. The methodology and results of the survey are provided in Appendix C, Natural Resources. The aquatic habitat survey indicates that most of the fish species captured are indicative of fish tolerant of poor water quality, including common carp (*Cyprinus carpio*), red shiners (*Cyprinella lutrensis*), golden shiners (*Notemigonus crysoleucus*), sailfin molly (*Poecilia latipinna*), western mosquitofish (*Gambusia affinis*), green sunfish (*Lepomis cyanellus*), warmouth (*L. gulosus*), bluegill (*L. macrochirus*), and largemouth bass (*Micropterus salmoides*). Typical aquatic plant species found in the WSC study area include southern cattail (*Typha dominensis*), softstem bulrush (*Schoenoplectus tabernaemontani*), curly dock (*Rumex crispus*), swamp smartweed (*Polygonum hydropiperoides*), pickerelweed (*Pontederia cordata*), creeping primrose-willow (*Ludwigia repens*), Mexican primrose-willow (*L. octovalvis*), spikerush (*Eleocharis* spp.), fragrant flatsedge (*Cyperus odoratus*), *Carex* sedges (*Carex* spp.), giant reed (*Arundo donax*), and alligatorweed (*Alternanthera philoxeroides*).

WETLANDS*

According to the U.S. Environmental Protection Agency (EPA) and USACE, wetlands are areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted to life in saturated soils. During site surveys conducted in April 2012, sporadic fringe wetlands were identified adjacent to the WSC.

Since the WSC are considered jurisdictional waters of the U.S. as identified in 40 CFR 122.2, they are subject to protection under Sections 401 and 404 of the Clean Water Act (CWA) and Section 10 of the Rivers and Harbors Act of 1899.

RIPARIAN RESOURCES*

The study area is located near the intersection of three major ecological regions: Oaks and Prairies, Edwards Plateau, and South Texas Brushlands. Because of the proximity of the study area to each of these ecoregions, the vegetation and wildlife of the study area exhibits characteristics of each region. Bexar County is located within a transition area between arid climates to the west and mesic climates to the east. Furthermore, the study area is located at the southern edge of many temperate species ranges and at the northern edge of many tropical species ranges. This unique location provides a highly diverse and dynamic biotic ecosystem, particularly within the riparian zone.

The aquatic and associated riparian habitats of a highly functioning riverine system are some of the most productive and diverse ecosystems in North America. There is little doubt that the naturally spring fed system of the San Antonio River and tributaries historically provided huge riverine benefits to South Texas ecosystems. Numerous historic accounts have documented the structure and high function of this system. The high level of ecological diversity associated with natural, intact riparian habitats located along the transition areas between the three ecoregions in the area is particularly evident in the aquatic ecosystems. The complex and robust foodweb with high diversity and high biomass (populations of individual organisms) at the lower aquatic trophic levels supplies the energy and drives the ecosystem through all higher aquatic and terrestrial trophic levels.

HISTORIC VEGETATION*

Historically, the vegetation of San Antonio was dominated by honey mesquite (*Prosopis glandulosa*), huisache (*Acacia farnesiana*), bluewood (*Condalia hookeri*), and lotebush (*Ziziphus obtusifolia*), mescal bean (*Sophora secudiflora*), and retama (*Parkinsonia aculeata*) (Havard, 1885). Along the riparian habitats, large pecans (*Carya illinoinensis*) and cottonwoods (*Populus deltoides*) dominated the overstory with black walnut (*Juglans nigra*), bald cypress (*Taxodium distichum*), black willow (*Salix nigra*), and Texas ash (*Fraxinus texensis*) also present. Other trees in the San Antonio area included sugar hackberry (*Celtis laevigata*), netleaf hackberry (*Celtis reticulata*), red mulberry (*Morus rubra*), and Osage orange (*Maclura pomifera*). Upland habitats were dominated by live oak (*Quercus virginiana*), lime prickly ash (*Zanthoxylum fagara*), algerita (*Mahonia trifoliata*), Texas persimmon (*Diospyros texana*), gum bumelia (*Sideroxylon lanuginosum*), yaupon (*Ilex vomitoria*), and deciduous holly (*Ilex decidua*). Along with numerous herbaceous forbs, dominant grasses in the uplands included buffalograss (*Bouteloua dactyloides*), hairy grama (*B. hirsuta*), purple threeawn (*Aristida purpurea*), little bluestem (*Schizachyrium scoparium*). Panic grass (*Panicum* spp.) and Indian woodoats (*Chasmanthium latifolium*) dominated riparian habitats. Havard (1885) documented the exotic and invasive Bermudagrass (*Cynodon dactylon*), Johnsongrass (*Sorghum halepense*), giant cane, and chinaberry (*Melia azedarach*) in San Antonio as early as the mid 1880's.

CURRENT VEGETATION*

Current vegetation in San Antonio is typical of urbanized central Texas communities with manicured lawns and landscaped vegetation. Vegetation along the WSC consists primarily of non-native herbaceous species and shrub saplings that are routinely mowed. Because of the age of the communities adjacent to the WSC, the vegetation bordering the SACIP floodway ROW consists of relatively large and mature trees associated with the surrounding neighborhoods. Although many of the trees and shrubs first described by Havard in the 1880's are still evident in San Antonio today, the dominant landscaped trees found today include live oak, pecan, hackberry, and crapemyrtle (*Lagerstroemia indica*). Dominant herbaceous species include Bermudagrass, Johnsongrass, giant ragweed (*Ambrosia trifida*), yellow bluestem (*Bothriochloa ischaemum*), and common sunflower (*Helianthus annuus*). As with other urbanized areas, exotic plant species have escaped the landscaped settings and become established in natural areas throughout the city.

Although the study area is heavily disturbed and urbanized, the presence of the high quality overstory component of the adjacent neighborhood habitat provides invaluable habitat for wildlife, including resident and migratory bird species. In addition, many residential properties have planted shrubs and trees along the fence lines abutting the WSC floodway, providing a distinct edge habitat in contrast to the maintained non-native grasses of the floodway.

SURFACE WATER QUALITY*

Existing water quality in the WSC is affected by rainfall and associated stormwater flows originating from residential, commercial, and industrial point and nonpoint sources. The State of Texas List of Impaired Water Bodies, also known as the CWA Section 303(d) List, identifies: 1) water bodies that do not meet the standards set for their use; 2) which pollutants are responsible for the failure of the water body to meet standards; and 3) water bodies that are targeted for clean-up activities within the next two state fiscal years. According to the Draft 2012 Texas Commission on Environmental Quality (TCEQ) Section 303(d) list (TCEQ, 2012), the TCEQ has designated the Alazán Creek, Apache Creek, and San Pedro Creek segments of the San Antonio River Basin (Segments 1911C, 1911B, and 1911D, respectively) as impaired water bodies. Based on samples collected by TCEQ in December 2001 and 2003, all three creeks fail to meet the criteria for recreational uses due to elevated concentrations of *E. coli* bacteria. In addition, Apache Creek and San Pedro Creek exceed screening levels for aquatic life use due to depressed dissolved oxygen. Alazán Creek and San Pedro Creek exceed screening levels for general use due to elevated nutrients (ammonia and chlorophyll-a, Alazán Creek; nitrates, San Pedro Creek).

GROUNDWATER*

The Edwards Aquifer lies beneath the study area. It is the primary source of water for the City, and is designated by the EPA as a sole source aquifer for the area (USGS 2013). The Edwards Aquifer surface features include the contributing zone, recharge zone, and artesian zone. The contributing zone and recharge zone are both located to the northwest of the study area. The recharge zone occurs along the Balcones Escarpment and is associated with the faults upslope of the WSC study area. The study area is located in the artesian zone.

WILDLIFE*

The presence of numerous springs and streams along the Balcones Escarpment and the convergence of the Edwards Plateau, South Texas Brushlands, and Blackland Prairies ecological regions have long been recognized as providing valuable habitat for many wildlife species in the San Antonio area, particularly birds (Beckham, 1887; Attwater, 1892; Quinlan and Holleman, 1918; Griscom, 1920).

Wildlife inhabiting the study area includes species typical of herbaceous habitats tolerant of human activity and disturbance. These include eastern fox squirrel (*Sciurus niger*), Virginia opossum (*Didelphis virginiana*), striped skunk (*Mephitus mephitus*), Guadalupe spiny softshell turtle (*Apalone spinifera guadalupensis*), water snakes (*Nerodia* spp.), red-eared sliders (*Trachemys scripta*), eastern cottontail rabbits (*Sylvilagus floridanus*), and small rodents. Avian species utilizing the existing WSC aquatic habitats are limited to birds that prefer open water and shoreline habitats such as herons, egrets, cormorants, and migrating shorebirds. Since riparian woodland and shrubland habitats are absent, many species of warblers, wrens, orioles, buntings, flycatchers, and tanagers dependent on aquatic and riparian habitats are absent from the avian community in the WSC study area.

The San Antonio Audubon Society lists 540 bird species on the Bexar County bird list. Many of these species utilize the riparian corridors in San Antonio, such as the WSC, for migration, wintering, breeding, and foraging habitats. During the 2012 spring and fall migrations, 75 bird species were identified during surveys specifically utilizing the WSC aquatic and riparian habitats and an additional 33 bird species were identified utilizing adjacent neighborhood habitats. Bird species associated with the WSC study were dominated by species typical of mowed, maintained, urban habitats including Great-tailed Grackles (*Quiscalus quiscula*), White-winged Doves

(*Zenaida asiatica*), Rock Pigeons (*Columda livia*), House Sparrows (*Passer domesticus*), and European Starlings (*Starrus vulgaris*). Species often found in aquatic habitats included Neotropic Cormorants (*Phalacrocorax brasiliensis*), Snowy Egrets (*Egretta thula*), Mallards (*Anas platyrhynchos*), Double-crested Cormorants (*Phalacrocorax auritus*), Great Egrets (*Ardea alba*), Black-bellied Whistling Ducks (*Dendrocygna autumnalis*), and Yellow-crowned Night-herons (*Nyctanassa violacea*). Other species typical of urban greenspaces utilizing the WSC include Northern Mockingbird (*Mimus polyglottos*), Northern Cardinal (*Cardinalis cardinalis*), House Finch (*Carpodacus mexicanus*), Cedar Waxwing (*Bombycilla cedrorum*), Mourning Dove (*Zenaida macroura*), and Blue Jays (*Cyanocitta cristata*).

A total of 141 bird species potentially found within Bexar County are listed as a species of concern by one or more entities (Appendix C, Natural Resources, Institutional Recognition). The list of bird species that have been observed in Bexar County includes three Federally listed endangered species and eleven state listed endangered, threatened, or species of concern. Additionally, other species of concern have been identified by the USFWS (2008), Partners in Flight (PIF) (Rich et al., 2004), the Audubon Society (Butcher et al., 2007), the U.S. Shorebird Conservation Plan (2004), and the Draft Waterfowl Conservation Plan (2012). The USFWS lists 78 Birds of Conservation Concern that occur in Bexar County and the Department of Defense PIF, Edwards Plateau BCR Oaks and Prairies BCR, and Tamaulipan Brushland BCR designate 92 bird species occurring in Bexar County as conservation species. The Audubon Society places species of highest national concerns on the Red Watchlist and species that are declining and rare species on the Yellow Watchlist. In Bexar County, 14 species are designated as Red Watchlist species, 32 Yellow Watchlist species are designated as declining, and 11 species are designated as rare. The U.S. Shorebird Conservation Plan identifies four shorebirds occurring in Bexar County as highly imperiled and another 15 species of high concern. Finally, the 2012 North American Waterfowl Management Plan identified six waterfowl species found in Bexar County that are declining and are of conservation concern.

THREATENED AND ENDANGERED SPECIES*

The USFWS Threatened and Endangered Species list for Bexar County lists 19 species, and all, with the exception of the Whooping Crane (*Grus Americana*), are associated with karst and Edwards Aquifer dependent habitats, or are associated with the live oak/Ashe juniper (*Juniperus ashei*) habitats of the Edwards Plateau. Neither of these habitat features is found in the WSC study area. San Antonio is on the extreme western edge of the Whooping Crane's migration corridor, and the species is considered a rare migrant to Bexar County. The complete list of Federally listed threatened and endangered species for Bexar County can be found at the USFWS Southwest Region website (http://www.fws.gov/southwest/es/ES_ListSpecies.cfm).

Similarly, the majority of the rare, threatened, and endangered species listed by the Texas Parks and Wildlife Department (TPWD) are not found in the study area. However, the Peregrine Falcon (*Falco peregrinus*) and State-threatened Zone-tailed Hawk (*Buteo albonotatus*) were observed in the WSC study area during the avian surveys for this study. Potential habitat for the Texas garter snake (*Thamnophis sirtalis annectens*) exists within the study area. The complete state list can be found at the TPWD endangered species website (http://www.tpwd.state.tx.us/gis/ris/es/ES_Reports.aspx?county=Bexar).

Table 2 identifies the Federal and State listed species that utilize riverine habitats and could potentially utilize the WSC.

Table 2. Federal and State listed species potentially occurring within the WSC study area.

Common Name	Scientific Name	Listing[1]	Utilizes Aquatic/ Riparian Habitats	Habitat within Westside Creeks Study Area
Birds				
American Peregrine Falcon	*Falco peregrines anatum*	ST	Yes	Yes[2]
Arctic Peregrine Falcon	*Falco peregrines tundrius*	SOC	Yes	Yes[2]
Interior Least Tern	*Sterna antillarum athalassos*	SE	Yes	Yes[2]
White-faced Ibis	*Plegadis chihi*	ST	Yes	Yes[2]
Whooping Crane	*Grus americana*	FE, SE	Yes	Yes[2,3]
Wood Stork	*Mycteria americana*	ST	Yes	Yes[2]
Zone-tailed Hawk	*Buteo albonotatus*	ST	Yes	Yes[2]
Insects				
Rawson's metalmark	*Calephelis rawsoni*	SOC	Yes	Yes
Mammals				
Cave myotis bat	*Myotis velifer*	SOC	No	Yes[4]
Ghost-faced bat	*Mormoops megalophylla*	SOC	No	Yes[4]
Mollusks				
Creeper (squawfoot)	*Strophitus undulatus*	SOC	Yes	Yes[5]
Golden orb	*Quadrula aurea*	FC, ST	Yes	Yes[5]
Reptiles				
Texas garter snake	*Thamnophis sirtalis annectens*	SOC	Yes	Yes
Texas indigo snake	*Drymarchon melanurus erebennus*	ST	Yes	Yes[3]
Timber/Canebrake rattlesnake	*Crotalus horridus*	ST	Yes	Yes[3]
Plants				
Big red sage	*Salvia pentstemenoides*	SOC	Yes	Yes[5]
Correll's false dragon-head	*Physostegia correllii*	SOC	Yes	Yes[5]

[1] FE – Federally Endangered, FC – Federal Candidate, SE – State-listed Endangered; ST – State-listed Threatened; SOC – State Species of Concern; [2] Potential migrant; [3] Limit of known range; [4] Potential foraging area; [5] Historic WSC habitat may have been suitable for species

MIGRATORY BIRD STOP-OVER HABITAT

Migrating and breeding birds utilize riparian habitats more than any other habitat in North America with many species considered riparian obligates because they require quality riparian habitat as a life requisite. During migration, riparian habitats serve a critical role as stop-over habitat. The past several decades have seen a decline in Neotropical migratory bird numbers. Recently, it has been recognized that the loss, fragmentation, and degradation of migratory stop-over habitat is potentially the greatest threat to the survival and conservation of Neotropical birds.

In arid areas of the United States, stop-over sites are restricted, and the riparian corridors of south central Texas are the primary stop-over resource for migrating birds. Avian surveys in the WSC study area further demonstrate the value of aquatic and riparian habitats in urban landscapes for migratory birds. Avian surveys conducted near the WSC on the relatively pristine Medina River and an urban stream (Medio Creek) where the high quality riparian corridor remains intact. Avian diversity between these two sites was statistically insignificant, even though the avian community on Medio Creek was subjected to urban impacts such as noise and light pollution. As is the trend throughout the nation, naturally functioning riverine ecosystems in the southwest are decreasing. Due to the historic rarity of these systems in the southwest the impact of their loss or degradation is more acutely felt. Their loss and/or degradation places extreme pressures on the carrying capacity for the few remaining functional systems and places further stress on the South Texas ecoregion when considered in connection with the life requisites of the migratory birds of the Central Flyway.

The WSC study area is an ecologically unique system important to a successful migration and breeding of neotropical migrants utilizing the Central Flyway. Riverine habitats bordering coastal regions serve as a last opportunity for Trans-Gulf migrants to refuel during fall migration or provide a first stop for recovery and replenishment of energy reserves during spring migration. The location and historical ecological diversity of the WSC supports stop-over habitat needs for a wide range of migratory bird species.

Historically, after passing through the Texas coast, the riverine system of the San Antonio area was one of the first productive stop-over habitats for northbound neotropical migratory birds, and one of the last highly productive stop-over habitats during the southern migration. The energy reserves for birds are severely depleted during spring and fall migrations, and with the current trend of decreasing availability of structurally sound and functioning riverine systems, stop-over habitat has been identified as a limiting factor for their successful completion of migration and subsequent breeding success.

WSC ECOLOGICAL FOOD WEB

The WSC riverine food web has experienced trophic level collapse. Figure 6 depicts the trophic level relationships of the WSC foodweb. The basic concept is that energy requirements for a species within an upper trophic level require an order of magnitude of energy from the trophic level immediately below it. For example, to drive a single unit of biomass (a single organism) at the top of the foodweb (tertiary and secondary consumers) 100 to1000 units of biomass are required at the bottom of the foodweb (primary producers). For the WSC riverine system, the tertiary and secondary avian consumers are hawks, herons, kingfishers, and insectivorous birds, while the primary avian consumers include birds that consume seeds and other plant materials. Primary producers are organisms that convert solar energy directly into food such as aquatic and terrestrial plants and algae. Based on this relationship, for the WSC riverine system to support a greater diversity and number of higher trophic organisms such as the bird species, it must support an even greater diversity and number of primary producers and consumers. The homogenous nature of the aquatic and riparian habitats along the WSC does not support species diversity or an adequate quantity of primary producers, and therefore, tertiary and secondary consumers are not able to find the necessary fuel to meet their life requisites for survival, breeding, and reproducing.

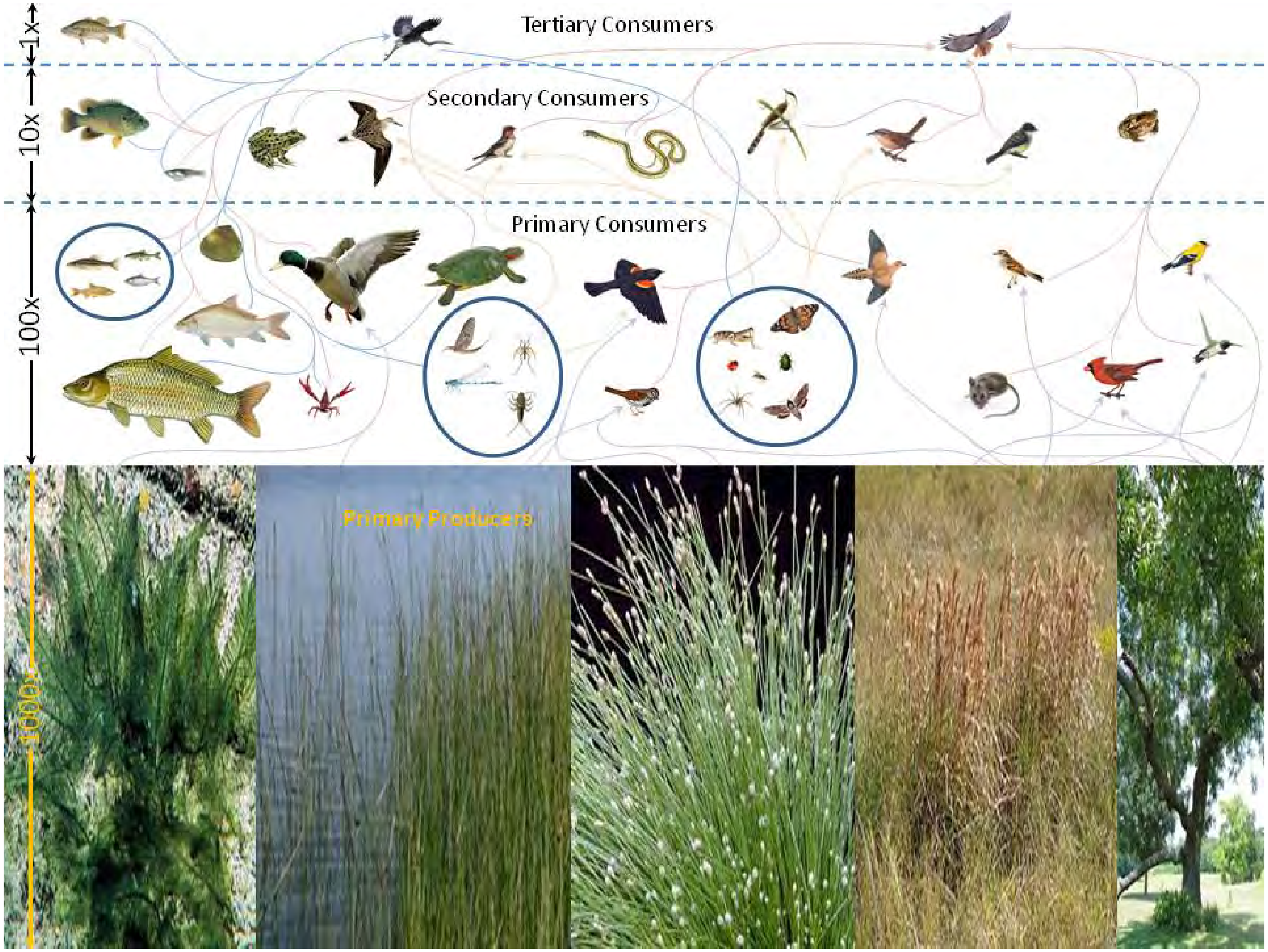


Figure 6. Ecological Trophic Levels and Foodweb Pathways of the Westside Creeks Riverine System.

CHAPTER 3: PLAN FORMULATION

Planning is the deliberate activity of developing an optimal strategy for solving problems and achieving a desired set of goals. The goal of the WSC study is to restore structure and function to the riverine habitat within the WSC segment of the SACIP. Inherent in this goal is the requirement to ensure that ecosystem restoration and recreation features do not adversely affect the FRM benefits and complement the FRM benefits where possible. The plan formulation for ecosystem restoration and recreation for the WSC study uses established, documented, and proven methodologies in an incremental approach.

PROBLEMS AND OPPORTUNITIES

The problem and opportunity statements guide formulation. Specific problems for the WSC can be ascribed to the degradation of the riverine ecosystem, residual flood risk, and a shortage of recreation facilities.

Problem 1 – Construction and maintenance of engineered FRM channels has resulted in the loss of natural ecological structure and function in the existing floodplain as exhibited by the degraded or absent riverine habitats. This degradation and loss is part of a larger National and International concern for degraded and lost stop-over habitat for migratory birds.

Opportunity 1 – Restore natural ecological structure and function to the riparian and aquatic components of the WSC riverine system such that they support a diversity of aquatic life. Restoration of riverine structure and function may also provide stop-over habitat benefits for migratory birds.

Problem 2 – Depths of flooding at structures within the 1% ACE floodplain for the WSC study area range from 0.0008 feet to 7.1 feet, with median flood depths of 1.3 feet on Apache Creek to 1.9 feet on Martinez Creek.

Opportunity 2 – Manage residual flood risk to those structures within the WSC study area that could be affected by the 1% ACE.

Problem 3 – An unaccounted for affect of the SACIP FRM project is the cultural, social, and economical separation of communities previously connected by physical paths and common/shared recreation activities.

Opportunity 3 –Provide recreation opportunities to restore community connections and reduce the shortage of recreation opportunities in the WSC as appropriate for the scale and sensitivity of the ecosystem restoration. Though USACE does not formulate for OSE, the positive effects of common recreation areas are well documented. Those positive effects related to WSC include the potential for improvements in health, sense of security and community, air quality, and water quality.

PROBLEM 1 – DEGRADED AND LOST RIVERINE STRUCTURE AND FUNCTION

Channelization of the WSC led to a number of ecological consequences for the riverine habitat. Historically, these creeks provided natural pool-riffle-run sequences through natural channel forming processes which balanced the sediment load through continuous changes in sinuosity. The natural channel forming process influenced and supported the function, structure, and diversity of riparian and aquatic components of the riverine ecosystem. The effect of channelization was a loss of sinuosity and the reduction in and degradation of pool-riffle-run sequences. The continuous cycle of transportation and deposition of sediments through the system which supports all levels of aquatic life is disrupted. Increased water velocities result in severe erosion within the project area and increase sedimentation downstream where velocities and bed slope return to a more natural and gentle condition. Continued maintenance of the channel ensures no woody vegetation grows and the non-native herbaceous vegetation is maintained to an average of six inches in height. Excessive erosion caused by the increased bed slope and resulting increased velocities generates a requirement for continuous maintenance of the pilot channel through lining with concrete rubble and other components, which effectively restrains the natural process by which streams balance bed slope, velocity, and sediment. The degradation of the aquatic lower trophic levels resulting from the effects of the channelization greatly reduces the biotic productivity that organisms in the upper trophic levels require; this is especially true for migratory birds that key in on riparian habitats and places additional stress on birds that are already low on energy reserves.

Broadly, the losses to structure and function of the WSC riverine system resulting from channelization and maintenance include:

- Loss of vertical and horizontal vegetative structure,
- Loss of woody vegetation,
- Lack of soft and hard mast diversity,
- Loss of native herbaceous vegetation to support a functioning riparian meadow habitat,
- Reduced allochthonous material inputs to the aquatic habitat,
- Restriction of natural channel forming processes,
- Loss of pool-riffle-run sequences,
- Lack of proper substrates to support aquatic life requisites caused from the lack of balanced sediment transport,
- Severe increase in aquatic and terrestrial temperatures,
- Lower dissolved oxygen concentrations in the aquatic system,
- Loss of slackwater habitats, and
- Loss of riparian and aquatic structure to support a healthy and adequate community of lower trophic level organisms to fuel energy needs through higher trophic levels

The above listed degradations paint an accurate picture of the structurally and functionally homogenous and restrained riverine system which characterizes the existing conditions and future without-project conditions of the WSC. The result is degraded riverine habitat which no longer supports the historic level of organism diversity at any trophic level. Capitalizing on the restoration opportunity for WSC and the opportunity to provide benefits to a diversity of migratory bird species requires addressing, to some level of restoration, the components of structural and functional losses listed above.

PROBLEM 2 – RESIDUAL FLOOD RISK

A preliminary analysis resulted in a determination that residual flood risk following the construction of SACIP is insufficient to support a structural alternative to further reduce flood risk in the WSC study area. Non-structural measures have already been applied where desired in the WSC study area as a result of the FEMA VAP grant. Therefore, no objective was developed for problem 2. However, protection of the existing levels of flood risk mitigation is a constraint for the ecosystem restoration and recreation formulation.

PROBLEM 3 –DISCONNECTED COMMUNITIES

The City owned 602.26 acres of park land in the study area in 2005 or 2.84 acres per 1,000 residents. Based on the national average of 16 acres of park lands for 1,000 residents, there is a shortage of 2,787 acres of parklands for the residents of the communities included in the WSC study area. The shortage of recreation facilities and the current condition of the channelized WSC plays a part in the physical and psychological well-being in the population residing in the WSC study area. The WSC communities are disconnected from each other, community amenities, and the creeks that once connected the residents through recreation.

PLANNING GOAL AND OBJECTIVES

PLANNING GOAL

The goal of this study is to examine ways to restore structure and function of the riverine habitat and provide complementery recreational opportunities within the WSC while maintaining the existing flood risk management benefits.

OBJECTIVE 1 – RIVERINE ECOSYSTEM RESTORATION (PROBLEM STATEMENT 1)

Objective 1 – Restore, to the extent practicable, a sustainable, dynamic riverine ecosystem providing habitat for aquatic and riparian dependent migratory and native resident bird species in the Westside Creeks study area over the next 75 years.

Construction and maintenance of FRM measures have resulted in unconsidered consequences for the riverine ecosystem along the 35 miles of the SACIP. Channelization increased bed slope and removed sinuosity, severely altering the function and biotic viability of the historic WSC riverine habitat. The result is a system where the sediment transport is out of balance, few to none of the aquatic structures remain that are necessary to support and sustain a diverse community of native aquatic organisms, and the required shading and allochthonous inputs from the riparian vegetation have been removed.

OBJECTIVE 2 – COMMUNITY CONNECTIVITY THROUGH RECREATION (PROBLEM STATEMENT 3)

Objective 2 – Maximize, to the extent practicable, recreation benefits along the Westside Creeks compatible in scope and scale of the project's ecosystem restoration objective and consistent with national, regional, and local recreation goals.

Including recreation in the WSC study addresses the shortage of recreation facilities in the WSC study area. More importantly, formulating for recreation in conjunction with any ecosystem improvements that might be recommended ensures disturbances to any critical habitats are within tolerable limits.

CONSTRAINTS

The following planning constraints are applicable to the WSC study.

- Avoid increasing water surface elevations as established by the DFIRM completed for FEMA, effective date 29 September 2010.

- Opportunities to expand the existing ROW are limited to those identified in the San Antonio River Watershed Master Plan.

ECOSYSTEM RESTORATION BENEFITS

The WSC study uses a measure of avian community response as the ecological metric (criteria) to compare alternatives against their ability to address the ecosystem restoration objective. Riverine structure and function from pre-restoration conditions through completed restoration can be quantified by using migratory birds as a representative of the highest trophic levels in the WSC ecological system to measure the success of the ecosystem restoration objective. Therefore, restoration management measures are largely identified for their ability to restore the lower trophic levels (primary producers and primary consumers) of the riverine ecosystem, thereby providing the necessary biomass required to satisfy the increased energy requirements of a more diverse avian community.

The WSC Avian Index of Biotic Integrity (AIBI) allows for characterization of the existing biotic integrity of the WSC and the future with-project biotic integrity of the creeks resulting from the various measures and combinations of measures considered during the study. In addition to applying the AIBI model to the existing conditions of the WSC, the model was applied to two reference reaches. The comparison of the WSC with a moderately human-disturbed suburban reference reach (Medio Creek) and a primarily undisturbed rural reference reach (Medina River) set an acceptable expectation for the level of restoration achievable for the creeks in the study. The product of AIBI and acres are utilized as a single unit of measure, average annual avian community unit (AAACU), which along with average annual cost (AAC) is used to compare and rank the numerous combinations of management measures.

Comparison and ranking ultimately provides an array of alternatives that, for their cost, provide the best return in ecological benefit. For the purpose of the WSC study, the measured ecological benefit is the ability of the riverine restoration to provide the life requisites to a diverse community of migratory bird species. Because birds reside at the highest trophic levels of the WSC food web, they are a good biomarker of the health of the riverine ecosystem, and inherently, it can be assumed that alternatives that provide high benefits to bird species are providing high aquatic and riparian benefits as well.

PRELIMINARY MEASURES, CRITERIA, AND SCREENING

Construction of the SACIP straightened the San Antonio River and its tributaries and converted the woodland and riparian meadow habitats of the associated riparian corridor to a mowed, primarily non-native, grass-lined channel within the FRM project area. Prior to channelization, the creeks served as a focal point for recreational activity and community cohesiveness for the families of the WSC neighborhoods. Channelization segmented roads that once crossed creeks, creating dead-ends at the banks of the floodway channel. Identification of management measures for ecosystem restoration seek to address the degradation of the WSC habitats such that specific management measures are identified to provide incremental benefits along an array of plans that address the restoration objectives. Recreation measures seek to reduce the shortage of recreation facilities while ensuring adverse impacts to the restoration are minimized, and connectivity to existing recreation and other public resources in the WSC communities is maximized.

ECOSYSTEM RESTORATION MANAGEMENT MEASURES

Minimal restoration of the WSC riverine system should address at least one of the degraded or lost structural/functional components for one of the four WSC. The maximum level of restoration achievable for the study area would begin to address all the loss of function and structure listed for all four WSC. A description of each management measure identified is provided below, and Table 3 provides a cross-reference of how each identified management measure addresses the structural and functional degraded features. In the table, fully shaded circles indicate that the management measure fully addresses the loss of structure or function, while empty circles indicate that the measure does not address the loss whatsoever.

Table 3. Potential ecosystem restoration management measures to address specific areas of structure and/or function loss or degradation in the Westside Creeks Study Area.

Structure & Function Losses	Change Maintenance	Riparian Meadow	Pilot Channel	Riparian Woody Vegetation	Slackwater	Wetland
Vegetative structural diversity	◔	◑	○	●	◑	◑
Native woody vegetation	○	○	○	●	○	○
Soft/hard mast diversity	◔	◑	○	●	◑	◑
Native riparian meadow	○	●	○	○	○	○
Allochthonous materials	◔	◑	○	●	○	◑
Channel forming processes	○	○	●	○	○	○
Pool-riffle-run sequences	○	○	●	○	○	○
Sustainable habitat substrates	○	○	●	○	○	○
Slackwater habitat diversity	○	○	●	○	●	○
Lower trophic level habitat	◔	◕	◕	●	◕	◕
Aquatic and terrestrial temperature	◔	◑	◑	◕	◔	○
Dissolved oxygen concentration	◔	◑	◑	◕	◔	○

*Shaded circles = level to which a management measure addresses structure & function loss (fully shaded = fully addresses); empty circle = management measure does not address structure & function loss.

Change Maintenance: Implement maintenance regime changes to allow an increase in structural diversity within the herbaceous component of the riparian corridor. Specifically, this management measure consists of a reduction in the frequency of mowing within the floodway channel.

Riparian Meadow: Plant native mesic and hydrophilic grasses and forbs to restore the native herbaceous component of the riverine riparian habitat, which would increase diversity within the riparian corridor, provide some limited increase in carrying capacity at the lower trophic level, and increase structural diversity of allochthonous materials in the aquatic component of the riverine system.

Pilot Channel: Utilize Natural Channel Design (NCD) principles to restore the sinuosity function and structural diversity of the aquatic habitat component of the riverine system. Specifically, re-construct the creek bed utilizing a pilot channel sized to the channel forming flow. The NCD methods include using vertical and horizontal structures in the form of rock vanes appropriately spaced within the pilot channel to balance the sediment transport function of the creek. The NCD methods also restore pool and riffle habitats with proper substrates to support aquatic organisms. The pool and riffle habitats provide habitat diversity which increases the species diversity of lower trophic level organisms such as aquatic invertebrates, small fish, and amphibians that provide energy to migratory and breeding birds. The NCD method develops a functional, self-sustaining system providing valuable hydraulic transport, geomorphic functions, and ecological functions. Thus, NCD creates a stable channel that effectively transports water and sediment while maintaining the structural characteristics necessary to ensure habitat sustainability and biotic productivity across all trophic levels.

Riparian Woody Vegetation: Plant native woody species, where hydraulically feasible, to restore the structure and function of the riparian corridor. This management measure in conjunction with the riparian meadow management measure restores the historical vegetative, structural, and functional diversities of the riparian habitat as well as providing structural and functional components necessary for a highly productive aquatic habitat to include shade, woody debris, leaf pack, and other vital allochthonous materials. The input of allochthonous materials to the aquatic system is the organic driving force of the aquatic ecosystem. As organisms at the bottom of the trophic level consume the detritus they in turn provide energy to higher level trophic organisms. The energy utilized by organisms up the trophic level increases by an order of magnitude; therefore, the more allochthonous material provided to the aquatic system, the more productive the lower trophic levels will be to better support the upper trophic level organisms including migratory and breeding birds.

Slackwater: Perform minor grading and excavation along the banks of the pilot channel to create slackwater areas that mimic the function of natural velocity refugia. The slower or non-existent velocities of these habitats allow the accumulation of organic materials, and the resulting detritus supports a highly productive and diverse micro-organism community. These slackwater areas are vital microhabitats within the aquatic system which provide nursery, cover, foraging, and resting areas away from the main channel flows. As an increased number of lower trophic organisms are concentrated in the slackwater habitats, higher trophic organisms, especially migratory birds in need of quick and easily obtainable energy resources, are able to concentrate feeding efforts with minimal energy expended.

Wetlands: Where appropriate hydrology and hydric soil conditions exist, provide shallow depressions adjacent to the pilot channel with hydric plants to create off-channel wetlands. Wetlands increase habitat diversity, providing a different type of productive habitat that supports the biota of the in-stream aquatic community at the lower trophic levels.

Bridge Modifications: Modification to bridges is a management measure which could indirectly support more specific restoration management measures mentioned above. Specifically, modification to bridge abutments could create additional hydraulic capacity which would allow inclusion of woody vegetation within the floodway without increasing the existing 1% ACE water surface elevation.

Right of Way (ROW) Expansion*:* Similar to bridge modifications, expansion of the ROW could indirectly support more direct restoration management measures. ROW expansion could provide additional area for restoration management measures such as wetlands and slackwater as well as increasing hydraulic capacity and allowing additional woody riparian vegetation plantings within the floodway.

RECREATION MANAGEMENT MEASURES

As part of the channelization of SACIP, the bed and banks of the WSC channels are no longer conducive to recreational uses once enjoyed by the community such as fishing, swimming, and general community gatherings. The formulation of recreation for WSC identifies individual management measures which could address these impacts while not detracting from ecosystem restoration efforts. A description of each management measure identified is provided below.

Trails: A linear system of hike and bike trails within the ROW of the WSC floodway channel is the primary measure evaluated. Conceptual development connects the new trail to existing hike and bike trails and public transit connections. A linear recreational pathway connected to existing recreation and transportation amenities provides a platform for the local community to become more cohesive through the ability to recreate as well as appreciate and value nature together.

Shade Structures: Shade structures are considered at trailhead and overlook locations where riparian woody vegetation is deemed unfeasible. These structures include picnic tables and water fountains, and provide gathering areas for community activities as well as rest points from active recreation. Placement is evaluated with regard to locations that provide opportunities to appreciate nature while minimizing the disturbance to the ecosystem.

Interpretive Boards: Interpretive sign placement takes advantage of the educational value of the ecosystem restoration without distracting from the restoration. Way-finding signs at trailheads and various locations along the trails instruct users on navigating the trails, locations of recreation and community amenities relative to their position, and care and conduct while using the trails to preserve access, health, safety, and the restoration management measures.

INITIAL SCREENING CRITERIA

INITIAL SCREENING CRITERIA – ECOSYSTEM RESTORATION

The potential project area for the WSC lies within an existing and highly functional FRM channelized floodway. Additionally, the potential ecosystem restoration project area is located in the middle of the 7th largest city in the U.S. The requirement to maintain the existing protection provided by the constructed FRM project combined with the reality that a ***complete*** return to pre-construction ecosystem benefits is not feasible guided some early screening of management measures. Potential management measures are screened early in the formulation process based on identified risks, and knowledge of costs and benefits based on institutional knowledge of other projects and data collected specifically for the WSC study. The following represent the general categories of criteria utilized for initial screening:

- level of ecological lift in comparison to potential implementation cost,
- likelihood of triggering an adverse cost risk,
- likelihood of triggering an adverse floodway performance risk, and
- likelihood of affecting performance or sustainability of previous downstream ecosystem restoration projects.

INITIAL SCREENING CRITERIA – RECREATION

The recreation plan was developed after the NER plan was identified. The following criteria are utilized in the development of the recreation plan:

- comply with and complement local, city, and state recreation master plans,
- tie into existing trails where possible,

- limit trails and interpretive boards to one side of the creek, and minimize their placement through higher density vegetation to minimize adverse impacts to ecosystem restoration benefits,
- create cohesive linear trail corridors with no dead ends,
- street level connections are to streets with designated bike lanes and/or access to public transportation,
- avoid connection to streets without sidewalks,
- avoid connections to streets in close proximity to interstates, railroads, high traffic parking lots, industrial areas, or other incompatible uses,
- maximize access to common public facilities such as parks, schools, churches, etc.,
- minimize creek crossings and locate downstream of vehicular bridges to minimize adverse impacts to ecosystem restoration measures, and
- position any trail crossing perpendicular to the creek to minimize hydraulic impacts.

KEY UNCERTAINTIES

Key uncertainties were identified early in the study phase and monitored throughout the plan formulation process. These uncertainties are listed below with a description of the associated risk and the steps taken throughout the formulation process to reduce that risk.

- ***Civil:*** Utilities within the study area include water, sanitary sewer, electric, gas, and communications. Quantities for utility relocation estimates were based on available information with the understanding that a detailed survey of the project site will be required at the beginning of Preconstruction Engineering and Design (PED). The exact depth of those utilities and the completeness and accuracy of the available files remain unknown. This is true of most feasibility studies, and a contingency factor is applied to compensate, but the accuracy of this factor will not be known until the detailed survey is completed in PED.
- ***Costs:*** As with any feasibility level cost estimate, contingency costs are estimated to account for risks associated with the project. The contingencies during formulation are calculated using the Abbreviated Cost Schedule Risk Analysis (ACSRA) worksheet recommended by the USACE Mandatory Center of Expertise (MCX) for Cost Engineering. As with all potential projects, there are several design details that are not completed until PED. The following items are identified as risks which warranted higher contingencies in the cost estimate:

  - utility relocation uncertainties discussed in civil uncertainties; contingencies associated with utility relocation were increased to 27.08% in the ACSRA to account for uncertainties,
  - utility line fractures during construction due to age of the existing infrastructure,
  - limitations on accessibility for construction equipment, particularly near bridges,
  - intent that excess material is discarded within 5 miles of the project site to a licensed site; contingencies associated with channel excavation were increased to 14.58% in the ACSRA to cover cost if disposal sites are located outside of the 5 mile radius, and
  - slope stability at points of excavation that are notably deep or near the existing floodway channel banks.
  - Quantities for excavation are based on Hydrologic Engineering Center River Analysis System (HEC-RAS) modeling rather than detailed topography surveys. Historically these numbers have been very close on other projects, but the HEC-RAS model was, in large part, an existing model rather than one developed by USACE specific to this project.
  - Quantities for plantings are based on conceptual level modeling and an assumed ROW based on scanned drawings of the SACIP designs. Once the detailed survey and

engineering is complete, it could be determined that the lands and densities for vegetation have a variance from the conceptual plan.

- ***Geotechnical:*** Twenty-one fault lines are identified in the study area. There could be issues with existing slopes that would not be revealed until detailed design/construction analysis. Faulting can contribute to poor performance of slopes and structures, contribute to seepage issues, result in increased construction costs, and can result in increased maintenance requirements over time. The largest initial risks stemmed from twenty-one fault crossings at various locations in the study area and long-term stability of the existing slopes. These concerns are largely based upon experience from design and construction of the adjacent SACIP Mission Reach project; so, it is set as a benchmark by which to assess qualitative risk. Specifically, design and construction cost impacts and evaluation metrics for fault crossings and slope instability are used to assess the likelihood and consequences of these risks to the WSC project. This allowed the cost of these risks to be incorporated into the contingency costs for the project alternatives.
- ***Cultural Resources:*** Discovery of a significant cultural resource in any proposed project footprint may require mitigation due to unavoidable impacts. The literature search of THC records revealed that no cultural resources have been recorded within the WSC APE. There have been other projects in the San Antonio River basin that have turned up previously undocumented sites of varying archeological significance during construction even after detailed archeological surveys. However, the sites discovered along the San Antonio River are deeply buried between 4 and 6 feet below the ground surface and outside the river bed within the floodplain. All sites encountered during construction were found when the creek banks were laid back or removed. All of the measures under consideration for the WSC study area limit ground disturbance to 18-24 inches below the current surface and are confined within the channel, therefore, the risk of encountering deeply buried cultural deposits while implementing these measures is very low. To further reduce the risk of impacts to cultural resources, USACE will have an archeological monitor who meets the Secretary of the Interior's standards on site during ground disturbing activities. In accordance with a Programmatic Agreement developed through consultation with the Texas SHPO, the monitor will watch the construction and identify the presence of cultural materials if they are encountered. If a potential site is found, the monitor will be afforded the time to make an assessment of a site's significance and carry out appropriate mitigation on NRHP eligible sites before construction is allowed to continue in the vicinity of the site. This type of monitoring has been used successfully in other areas of the SACIP, and the Texas SHPO agrees it is an effective approach for the WSC project area. Finally, the monitor will educate the construction crew what to look for as they work to aid the monitoring in identifying all potential cultural materials.
- ***Real Estate:*** To minimize adverse effects to schedule and cost, investigation has already commenced with regard to ownership and easements within the SACIP limits of construction as it relates to the WSC study area. A more accurate real estate assessment for uncertainties will continue to be coordinated between the PDT District level leadership, SARA and Real Estate Division. The following items are identified as risks which warrant further real estate actions:

    - a detailed survey of the WSC project site will be required immediately upon the initiation of PED,
    - identify temporary work areas (construction staging sites) during WSC construction,
    - identify disposal site (licensed site or real estate property of SARA or the City) for discarding excavated material, and

  - USACE or SARA will perform the Attorney Opinion of Compensability Report for each of the utility relocations within the WSC project area.

- ***Environmental:*** Three years of ongoing drought conditions may affect existing conditions and the no action alternative resulting in under/over stating benefits. The environmental risk is minimized by planting site-specific native plant species adapted to the periodic droughts consistent with the local climate. Irrigation after planting/seeding ensures the establishment of the vegetation so that the plants can build enough energy reserves to withstand extended drought in the future.

SCREENING AND SCALING OF MANAGEMENT MEASURES – ECOSYSTEM RESTORATION

MANAGEMENT MEASURES SCREENED FROM FURTHER CONSIDERATION

Change Maintenance: Potential habitat improvements might result from simply changing the maintenance regime by mowing less frequently. The existing vegetation is 98% non-native and is dominated by invasive species. The current maintenance regime, while not eliminating seed production, does provide some reduction in seeding. Less frequent mowing would allow these species to significantly increase the amount of seed produced. This increased seed production would have negative impacts as the seeds from non-native, invasive species spread downstream and take root where restoration efforts have already been implemented. Further, the roughness coefficient for the non-native species is not the same as for native riparian meadow species. For example, Johnsongrass is a non-native species currently occupying the WSC. This grass stem, which can reach six feet in height, is stiffer and will not lie down during high flow conditions like the more flexible native herbaceous species. With a change to less frequent mowing, it is highly likely that Johnsongrass becomes the dominant species along the WSC. Changing the maintenance regime without changing to native vegetation could have a slight negative impact on the existing flood risk reduction provided by the SACIP. Due to increased/expanded proliferation from increased seed production, which would lead to a net negative impact for the San Antonio River Watershed, and the potential for some negative impact to the existing flood risk reduction within the WSC area, the management measure to change the maintenance regime is removed from further consideration.

Bridge Modification: Bridge modifications are considered for the purpose of increasing conveyance and allowing concrete removal to provide additional opportunities for restoration management measures. Full scale removal and reconstruction of bridges represents an unacceptable cost in relationship to the scale of potential benefits. A sensitivity analysis conducted to determine the rough order of magnitude change in water surface elevation that might result from modifying only the bridge abutments determined the change in water surface elevation (0.1-0.2 feet) is not sufficient to allow for the increased roughness and slower velocities that would result from concrete removal. Furthermore, this introduces geotechnical risk to the existing infrastructure which exceeds risk tolerance limits and necessitates increased costs for geotechnical remediation. The bridge modifications raise the same concerns as full scale removal and replacement of bridges; costs are not proportionate to the potential benefits. Therefore, bridge modifications were removed from further consideration.

SCALING THE POTENTIAL PROJECT SIZE

During the screening process, the potential project footprint was scaled to include only those areas most likely to provide ecosystem restoration benefits commensurate with the potential costs. This exercise considered possible costs for ecosystem restoration, as well as external limitations from the surrounding landscape. Portions of the original study area where undue burden would be placed on the sponsor for maintenance to sustain the restoration or where the restoration benefits would be severely limited due to external pressures were screened from further ecosystem restoration study. The boundaries of the potential project area as further refined by this scaling process are identified below.

- San Pedro Creek –The potential project area is bounded by Camp St, just downstream of the San Pedro Creek tunnel outlet and continues to the confluence with the San Antonio River.
- Apache Creek – The upstream end of the potential project area is at the dam at Elmendorf Lake, and extends downstream to the confluence with San Pedro Creek.
- Alazán Creek – The upstream potential project area limit is set at the dam for Woodlawn Lake, and continues downstream to the confluence with Apache.
- Martinez Creek – The upstream end of the potential project area is set at Hildebrand Avenue, and continues downstream to the confluence with Alazán Creek.

ROW Expansion: This study area is highly urbanized, making acquisition of additional ROW relatively expensive. The result is a general desire to stay within the existing ROW to keep costs scaled relative to the achievable restoration benefits. However, some publicly owned lands were considered for ROW expansion. These lands are adjacent to the creeks and include public parks and properties evacuated using funds provided by FEMA in 2002-2004 as a result of the flooding that occurred during the October 1998 storms. The public lands considered include:

- portions of Mario-Farias Park at the confluence of Martinez Creek and Alazán Creek,
- City property adjacent to Elmendorf Lake downstream of General McMullen, evacuated as part of the FEMA VAP,
- portions of Amistad Park on Apache Creek, downstream of Navidad, and
- City property adjacent to Martinez Creek, between Magnolia and Craig Place, evacuated as part of the FEMA VAP.

Considerations regarding topography, surrounding land use, and hydraulics result in dropping all potential ROW expansions except the City property adjacent to Martinez Creek from further formulation efforts. The ROW expansion adjacent to Martinez Creek, because of the low floodway banks in this area, is deemed a suitable location for a small scale off channel wetland area.

Pilot Channel: Large portions of creek bed and floodway slope for Apache Creek are concrete lined. Installation of the pilot channel management measure for the entire 2.7 miles of Apache Creek requires removal of most of the concrete, and introduces geotechnical risk. The geotechnical risk can be addressed, but remediation measures are extremely costly. The increased cost triggers the initial management measure screening criteria associated with ecological lift versus high costs to implement. However, when considering the WSC system, especially the aquatic ecological connectedness and sediment transport functions along with the location of Apache Creek within the context of Martinez Creek and Alazán Creek, it does not make sense to completely abandon the pilot channel concept for Apache Creek. A more detailed analysis indicated the pilot channel measure can be implemented on the lower third of the creek (0.8 miles) without extreme cost or unacceptable geotechnical risks. Implementing the pilot channel in this location maintains the continuity of sediment transport and aquatic ecological functions.

EVALUATION OF FINAL LIST OF MANAGEMENT MEASURES

Through the screening process discussed above, a final list of potential management measures is developed for each creek. The major cost elements and additional detail of how each management measure addresses the structure and function degradation and losses shown in Table 3 are discussed below. This final list of management measures is utilized to formulate alternative plans for addressing the ecosystem restoration objective. Some management measures can stand alone as an alternative plan or be combined with other management measures; other management measures must be combined to form an alternative plan. The stand alone ability and relationship between management measures is discussed for each measure below.

No Action: The no action management measure would result in no additional costs beyond the current annual expenditure for regular operation and maintenance of the existing FRM channel features. The no action management measure does not address the ecosystem restoration objective, but is included for comparison of action management measures. The no action would continue to provide minimal habitat for most migratory, breeding, and wintering birds in the San Antonio Area. Migratory birds will continue to focus on the WSC as they key in on riparian systems in general, but waste precious energy and time attempting to replenish energy reserves in a system with low biotic productivity. Although the degraded ecosystem in WSC may not directly result in the decline of species populations, it would remain a component of an ever increasing landscape of degraded habitats which cumulatively lead to the decline and loss of avian species.

Riparian Meadow (RM): Restoration of the riparian meadow would partially address the restoration objective for the WSC by providing some increased vertical structure diversity in the riparian habitat, some increased insect (primary consumer) biomass production, and some increased allochthonous material input to the aquatic habitat. The increase in allochthonous materials and temperature reduction from minimal shading would provide limited benefits in dissolved oxygen levels for the aquatic environment. The increase in allochthonous materials provides energy at the base of the food web and fuels the lower trophic organisms that feed in the aquatic system. In addition, the habitat diversity provided by the riparian meadow would increase the population and diversity of invertebrates required by many riparian and grassland migratory and breeding birds. The increased height of the riparian meadow vegetation also provides nesting and feeding cover for ground nesting birds.

Major cost components for establishment of a native riparian meadow include:

- removal of top six inches of existing soil to remove the non-native seed bank,
- ripping to a depth of 12-18 inches to reduce compaction and provide an acceptable strata for deep root growth,
- incorporation of compost material into the top 2-4 inches to promote germination and sustained growth,
- planting a diverse mix of native riparian meadow seeds, and
- provisions for short-term watering to aid in quick establishment of ground cover of the exposed floodway slopes.

The change from non-native herbaceous vegetation to a restored native riparian meadow would be a hydraulically neutral action. It can be implemented as a standalone alternative.

Pilot Channel (PC): The pilot channel management measure supports the ecosystem restoration objective by addressing the problems associated with the increased bed slope and loss of aquatic habitat structure and function.

Specifically, the pilot channel management measure would mimic the ecological functions of the channel forming process through construction of a pilot channel sized to carry the channel forming flow and the use of in-stream structures. The pilot channel and associated in-stream structures flatten the bed slope during channel forming events thereby balancing movement of sediment through the system creating a stable stream channel. The in-stream structures will restore pool-riffle complexes and support appropriate substrate deposition for pool and riffle habitats. Further, the pilot channel management measure, primarily through the pool/riffle habitats, will allow some slackwater micro habitat formation. Riffles increase dissolved oxygen levels, and increased pool depths provide high temperature refugia for aquatic life. Properly functioning riffles and pools are important primary consumer habitats, serving as breeding, brooding, and foraging grounds for a diverse list of benthic organisms, aquatic insects, and fish. Pools support the aquatic functional need for allochthonous material inputs by providing a low velocity location where these materials fall out of the velocity stream and begin the decaying process to return energy to the system. As previously mentioned, migratory and breeding birds are attracted to riparian ecosystems because of the high diversity and productivity these systems offer. The pools and riffles provide the substrate and habitat for the organisms that efficiently provide the energy required to support migratory and breeding birds.

Major cost components for establishment of the pilot channel include:

- excavation to accommodate the pilot channel and initial pool depths, and construct riffle structures,
- grading to form the pilot channel and transition to existing floodway slopes,
- rock constructed in-stream structures,
- armoring, and
- utility relocation.

The amount of ground disturbance from the excavation to construct the pilot channel would require re-establishment of a large portion of the slope vegetation. For this reason, the pilot channel management measure is not considered as a stand-alone management measure, but rather implementable only in combination with the riparian meadow management measure.

Riparian Woody Vegetation (RWV): The riparian woody vegetation management measure would support the ecosystem restoration objective by addressing the problems of lack of aquatic shading, reduced allochthonous material inputs, lack of stratification of vertical structure, lack of terrestrial shading, and lack of soft and hard mast diversity.

A well developed, age and species diverse woody riparian habitat provides numerous ecological benefits to the riparian and aquatic components of the riverine system which are requirements for many migratory birds. Woody vegetation provides an important source of allochthonous material to the aquatic environment through leaf drop to small and large woody debris. These allochthonous inputs add energy to the aquatic system required by the organisms lowest on the primary producer and consumer scale; these organisms are at the true base of the system and are required in large sustained numbers of individuals to ensure there is adequate energy surplus at each trophic level to feed the next higher level through to the upper level consumers. In addition to providing the allochthonous material that is the foundation of the aquatic and riparian food web, the woody vegetation provides additional nesting, foraging, and cover habitats for a greater diversity of migratory and breeding birds. Different species of breeding birds require different nesting substrates (ground, shrub, lower canopy, upper canopy, cavity, etc.) and the inclusion of woody vegetation in the landscape significantly increases the nesting opportunities to a larger diversity of birds as well as increasing the carrying capacity of the riverine system. In addition, the cover habitat for migratory birds utilizing the WSC as a stop-over provided by the woody vegetation near a more productive aquatic system reduces the energy expended during stop-over and the risk of predation by foraging in a more open area.

Major cost components for the establishment of the RWV include:

- spot treatment herbicide to remove herbaceous competition in the immediate area around the seedling,
- purchase of seedlings in a diverse mix of native riparian shrubs and trees,
- planting of seedlings, and
- provisions for short term watering to aid in quick establishment.

Consistent with the study constraints, implementation of the RWV would require an increase in hydraulic capacity within the floodway to accommodate the increased hydraulic roughness of RWV. Implementation of the pilot channel management measure would gain some hydraulic capacity through the excavation required to implement that management measure. Therefore, the RWV management measure would be implemented only in combination with the pilot channel management measure. To further assist with maintaining hydraulic neutrality and implementing the RWV measure, two stem densities were considered. Seventy stems per acre is a density most closely related to the natural late successional density of a wooded riparian corridor for the region. Therefore, a density of 70 stems per acre was the preference during planning, but where 70 stems could not be achieved due to hydraulic constraints, a density of 30 stems per acre was tested against the hydraulic conditions.

Slackwater (SW): The slackwater management measure would support the ecosystem restoration objective by adding an important micro-habitat to the aquatic ecosystem.

Natural channel forming processes create areas, generally along the bank margins, where the velocity is slower. These are generally small areas, but they pay big benefits to the aquatic system. Slackwater habitats serve as velocity refugia for many aquatic organisms to rest and forage. Due to the slower velocities, allochthonous materials tend to congregate and pack in these areas, and therefore slackwaters are generally locations with high energy for the lower trophic aquatic organisms. The aquatic food chain of primary producers through to primary consumer is supported at a micro level in slackwater habitats. These are the locations that provide easy hunting and foraging for primary consumers due to the small area – high population effect of these habitats. Migratory birds utilizing stop-over habitats must consume a significant amount of energy in as little time as possible. Slackwater habitats provide a highly productive and concentrated energy resource that many migratory birds key into. Similarly, the slackwater habitats continue to provide a dependable energy resource for breeding birds to meet the energy demands of breeding and fledging young.

Major cost components for the establishment of slackwater are:

- minor excavation,
- minor grading, and
- slope armoring.

Implementation of the slackwater management measure would require mobilization of equipment and staging sites for each location. Since the pilot channel is continuous and requires multiple staging sites, significant cost reduction for this management measure would be realized by combining the slackwater work with the pilot channel work. Furthermore, due to the highly erosive nature of the existing channel, the slackwater areas would remain difficult to maintain without the installation of the pilot channel which would slow velocities. Therefore, slackwater would only be implemented in combination with the pilot channel.

Wetland (WL): The wetland management measure would support the ecosystem restoration objective by addressing the loss of aquatic habitat structure and function.

Off channel wetlands occur in low lying areas that retain overflow of the adjacent creek during overbank flow events. Because these areas are intermittently inundated and the underlying soils are saturated for longer periods of time, the vegetation in the wetland area is dominated by plant species that are adapted to wetter soil conditions such as sedges, rushes, and other wetland species. The relatively lush vegetation supports a rich and diverse invertebrate community that serve as the primary food resource for many upper level consumers. In addition, the dense wetland vegetation provides cover for many wildlife species, especially secretive species such as bitterns and rails which are camouflaged to blend in with the tall reeds and rushes of the wetland habitats.

Furthermore, the wetlands provide water quality benefits by trapping sediments and capturing excess nutrients and other pollutants from stormwater runoff. Wetlands also function as ‘sponges’ and provide some measure of flood protection by absorbing excess runoff and releasing it slowly after flood events.

Major cost components for the establishment of wetland include:

- real estate acquisition,
- excavation,
- grading,
- armoring,
- planting a diverse mixture of wetland vegetation, and
- provisions for short term actions to aide in establishment.

Implementation of the wetland management measure would require ensuring a consistent, if intermittent, source of water. The nearest source is Martinez Creek, but modifications to the existing channel would be required. Operation and maintenance of a wetland area would be labor intensive without a balanced sediment transport system. For this reason the team determined the wetland management measure would only be implemented in combination with the pilot channel management measure.

ALTERNATIVE COMPARISON

COMPARISON CRITERIA

The next step in formulation is to compare combinations of the final list of management measures through a Cost-Effective Incremental Cost Analysis. This analysis requires two criteria for the comparison: an ecological benefit criterion and a cost criterion.

The AIBI Model was used for the WSC to determine potential benefits gained with regard to the ecosystem restoration objective. The index is multiplied by the number of acres over which the measure(s) will be applied to derive the associated Avian Community Units (ACUs). The ACUs are annualized over a 75 year period to get Average Annual ACUs (AAACUs). A 75 year period was selected based on the length of time required for trees to reach maturity and provide full benefits. AAACUs for the future with project condition were subtracted from the future without project to determine the AAACU benefit for each fully formed plan; this represents the level of ecological lift of a plan over the future without project condition. First costs were annualized over 75 years at 3.75% to get average annual costs (AAC).

COST EFFECTIVE AND INCREMENTAL COST ANALYSIS

Utilizing the list of final management measures, a set of incrementally combined fully formed plans for each creek was developed. Table 4 displays the fully formed plans for each creek and associated AAACU and AAC. Riparian meadow was the only stand-alone management measure to be a fully formed plan. Seven incrementally formed plans were developed for San Pedro Creek, Alazán Creek, and Apache Creek, and thirteen plans were formed for Martinez Creek. Martinez Creek is the only one of the four creeks where the wetland management measure was feasible; incrementally building plans to accommodate this additional management measure accounts for the additional fully formed plans for Martinez Creek.

Table 4. Average Annual Avian Community Units (AAACU) and Average Annual Cost (AAC) for Alternative Comparison During the Westside Creeks Ecosystem Restoration Study.

	San Pedro		Alazán		Martinez		Apache	
Fully Formed Plans	**AAACU (Lift)**	**AAC ($1,000)**	**AAACU (Lift)**	**AAC ($1,000)**	**AAACU (Lift)**	**AAC ($1,000)**	**AAACU (Lift)**	**AAC ($1,000)**
Riparian Meadow (RM)	13	230	16	240	11	173	5	93
Riparian Meadow + Pilot Channel (PC)	16	555	19	615	14	666	6	211
RM + PC + RWV (30)	32	557	31	616	22	667	12	212
RM + PC + RWV (70)	36	558	33	617	24	668	14	212
RM + PC + Slackwater (SW)	20	573	23	633	16	670	6	216
RM + PC + Wetland (WL)	n/a	n/a	n/a	n/a	21	729	n/a	n/a
RM + PC + WL + SW	n/a	n/a	n/a	n/a	24	734	n/a	n/a
RM + PC + SW + RWV (30)	36	575	34	635	24	671	12	217
RM + PC + SW + RWV (70)	39	577	36	635	26	672	14	218
RM + PC + WL + RWV (30)	n/a	n/a	n/a	n/a	29	730	n/a	n/a
RM + PC + WL + RWV (70)	n/a	n/a	n/a	n/a	31	731	n/a	n/a
RM + PC + SW + WL + RWV (30)	n/a	n/a	n/a	n/a	32	735	n/a	n/a
RM + PC + SW + WL + RWV (70)	n/a	n/a	n/a	n/a	34	736	n/a	n/a

RM = Riparian Meadow; PC=Pilot Channel; RWV=Riparian Woody Vegetation; 30 & 70 refer to stem density per acre; SW= Slackwater; WL=Wetland.

All fully formed plans and associated AAACU and AAC were input in to the Institute for Water Resources (IWR) Planning Suite, version 2.0.6.0. This version of the Planning Suite has been certified for use as a planning model in USACE studies. IWR Planning Suite builds all combinations possible from the plans input and the relationships assigned. The combinations are compared for cost effectiveness and an incremental cost analysis (CE/ICA) is performed on the remaining cost effective combinations. The purpose of this CE/ICA analysis is to find a cost-effective final array of the incrementally justified plans. This final array would indicate which combinations of fully formed plans, when the creeks are combined, provide the best incremental annual benefit for the incremental annual cost. The final array of plans is referred to as the best buy array.

The CE/ICA analyzed 7,168 possible combinations; ninety-six of those plans were determined to be cost-effective. Of the cost-effective plans six action plans and the no-action plan were identified as the best-buy array. The best-buy array was carried forward as the final array of alternative plans for ecosystem restoration of the WSC, and the best-buy plans will be referred to as alternatives from this point forward.

Table 5 lists the seven alternatives, and which creeks and associated management measures are included for each alternative. Figure 7 is a graphical representation of the final array of alternatives and their and their respective incremental annual cost per output unit and incremental outputs.

Table 6 displays the costs and benefits characteristics for the six action alternatives in the final array.

Table 5. Final Array of Alternatives for Westside Creeks Study.

	San Pedro	Apache	Alazán	Martinez
Alt. 1	No Action	No Action	No Action	No Action
Alt. 2	RM, PC, SW, RWV	No Action	No Action	No Action
Alt. 3	RM, PC, SW, RWV	RM, PC, SW, RWV	No Action	No Action
Alt. 4	RM, PC, SW, RWV	RM, PC, SW, RWV	RM	No Action
Alt. 5	RM, PC, SW, RWV	RM, PC, SW, RWV	RM	RM
Alt. 6	RM, PC, SW, RWV	RM, PC, SW, RWV	RM, PC, SW, RWV	RM
Alt. 7	RM, PC, SW, RWV	RM, PC, SW, RWV	RM, PC, SW, RWV	RM, PC, SW, RWV,WL

RM = Riparian Meadow; PC=Pilot Channel; RWV=Riparian Woody Vegetation at 30 & 70 stems per acre; SW= Slackwater; WL=Wetland.

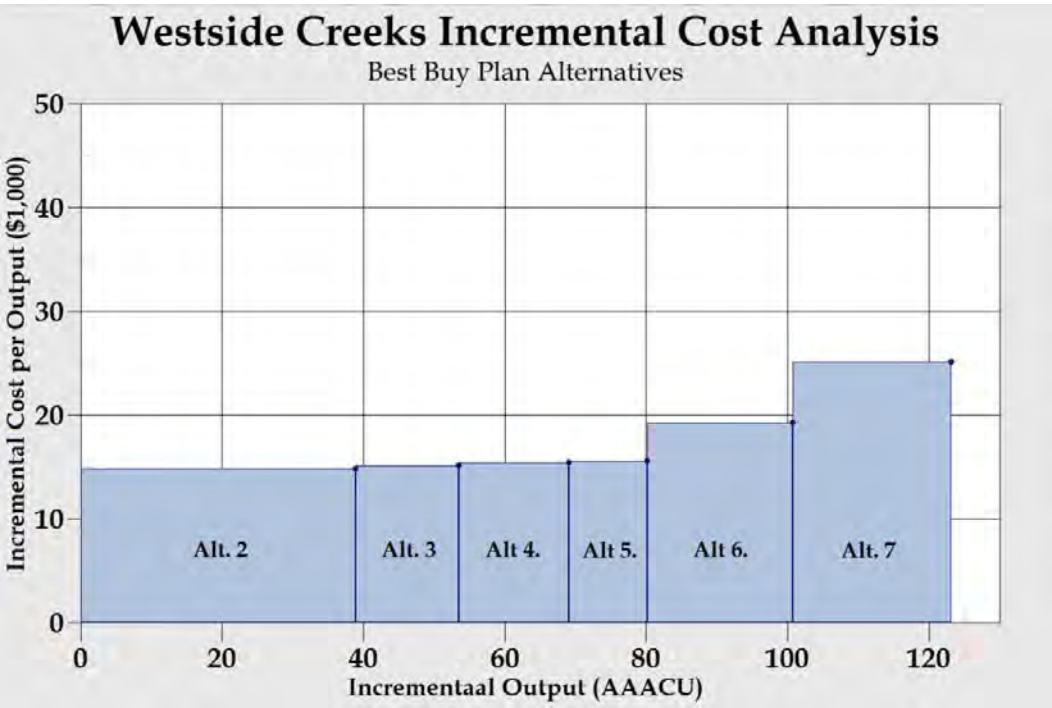


Figure 7. Final Array of Alternatives Resulting from the Cost Effective Incremental Cost Analysis for Westside Creeks Study.

Table 6. Cost and Benefit parameters for six action alternatives in the final alternative array of the Westside Creek study.

Cost and Benefit Category	Alternative					
	2	3	4	5	6	7
First Cost (October 2012 Prices)	$14,030,105	$19,340,894	$25,181,767	$29,392,546	$39,008,264	$52,700,093
Average Annual Cost	$576,550	$794,791	$1,034,815	$1,207,852	$1,602,998	$2,165,647
Total Average Annual Avian Community Units (with project)	101	147	227	285	305	328
Existing TAACU	62	94	158	204	204	204
Without Project Acres	67	101	172	222	222	222
With Project Acres	67	101	172	222	222	227
With Project TAAACU / Acre	1.49	1.45	1.32	1.28	1.37	1.44
Existing TAACU/ Acre	0.91	0.92	0.92	0.92	0.92	0.92
Benefit (ACCU)	39	53	69	81	101	124
Benefit Per Acre	0.58	0.53	0.40	0.36	0.46	0.54
First Cost ($1,000)	$14,030	$19,341	$25,182	$29,393	$39,008	$52,700
Annual Cost ($1000)	$577	$795	$1,035	$1,208	$1,603	$2,166
Incremental Benefit (AACU)	39	14	16	11	21	22
Average Annual Cost per AACU ($1000)	$15	$15	$15	$15	$16	$17
Incremental Annual Cost ($1,000)	$577	$218	$240	$173	$395	$563
Incremental Annual Cost per unit (AACU) ($1,000)	$15	$15	$15	$15	$19	$25
Incremental Annual Cost Per Acre ($1,000)	$8.56	$2.15	$1.40	$0.78	$1.78	$2.47
Total Cost Per Acre ($1,000)	$208	$191	$147	$132	$175	$232
Annual Cost Per Acre ($1,000)	$9	$8	$6	$5	$7	$10

The final array of alternatives represents an incremental cost ranking of those plans that best meet some level of the restoration to the WSC study area and improves the study area's ability to provide habitat to a diversity of migratory bird species. Some plans come closer to fully meeting the objective than others, but all provide some level of restoration that is cost effective.

NATIONAL ECOSYSTEM RESTORATION PLAN

The ACU measures avian diversity; the avian community resides at the higher trophic levels within the WSC riverine system. At the foundation of ecological principles is the fact that diversity at lower trophic levels is necessary to provide diversity at higher trophic levels. Therefore, a diverse avian community implies a diversity of organisms exists at the lower trophic levels. Because all the action plans in the final array of alternatives represent some level of restoration and provide limiting habitat for diverse mix of migratory bird species, additional criteria need to be considered during the “is it worth it” analysis to help differentiate each alternative from the others in selecting the recommended NER.

SELECTION CRITERIA FOR THE NATIONAL ECOSYSTEM RESTORATION PLAN

Each plan in the final array represents an incremental increase in the level of restoration which can be viewed from two perspectives – quantity of restoration (acres restored versus acres available) and quality of restoration achieved. Inherent in the concepts of quantity and quality for restoration of the WSC riverine system is also the idea of providing restoration that, to the extent practicable, addresses the carrying capacity potential of the study area. A large quantity of low quality restoration does not optimize the carrying capacity potential of the restoration area.

QUANTITY OF RESTORED RIVERINE HABITAT AS A SELECTION CRITERIA

Through the plan formulation process and the CE/ICA, the largest possible level of riverine restoration for the WSC study area was identified as Alternative 7. Therefore, the potential quantity of restoration along the WSC, as developed through this study, is limited to 227 acres of riparian habitat and 11.2 miles of creeks, and a total lift of 123 AAACU. With these maximum quantity parameters, selection criteria can be established for “the percent of available restoration achieved” to be considered with other criteria in deciding whether an alternative “is worth it”. Some alternatives in the final array provide a full suite of management measures applied to a particular amount of acres and stream miles; these alternatives offer the greatest level of restoration (full restoration) achievable for the specific area applied. Other alternatives provide a mix of full restoration along with partial restoration (riparian meadow only) on different portions of the WSC riverine system. The percent of available restoration achieved will therefore include the descriptive text “full restoration”, “partial restoration”, or “mixed levels of restoration” to help differentiate between alternatives regarding the restoration achieved.

QUALITY OF RESTORED RIVERINE HABITAT AS A SELECTION CRITERIA

The ACU provides a quantitative way to express benefits gained. However, the ACU by itself does not provide a measure of habitat quality. More habitat units do not necessarily indicate higher quality as simply adding more acres with a minimal increase in the suitability index will raise the number of habitat units. The suitability index, or in the case of WSC the avian index of biotic integrity (AIBI), is the measure of quality. For this analysis, the following formula was used to indicate a percent increase in quality for a plan over the no action alternative.

$$\left\{\left(\frac{AIBI_{best\ buy\ plan}}{AIBI_{future\ without\ project\ condition}}\right)-1\right\}\times 100 = percent\ increase$$

Examining the percent increase in habitat quality of each alternative over the no action alternative quality as a selection criterion allows a better understanding of the full benefits provided by each alternative in the final array.

CARRYING CAPACITY OF LOWER TROPHIC LEVEL ORGANISMS AS A SELECTION CRITERIA

The WSC restoration study objective is to provide a diversity of riverine habitat to better serve a diversity of migratory bird species (widest possible number of groups), but it is also to increase the amount of this limiting habitat available for migratory birds to serve the widest possible number of individuals. The AIBI addresses the question of species diversity (groups), but other criteria are needed to understand how the different alternatives address increasing carrying capacity (individuals) of any riverine migratory bird habitat restored.

Specific areas of structure and function losses within the WSC riverine system are discussed in Problem 1 – Degraded and Lost Riverine Structure and Function. The structural and functional degradation within the WSC culminates in lost habitat at the lowest levels of the riverine trophic system resulting not only in an inability for the existing habitat to support a diversity of primary consumer species, but also a loss of ability to support large numbers of individuals from any species at any trophic level (See Figure 6 and the WSC Ecological Food Web section). In ecological terminology, the WSC potential carrying capacity is not realized under the no action alternative. Plans which provide the greatest increase in the carrying capacity of the WSC study area are the most effective in realizing the objective of restoring a dynamic riverine ecosystem which supports migratory birds.

Carrying capacity was not directly measured for WSC. However, utilizing accepted ecological concepts regarding the number of individuals, or biomass, required to fuel a single unit of biomass at the next level of the trophic system can be utilized in a semi-quantitative assessment. Specifically, for the "is it worth it" analysis, a conceptual level of biomass (individual organisms) achieved at the primary producer level for each plan will be discussed. This conceptual level of primary producer biomass was developed using the common ecological concept that energy requirements for a species within an upper trophic level require an order of magnitude of energy from the trophic level immediately below it. For this analysis, the PDT assumed a single unit of biomass for each acre of restored riparian meadow, woody vegetation, or wetland, and a single unit of biomass for each riffle-pool complex restored as a result of the pilot channel management measure. The total percent biomass attributed to each best buy plan is a function of the contribution of each habitat's biomass:

$$\left\{\left(\frac{w_i}{w_7}+\frac{x_i}{x_7}+\frac{y_i}{y_7}+\frac{z_i}{z_7}\right)/4\right\}\times 100 = B$$

Where: w_i= the number of pool/riffle/run sequences for best buy plan *i*
x_i= the number of acres of restored riparian meadow for best buy plan *i*
y_i= the number of acres of restored woody vegetation for best buy plan *i*
z_i= the number of acres of restored wetlands for best buy plan *i*; and
B= the potential percent total biomass achieved by best buy plan *i*

UNCERTAINTY AND RISK CONSIDERATIONS AS SELECTION CRITERIA

The largest source of risk and uncertainty is associated with utility relocations. Based on professional judgment and past experiences in the region, utility relocations at or under 10% of project first costs are within the expected and acceptable levels for an urban waterway. Utility relocations are only associated with those plans which include the pilot channel management measure. For each alternative in the "is it worth it" analysis the proportion of first cost which is associated with utility relocations is reported. This is not so much a criteria for selection as it is a means to ensure that the utility risk and uncertainty of any plan considered for selection as the NER is understood, and that any plan which exceeds the 10% of first cost parameter is fully explained prior to consideration as the NER plan.

SELECTION CRITERIA FOR "IS IT WORTH IT" ANALYSIS OF FINAL ALTERNATIVE ARRAY

The "is it worth it" analysis for each action alternative includes quantitative and qualitative discussions utilizing the following selection criteria:

- incremental cost (AAC),
- incremental benefit (AAACU),

- quantity of available riverine habitat restored (expressed as percent of 227 riparian acres, 11.2 miles of stream, and the potential 123 AAACUs possible under full restoration),
- quality of restoration as compared to no action alternative (expressed as a percent of total WSC system),
- carrying capacity for lower trophic levels (expressed as a percent of total available), and
- uncertainty and risk as related to the percentage of costs to implement ecosystem restoration that are attributable to utility relocations.

Table 7 displays the selection criteria values for the six action alternatives. Each plan along the array represents an "enlargement" of the project in size and/or quality. Table 7 also shows the relative increase in the selection criteria values as the project is "enlarged". The following "is it worth it" section provides a discussion and analysis of the information presented in Table 7 and Figure 8.

IS IT WORTH IT ANALYSIS ON FINAL ARRAY OF ALTERNATIVES

NO ACTION – ALTERNATIVE 1

The no action plan is included as a point of comparison to other alternatives. With the no action plan, the WSC riverine system would continue to exist in its degraded state, and likely worsen as invasive vegetation continues to dominate. There would be no increase in habitat for migratory birds. The PDT feels that the no action plan is not acceptable.

IS IT WORTH IT? – ALTERNATIVE 2

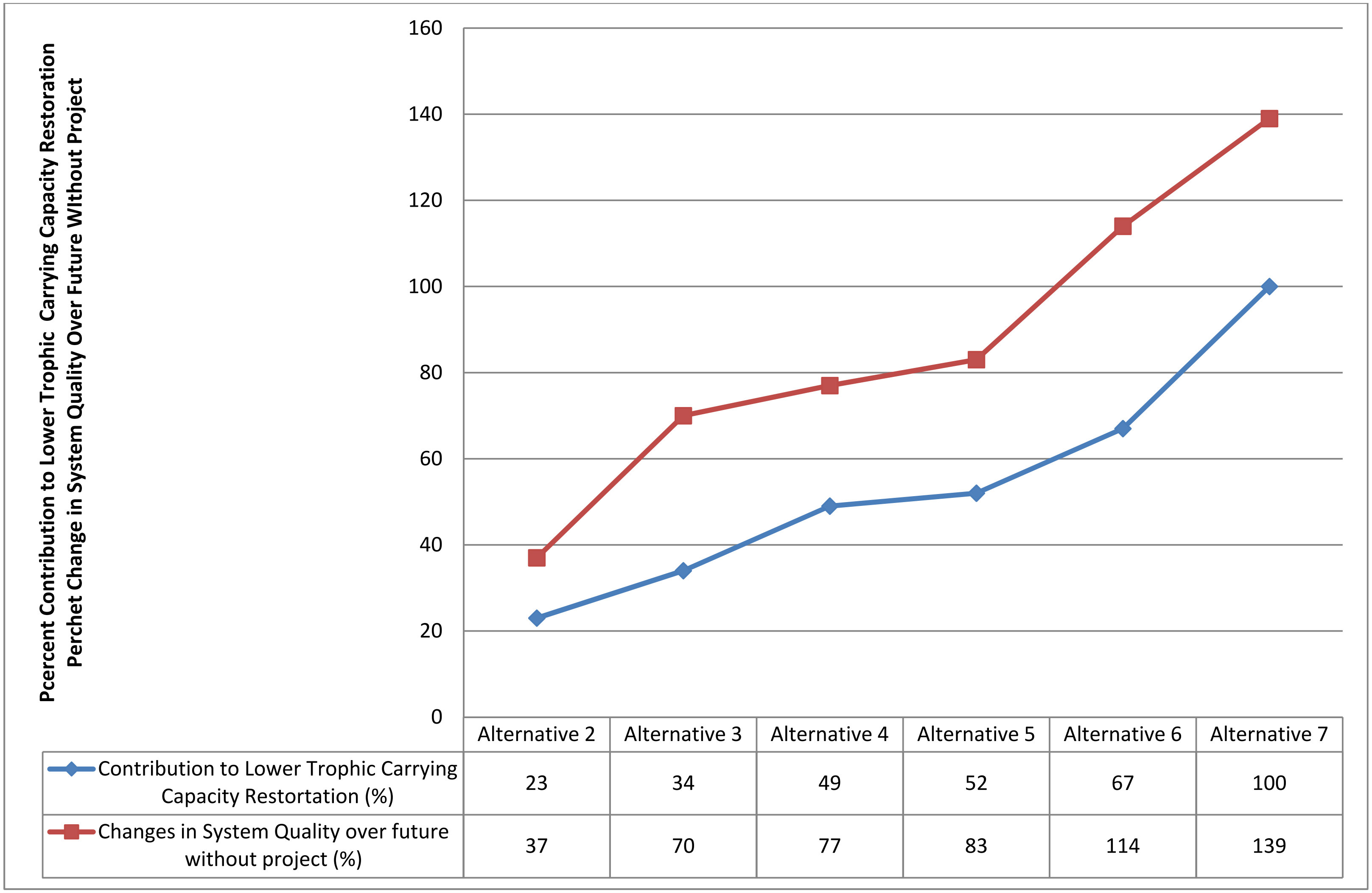
Alternative 2 provides restoration for 67 of the 227 acres available for riparian restoration and restores 2.4 miles of the 11.2 miles available for aquatic restoration within the WSC riverine system. This alternative includes a mixed meadow and woody vegetation riparian corridor and a pilot channel that restores 51 pool-riffle complexes along San Pedro Creek. Alternative 2 represents the fullest extent of riverine restoration possible for San Pedro Creek as found through the formulation of this study. The remaining 160 acres of riparian corridor and 8.8 miles of stream in the WSC riverine system would not receive any restoration under this alternative. Alternative 2 has a first cost (October 2012 prices) of approximately $14 million. The estimated cost of utility relocations along San Pedro Creek is $961 thousand, which represents 6.8% of the total first cost of this alternative.

The restoration measures implemented with Alternative 2 fully address, to the extent possible, all the previously described areas of structure and/or function loss or degradation along San Pedro Creek (Problem 1 – Degraded and Lost Riverine Structure and Function). Restoration of 51 pool-riffle complexes and a mixed meadow and woody vegetation riparian corridor would provide primary producer habitats necessary to restore a sustainable foodweb through all trophic levels of San Pedro Creek's riverine system.

From a quantity of available restoration perspective, Alternative 2 represents a 30% achievement in acres of riparian restoration, 21% in miles of aquatic restoration, and 32% of the available avian community units to be gained within the WSC riverine system (Table 7). The quality of the habitat for the WSC riverine system would increase 37% over the future without-project condition. The carrying capacity for lower trophic organisms would be 23% of the achievable carrying capacity restoration for the WSC system. This alternative provides 39 units of benefit at an incremental AAC of $15 thousand per incremental AAACU.

Table 7. Comparison of Action Alternatives Against National Ecosystem Restoration Plan Selection Criteria for the Westside Creeks Study.

	Incremental Cost (AAC)	Incremental Benefit (AAACU)	Incremental Cost per Output (AAC per AAACU)	Habitat Quality Increase Over no action (%)	Extent of Potential Restoration Achieved			Primary Producer Carry Capacity Restored (% of potential)	Total Utility Relocation Cost as a Percent of Total ER First Cost
					% of Total AAACU	% of Total Acres	% of Total Miles		
Alternative 2	$577	39	$15,000	37	32	30	21	23	6.8%
Alternative 3	$218	14	$15,000	70	43	44	46	34	7.5%
Alternative 4	$240	16	$15,000	77	56	44	46	49	5.8%
Alternative 5	$173	11	$15,000	83	65	44	46	52	4.9%
Alternative 6	$395	21	$19,000	114	82	98	75	67	6.8%
Alternative 7	$563	25	$25,000	139	100	100	100	100	18.9%



	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7
◆ Contribution to Lower Trophic Carrying Capacity Restortation (%)	23	34	49	52	67	100
■ Changes in System Quality over future without project (%)	37	70	77	83	114	139

Figure 8. Relative change of carrying capacity and system quality selection criteria for the of Westside Creeks alternative array.

Alternative 2 is worth the Federal and local investment. The addition of this diverse, high quality, high energy producing riverine habitat will allow a greater diversity and number of migratory birds to find the cover, resting, nesting, and most importantly the energy requirements necessary to successfully complete their migration or successfully complete nesting and breeding activities.

IS IT WORTH IT? – ALTERNATIVE 3

Alternative 3 provides restoration of an additional 34 acres of riparian corridor and 2.7 miles of aquatic habitat. Combined with restoration from Alternative 2, this alternative provides restoration for 101 of the 227 acres available for riparian restoration and provides the full restoration possible for 5.1 miles of the 11.2 miles available for aquatic restoration within the WSC riverine system. This alternative includes riparian meadow for 1.9 miles and mixed meadow and woody vegetation for 0.8 miles of the 2.7 mile riparian corridor of the creek. Alternative 3 achieves the fullest extent possible of riverine restoration for San Pedro Creek and Apache Creek. The remaining 126 acres of riparian corridor and 6.1 miles of stream along Alazán Creek and Martinez Creek would not receive any ecosystem restoration under this alternative. Alternative 3 has a first cost (October 2012 prices) of approximately $19 million and an average annual cost of $795 thousand. Utility relocations would be required for 0.8 miles along Apache Creek. The estimated costs of utility relocation for Alternative 3 are approximately $1.4 million, or 7.5% of the total first cost.

The restoration measures implemented with Alternative 3 fully address, to the extent possible, all the previously described areas of structure and/or function loss or degradation along San Pedro Creek and Apache Creek (Problem 1 – Degraded and Lost Riverine Structure and Function). Restoration of 67 pool-riffle complexes and a mixed meadow and woody vegetation riparian corridor will provide primary producer habitats necessary to restore a sustainable foodweb through all trophic levels for San Pedro Creek and Apache Creek.

For the WSC riverine ecosystem, Alternative 3 achieves 44% of the available restoration for riparian habitats, 46% of available of aquatic habitats, and 43% of the available AAACU benefit available. The quality of habitat over the no-action plan is increased by 70%, and of the restoration available 34% of the carrying capacity for lower trophic organisms is achieved with Alternative 3. This alternative provides 53 AAACU of benefit for an incremental AAC of $15 thousand per incremental AAACU.

Alternative 3 is worth the Federal and local investment. Alternative 3 furthers the riverine restoration of Alternative 2 upstream thereby increasing the total available quality habitat for diversity of migratory bird species and for a larger number of individuals within those species. For a 38% increase in first cost over Alternative 2, there is a 33% increase in the quality of the riverine habitat, and an 11% increase in avian diversity over Alternative 2. Alternative 3 provides an additional 14 units of benefit for the same incremental cost per incremental AAACU as Alternative 2 ($15 thousand per AAACU).

IS IT WORTH IT? – ALTERNATIVE 4

Alternative 4 provides partial restoration of an additional 71 acres of riparian corridor and 3.3 miles of aquatic habitat along Alazán Creek. Alazán Creek is the longest creek in the WSC riverine system and flows to Apache Creek. Combined with Alternative 3, a total of 172 acres of the 227 acres of available riparian corridor will have some level of restoration achieved, and of the available 11.2 miles of stream a total of 8.4 miles will have some level of restored function and/or structure. This alternative adds the riparian meadow management measure to Alazán Creek, thereby achieving the fullest possible riverine restoration for San Pedro Creek and Apache and providing partial restoration along Alazán Creek. The remaining 55 acres and 2.8 miles of riverine habitat along Martinez Creek would remain in the future without-project condition. Alternative 4 has a first cost (October 2012 prices) of approximately $25 million with an AAC of approximately $1 million. There would be no additional utility relocation beyond those reported for the previous alternative to implement Alternative 4; therefore, the utility relocation cost remains at approximately $1.4 million, which equates to 5.8% of total first cost.

The restoration implemented with Alternative 4 addresses structure and/or function loss and degradation along San Pedro Creek, Apache Creek, and Alazán Creek. Adding riparian meadow to Alazán Creek will improve carrying capacity for lower trophic organisms within the riparian corridor and provide limited improvement within the aquatic habitat within Alazán Creek. When combined with the full restoration achieved for San Pedro Creek and Apache Creek, this alternative increases carrying capacity for all trophic levels within the WSC riverine system. While this alternative does not achieve the full extent of restoration possible for Alazán Creek, it does incrementally increase the quality of habitat for the WSC riverine system by 7% over the previous alternative for a total increase of 77% in habitat quality over the no action alternative. Alternative 4 does not add any pool-riffle complexes, but it does add 71 acres of riparian meadow which achieves restoration of 49% of the potential primary producer carrying capacity achievable for the WSC riverine system.

Alternative 4 is worth the Federal and local investment. This alternative increases the total contiguous riverine habitat available for a diversity of migratory bird species and individuals. An incremental increase of 16 AAACUs occurs with Alternative 4 for a combined total of 69 units of total benefit at an incremental AAC of $15 thousand per incremental AAACU. Lower trophic level carrying capacity is increased by 12% over the previous alternative. Alternative 4 would achieve 56% of the total available avian diversity benefit achievable for the WSC riverine system, which is an increase of 13% over Alternative 3. Avian diversity benefits are increased by 16 units with Alternative 4 at the same incremental cost per incremental AAACU as Alternatives 2 and 3 ($15 thousand per AAACU).

IS IT WORTH IT? – ALTERNATIVE 5

Alternative 5 provides partial restoration of an additional 50 acres of riparian corridor and 2.8 miles of aquatic habitat along Martinez Creek. Combined with Alternative 4, a total of 222 acres of the 227 acres of available riparian corridor will have some level of restoration achieved, and all of the 11.2 miles of available stream will have some level of restored function and/or structure. Only 5 acres of available riparian acreage would remain without some level of restoration applied. The incremental habitat restoration gained with Alternative 5 is riparian meadow along Martinez Creek. With this alternative some level of restoration would be achieved for all creek segments within the WSC riverine system. The fullest possible restoration identified would occur along San Pedro Creek and Apache Creek with partial restoration along Alazán Creek and Martinez Creek. Alternative 5 has a first cost (October 2012 prices) of approximately $29.4 million with an AAC of approximately $1.2 million.

No additional utility relocations would be required for implementation of this alternative, and utility relocation cost remains at $1.4 million, equating to 4.9% of total first cost

Implementation of Alternative 5 provides improved lower trophic level carrying capacity for the entire WSC riverine system and achieves 52% of the total available restored capacity identified. Similar to Alternative 4, the full potential of restoration is not achieved for Martinez Creek; however, this alternative does incrementally increase the quality of habitat for the entire WSC riverine system by 6% over the previous alternative for a total increase of 83% over the no action alternative.

Alternative 5 has a first cost (October 2012 prices) of approximately $29.4 million with an AAC of approximately $1.2 million). An incremental increase of 11 AAACUs occurs with Alternative 5 for a combined total of 80 units of total benefit at an incremental AAC of $15 thousand per incremental AAACU.

Alternative 5 is worth the Federal and local investment. Alternative 5 provides an increasing level of benefit for the same incremental cost per incremental AAACU as Alternatives 2, 3 and 4 ($15 thousand per AAACU). Alternative 5 requires an incremental increase of approximately $4.2 million over the approximate $25 million first cost of Alternative 4. The 80 total AAACUs achieved with Alternative 5 represent 65% of the total benefits determined as achievable for the WSC system, an increase of 9% over the previous alternative. Alternative 5 increases the available restored habitat for use by migratory birds by approximately 31% for a 17% increase in first cost.

IS IT WORTH IT? – ALTERNATIVE 6

There are no additional acres of riparian meadow or miles of creek added with this alternative. But, Alternative 6 increases the quality of restoration and increases the lower trophic organism carrying capacity for 71 acres of riparian corridor and 3.3 miles of aquatic habitat within the WSC riverine system. The increment of restoration achieved with this alternative is the addition of the pilot channel, slackwater, and riparian woody vegetation management measures to Alazán Creek. When combined with the riparian meadow restoration achieved in Alazán Creek from Alternative 4, this alternative represents restoration to the fullest extent possible for this 3.3 mile creek. Therefore, with this alternative partial restoration would be achieved along 8.4 miles of aquatic and 222 acres of riparian corridor, or 75% and 98%, respectively, of these riverine habitats types available in the WSC system. The implementation of Alternative 6 provides a 114% improvement in habitat quality over the no action alternative, and represents an incremental increase of 31% in habitat quality over Alternative 5.

Alternative 6 more than doubles lower trophic productivity and carrying capacity compared to Alternative 5 enabling the WSC sytem to support significantly higher numbers of organisms within each species. This is done in part by adding 79 pool-riffle complexes for a restoration of 146 pool-riffle sequences in the 11.2 mile WSC riverine system. When combined with the riparian meadow, riparian woody vegetation, and slackwater management measures implemented with this alternative, 67% of the lower trophic organism carrying capacity is restored for the WSC riverine system. Twenty-one AAACUs are incrementally added for a total migratory bird diversity benefit of 101 AAACUs, which represents 82% of the diversity benefits available in the system.

Alternative 6 has a first cost (October 2012 prices) of approximately $39 million with an AAC of approximately $1.6 million. Additional utility relocations would be required with implementation of this alternative. Moving from Alternative 5 to Alternative 6, first costs increase by $9.6 million dollars while utility relocation costs increase by $1.2 million. The total utility relocation cost associated with Alternative 6 is $2.7 million, or 6.8% of the total first cost to implement.

While Alternative 6 represents a 33% increase in first cost and a 25% increase in AAC, which is the largest increase in first cost and AAC of all previous alternatives, this alternative is worth the Federal and local investment. As demonstrated in Figure 8, Alternative 6 represents surge in habitat quality and lower trophic carrying capacity benefits. While the values for these two benefit categories continued to increase with previous alternatives, these increases were demonstrating a flattening trend; however, with Alternative 6 the graph demonstrates the sharp rise in these benefits. Alternative 6 has an incremental average annual cost of $19 thousand per incremental AAACU, which is $4 thousand more per AAACU than previous alternatives. This represents a 27% increase in cost per unit of migratory bird diversity benefit. However, this alternative provides an overall increase in habitat quality of 31%, and the 116% increase in pool-riffle complexes contributes to the achievement of over two thirds of the available carrying capacity for lower trophic organisms. Alternative 6 provides limiting habitat to a diverse group of migratory bird species and, in comparison to Alternative 5, more than doubles the carrying capacity of the WSC system. Millions of birds utilize the Central Flyway during their migratory journey each spring and fall, and each individual must compete for the limited amount of quality riverine stop-over habitat available. The ability of Alternative 6 to support large numbers of individuals as well as a variety of bird species more fully addresses the restoration objective than the previous alternatives in the final array.

IS IT WORTH IT? – ALTERNATIVE 7

Partial restoration of Martinez Creek was achieved with Alternative 5 which added riparian meadow to the creek corridor. Alternative 7 increases the quality of restoration for 50 acres of riparian corridor and for 2.8 miles of aquatic habitat with the WSC riverine system by adding the pilot channel, riparian woody vegetation, and slackwater measures to Martinez Creek. Alternative 7 also adds a 5 acre wetland adjacent to Martinez Creek, bringing the total acreage restored to 227. The additional restoration achieved with Alternative 7 is a diverse mix of meadow and woody vegetation in the riparian corridor of Martinez Creek and increased aquatic restoration. The implementation of the pilot channel measure provides an additional 77 pool-riffle complexes in the creek's aquatic habitat. Alternative 7 has a first cost (October 2012 prices) of approximately $52.7 million with an AAC of approximately $2.2 million. This alternative incrementally provides 22 AAACU for a combined benefit of 123 AAACU at an incremental AAC of $25 thousand per incremental AAACU.

Alternative 7 represents a 35% increase in first cost and AAC. This increase in cost is larger than the increase seen for Alternative 6, but the increase in AAACU is only approximately 22% as compared to the 26% increase shown with Alternative 6. The alternative provides a 52% increase in pool-riffle complexes as compared to the 116% increase provided by Alternative 6. Alternative 7 does provide an overall increase of 139% in habitat quality for the WSC riverine system as compared to the no action alternative.

The single largest reason for the significant increase in cost for Alternative 7 is associated with utility relocations required to implement the pilot channel management measure. The estimated utility relocation cost for Alternative 7 is approximately $9.9 million, which represents approximately 19% of the total first cost to implement Alternative 7. This is twice the percent of first cost for utility relocation considered acceptable by the PDT for urban ecosystem restoration. Moving from Alternative 5 to Alternative 6, first costs increase by $9.6 million dollars while utility relocation costs increase by $1.2 million. Approximately 12.7% of the increase in total cost relates to relocations, and 87.3% of the costs would be directly related to constructing ecosystem restoration measures in Alternative 6. Moving from Alternative 6 to Alternative 7, first costs increase by $13.7 million while utility relocation costs increase by $7.3 million; approximately 53% of the increase in costs is due to utility relocations. Only 47% of the increase in total costs results from constructing additional ecosystem restoration measures. Since most of the cost increase associated with Alternative 6 is directly attributable to ecosystem restoration measures, and the ecosystem restoration benefits (AAACU, quality and capacity) are increasing as well, moving to Alternative 6 is justified. However, a high percentage of the cost increase incurred when moving from Alternative 6 to Alternative 7 is associated with utility relocations and not construction of ecosystem restoration measures. Therefore, Alternative 7 is not deemed worth the increase in cost for the benefits gained.

Given the risk and uncertainty associated with the buried utilities, and the 35% increase in first cost compared to the 22% increase in AAACUs, the benefits of Alternative 7 are not worth the cost and risks associated with implementation of this alternative.

SELECTION OF NATIONAL ECOSYSTEM RESTORATION PLAN

Alternative 6 is recommended as the National Ecosystem Restoration (NER) Plan. This alternative achieves an 86% restoration solution and provides the most practicable alternative to address the ecosystem restoration objective for WSC.

NATIONAL SIGNIFICANCE – MIGRATORY BIRDS AND THE CENTRAL FLYWAY

Migrating and breeding birds utilize riparian habitats more than any other habitat in North America with many species considered riparian obligates because quality riparian habitat is a life requisite. As is the trend throughout the nation, naturally functioning riverine ecosystems in the southwest are decreasing. Due to the historic rarity of these systems in the southwest the impact of their loss or degradation is more acutely felt. Their loss and/or degradation places extreme pressures on the carrying capacity for the few remaining functional systems and places further stress on the South Texas ecoregion when considered in connection with the life requisites of the migratory birds of the Central Flyway.

The WSC study area represents an ecologically unique location important to a successful migration and breeding of neotropical migrants utilizing the Central Flyway. Whether from a broad multi-national perspective or a regional perspective, the WSC study area is recognized as sitting on a conceptual transition zone between arid and mesic, as well as, tropical and temperate climates. The uniqueness of the WSC study area is attributed to not only its location along the southern portion of the Central Flyway, but also to its ability to provide a last stop for fall migration or first stop for spring migration providing ecological diversity to accommodate the riverine stop-over habitat needs to a wide range of migratory bird species. Specifically, the WSC study area offers an opportunity to provide riverine habitat at a critical location along the Central Flyway.

Although migratory birds are capable of making spectacular nonstop flights over large distances, few migrants actually engage in nonstop flights between wintering and breeding habitats. Instead, migration is divided into alternating phases of flight and stop-over. Cumulatively, the time migratory birds spend at stop-over sites far exceeds the time spent in flight and is the primary determinant in the total duration of the migration. Riverine habitats provide more productive foraging environments in a concentrated area than associated uplands, and many bird species key into riparian areas as they fly through unfamiliar habitats, especially those migrating through the southwestern U.S. Because migratory birds in the southwestern U.S. depend on these riparian and aquatic habitats to successfully complete their northward migration to breeding grounds, these stop-over habitats, including WSC, are essential for the conservation, survival, or recovery of migratory birds and can be defined as “limiting habitats” as defined in the PGN.

NATIONAL ECONOMIC DEVELOPMENT PLAN

In addition to the NER component, the recommended plan will also include a recreation component that will generate National Economic Development (NED) benefits. The recreation component would be similar in features for each alternative, differing only in scale. For this reason, recreation was only formulated for the recommended NER plan. As described in ER 1105-2-100, recreation features cannot increase the Federal cost of the ecosystem restoration project by more than 10%. The recreation component was formulated at a first cost of $ 5.3 million, which increases the Federal cost of the ecosystem restoration project by less than 10%.

Formulation for recreation was performed at a broad level. Because recreation must be consistent with the ecosystem restoration so that ecosystem restoration benefits are not reduced by recreation features, the final number and placement of recreation features will require a greater degree of ecosystem restoration design than exists in the WSC GRR. In addition to compatibility with the ecosystem restoration component, formulation for recreation is also consistent with the Westside Creeks Restoration Conceptual Plan and City of San Antonio parks master planning. The central element of the recreation plan is a 44,600 linear foot trail system placed within the authorized SACIP ROW connecting existing trails, parks, and the Mission Reach trails where possible. In addition to trails, other components include shade structures (6), interpretive/directional signage (50), benches (15), water fountains (15), picnic tables with pads (23), and trash receptacles (23).

To determine annual costs, net benefits and the benefit-to-cost ratio, the following parameters were used: 3.75% Federal discount rate (per EGM 13-01 for FY 13), a 50 year period of analysis, 18 month construction time, and an annual OMR&R cost of $39 thousand. The recreation first cost was rounded up to $5.3 million. The annual cost for the recreation component is $282 thousand. Annual benefits, estimated using the Unit Day Value Method, are $3.9 million. Net benefits for recreation are $3.6 million. The benefit-to-cost ratio for recreation is 3.74.

TENTATIVELY SELECTED PLAN

The recommended plan for the WSC is the combination of the recommended NER and NED plans. It provides partial to full restoration for 222 acres and 11.2 stream miles covering all four creeks in the WSC as well as 8.4 miles of concrete trails while maintaining the current performance level of the existing FRM channels. The restoration features include the establishment of mixed native riparian meadows and woodlands, and in stream features to restore and sustain pool-riffle complexes and slack water areas. Recreation features associated with the walk, jog, and bike trails include shade structures, water fountains, picnic tables, benches, and information boards providing directions, safety information, and educational information.

For the Westside community, restoration of the WSC ecological structure and function will bring back an urban creekway ecosystem that once was known for social gathering, fishing, swimming holes and natural summer wading pools, crawdads, bullfrogs and birds. Interaction with these creeks is as much a part of the culture of the community as they are part of the ecosystem. Through the local creation of the Westside Creeks Restoration Conceptual Plan and the first round of this feasibility study’s NEPA public meetings, the local neighborhoods have spoken passionately about what a restored ecosystem would mean today, tomorrow and for generations to come. They envision all generations once again safely interacting with the creeks, enjoying hike and bike trails and reconnecting with nature in an urban setting. The Westside neighborhoods have great pride in all four creeks and they look forward to witnessing their environment restored and seeing it contribute to the broader health of the San Antonio River Watershed, the Central Flyway, and the existing Mission Reach and Eagleland ecosystem restoration projects.

Migratory bird numbers are declining, and stop-over habitat has just recently been recognized as a limiting habitat that is essential for the conservation and survival for these birds. From a national perspective, the recommended plan will provide 222 acres and 11 miles of restored riverine habitat to counter the negative trend of loss and degradation occurring in riverine systems, one of the most sought out stop-over habitats by migratory birds. Ecosystem restoration benefits garnered from implementation of the WSC NER plan will be amplified through the connection the project will have with previously restored and protected riverine and upland habitats within and alongside the SACIP. As stated by Dr. Rodewald in the Cornell Lab of Ornithology letter of support, the cumulative impact of restoration to WSC, when added to other national efforts for reversing the trend of loss and degradation of migratory bird stop-over habitat is tremendous (Appendix N).

As shown in Table 8, the combined ecosystem restoration and recreation recommended plan first cost is $42.9 million with an annual cost of $1.8 million.

Table 8. First Annual Cost for the Westside Creeks Tentatively Selected Plan Using the 2010 Cost Book.

Component	First Cost ($ millions)
Ecosystem Restoration	$39.0
Recreation	3.9
Recommended Plan	$42.9
Annual Cost at 3.75% over 75 years	$1.8

Costs during plan formulation were developed using MII V 4.1 software and the 2010 Cost Book. The effective date of costs was set at October 2012. After the NER Plan was chosen and concurred with by USACEHQ, the Fort Worth District upgraded to MII V4.2 and the 2012 Cost Book. Costs for the recommended plan were updated with the 2012 Cost Book, with the effective date remaining at October 2012. The change in costs of restoration alternatives was proportional, and 4% or less for every alternative. The resulting change in cost for the NER Plan is an increase of $6.3 million; so, the estimated first cost for the NER plan using the 2012 Cost Book is $45.3 million. The estimated first cost for the NED Plan using the 2012 Cost Book is $5.3 million. Therefore, the estimated first cost for the NED/NER Plan is $51 million (Table 9).

Table 9. First annual cost for the Westside Creeks tentatively selected plan using the 2012 Cost Book.

Component	First Cost ($ millions)
Ecosystem Restoration	$45.3
Recreation	5.3
Recommended Plan	$50.6
Annual Cost at 3.75% over 75 years	$2.1

REGIONAL ECONOMIC DEVELOPMENT, ENVIRONMENTAL QUALITY, AND OTHER SOCIAL EFFECTS

In addition to the NED and NER accounts, three other accounts for consideration are identified in the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) and ER 1105-2-100, Planning Guidance Notebook (PGN): Regional Economic Development (RED), OSE, and Environmental Quality (EQ). The following provides a description of these accounts and the potential effects of the RECOMMENDED PLAN.

RED considers the changes in the distribution of regional economic activity that could result from the plan. It is expected that providing recreation opportunities to this currently underserved area could result in an increase in overall recreation use. Additionally, since there is a shortage of recreation in the San Antonio area, it could be expected that recreation activities could shift from currently overburdened areas to the newer trails.

EQ considers effects of significant natural and cultural resources. EQ in the WSC would be improved by restoring a more natural riverine system as well as by the community response to the restoration and recreation opportunities. The RECOMMENDED PLAN is expected to generate renewed pride and social connectivity in the WSC communities to each other and the creeks, increasing interest in local programs to improve the environmental quality of the creeks for additional recreation opportunities in the future. In addition, studies have shown natural riparian corridors have positive impacts on water quality and air quality in the immediately surrounding area.

OSE registers plan effects that are relevant to the planning process, but not reflected in the other three accounts. Residents of the WSC communities share tales of a childhood where the creeks were a gathering point for community social activities. The RECOMMENDED PLAN provides facilities to support these social gatherings in a way that minimizes the risk to the restored environment. Providing trails for biking reduces bike traffic on the roads and complements the Department of Transportation’s plan to reduce bicycle related crashes and fatalities. Providing easily accessible recreation opportunities supports national programs to reduce obesity in a community that has the highest rate of childhood obesity in San Antonio. The RECOMMENDED PLAN provides opportunities for improved physical and psychological health.

EFFICIENCY, ACCEPTABILITY, COMPLETENESS, AND EFFECTIVENESS

Both the P&G and the PGN require plans be considered for completeness, effectiveness, efficiency, and acceptability. Below is a discussion of the four evaluation criteria as related to the RECOMMENDED PLAN for the WSC.

Efficiency is the extent to which an alternative is the most cost-effective means of addressing the identified problems and opportunities. Formulation of the NER component of the RECOMMENDED PLAN utilized a cost effective incremental cost analysis which resulted in an array of cost-effective plans. The recommended NER was selected from the final array of cost-effective plans through a qualitative and quantitative analysis presented in the section entitled National Ecosystem Restoration Plan. The RECOMMENDED PLAN would be implemented within a previous USACE authorized and constructed FRM project and therefore requires a level of engineering expertise more appropriate to USACE than other agencies.

Acceptability is addressed in two ways – implementability and satisfaction. Implementation of WSC RECOMMENDED PLAN is technically feasible and environmentally acceptable. The addition of ecosystem restoration and recreation purposes as described in the RECOMMENDED PLAN would not have adverse impacts on the existing FRM component of the SACIP. The restored riverine benefits and their positive contribution to limiting habitat for migratory birds is supported by the U.S. Fish and Wildlife Service and other agencies and groups. The local sponsor and WSC community are supportive of the efforts to restore the ecological function of the creeks as well as the community cohesiveness lost with channelization.

Completeness ensures all necessary components of the plan are accounted for so that benefits are realized. The planning team worked throughout the formulation process to address to the extent possible all necessary investments or actions to ensure benefits would be realized with implementation of any plan. However, some factors are beyond the control of the planning or implementation teams. Perhaps the biggest factor that would not eliminate but could delay the realization of all the recommended plan benefits is the potential for prolonged drought conditions in the south Texas region. Currently, there has been three years of on-going drought conditions. Such conditions can complicate establishment of restored vegetation. However, another similar river restoration project in the area is having success in establishing native vegetation during these conditions, and the lessons learned from that project are available in advance of implementation of a project for WSC. Conversely, the on-going drought conditions only emphasize the importance of restoration for the aquatic component of the WSC riverine system. For south Texas creeks and rivers, the most critical summer-time component to aquatic organisms is properly functioning, and spaced pools of adequate depth. The recommended plan would provide an appropriate number of functional pool habitats in San Pedro, Apache, and Alazán Creeks to sustain a healthy robust aquatic community during the hot summer months and drought conditions.

Effectiveness is how well a plan addresses the stated problems and opportunities and contributes to attaining the stated objective(s). The recommended plan for WSC would achieve restoration on 98% of the available acres and 75% of the available stream miles identified for the project. The restoration would increase the habitat quality for the WSC riverine system by 114% over the no-action alternative, and optimizes 67% of the carrying capacity for lower trophic organisms in the system. These numbers indicate that the restoration objective to restore the riverine ecosystem and provide habitat for aquatic and riparian dependent migratory birds is achieved to the extent practicable. Combined with the recreation NED plan, the restoration features of the WSC recommended plan will provide a hospitable environment for families of the WSC community to enjoy, learn, and value the natural environment while building a combined socially and ecologically sustainable community.

CHAPTER 4: ENVIRONMENTAL CONSEQUENCES*

Generally, an environmental consequences section would include discussion regarding the impacts of various alternative plans on the natural resources of the study area, allowing the study team to determine whether any potential adverse environmental impacts might preclude the selection of one alternative over another. However, since all the creeks included in this study were in the same homogenous state (grass-lined trapezoidal flood channels with no native riparian habitat), the restoration measures identified for each creek are the same, only differing in scale of application. This resulted in a final set of alternatives that are additive, meaning that each progressive alternative includes all restoration elements of the previous alternative and then adds another increment of restoration, until the final alternative includes full restoration of all the creeks to the extent practicable. Thus, discussions of environmental consequences have been limited to the “no action” alternative and Alternatives 5, 6 and 7, which all include at least partial restoration to all the four creeks and would impact the majority of the acreage within the study area.

LAND USE

As stated in Chapter 2, Land Use*, the WSC study area is completely developed with residential, industrial, and urban land uses. Under the No Action Alternative this wouldn’t change.

Ecosystem restoration along the WSC is consistent with current land uses and enhances existing public use areas and the general quality of life for local residents. For Alternatives 5, 6, and 7, a total of 222 to 227 acres of riparian corridor would have some level of ecosystem restoration achieved. In addition, 8.4 miles of recreational trails would be constructed along the four WSC with each of these alternatives; however, the land use and FRM function of the study area would remain unchanged.

For Alternatives 5, 6, and 7, there would be an insignificant impact to land use for the disposal site, since site selection criteria includes compatibility with existing land uses and compliance with the FPPA. There would be an inconsequential impact to the disposal site resulting from implementation of the proposed alternatives. The excavated soil would be mounded at the disposal site then contoured to blend into the surrounding area. Appropriate runoff and erosion management Best Management Practices (BMPs) would be utilized at the disposal site until the successful establishment of site-specific native vegetation. The placement of spoil on this site would result in a change to the topography of a small geographic area.

GEOLOGY

The existing faults that cross portions of the study area are inactive and would not be impacted by the proposed project activities. Since the No Action Alternative would leave the floodway in its existing condition, no adverse impacts to the WSC geology would result. Although Alternatives 5, 6 and 7 would require excavation of a pilot channel within the floodway, the maximum depth of the excavation would only be approximately 6 feet with an average of 2 feet; therefore the excavation would not impact any sensitive or significant geological features.

SOILS

Because the study area is located within the city limits of San Antonio, Section 1541(b) of the FPPA of 1980 and 1995, 7 U.S.C. 4202(b), does not apply to prime farmland soil types within the study area. Furthermore, the soil structure within the existing SACIP project area has been previously disturbed and modified and is now more consistent with urban soil complexes.

NO ACTION

Under the No Action Alternative, soils would not be directly impacted by ground disturbance; however, sediment transport within the WSC would remain imbalanced requiring continued maintenance of the floodway and channel due to erosion and sedimentation.

ACTION ALTERNATIVES

Under implementation of any of the action alternatives, several activities have the potential to expose soils. These include: 1) excavation of various lengths and segments of the existing channels in one or more of the WSC's to establish pilot channels that would restore pool/riffle/run complexes in the system; 2) reconfiguration of most of the stormwater outfalls within the applicable reaches to a more natural condition through removal of existing concrete headwalls and linings; 3) removal of concrete and rock riprap armoring along the applicable reaches, with the exception of the upper reaches of Apache Creek. In addition, for each alternative the upper six inches of soil within the floodway would be excavated to remove the non-native seedbank, herbicide would be applied to prevent non-native species from resprouting, the exposed subsoil would then be ripped to a depth of 12-inches, 8-inches of organic topsoil would be distributed throughout, and the affected area revegetated with site-specific native vegetation to stabilize the soils and restore ecological functions. During project implementation, appropriate BMPs would be applied to reduce and control runoff and erosion until the vegetation becomes sufficiently established.

Implementation of any of the action alternatives would result in temporary impacts to soils during construction since the removal of vegetation would expose the soils to increased wind and water erosion. These impacts would be minimized by the use of appropriate BMPs for controlling runoff, erosion, and sedimentation.

In the long-term, soils along the WSC would be stabilized through the presence of native riparian vegetation. Additionally, soils would improve in richness over time, due to the large contribution of organic matter from the establishment of native trees and shrubs.

CLIMATE

Because of the limited scale of the WSC study area, none of the alternatives, including the No Action Alternative, would affect climatic conditions.

RIVERINE RESOURCES

Each proposed alternative for the WSC study would restore a level of riverine ecosystem function to the WSC floodway. The riverine resources for WSC encompass the ecological elements that comprise a healthy, functional, aquatic ecosystem, including the aquatic, riparian, and adjacent upland environments in the WSC study area. Because the WSC study is an ecosystem restoration study, impacts to the WSC riverine resources are designed to be beneficial. The potential impacts to riverine resources resulting from the implementation of each alternative are assessed below.

VEGETATION

NO ACTION

Under the No Action Alternative, there would be no direct impacts, but the floodway vegetation would continue to be routinely mowed and maintained. The existing non-native, invasive species would continue to provide a seed source for dispersal downstream, contributing to the spread of non-native invasive species and adversely impacting downstream restoration efforts.

ACTION ALTERNATIVES

As part of ecosystem restoration, all action alternatives include the reestablishment of site-specific, native plant species. Creek margins, slackwater areas, and wetlands would be planted with hydrophilic (water loving) vegetation making these areas highly productive environments for many species of fish, reptiles, amphibians, birds, and small mammals. There would be significant beneficial effects from planting approximately 222 to 227 acres of native riparian vegetation, and establishing hydrophilic vegetation in the wetter areas. Appropriate native vegetation would improve water quality by filtering out sediments and chemical constituents. Additionally, it would provide forage, cover, and organic inputs to the riverine ecosystem, developing the lower trophic levels utilized by fish and wildlife species that have been absent from the WSC for the past 40 to 50 years and improving aquatic habitat quality. Site-specific native vegetation would also be planted on the disposal site where the excavated material from WSC is placed.

For each of the action alternatives, the proposed wetland and woody vegetation would further increase the organic allochthonous material to the aquatic system and provide the energy to the lower level trophic organisms that drive and support the WSC ecosystem.

The appropriate use of BMPs such as erosion control practices and tree protection devices at construction sites would protect existing trees and large blocks of vegetation/habitat adjacent to the construction areas. Temporary construction impacts to vegetation within staging areas are not anticipated, since staging areas would be either within the SACIP boundaries or located next to the boundaries on hardened surfaced (i.e. concreted) areas. Additionally, temporary impacts to vegetation within temporary construction easements would not occur since the WSC proposed alternatives are located primarily within the original SACIP footprint. Installation of appropriate vegetation within the WSC would provide connectivity of these upland sites with riparian forest and stream habitats, more closely mimicking historical conditions.

WETLANDS AND WATERS OF THE U.S.

The WSC are jurisdictional waters of the U.S. and subject to protection under Sections 401 and 404 of the CWA. Although a USACE permit would not be issued for the proposed ecosystem restoration (USACE does not permit its own actions), probable construction activities associated with implementation of any of the proposed action alternatives have been reviewed by USACE (Fort Worth District Regulatory Branch), and would be covered by Nationwide Permit (NWP) 27, Stream and Wetland Restoration Activities.

In Texas, all activities carried out in compliance with the terms and conditions of NWP 27 are also considered to be in compliance with Section 401 of the CWA and do not require separate permitting for Water Quality Certification from TCEQ. A more detailed description of how the proposed alternatives meet the criteria set forth under NWP 27 is provided in the Environmental Compliance, Section 404 of the Clean Water Act section of this GRR and integrated EA.

NO ACTION

Under the No Action Alternative, there would be no direct impacts to waters of the U.S. other than those that routinely occur from on-going maintenance activities and due to unbalanced sediment transport processes, such as erosion and sediment deposition.

ACTION ALTERNATIVES

There would be no net loss of wetlands or waters of the U.S. resulting from construction of any of the action alternatives and, although the WSCs would not be restored to their original conditions, sediment transport and biological function would be restored by implementation of any of the alternatives for the stream segments impacted as each higher numbered alternative adds channel restoration activities to greater lengths of streams segments than the previous alternative.

The disposal site will be located in an upland environment and will not impact waters of the United States.

SURFACE WATER QUALITY

As stated in Chapter 2, Surface Water Quality*, segments 1911B, 1911C, and 1911D of the San Antonio River (Apache, Alazán, and San Pedro Creeks) are listed as impaired waterbodies in the 2012 Draft 303(d) list for aquatic life, recreational, and/or general uses. Stormwater, which is important to surface water quality, has the potential to introduce sediments and other contaminants (petroleum products, chemicals, etc.) into lakes, rivers, and streams. Generally, higher densities of development (i.e. urban areas such as the WSC study area) require greater degrees of storm water management due to higher proportions of impervious surfaces, and rapid runoff that occurs following a storm.

NO ACTION

Under the No Action Alternative, there would be no direct impacts to surface waters, except those resulting from routine maintenance required to repair erosion and/or remove sediment and the existing disturbance; water quality impairments to San Pedro, Apache, and Alazán Creeks would remain.

ACTION ALTERNATIVES

Implementation of any of the proposed action alternatives would directly impact surface waters in the study area through construction activities associated with excavation and recontouring of pilot channels and development of riffle/run/pool complexes and slackwater areas over an increasing number of creeks and lengths of river miles moving from Alternative 5 to Alternative 7.

During the construction period, these impacts are expected to temporarily degrade water quality as a result of ground disturbing activities. Erosion and sedimentation controls, such as silt fencing and sediment traps, the application of water sprays, and the prompt revegetation of disturbed areas would be required during construction to reduce and control siltation or erosion impacts. In addition, every construction project poses a potential contamination risk from petroleum or chemical spills. The contractor would be required to prepare and follow a site-specific Spill Prevention Plan during construction, which would include use of BMPs such as proper storage, handling, and emergency preparedness, reducing the risk of such contamination.

Thus, impacts to surface waters during construction are considered to be temporary and insignificant.

Impacts to surface waters following implementation of any of the action alternatives is expected to be increasingly beneficial moving from the lower to the higher numbered alternative. This is because each subsequently higher numbered alternative adds additional areas of restoration that will benefit surface water impacts.

Excavation of the creeks to reconfigure pilot channels and develop riffle/run/pool complexes and slackwater areas would increase the acres of surface waters in the study area additively from Alternative 5 to Alternative 7. Establishment of aquatic plants and revegetation of the stream banks with native grasses, forbs, and woody species, which would act as effective vegetative filters, reducing amounts of sediments and other contaminants that would otherwise flow directly into/thru the WSC, would improve water quality over existing conditions. The long-term water quality impacts of constructing any of the proposed alternatives would be beneficial, and include an increase in surface water area, reduction in water temperature by vegetational influences, improved water chemistry, and an increase in organic allochthonous materials.

As previously discussed, Section 401 Water Quality Certification would not be required as activities conducted under a NWP 27 would comply with Section 401 of the CWA.

FLOODPLAINS

NO ACTION

Under the No Action Alternative, the floodplain of the WSC would remain unchanged.

ACTION ALTERNATIVES

Although the alternatives are located entirely within the 100-year floodplain, the primary design consideration of all alternatives is to ensure that the combination of all ecosystem restoration measures proposed would maintain hydraulic neutrality, i.e. not result in a decrease in floodplain capacity or an increase in flood risk within the study area. Similarly, the disposal site would be located in an upland area outside of both the 100- and 500-year floodplains. All alternatives would comply with Executive Order (E.O.) 11988 (see Environmental Compliance Section of this Chapter).

GROUNDWATER

The WSC study area is located outside of the Edwards Aquifer Recharge Zone; therefore, no impacts on groundwater are anticipated from the No Action Alternative or any Action Alternatives.

WILDLIFE

NO ACTION

Under the No Action Alternative, the wildlife habitat conditions in the WSC would remain unchanged. The insufficient populations of lower trophic level organisms in the creeks would continue to limit diversity of the wildlife community.

ACTION ALTERNATIVES

As discussed in the Plan Formulation section of the GRR, there would be significant long-term beneficial effects on fish and wildlife populations from the implementation of the proposed alternatives through geographic expansion and improved quality of their respective habitats. By removing the existing concrete-lined channels and restoring the WSC to a more natural condition, native fish populations could repopulate areas that have not been favorable for their existence or survival. Water quality improvements (resulting from planting riparian and hydrophilic vegetation) would improve habitat conditions for intolerant native species, and would restore balance to the native tolerant/native intolerant species over time.

The restoration of riparian vegetative structure would provide additional wildlife habitat (food, shelter, and reproductive resources) for small mammals, amphibians, reptiles, and birds. The restoration measures would also connect adjacent park and woodland areas and downstream habitats by reducing the existing fragmentation. The proposed study area, which is located in the Central Flyway for migratory waterfowl and neotropical bird species, would increase the amount of scarce riparian habitat and water resources along this migratory bird corridor. The ability of these species to find adequate resources along their migration route ultimately determines their ability to arrive at their breeding grounds in a healthy condition to establish territories, find mates, reproduce, and fledge young. For birds breeding in the riparian zones of the southwest, the improvement of the habitat increases the breeding bird’s ability to successfully breed and fledge young.

ALTERNATIVE 5

Alternative 5 would restore wildlife habitat to the extent possible to San Pedro Creek and Apache Creek. Although native plant species would be restored to Alazán Creek and Martinez Creek, the lack of instream habitat and woody habitat would be a limiting factor in providing wildlife habitat in these two streams.

ALTERNATIVE 6 (PROPOSED ACTION)

In addition to the wildlife habitat benefits provided in Alternative 5, Alternative 6 would restore wildlife habitat to the extent possible for Alazán Creek. Although native plant species would be restored to Martinez Creek, the lack of instream habitat and woody habitat would be a limiting factor in providing wildlife habitat in that stream.

ALTERNATIVE 7

In addition to the wildlife habitat benefits provided in Alternative 6, Alternative 7 would restore wildlife habitat to the extent possible for Martinez Creek.

Where construction or disposal is proposed, there would be an increased level of human disturbance, such as noise, vehicular traffic, and construction equipment, which could lead to temporary localized displacement of affected existing fish and wildlife populations. Mortality of fish or wildlife individuals is possible during the construction phase, but would be rare, as most species would avoid the areas of disturbance.

THREATENED AND ENDANGERED SPECIES

NO ACTION

Under the No Action Alternative, there would be no added benefits to listed species. Two state threatened species were observed within the WSC study area during field surveys (Peregrine Falcon and Zone-tailed Hawk).

ACTION ALTERNATIVES

As no Federally listed threatened or endangered species are expected to occur within the study area, no adverse impacts to these species would occur. Although there would be temporary disturbances to foraging areas for the Peregrine Falcon and Zone-tailed Hawk, the long-term habitat benefits of the project would significantly outweigh these impacts. Under the action alternatives, forging habitat for listed species migrating through the study area would be improved.

AIR QUALITY

NO ACTION

Under the No Action Alternative, there would be no adverse impacts to air quality within the study area.

ACTION ALTERNATIVES

For the action alternatives there would be a short-term inconsequential impact to air quality during implementation. Construction would generate fugitive dust from ground disturbing activities (e.g., grading, demolition, soil piles, etc.) in addition to the emissions of all criteria pollutants from the combustion of fuels in construction equipment. Fugitive dust emissions would be greatest during the initial site preparation activities and would vary from day-to-day depending on the construction phase, level of activity, and prevailing weather conditions. The quantity of uncontrolled fugitive dust emissions from a construction site is proportional to the area of land being worked and the level of construction activity. Emissions would be temporary in nature. The use of BMPs during construction (e.g. application of water for dust control) would minimize these emissions, including the use of cleaner burning fuels and energy efficient equipment.

NOISE

NO ACTION

Under the No Action Alternative, there would be periodic noise attributed to heavy equipment during the excavation of sediments from the routine maintenance.

ACTION ALTERNATIVES

For the action alternatives heavy equipment such as backhoes, front-end loaders, and cement and dump trucks would cause short-term, localized increases in noise levels. These short-term increases are not expected to substantially affect adjacent noise sensitive receptors or wildlife areas. Construction activities would increase noise levels temporarily at locations immediately adjacent to the study area, but would be attenuated by distance, topography, and vegetation.

Noise levels created by construction equipment would vary greatly depending on factors such as the type of equipment, the specific model, the operation being performed, and the condition of the equipment. The equivalent sound level of the construction activity also depends on the fraction of time that the equipment is operated over the period of time of the construction. Construction would occur during daylight hours, thus reducing the Day-night Average Sound Levels and the chances of causing annoyances. Because much of the construction activities would occur within the existing SACIP floodway, adjacent properties would be partially buffered from construction noises. The use of BMPs such as keeping equipment in good operating condition, proper training, and providing appropriate health and safety equipment would minimize the potential noise impacts associated with the proposed action. Construction would be conducted in accordance with City ordinances cited in Chapter 2, Noise*.

TRANSPORTATION

NO ACTION

Under the No Action Alternative, there would be no impacts to transportation.

ACTION ALTERNATIVES

For the proposed action alternatives, short-term, insignificant impacts to traffic volumes would be expected during construction activities. Local roads are well designed and are capable of handling a large volume of vehicles. However, during construction, traffic congestion could occur, particularly during the morning and evening rush hour as construction vehicles enter and exit the project area, or transport construction debris to the disposal site. Road closures or restricted access would not be anticipated; however, temporary detours or traffic control may be needed during working hours. A traffic control plan would be prepared by the construction contractor and submitted for approval to Federal and local officials prior to the start of any construction activities.

LIGHT

NO ACTION

Under the No Action Alternative and the action alternatives, the existing light sources in the WSC study area would remain.

ACTION ALTERNATIVES

The action alternatives would not introduce additional lighting to the WSC study area. Construction would occur during daylight hours and no construction lighting would be required. Therefore, no adverse impacts from lighting would be anticipated.

CULTURAL RESOURCES

ARCHEOLOGICAL RESOURCES

NO ACTION

Under the No Action Alternative, cultural resources would not be impacted by the USACE undertaking. Any significant cultural resources will remain deeply buried and protected. Overall, no known significant impact to cultural resources under the No Action alternative would occur.

ACTION ALTERNATIVES

Riparian meadow restoration included in all of the action alternatives requires the removal of the top six inches of existing soil to eliminate the non-native seed bank and ripping to a depth of 12-18 inches to reduce compaction and provide acceptable strata for deep root growth. Soils accumulate rapidly in alluvial riverine settings, therefore, cultural bearing deposits would not be expected within that first 18 to 24 inches of top soil. As such, implementation of riparian meadow measures for any of the action alternatives would result in no significant consequences to cultural resources.

Creation of slackwater areas requires minor excavation, grading and armoring within the channel. Creation of a pilot channel requires excavation, grading of slopes, placement of rock for riffle structures, slope armoring, and utility relocation. For the channel restoration activities, the depth of ground disturbance would be zero to four feet. Construction would be confined to the existing channel and would not extend to the flood plain beyond the current banks. The excavation of the pilot channel would primarily affect the center of the existing creek channel. The likelihood of intact cultural resources within the channel bed is very low. However, slope shaping and utility excavation have a slightly higher potential to encounter cultural resources, although initial utility placement would have disturbed resources in those locations. Significant cultural resources could therefore be adversely affected by these activities.

For Alternative 7, the land for the five acre wetland site was part of a buy-out under a FEMA program to remove a residential structure from the flood plain. The potential to impact significant cultural resources under this alternative are minimal due to previous disturbance from residential construction and the shallow depth of the proposed ground disturbing activities. While low, the likelihood of intact cultural bearing deposits in the proposed wetland area is slightly higher than in the rest of the proposed project areas.

Coordination with the Texas SHPO resulted in the development of a draft Programmatic Agreement to ensure compliance with Section 106 of the NHPA. To minimize the impacts to resources that may be encountered during construction, an archeological monitor would be on site to identify cultural resources should they be discovered. The monitor would assess the significance of the resource and mitigate the impacts to sites determined eligible for the NRHP before ground disturbing activities would be allowed to continue in the vicinity. In this way, no significant impacts for the implementation of the action alternatives would be expected.

ARCHITECTURAL RESOURCES

For all alternatives, including the No Action, there is no potential to effect above ground resources, specifically buildings and structures along the WSC construction footprint. No above ground significant resources are located within the proposed construction footprint for any of the WSC alternative plans. The limit for the APE for architectural view sheds is up to ½ mile from the existing boundary of the SACIP. However, ecosystem restoration along the creeks is not considered to be an adverse impact to view shed. The THC has concluded that no additional above-ground identification efforts are required for the WSC APE.

HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

NO ACTION

One potential hazardous material site (the Sloan Market Yard) located near San Pedro Creek was identified in Appendix G, HTRW. However, the Sloan Market Yard is located outside of the existing SACIP floodplain. Under the No Action, no hazardous, toxic, or radioactive waste would be uncovered as there would be no excavation of the pilot channel.

ACTION ALTERNATIVES

As noted above, the Sloan Market Yard is located outside of the existing SACIP floodplain where no excavation would occur. Therefore, no anticipated adverse impacts are expected by implementation of Alternatives 5, 6, or 7. The exposure of any unanticipated hazardous materials unearthed during excavation activities would be dealt with in a manner consistent with Engineering Regulation 1165-2-132 Hazardous, Toxic and Radioactive Waste Guidance for Civil Works Projects.

To minimize potential impacts from hazardous and regulated materials during construction, all fuels, waste oils, and solvents would be collected and stored in tanks or drums within a secondary containment system that consists of an impervious floor and bermed sidewalls capable of containing the volume of the largest container stored therein.

The refueling of machinery would be done following accepted guidelines, and all vehicles would have drip pans, when not in use, to contain minor spills and drips. Although it would be unlikely for a major spill to occur, any spill of five gallons or more would be contained immediately within an earthen dike, and the application of an absorbent (e.g., granular, pillow, sock, etc.) would be used to absorb and contain the spill. Any major spill of a hazardous or regulated substance would be reported immediately to SARA and USACE environmental personnel who would notify appropriate Federal and State agencies.

Additionally, all construction personnel would be briefed as to the correct procedures for preventing and responding to a spill. All waste oil and solvents would be recycled if practicable. All non-recyclable hazardous and regulated wastes would be collected, characterized, labeled, stored, transported, and disposed of in accordance with all Federal, State, and local regulations, including proper waste manifesting procedures. A Spill Prevention Plan would be in place prior to the start of construction, and all personnel shall be briefed on the implementation and responsibilities of this plan. Adoption and full implementation of the construction measures described above would reduce adverse hazardous/regulated substances impacts to insignificant levels.

VISUAL AESTHETICS

NO ACTION

The No Action Alternative would result in the same continuously mowed and maintained floodway with concrete armoring. These conditions would not do anything to alleviate the aesthetic conditions for which residents built fences in their backyards to block from view.

ACTION ALTERNATIVES

The action alternatives would improve the visual aesthetics of the WSC floodway by restoring native vegetation. The diversity of native plant species and vertical vegetative structure would emulate the natural aquatic and riparian habitats of the region, creating a more natural view shed within the WSC.

SOCIOECONOMICS

NO ACTION

Under the No Action Alternative, no changes would be made to the socioeconomic environment of the WSC neighborhoods.

ACTION ALTERNATIVES

One of the constraints of the study is the need to maintain water surface elevations, so that there would be no increase in adverse flood risk to WSC population. An ancillary benefit of the ecosystem restoration of the action alternatives is the reconnection of neighborhoods aesthetically and physically divided by earlier channel modifications to the creeks. With recreation also being considered, benefits would not only accrue to the local neighborhoods, but to the city as a whole. Given these expectations, no economic justice concerns are anticipated and the proposed project would be consistent with EO12898 (see Environmental Compliance section of this Chapter).

Since the project area is located near residential areas where children may be present, EO13045 is considered in this EA (see Environmental Compliance section of this Chapter). The construction area would be flagged or otherwise fenced. Therefore, issues regarding Protection of Children are not anticipated.

OTHER SOCIAL EFFECTS

NO ACTION

Under the No Action Alternative, the WSC would continue to be aesthetically displeasing to the community and the WSC would continue to be fenced off from the adjacent communities.

ACTION ALTERNATIVES

Under the action alternatives, the WSC would provide recreational value to the community and the natural aesthetics of the restored riverine habitats would be something the community would appreciate instead of ignore.

RECREATION

NO ACTION

Under the No Action Alternative, there would be no recreational trails provided for Alazán Creek, Martinez Creek, and San Pedro Creek or the lower portion of Apache Creek. The shortage of recreation facilities in the WSC community would remain unaddressed.

ACTION ALTERNATIVES

For the action alternatives approximately 8.4 miles of recreational trails would be constructed along the WSC in locations that would be compatible with the ecosystem restoration measures. The linking of the WSC trails to the existing trails in the upper portion of Apache Creek, Elmendorf Lake, Woodlawn Lake and the San Antonio Trail system at Mission Reach would result in beneficial effects to recreation within the city and region. All 222 to 227 acres of the proposed ecosystem restoration project would be accessible for public use. The trails would improve and increase outdoor recreational opportunities (i.e. hiking, biking, and bird watching).

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The Proposed Action would not entail any significant irretrievable or irreversible commitments of resources. Construction of ecosystem restoration and recreation management measures would require minor consumption of petroleum products, and importing materials such as rock, soil, gravel, and vegetation. The Proposed Action would entail long-term sustainability of restored environmental resources.

INDIRECT EFFECTS

Indirect effects, as defined by CEQ’s regulations, are “caused by the proposed action and occur later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems” (40 Code of Federal Regulations [CFR] 1508.8). Indirect effects differ from direct impacts associated with the construction and operation of the proposed project and are caused by an action or actions that have an established relationship or connection to the proposed project. However, indirect effects can be linked to direct effects in a causal chain, which can be extended as indirect effects that produce further consequences.

As previously discussed, implementation of the proposed action would directly result in a net beneficial impact to the WSC and the associated vegetation and wildlife. In addition, the proposed WSC ecosystem restoration measures would result in benefits that extend further outside the study area for several notable environmental resources. These benefits would increase over time as the WSC habitats develop and mature.

The indirect effects were examined for the study area as identified in Figure 1. As discussed below, even though portions of the indirect effects study area are located outside the proposed WSC restoration limits, these areas would receive ecological benefits resulting from restoration activities.

Wildlife often utilize riparian habitats, especially in urban landscapes, as travel corridors to move between patches of habitat. The proposed study would extend the existing wildlife corridor located downstream of WSC through the study area facilitating the dispersal and gene flow into previously isolated patches of habitat.

The establishment of native plant species in the study area and the removal and control of non-native, invasive species provides significant indirect benefits. The seed production of the vegetation in the study area can be transported downstream, especially during flood events, and deposited in previously restored areas such as the Mission Reach on the San Antonio River. Under the No Action Alternative, these seeds would generally be comprised of non-native invasive species resulting in increased maintenance costs for invasive species control efforts in the soon to be completed Mission Reach aquatic restoration project area. With implementation of the recommended plan, the seed source would generally be comprised of native species adapted to the conditions of the floodway and would support and enhance previous restoration efforts along the San Antonio River. The improved riverine habitats of the WSC would improve water quality downstream as the aquatic, wetland, and riparian vegetation would filter pollutants and sediments. The habitat restored as the result of the WSC study would connect with the riverine habitats downstream.

CUMULATIVE IMPACTS

CEQ regulations define a cumulative impact as an effect which results from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions (40 CFR Section 1508.7). Relatively minor individual impacts may collectively result in significant cumulative impacts. Project-related direct and indirect impacts must be analyzed in the context of non-project-related impacts that may affect the same resources. Cumulative impacts are the incremental impacts that the project’s direct or indirect impacts have on a resource in the context of other past, present and future impacts on that resource from related or unrelated activities. Unlike direct impacts, quantifying cumulative impacts may be difficult since a large part of the analysis requires forecasting future trends of resources in the study area and future projects that may impact these resources.

The initial step of the cumulative impacts analysis uses information from the evaluation of direct and indirect impacts in the selection of environmental resources that should be evaluated for cumulative impacts. The proposed action would not contribute to a cumulative impact if it would not have a direct or indirect effect on the resource. Similarly, CEQ guidance recommends narrowing the focus of cumulative impacts analysis to important issues of national, regional, or local significance. Therefore, the cumulative impact analysis for WSC was focused on those resources that were substantially directly or indirectly impacted by the study and resources that were at risk or in declining health even if the direct/indirect impacts were insignificant.

The resources considered for cumulative impacts assessment include: riverine habitat (riparian and aquatic vegetation and pool/riffle/run complexes) and wildlife. Each of these resources would be substantially directly and/or indirectly impacted by the WSC study. For the purposes of this cumulative impact analysis, the resource study area for riverine habitat and wildlife is the non-recharge floodplains of tributaries to and the San Antonio River within and downstream of Bexar County.

Past, present and future projects influencing riverine habitats and wildlife in the cumulative study area are presented in Table 10. Transportation, utility, development, and other construction projects have occurred in the past and impacted riverine resources in the WSC cumulative study area. After 1972, these impacts would have been regulated by USACE under the Clean Water Act. These types of development projects would be expected to continue in the future and would be regulated through the USACE permitting process.

The health and historic context of the riverine habitat and wildlife resources, specifically migratory birds utilizing the Central Flyway, has been described in previous sections of this report (Existing Conditions, Alternative Formulation, and Consequences). In fact, the historic and continued decline of these resources lies at the core of the significance and need for the WSC ecosystem restoration project.

Table 10. Past, Present, and Future Projects Impacting Rivierine Habitats in the WSC Cumulative Study Area

Projects	Riverine Resources Cumulative Impact[1]	Wildlife Resources Cumulative Impact[1]
Past Projects		
SACIP[2]	-	-
Eagleland Section 1135 Ecosystem Restoration Project[2]	+	+
Mitchell Lake Improvements Project	+	+
Creation of Elmendorf and Woodlawn Lakes	-	0
Salatrillo Creek Demonstration Project	+	+
Construction of Fort Sam	-	-
Honey Creek Demonstration Project	+	+
Camp Bullis Military Reservation	0	-
Randolph Air Force Base	0	0
Lackland Air Force Base	0	0
Lackland Air Force Base Wetland Restoration Project	+	+
Kelly Air Force Base	0	0
Present Projects		
San Antonio River Channel Improvement Project Ecosystem Restoration and Recreation (Mission Reach)[2]	+	+
Fort Sam Medical Facilities	0	0
San Antonio River Improvement Project, Section 408	+	+
Reasonably Foreseeable Projects		
Leon Creek Watershed Flood Damage Reduction Feasibility Study[2]	-	-
Straus Medina Mitigation Bank	+	+
Future Fort Sam Construction Activities	0	0
Elmendorf and Woodlawn Lakes Improvements	0	0
Olmos Creek Section 206 Ecosystem Restoration Project[2]	+	+

1 A positive symbol (+) denotes a positive impact, a zero (0) denotes no impact, and a negative symbol (-) denotes a negative impact.
2USACE Civil Works Project

RIVERINE HABITAT

Past impacts specific to the WSC and San Antonio River riverine habitats are documented in Chapter 2, Riverine Resources. Over the past 125 years, pristine riverine habitats in Bexar County have been lost due to demand for natural resources, agriculture, urbanization, channelization to address flood risks, and the introduction of non-native invasive species. As urban sprawl incorporates the remaining areas of Bexar County, the importance of riverine habitats and their associated floodplains in the outer areas of the county has been realized. As a result, with the exception of some non-cultivated agricultural areas, much of the riparian buffers surrounding these stream channels have been severely degraded. Several restoration projects have been and are currently under construction including the Eagleland and Mission Reach projects on the San Antonio River. The conservation of riverine resources in Bexar County continues to be a priority and initiatives by the City, SARA, SAWS, Bexar County, TPWD, and non-profit conservation organizations such as the Nature Conservancy and the Texas Land Conservancy are making progress in increasing the extent of restored and protected riverine habitats. Although future restoration and conservation initiatives will undoubtedly continue, the City and Bexar County are one of the top ten urban growth centers in the U.S. As a result urban pressures would continue to encroach on the county's suburban and rural riverine ecosystems. Because of projected future population growth and subsequent urbanization, the sustainability and ecological viability of riverine habitats for fish and wildlife as well as human uses, highlights one of the greatest ecological needs of the county. The proposed action would effectively provide approximately19 miles of connected, restored riverine system along a critical stop-over corridor for the birds utilizing the Central Flyway.

WILDLIFE

Fish and wildlife inhabiting the WSC prior to urbanization and channelization would have consisted of a diverse community of native invertebrate, fish, amphibian, reptile, mammal, and bird species. As the area urbanized, wildlife species intolerant of urban impacts such as the Texas tortoise, indigo snakes, bobcat, and black bear migrated out of the area over time and tolerant species such as raccoons, opossums, and Great-tailed Grackles now thrive. After channelization of WSC and other streams in Bexar County, the aquatic habitat that supported a diverse community of amphibians and aquatic invertebrates disappeared, further reducing wildlife diversity in the urbanized areas. Finally, the introduction of non-native fish and wildlife species such as tilapia, tetras, house mice, Norway rats, European Starlings, Rock Doves, and feral cats and vegetative species such as Johnsongrass, Bermuda grass, KR bluestem, and giant cane that have reduced habitat values, placed increased demands on scarce wildlife resources, and resulted in the non-native species out-competing native species. Currently the habitat conservation efforts discussed in the habitat section above have mitigated these effects in some limited areas, but without additional restoration of riverine and terrestrial habitats, improvements to the viability and diversity of fish and wildlife would be limited.

In the earlier discussion of direct impacts of the proposed actions, substantial beneficial effects were recognized that improve habitat not only for migratory birds and other upper tier trophic species, but more importantly for lower trophic level organisms that support these more visible and mobile species. As further discussed, these beneficial impacts are not limited to the WSC study area, but expand further into the San Antonio River Basin. For migratory birds, the benefits of the proposed WSC habitats might be realized several thousand miles away after the successful breeding and fledging of young on the arctic tundra.

The proposed actions alone cannot ensure the continued survival and existence of migratory birds and other organisms depending on riverine resources in the southwest. However, the proposed actions can contribute to the cumulative conservation, preservation, and restoration efforts underway both locally, regionally, nationally, and internationally. Locally, previous and ongoing restoration efforts on the San Antonio River at Eagleland and Mission Reach will improve migratory bird habitats in the San Antonio area. Additional conservation efforts in the region, including the implementation of the South Edwards Habitat Conservation Plan, conservation easements initiated by non-governmental conservation organizations, and international initiatives such as the Partners in Flight and Joint Ventures will continue to provide pieces of the migratory bird habitat puzzle that will ensure migratory birds have the resources to complete migration and successfully breed and fledge young.

The cumulative habitat incorporated into these migratory bird conservation efforts are predicated on the establishment of the lower trophic levels by ensuring that aquatic, riparian, and upland habitats properly function ecologically.

MITIGATION REQUIREMENTS

No mitigation would be required with the implementation of the TSP.

ENVIRONMENTAL COMPLIANCE

This section demonstrates how the Proposed Action would comply with applicable environmental laws and regulations.

ADVISORY CIRCULAR 150/5200-33A - HAZARDOUS WILDLIFE ATTRACTANTS ON NEAR AIRPORTS

The advisory circular provides guidance on locating certain land uses having the potential to attract hazardous wildlife to or in the vicinity of public-use airports. The circular provides guidance on wetlands in and around airports and establishes notification procedures if reasonably foreseeable projects either attract or may attract wildlife.

In response to the Advisory Circular, the United States Army as well as other Federal agencies, signed a Memorandum of Agreement (MOA) with the Federal Aviation Administration (FAA) to address aircraft-wildlife strikes. The MOA establishes procedures necessary to coordinate their missions to more effectively address existing and future environmental conditions contributing to aircraft-wildlife strikes throughout the United States. All of Apache Creek and portions of Alazán Creek and San Pedro Creek are located within the 10 mile radius of Kelly Air Force Base. The lower portion of San Pedro Creek is within the 10-mile radius of Stinson Municipal Airport. While a portion of Martinez Creek is within the 10-mile radius of the San Antonio International Airport, the only measure implemented in this area would be the restoration of native riparian meadow and aquatic vegetation.

In accordance with the Advisory Circular, USACE is coordinating with the FAA and the Animal and Plant Health Inspection Service (APHIS) of the U.S. Department of Agriculture to address potential hazardous wildlife attractants near airports within San Antonio with respect to the Proposed Action. Copies of all coordination letters are included in Appendix N.

SECTION 404 OF THE CLEAN WATER ACT

USACE under direction of Congress regulates the discharge of dredged and fill material into all waters of the United States, including wetlands. Although USACE does not issue itself permits for construction activities that would affect waters of the United States, USACE must meet the legal requirement of the Act. As stated in Chapter 4, Wetlands and Waters of the U.S. the proposed project would meet the qualifications for a NWP 27. Activities authorized under NWP 27 include:

- ***"the removal of accumulated sediments,***

- ***the installation, removal, and maintenance of small water control structures, dikes, and berms,***
- ***the installation of current deflectors,***
- ***the enhancement, restoration, or creation of riffle and pool stream structure,***
- ***the placement of in-stream habitat structures,***
- ***modifications of the stream bed and/or banks to restore or create stream meanders,***
- ***the backfilling of artificial channels and drainage ditches,***
- ***the removal of existing drainage structures,***
- the construction of small nesting islands,
- the construction of open water areas,
- the construction of oyster habitat over un-vegetated bottom in tidal waters,
- ***activities needed to reestablish vegetation, including plowing or disking for seed bed preparation and the planting of appropriate wetland species,***
- ***mechanized land clearing to remove non-native invasive, exotic or nuisance vegetation, and***
- ***other related activities."***

Aforementioned activities highlighted in bold and italicized text are those that apply to the WSC proposed alternatives. No net loss of waters of the United States would occur under the proposed alternatives. Under a NWP 27, the conditions for a water quality certification would be met and a Section 401 water quality certification would not be required by the TCEQ.

SECTION 402 OF CLEAN WATER ACT

The construction activities that disturb upland areas (land above Section 404 jurisdictional waters) are subject to National Pollutant Discharge Elimination System (NPDES) requirements of Section 402(p) of the Clean Water Act (CWA). Within Texas, TCEQ is the permitting authority and administers the Federal NPDES program through its Texas Pollutant Discharge Elimination System (TPDES) program. Construction activities that disturb one or more acres are subject to complying with TPDES requirements. Operators of construction activities that disturb 5 or greater acres must prepare a Storm Water Pollution Prevention Plan (SWPPP), submit a Notice of Intent to TCEQ, conduct onsite posting and periodic self-inspection, and follow and maintain the requirements of the SWPPP. During construction, the operator shall assure that measures are taken to control erosion, reduce litter and sediment carried offsite (silt fences, hay bales, sediment retention ponds, litter pick-up, etc.), promptly clean-up accidental spills, utilize BMPs onsite, and stabilize site against erosion before completion.

SECTION 176(C) CLEAN AIR ACT

Federal agencies are required by this Act to review all air emissions resulting from Federal funded projects or permits to insure conformity with the SIPs in non-attainment areas. The San Antonio metropolitan area is currently in attainment for all air emissions; therefore, the proposed study would be in compliance with the Clean Air Act.

EXECUTIVE ORDER 13112, INVASIVE SPECIES

The Executive Order (EO) 13112 recognizes the significant contribution native species make to the well-being of the Nation's natural environment and directs Federal agencies to take preventive and responsive action to the threat of the invasion of non-native plants and wildlife species in the United States. This EO establishes processes to deal with invasive species and among other items establishes that Federal agencies "will not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless, pursuant to guidelines that it has prescribed, the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species; and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions."

The channelization of the WSC has caused degradation of the riverine environment resulting in the loss of an aquatic environment supporting native aquatic species. Linked to the aquatic degradation is the loss of native riparian vegetation species, which is vital to the aquatic environment and supports native residential and migratory, game and nongame wildlife species. Virtually no natural, native riverine environment remains. The loss of appropriate native riparian vegetation has resulted in the loss of the necessary components for the life cycle of the numerous insect species, which are the vital prey base for the native aquatic and riparian-dependent insectivore species. The imbalance in the predator/prey relationship has assisted in the invasion of non-native invasive species into the aquatic and riparian habitats. The measures included in the WSC ecosystem restoration study would remove the invasive plant species and the seed bank in the top six inches of topsoil and replace them with native plant species adapted to the study area. Required operation and maintenance of the WSC study area by the non-Federal sponsor during long-term management of that area would keep the negative influence of non-native invasive plants at a minimum. The Proposed Action would be in compliance with EO 13112 by restoring native aquatic and riparian vegetation species to the degraded habit. The WSC floodway is dominated by non-native invasive plant species.

EXECUTIVE ORDER 11988, FLOODPLAIN MANAGEMENT

EO 11988 was enacted May 24, 1977, in furtherance of the National Environment Policy Act of 1969, as amended (42 U.S.C. 4321 et seq.), the National Flood Insurance Act of 1968, as amended (42 U.S.C. 4001 et seq.), and the Flood Disaster Protection Act of 1973 (Public Law 93-234, 87 Star. 975). The purpose of the EO was to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative.

The order states that each agency shall provide and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities. FEMA's DFIRM of the study area data were analyzed to establish the locations of the 100-year and 500-year flood zones. All alternatives were designed to ensure that the combination of all ecosystem restoration measures proposed would not result in a decrease in the floodplain capacity and an increase in flood risk to the study area. The Proposed Action would remain in compliance with EO 11988 by protecting the values of the WSC floodplains.

EXECUTIVE ORDER 13186, MIGRATORY BIRDS

The importance of migratory non-game birds to the nation is embodied in numerous laws, executive orders, and partnerships. The Fish and Wildlife Conservation Act demonstrates the Federal commitment to conservation of non-game species. Amendments to the Act adopted in 1988 and 1989 direct the Secretary to undertake activities to research and conserve migratory non-game birds. EO13186 directs Federal agencies to promote the conservation of migratory bird populations, including restoring and enhancing habitat. Migratory Non-game Birds of Management Concern is a list maintained by the USFWS. The list helps fulfill a primary goal of the USFWS to conserve avian diversity in North America. Additionally, the USFWS' Migratory Bird Plan is a draft strategic plan to strengthen and guide the agency's Migratory Bird Program. The proposed ecosystem restoration would contribute directly to the U.S. Fish and Wildlife Service Migratory Bird Program goals to protect, conserve, and restore migratory bird habitats to ensure long-term sustainability of all migratory bird populations.

TEXAS SENATE BILL 2

In Texas, Senate Bill 2, 77th Legislature of Texas recognizes the San Antonio River basin as a critical fish and wildlife resource. This bill requires TPWD, Texas Water Development Board (TWDB), TCEQ, and other agencies to establish an interagency instream flow program to determine conditions necessary to support a sound ecological environment. In restoring the ecological and hydraulic functions of the WSC, the Proposed Action is consistent with this State legislation.

EXECUTIVE ORDER 12898, ENVIRONMENTAL JUSTICE

EO 12898 “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations” dated February 11, 1994, requires all Federal agencies to identify and address disproportionately high and adverse effect of its programs, policies, and activities on minority and low-income populations. Data was compiled to assess the potential impacts to minority and low-income populations within the study area. Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies. Even though minorities account for a large portion of the local population and the low-income population is above the national and local averages, construction of the proposed alternatives would not have a disproportionately high or adverse affect on these populations. Because of the high number of Spanish speaking individual in the WSC area, public meetings had and will continue to have translators. All notices regarding the project would have Spanish versions and construction signs would be posted in both Spanish and English. No environmental justice concerns are anticipated and the Proposed Action would be consistent with EO 12898.

EXECUTIVE ORDER 13045, PROTECTION OF CHILDREN

EO 13045 “Protection of Children from Environmental Health Risks” dated April 21, 1997 requires Federal agencies to identify and address the potential to generate disproportionately high environmental health and safety risks to children. This EO was prompted by the recognition that children, still undergoing physiological growth and development, are more sensitive to adverse environmental health and safety risks than adults.

Short-term impacts on the protection of children would be expected. Numerous types of construction equipment such as backhoes, bulldozers, graders, and dump trucks, and other large construction equipment would be used throughout the duration of construction of the Proposed Action. Because construction sites and equipment can be enticing to children, construction activity could create an increased safety risk. The risk to children would be greatest in construction areas near densely populated residential neighborhoods. During construction, safety measures would be followed to protect the health and safety of residents as well as construction workers. Barriers and “No Trespassing” signs would be placed around construction sites to deter children from playing in these areas, and construction vehicles and equipment would be secured when not in use. Since the construction area would be flagged or otherwise fenced, issues regarding Protection of Children are not anticipated.

FISH AND WILDLIFE COORDINATION ACT

The Fish and Wildlife Coordination Act (FWCA) requires Federal agencies that are impounding, diverting, channelizing, controlling, or modifying the waters of any stream or other body of water to consult with the USFWS and appropriate State fish and game agency to ensure that wildlife conservation receives equal consideration in the development of such projects. From the initial stages of the WSC study, the USFWS and TPWD have been involved in the planning process. Both agencies provided comments through regular briefings throughout the planning process, and the USFWS signed a planning aid letter fully supporting the WSC (Appendix N). TPWD biologists participated in the WSC avian point count and field surveys and provided comments on the Avian IBI model used to assess existing and future WSC habitat conditions. USFWS and TPWD will continue to be involved, as agency resource availability permit, throughout the WSC study. A draft Coordination Act Report supporting Alternative 6 and the associated recreation facilities is expected from the USFWS following the public review period of the draft GRR and integrated EA.

ADAPTIVE MANAGEMENT AND MONITORING PLANS

In an effort to ensure the success of the proposed action, the restoration measures implemented will be periodically surveyed to provide feedback on the response of the ecosystem and its resources to the management measures taken. By connecting the ecosystem response to the restoration as well as the management measures, potential beneficial adaptations and adjustments to the project or management plan can be identified to ensure continued success of the project. This is especially true of the plantings that will have to be frequently monitored from their initial planting until reasonable stabilization is achieved. To accomplish this goal, periodic monitoring of the restoration measures will be conducted over a three-year period beginning after the completion of the construction of project features and the initial plantings. An adaptive management and monitoring plan is included in Appendix C. SARA will implement the plan to ensure successful establishment and maintenance of riverine habitat throughout the WSC study area.

CONCLUSIONS

The proposed alternatives, including the No Action, have been evaluated in this EA. No significant impacts to the human environment are identified from the implementation of the Proposed Action. The Proposed Action consists of a 6.5 mile pilot channel, approximately 150 pools/riffle/run complexes, slackwater habitats, approximately 220 acres of native aquatic and riparian herbaceous and/or woody vegetation as flood conveyance allows, and roughly 8 linear miles of recreation features.

The Proposed Action will cause no long-term adverse environmental impacts within the study area. There are no impacts to habitat for threatened or endangered species, and all impacts to wetlands and waters of the U.S. would be authorized by NWP 27. Adverse impacts to cultural resources, either buried or in the cultural landscape will be identified and appropriate mitigation will be completed prior to project construction.

As an ecosystem restoration project, the Proposed Action is intended to have long-term beneficial impacts to the WSC and surrounding areas. The Proposed Action is supported by the San Antonio River Authority, the City of San Antonio, Bexar County, the U.S. Fish and Wildlife service, the Texas Parks and Wildlife Department, and the WSC Restoration Oversight Committee.

Taking into account the findings of this section, an EIS would not be necessary. Accordingly, a Draft Finding of No Significant Impact (FONSI) was prepared for the Proposed Action.

CHAPTER 5: RECOMMENDED PLAN

The NER plan, Alternative 6, would achieve partial restoration of 11 miles of stream and 222 acres of riparian corridor, and restore 67% of the lower trophic organism carrying capacity for the WSC riverine system. The implementation of NER plan would provide a 114% improvement in habitat quality over the no action alternative, providing a total migratory bird diversity benefit of 101 AAACUs, which represents 82% of the diversity benefits available in the system, at a first cost (October 2012 prices) of approximately $46.1 million with an AAC of approximately $1.8 million.

The NED plan for recreation would provide 44,600 linear feet of walk, jog, and bike trails with associated recreational facilities at a first cost of $5.3 million, an AAC of approximately $281 thousand. With visitor days per year estimated at 481 thousand, the annual benefit is $3.9 million. The resulting net annual benefits are $3.6 million, and the benefit-to-cost ratio is 13.74.

The combined NER and NED plans are the recommended plan.

DESCRIPTION OF THE RECOMMENDED PLAN

The NER plan provides some level of restoration for 222 acres and 11 stream miles of aquatic habitat, and also puts in place approximately 8.4 miles of recreation trails and features. At maturity (75 years) the recommended plan would provide 222 acres of mixed riparian meadow and riparian woody vegetation. The 6.5 mile (34,517 linear feet) pilot channel network would incorporate 146 pool-riffle-run sections and 143 off channel slackwater areas in the existing SACIP ROW contributing to the restoration of aquatic habitat. Average Annual Avian Community Units would increase by 101, a 114% increase in habitat quality.

The recreation (NED) component would provide a 44,600 linear foot trail system placed within the project area with connections to existing trails, parks and the Mission Reach project where possible. In addition to trails, other components include shade structures (6), interpretive/directional signage (50), benches (15), water fountains (15), picnic tables with pads (23), and trash receptacles (23). The proposed recreation facilities would support approximately 481 thousand user days annually, providing an estimated $3.6 million in annual net benefits.

RESTORATION FEATURES

PILOT CHANNEL

For purposes of the feasibility study, the pilot channel was placed at or below the existing channel invert. Decreases in water surface elevation related to the construction of the pilot channel are used to determine the amount of woody vegetation the channel can support without adversely affecting the flood risk management function. Typical cross sections for the pilot channel and the rock cross vanes that sustain the pools are depicted in Figure 9 & Figure 10. Final pool placement will be determined during PED with consideration for minimizing utility relocations and ensuring geotechnical slope stability. In-stream structures would be constructed from natural materials, predominantly large rock and wood. These structures would consist of cross vanes, constructed riffles, rock vanes, and double wing deflectors which are installed to control the elevation (vertical stability) of the stream bed, provide bank protection, and improve habitat for aquatic life. A plan view of the proposed rock cross vanes is shown in Figure 11, and a photo of a functioning rock cross vane in another project is shown in Figure 12. Bioengineering methods

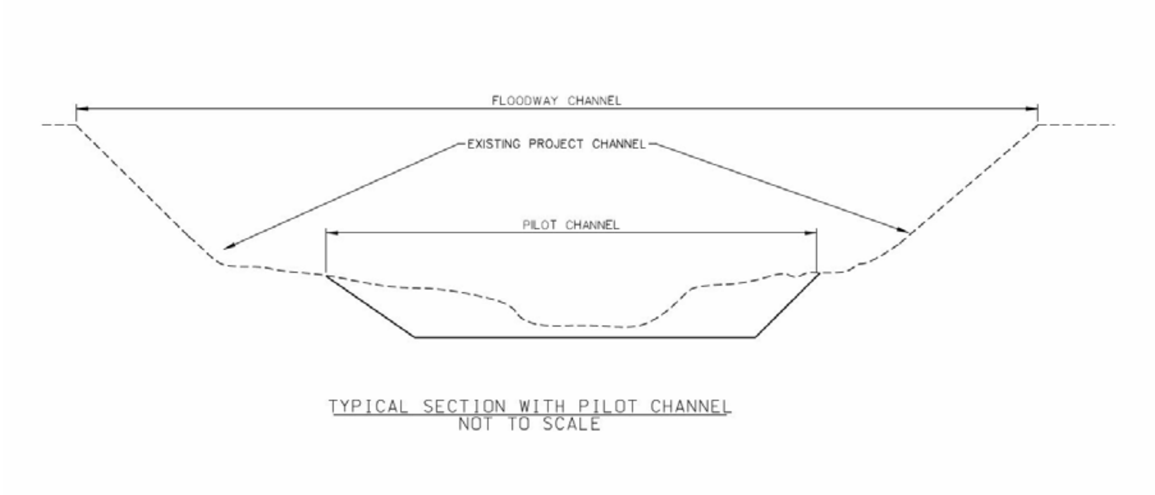


Figure 9. Typical Pilot Channel Cross Section for the Westside Creeks Recommended Plan

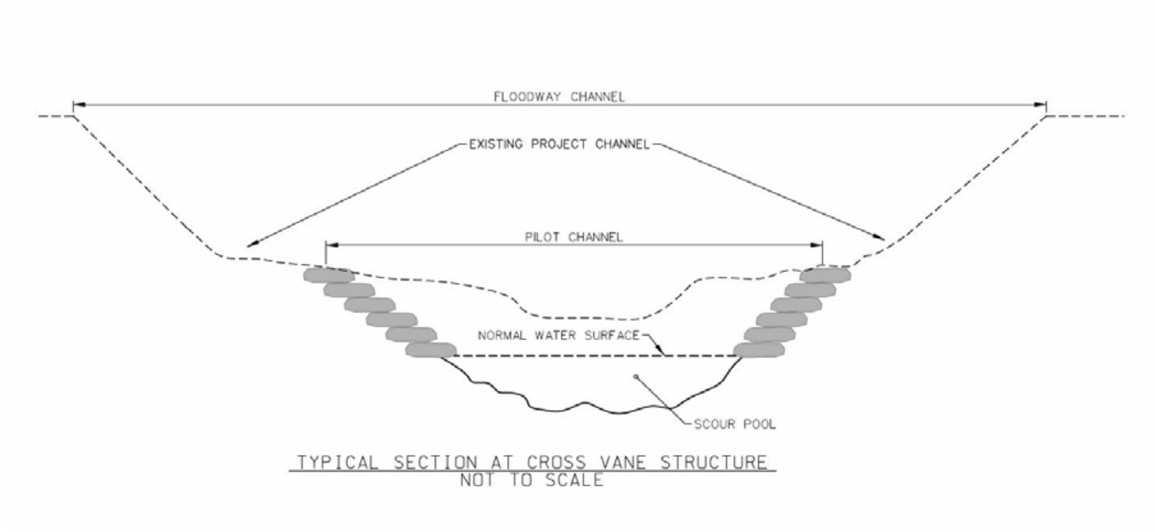


Figure 10. Typical Section for Rock Cross Vanes in the Westside Creeks Recommended Plan

or "soft armoring" measures such as turf reinforcement mats (TRM) would provide lateral steambank stability.

SAN PEDRO CREEK PILOT CHANNEL

The resulting channel between the confluence with San Antonio River and the confluence with Apache Creek is at the existing invert elevation, and has a bottom width of 44.7 feet, a top width of 67.1 feet, and a depth of 4.5 feet with 1V:2.5H side slopes. The channel invert elevation at the confluence with the San Antonio River with the pilot channel in place is 570.29 feet. Pilot channel placement reduced the water surface elevation 3-8 inches between the confluence with the San Antonio River and the confluence with Apache Creek.

From the confluence with Apache Creek upstream to Camp Street, the bankfull pilot channel required excavation to support long term sustainability of the NCD. The channel dimensions for

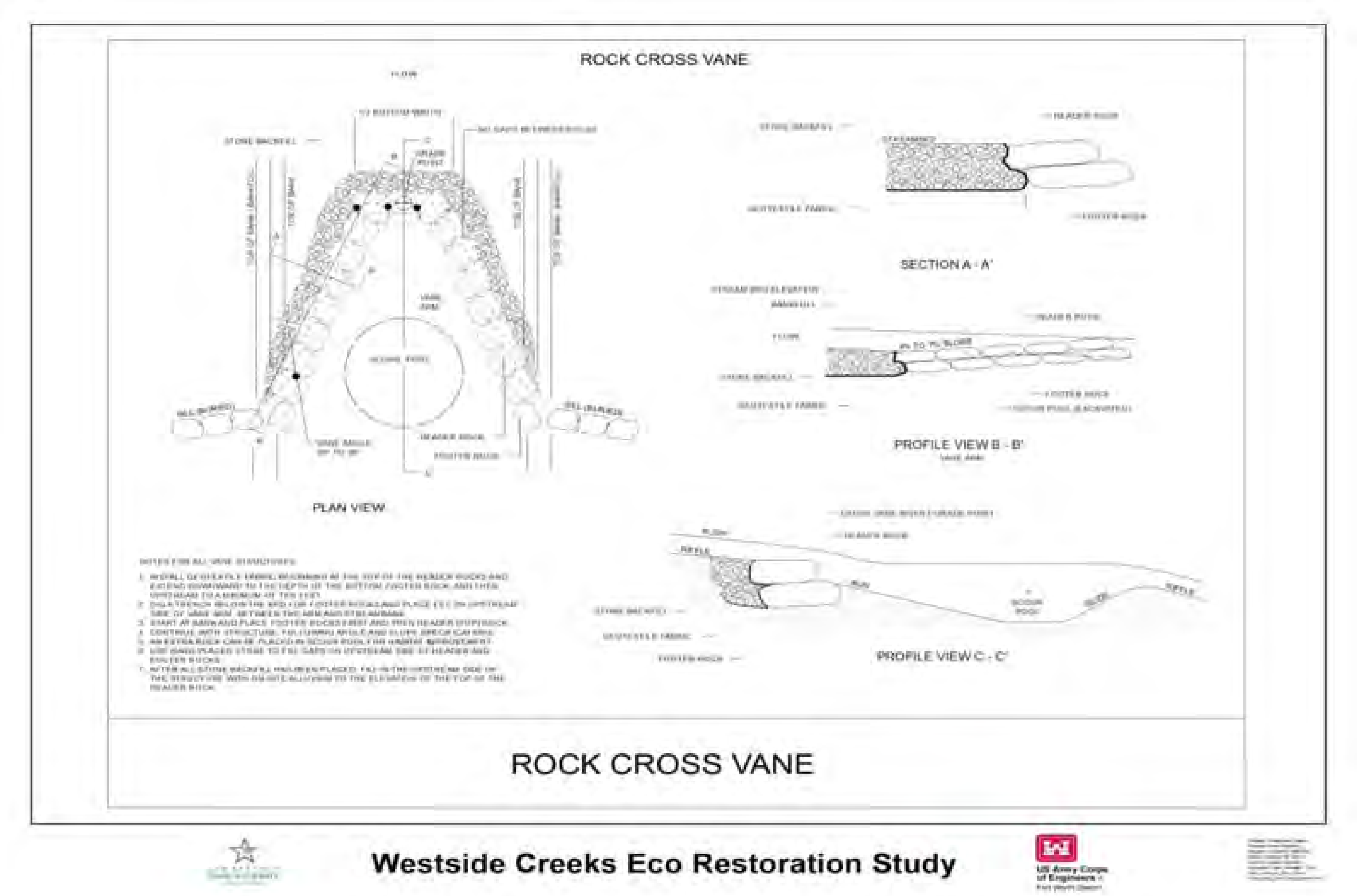


Figure 11. Typical Rock Cross Vane Anticipated for the Pilot Channels in the Westside Creeks Proposed Project

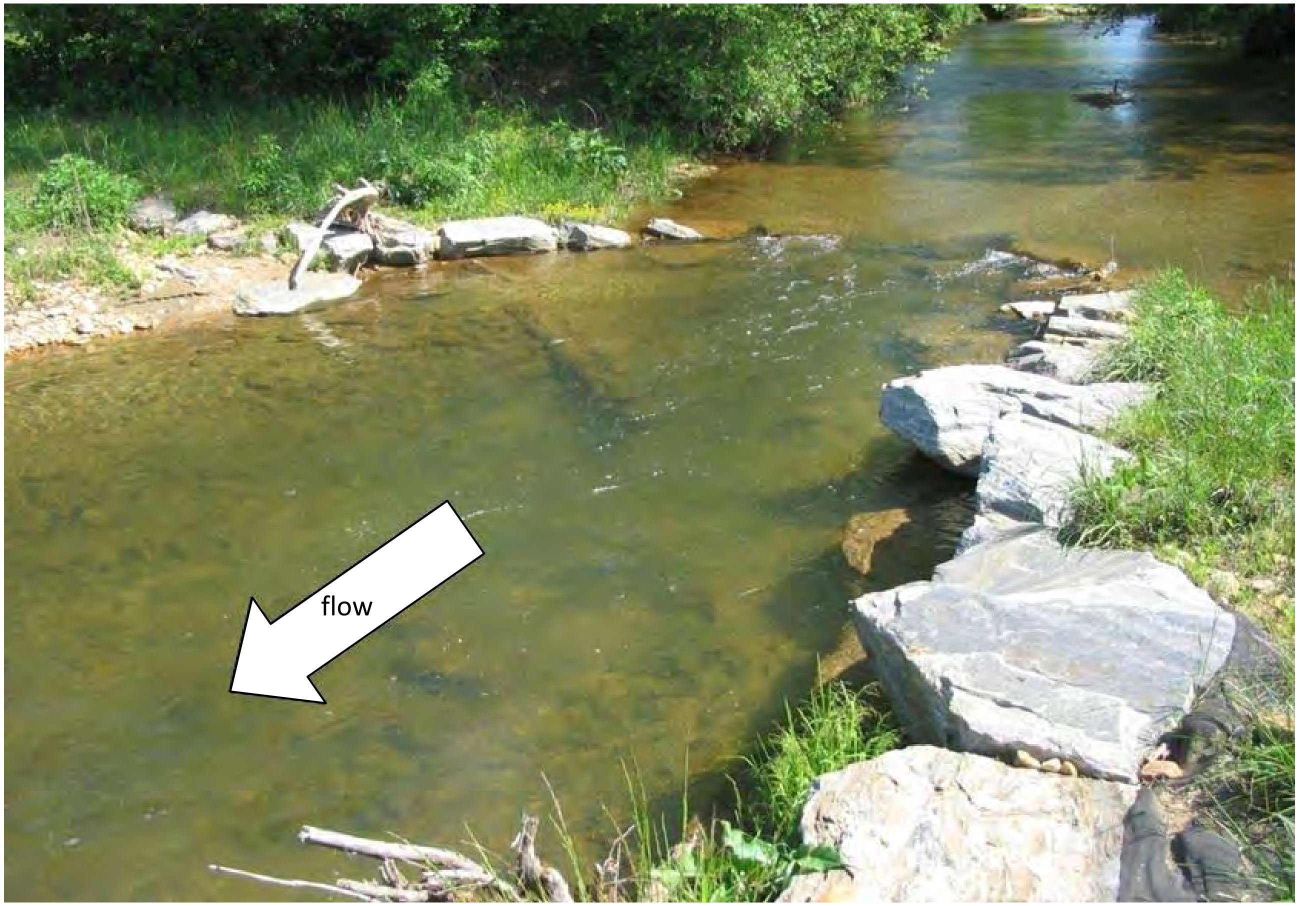


Figure 12. Photo of a Representative Functioning Rock Cross Vane

this segment are 14.7 feet bottom width, side slope of 1V:2.5H, depth of 1.7 feet, and a top width of 21.8 feet. The reduction in water surface elevation for this segment was 12-16 inches.

APACHE CREEK PILOT CHANNEL

The stream segment between the confluence with San Pedro Creek and the confluence with Alazán Creek provides a pilot channel width a bottom width of 41.6 feet, and a top width of 62.4 feet with 1V:2.5H side slopes. The channel depth is 4.2 feet. The resulting decrease in water surface elevation is 2-3 inches.

The stream segment from the confluence with Alazán Creek to just downstream of Trinity would have a pilot channel with a bottom width of 33.8 feet, a side slope of 1V:2.5H, a top width of 50.7 feet and a depth of 3 feet. With the pilot channel placed 2-3 feet below the existing invert elevation, the water surface elevation for the 1% ACE in this segment falls only 0.02-0.04 inches.

ALAZÁN CREEK PILOT CHANNEL

The first stream segment in Alazán Creek is marked by the confluence with Apache Creek on the downstream end, and the confluence with Martinez Creek on the upstream end. The pilot channel for this stretch of the creek has a bottom width of 30.6 feet with side slopes of 1V:2.5H. At a depth of 3.1 feet, the resulting top width is 45.9 feet. The pilot channel is placed at the existing invert elevation at the confluence with Apache Creek. The grade to the confluence with Martinez Creek results in the water surface elevation for the 1% ACE being lowered by 2-3 inches.

The second stream segment begins at the confluence with Martinez Creek and continues upstream to the dam’s outlet works. For this segment, the bottom width is 24.2 feet, and the top width is 36.2 feet. By maintaining the 1V:2.5H side slopes, the resulting channel depth is 2.4 feet. The corresponding decrease in 1% ACE water surface elevation for this segment is 2-3 inches.

RIPARIAN VEGATION

Mixed riparian meadow and riparian woody vegetation would be planted to cover 222 acres within the existing ROW of the SACIP. The location and density of the riparian woody vegetation is based on the constraint to not exceed the water surface elevations identified in the September 2010, FEMA DFIRM.

Riparian meadow plantings would be a mixture similar in nature to those used in other projects within the San Antonio River basin which include both terrestrial and aquatic vegetation representative of the historic vegetation for the study area documented in Chapter 2. Some examples are panic grass, and indian woodoats. It is expected that the correct herbaceous vegetation mixture would allow the vertical vegetative structure to flatten during events that are less frequent and have higher velocities. Therefore, the increased vertical height would not have adverse impacts on the existing hydraulic regime while providing environmental benefit. This measure is applicable on each of the four creeks in all areas not currently covered with concrete.

A conceptual plan for riparian woody vegetation plantings was developed based on the criteria established, but the exact nature and density of riparian woody vegetation plantings will be determined during PED. Figure 13 is a representative section of this conceptual plan. These woody vegetation plantings could be expected to include species consistent with historic vegetative composition, such as pecan, bald cypress, Texas ash, buttonbush, black willow, and common hoptree.

Figure 13. Representative Concept of Maximum Practicable Restoration for the Westside Creeks

RECREATION FEATURES

Recreation must be consistent with the ecosystem restoration so that ecosystem restoration benefits are not reduced by recreation features, therefore the final number and placement of recreation features will be determined during PED. However, a conceptual plan has been developed based on NED criteria and the planning criteria for the WSC study. In addition to compatibility with the ecosystem restoration component, formulation for recreation was done consistent with the Westside Creeks Restoration Conceptual Plan and City of San Antonio parks master planning. This resulted in the central element of the recreation component to be a trail system placed within the project area with connections to existing trails, parks and the Mission Reach project where possible. In addition to trails, other components include shade structures, interpretive/directional signage, benches, water fountains, picnic tables with pads, and trash receptacles.

The multi-purpose trail would be designed for walking, jogging, and bicycling. Trails constructed as part of the proposed WSC project will be limited to one side of the creek and located to avoid or minimize adverse impacts to riparian woody vegetation. The trails would be located to allow for access to the WSC project existing hike and bike trails, parks, community/recreation centers, public transit, schools, libraries, churches, bus stops, and community centers with places to work, shop, and play.

The primary recreation feature in the proposed plan is 44,600 linear feet of new trail. All trails would be ten feet wide and constructed of concrete. There would be approximately eight creek crossings designed perpendicular to the creek to minimize hydraulic impacts. Also, to promote accessibility from the local communities and existing recreation amenities, there would be approximately fourteen trailheads at street locations supporting an array of public amenities such as parks, schools, churches, bike lanes, and public transit. The conceptual recreation plan is shown in Appendix J.

There would be six shade structures located along the trails. These structures provide a resting area for trail users and shelter from climatic conditions. The shelters would likely be wood frame structures on concrete slabs, and have a roof but be open on all four sides. Shade structures would be proposed at trailheads and throughout the project at overlook locations, picnic/bench areas, and water fountain areas only where riparian woody vegetation is deemed unfeasible.

Day use facilities at various locations would provide approximately twenty-three picnic tables, fifteen water fountains, fifteen benches, and twenty three trash receptacles. These recreation amenities would be situated to take advantage of unique perspectives along the trail and be located at several trailheads, under trees and shade structures, and along the trail to alleviate the tired trail users.

Approximately fifty interpretive and directional signs would be provided. Most would be located in proximity to shade structures, day use facilities, trailheads at street connections, and in locations throughout the project to take advantage of the educational value of the ecosystem restoration.

A trail system of this type is expected to accommodate approximately 57,000 visitors per year per mile of trail, resulting in a capacity of 481,000 visitor days per year.

IMPACT OF RECOMMENDED PLAN ON EXISTING FLOOD RISK MANAGEMENT PROJECT

The data utilized in the study is the most up-to-date, and the water surface elevations computed for each alternative meet the criteria of not allowing the water surface elevation to exceed those published in the 2010 DFIRM. The hydraulic modeling will be refined during PED to insure the final design does not raise the water surface elevation.

BENEFITS GAINED FOR NATIONALLY, REGIONALLY, AND LOCALLY SIGNIFICANT RESOURCES

Restoration of the WSC riverine system will add to a larger habitat complex of the San Antonio River. With implementation of Alternative 6, this complex of preserved and restored riverine and upland habitat would increase from 1,270 contiguous acres to 1,492 acres and from 9 miles of contiguous restored aquatic habitat to approximately 20 miles. Restoration of the WSC system and of the larger San Antonio River complex will provide habitat benefits for a diverse community of aquatic organisms and wildlife; the most significant of which is the stop-over habitat benefits restoration would provide for nationally and internationally significant migratory birds of the Central Flyway.

As evidenced by the numerous conservation and management cooperatives established to address adverse impacts to avian populations in North America, migratory birds are of great ecological value and contribute immensely to biological diversity. Bexar County, Texas, provides essential feeding and resting habitat for migratory birds and is located in the heart of the Central Flyway. Over 300 species of birds are listed as neoarctic or neotropical migrants in North America and over 98% of those have been recorded in Texas. Therefore, of the more than 600 species of birds documented in Texas, 54% are neotropical species which depend on Texas to provide nesting or migration habitats. Many of these species are specifically dependent on south central Texas riparian areas such as those represented by Alternative 6. Neotropical migratory birds have been declining in numbers for several decades. Initially, the focus of conservation for this important group of birds was breeding habitat and wintering grounds; however, recently it has been recognized that the loss, fragmentation, and degradation of migratory stop-over habitat is potentially the greatest threat to the survival and conservation of neotropical birds (Smithsonian Migratory Bird Center). In arid areas of the United States stop-over sites are restricted to small defined habitats along shelter belts, hedgerows, desert oases and riparian corridors. The riparian corridors of south central Texas provide an opportunity for the birds to replenish fat reserves, provide shelter from predators and water for re-hydration prior to continuing, what is for most neotropical, a trip of over 1000 miles one-way. During the fall migration, the San Antonio area is located towards the end of the long flight, and therefore, provides the vital link between having enough fat reserves to complete the trip or perish.

SCARCITY

Historically, approximately one percent of the southwestern landscape was comprised of riparian habitats. The USFWS estimates 70% of the riparian habitats nationwide have been lost or altered. In the southwest, loss of native riparian vegetation exceeds 95% of historic habitats. These riparian habitats have been lost or altered due to river channelization, water impoundments, agricultural practices, and urbanization (Krueper, 1995). As riparian habitats across the country diminish, remaining riparian habitats become overcrowded and limited energy resources are not able to replenish fast enough for late arriving migrants or species that migrate later in the season.

In addition, species breeding in the riparian habitats must compete with a continuous onslaught of migratory birds utilizing their breeding habitat as stop-over habitats. Therefore, the restoration of riparian habitats across the country is essential for the continued existence of many migratory bird species.

REPRESENTATIVENESS

The ability of the WSC to exemplify a natural habitat or ecosystem in the south-central Texas area can be demonstrated by the results of the point count surveys conducted on the WSC and two reference reaches (Median River and Medio Creek). The Medina River is an example of one of the most ‘natural’ riverine systems in the study area. In fact, several Texas Birding Trail sites are located within the WSC reference reach for the Medina River emphasizing the high quality of habitat associated with the river. Medio Creek is located in a developing area of San Antonio with similar urban pressures of WSC. However, the functional riparian corridor adjacent to Medio Creek has been left intact. For the WSC study, Medio Creek is used as a model of the potential for the WSC restoration goals; i.e. what the WSC restoration efforts could ultimately achieve. Interestingly, the difference between the avian community diversity of Medio Creek and the Medina River is statistically insignificant. Therefore, using Medio Creek as a model, the WSC has the potential to be restored to a similar functional riverine habitat for migratory birds. The resulting restored WSC riverine habitat would therefore provide similar stop-over and breeding habitat for migratory birds.

STATUS AND TRENDS

The loss of riparian habitat throughout the nation, southwest region, and state is even more pronounced within Bexar County. Woody vegetation within the City of San Antonio has decreased by nearly 39% from 63,522 acres in 1985 to 38,753 acres in 2001. Additionally, the ranges of non-native, invasive species continue to expand throughout greater San Antonio as increased development and disturbances provide the catalyst enabling the species to establish in new areas. Without proactive restoration measures, encroachment and degradation of woodland and riparian habitats will continue. The steady decline of riparian habitat, especially woody riparian habitat, coincides with the decline of migratory bird populations across the country. Although the loss of riparian habitats is not the only factor, the loss of stop-over habitats, of which riparian habitats is the most productive, certainly contributes heavily to the decline of migratory bird populations.

CONNECTIVITY

In addition to connecting to previous USACE ecosystem restoration investments downstream at Mission Reach and Eagleland, the WSC would expand on a network of migratory bird “traps”, patches of highly productive habitats that attract an unusually high diversity of bird species throughout Bexar County. In particular, the WSC would connect two existing migratory bird traps, Woodlawn Lake Park and Mission San Juan. The WSC ecosystem restoration would provide connectivity of aquatic habitat and riparian habitat with the San Antonio River and also provide an additional “stepping stone habitat” between wintering and breeding neotropical migrant habitats. The addition of WSC to this network of habitats increases the avian “value” of the San Antonio area for migratory birds as it increases the range of foraging and nesting sites and provides a continuum of habitats which facilitates an efficient foraging strategy as birds feed up and down the WSC and between other productive areas.

LIMITING HABITAT

Limiting habitat is defined in the PGN as "habitat that is essential for the conservation, survival, or recovery of one or more species". Adequate migratory stop-over and breeding habitats are essential for the reproduction of migratory bird species, including numerous species of conservation concern. The number of migratory bird traps in Bexar County that are the result of avian conservation initiatives illustrates the importance of the study area within the Central Flyway as well as the magnitude and diversity of birds dependent on the area as wintering, stop-over, and breeding habitats. Even with the acreage of habitats preserved through conservation initiatives in Bexar County, the demand for stop-over habitats exceeds what is available. During avian point count surveys, a migrating American Bittern was observed feeding in Alazán Creek. The American Bittern is camouflaged to blend in with tall grasses and reeds and tends to be secretive, both as a foraging strategy and for defense. Having to forage out in the open in subpar habitat no doubt increased the biological stress on the bittern during a time when the replacement of energy reserves to complete its migration was essential. Even more telling was the observation of an Audubon's Yellow Watchlist species, the White-rumped Sandpiper, during point count surveys on Apache Creek. The White-rumped Sandpiper has one of the longest migration routes of any bird in the western hemisphere. It winters in the southern portion of South America and breeds in the northern tundra and Arctic islands in Canada and Alaska. During this migration, the sandpiper flies up to 2,500 miles and stops only to refuel for the next migration leg. The extensive body fat that the sandpiper needs to build up requires shoreline habitats associated with lakes, rivers, and wetlands where food is especially abundant. The loss of these limiting habitats makes the White-rumped Sandpiper particularly vulnerable to the loss of this strategic habitat, especially when the locations of major staging areas remain unknown.

BIODIVERSITY

The central concept driving the entire WSC study is the restoration of a diversity of habitats within the WSC study area. The diversity of habitats provides resources for a diverse community of lower trophic level organisms which in turn supports a more diverse upper level trophic community. The primary metric of the study, avian diversity, not only addresses the WSC resource of national significance, but measures the degree in which biodiversity improves throughout the WSC ecosystem. In essence, the success of the WSC study is defined by the degree and magnitude of biodiversity attained through the proposed ecosystem restoration measures.

BENEFITS OF THE RECOMMENDED PLAN TO OTHER FEDERAL GOALS AND OBJECTIVES

USACE formulates, designs, and constructs projects for specific missions and authorities including ecosystem restoration and recreation. USACE investment decisions are based on an established methodology to account for a project's benefit toward advancing a specific mission area. However, the lack of an accepted method to quantify the benefits a USACE project may have toward advancing other national priorities can leave much of the project's value to the nation unaccounted. Using the ecosystem restoration and recreation benefits as a foundation, a project such as the proposed WSC restoration could provide other nationally significant benefits such as meeting environmental and water quality goals in a densely populated urban area, promoting comprehensive watershed management, improving neighborhood transportation safety, providing access to outdoor recreation activities in communities with higher than average rates of obesity and diabetes, and reconnecting city residents to an urban creekway system through an outdoor living classroom for students of all ages to explore and learn about a restored urban ecosystem. Projects that more holistically meet the goals of multiple Federal agencies reflect a more realistic and modern view of governmental spending. The proposed WSC Restoration Project could assist in advancing several other Federal goals, initiatives and missions including the Executive Office, Environmental Protection Agency (EPA), Department of Interior (DOI), Council on Environmental Quality (CEQ), the Centers for Disease Control and Prevention (CDC), Housing and Urban Development (HUD) and First Lady Michelle Obama's campaign to improve the health of America's youth through the Let's Move and Let's Move Outside initiatives.

President Clinton signed EO 13186 regarding the Responsibilities of Federal Agencies to Protect Migratory Birds and EO 13112 regarding Invasive Species. EO 13186 states "…each agency shall, to the extent permitted by law and subject to the availability of appropriations and within Administration budgetary limits and harmony with agency missions … restore and enhance the habitat of migratory birds as practicable; and design migratory bird habitat and population conservation principles, measures, and practices into agency plans and planning processes (…watershed planning) as practicable, and coordinate with other agencies and non-Federal partners in planning efforts." EO 13112 states "Each Federal agency whose actions may affect the status of invasive species shall, to the extent practicable and permitted by law, identify such actions; …to provide for restoration of native species and habitat conditions in ecosystems that have been invaded." The restoration of the WSC would have net positive impacts on the goals of both EOs.

The EPA has taken the lead on the Urban Waters Federal Partnership that aims to stimulate regional and local economies, create local jobs, improve quality of life, and protect Americans' health by revitalizing urban waterways in under-served communities across the country. As discussed in Chapter 2, Socioeconomics*, the residents of the WSC study area are predominantly economically disadvantaged minorities. EPA notes that "urban patterns of development often make waterways inaccessible to adjacent neighborhoods. Lack of access limits a community's ability to reap the benefits of living so close to the water, whether through recreation, fishing or access to real estate." Such is the case with this project where the SACIP reduced flood risk but disconnected neighborhoods. The EPA notes that if "maintained properly, urban waters can also yield positive impacts for populations in both urban and upstream communities. The proposed WSC Restoration Project would restore the aquatic and riparian habitats of the creeks as well as add hike and bike trails where appropriate thus addressing several of the Partnership goals.

The DOI is spearheading the America's Great Outdoors (AGO) Initiative that President Obama launched to develop a 21st Century conservation and recreation agenda. The goals of AGO as stated in President Obama's April 16, 2010 memo are:

- Reconnect Americans, especially children, to America's rivers and waterways, landscapes of national significance, ranches, farms and forests, great parks, and coasts and beaches by exploring a variety of efforts, including:
    - promoting community-based recreation and conservation, including local parks, greenways, beaches, and waterways,
    - advancing job and volunteer opportunities related to conservation and outdoor recreation, and
    - supporting existing programs and projects that educate and engage Americans in our history, culture, and natural bounty.

The proposed WSC Restoration Project supports these Administration goals by creating corridors and connectivity across outdoor spaces, and promoting community-based recreation and conservation. The proposed ecosystem restoration of the creeks would reconnect families to the creeks and provide an outdoor classroom for young and old alike to learn about watersheds, riparian zones, migratory birds, and native plants and animals.

The TCEQ is advancing President Obama's Commitment to Clean Water by "designing and deploying innovative policies, programs and initiatives to directly address today's clean water challenges" including enhancing communities and economies by restoring water bodies. The proposed restoration of the WSC, in conjunction with other locally funded projects, is aligned with the TCEQ goal to enhance the use, enjoyment and stewardship of America's waters.

Centers for Disease Control (CDC) addresses healthy community design seeking to improve people's health by increasing physical activity, reducing injuries, increasing access to healthy foods, improving air and water quality, minimizing climate change and strengthening the social fabric of a community amongst other goals. The proposed WSC Restoration Project is located in neighborhoods that have some of the highest bicycle accident fatalities in the area as well as higher than average rates of diabetes and obesity. The proposed restoration of the WSC will bring native grasses, flowers, shrubs and trees into the area that will assist in addressing urban air quality issues and the natural channel design of the aquatic habitat will increase dissolved oxygen and restore the sediment transport mechanisms of the creeks. The recreation components of the project, hike and bike trails will provide safe, new recreation and basic transportation infrastructure to underserved communities. The native trees that will be planted within the urban core of the 7th largest city in the nation are carbon sinks that will help improve stormwater runoff, provide shade and cool water temperatures, control noise pollution, and clean urban air. All of these benefits address CDC healthy community design issues.

Housing and Urban Development (HUD) emphasizes sustainable communities that address health, bikeable cities, and community accessible parks while promoting 'livability principles' such as supporting existing communities, value communities, and neighborhoods, providing more transportation choices and coordinating policies and leveraging investments. The proposed WSC Restoration Project will positively touch on each one of these issues although none of them are the project's main objective.

Lastly, the First Lady's Let's Move and Let's Move Outside initiatives are aimed at addressing childhood obesity in America. "Let's Move Outside, administered by the Department of Interior, was created to get kids and families to take advantage of America's great outdoors-which abound in every city, town and community. Kids need at least 60 minutes of active and vigorous play each day to stay healthy, and one of the easiest and most enjoyable ways to meet this goal is by playing outside. By linking parents to nearby parks, trails and waters – and providing tips and ideas – Let's Move Outside can help families develop a more active lifestyle." The proposed WSC project provides facilities near homes and schools to engage in recreational activities consistent with the goals of the Let's Move Outside program.

As demonstrated in this section, the national benefits that can result from the proposed WSC Restoration Project extend beyond the analysis used to assess the interest of USACE in this proposed project. The environmental and recreation benefits serve as the foundation for a greater national value. The proposed WSC Restoration Project supports healthy living, sustainable communities, stewardship of natural resources, and urban outdoor recreation, to name only a few.

PROJECT IMPLEMENTATION

Project implementation for ecosystem restoration projects is comprised of three phases - Pre-construction Engineering and Design (PED), construction, and monitoring and adaptive management.

PRE-CONSTRUCTION ENGINEERING AND DESIGN

The PED phase is cost shared 75% Federal, 25% non-Federal. Prior to initiating the PED phase, the design team must develop a Project Management Plan (PMP) which defines the scope, work breakdown structure, schedule, and budget to complete PED. Additional items in the PMP are related to value management and engineering, quality control, communication, change management, and acquisition strategy. The draft PMP must be developed, negotiated, and agreed upon by all parties of the PED phase prior to initiation of the PED phase.

A number of activities are expected to take place during PED. These include the completion of a Design Documentation Report (DDR), plans and specifications (P&S), execution of the Project Partnership Agreement (PPA), and contract award activities.

The development of the DDR includes completing the final design of project features. As part of the DDR, the team will complete any ground surveys, utility surveys, and drilling and testing for subsurface (geotechnical) conditions as necessary to complete the final design. If the final design appears to disturb the Sloan Market Yard site immediately east of San Pedro Creek upstream of the confluence with Apache Creek, testing for site specific contaminants will be required. The pilot channel alignment, pool-riffle structure locations, and erosion protection locations will be further defined based on surveys, hydraulic analysis, and testing. Design parameters for all project features will be defined for development of the plans and specifications. Continued coordination with SHPO will ensure requirements for archeological resource investigations and mitigation continue to be met with an archeologist on site during construction for monitoring, identification, and proper documentation/preservation of any cultural resources that might be uncovered during construction.

P&S includes the development of project construction drawings and specifications, estimation of final quantities, and completion of the government cost estimate. Drawings and specifications are made available to contractors interested in bidding on the construction of the proposed project. It is estimated that as many as 4 sets of P&S will be developed for the pilot channel, aquatic features, and riparian vegetation. Arrangements for onsite archeological monitoring during construction should be finalized prior to the conclusion of P&S so they may be documented in the PPA.

A PMP for the construction phase must be developed, negotiated, and agreed upon by all parties of the construction phase prior to initiation of the construction phase.

The PPA is a binding agreement between the Federal government and the non-Federal sponsor which must be approved and executed prior to the start of construction. The PPA sets forth the obligations of each party. The non-Federal sponsor must agree to meet the requirements for non-Federal responsibilities which will be identified in future legal documents. Some of the likely responsibilities are:

- Provide 35% of the separable project costs allocated to environmental restoration. These include, but may not be limited to:

  - provide 25% of design costs allocated by the Government to ecosystem restoration in accordance with the terms of the design agreement entered into prior to commencing the PED phase for the project,
  - provide all easements and rights of way (all lands are within the existing SACIP project area), including suitable borrow and dredged or excavated material disposal areas, necessary for construction, operation, and maintenance of the ecosystem restoration features,
  - perform, or ensure performance of all utility relocations necessary for construction, operation, and maintenance of the ecosystem restoration features, and
  - provide or pay to the Government the cost of providing all retaining dikes, wasteweirs, bulkheads, and embankments, including any monitoring features and stilling basins, that may be required at any dredged or excavated material disposal areas required for construction, operation, and maintenance of the ecosystem restoration features.

- Provide 50% of the separable project costs allocated to recreation. These include, but may not be limited to:

  - provide 25% of design costs allocated by the Government to recreation in accordance with the terms of the design agreement entered into prior to commencing the PED phase for the project,
  - provide all easements and rights of way (all lands are within the existing SACIP project area), including suitable borrow and dredged or excavated material disposal areas, necessary for construction, operation, and maintenance of the recreation features,
  - perform, or ensure performance of all utility relocations necessary for construction, operation, and maintenance of the recreation features, and
  - provide, during construction, any additional costs necessary to make the total non-Federal contribution equal to 50% of the separable project costs allocated to recreation.

- For so long as the project remains authorized, operate, maintain, repair, replace, and rehabilitate the completed project at no cost to the Federal Government in a manner compatible with the project's authorized purposes and in accordance with applicable Federal laws, State laws, and specific directions prescribed by the Federal Government.
- Give the Government a right to enter, at reasonable times and in a reasonable manner, property which the non-Federal sponsor owns or controls to gain access to the project for the purposes of inspection, completion, operation, maintenance, repair, replacement, or rehabilitation of the project.
- Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970 as amended, and Section 103 of the WRDA 1986, Public Law 99-662 as amended, which provide that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.
- Hold and save the United States free from all damages arising for the construction, operation, maintenance, repair, replacement, and rehabilitation of the project except for damages due to the fault or negligence of the United States or its contractors.
- Keep and maintain books, records, documents, and other evidence pertaining to the costs and expenses incurred pursuant to the project for a minimum of three years following completion of the project accounting for which such books, records, documents, or other evidence is required, to the extent and in such detail as will properly reflect total project costs, and in accordance with financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20.

- Prevent obstructions or encroachments on the project which might interfere with the proper functioning of the project, hinder operation and maintenance, or reduce the benefits of the project.
- Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987, Public Law 100-17, and the Uniform Regulations contained in 49 CFR part 24, in acquiring easements, rights of way, and performing relocations for construction, operation, and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said acts.
- Comply with all applicable Federal and State laws and regulations, including Section 601 of the Civil Rights Act of 1964, Public Law 88-352, and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled “Nondiscrimination on the Basis of Handicap Programs and Activities Assisted or Conducted by the Department of the Army.”
- Do not use funds from other Federal programs, including any non-Federal contribution required as a matching share, to meet the non-Federal obligations for the project unless the Federal agency providing the Federal portion of such funds verifies in writing that the expenditure of such funds for such purpose is appropriate and authorized.
- Provide and maintain recreation features, access roads, parking areas, and public use facilities open and available to all on equal terms.
- Obtain any and all water rights necessary for the operation of the project.

REAL ESTATE ACQUISITION

The non-Federal sponsor is responsible for the lands, easements, rights-of-way, relocations, and disposal areas required for project construction, operation, and maintenance of WSC. No lands beyond the existing Federal project (SACIP) are required for this proposed project. Following the Execution of the PPA, the non-Federal sponsor will be provided a right of way map delineating the real estate necessary for construction, operation, and maintenance of the proposed project. Real estate activities will be coordinated between SARA’s Real Estate Office and the Real Estate Office of the Fort Worth District. Also, prior to any solicitation of construction contracts for WSC, the District Chief of Real Estate is required to certify in writing that sufficient real property interest is available to support construction of the contract.

CONTRACT ADVERTISEMENT AND AWARD

Once the PPA is executed, the plans and specifications completed, and the rights of entry provided to SWF, a construction contract will be solicited and advertised. Prior to awarding the contract, the non-Federal sponsor must provide any applicable cash contribution. The contract will be awarded to the lowest responsive bidder and notice to proceed can be expected within 30-45 days from bid opening.

PROJECT CONSTRUCTION

After award of the construction contract, the Government will manage project construction. Up to 5 contracts may be awarded. Inherent with this contract, a warranty period for actual construction items and plantings will be specified. Construction of the pilot channel, riffle structures, cross vane structures, and pools is estimated to take 36 months to complete. Planting of riparian meadow will begin in areas where the channel work is complete. Planting will occur over at least two seasons within the same planting area. There will be a 2 year contract period beyond each specific planting period to ensure the riparian meadow is alive and thriving. This activity includes removing any non-native or invasive species, watering (if needed), and replacement vegetation to ensure a minimum survival rate. During construction, an archeologist will monitor excavation. Should any significant cultural resources be identified, mitigation procedures will take place prior to further excavation. Total implementation time is expected to be 60 months.

MONITORING AND ADAPTIVE MANAGEMENT

Monitoring and if necessary, adaptive management will occur for a period of three years as evidence for successful establishment of the project prior to the project being turned over to the non-Federal sponsor for operation and maintenance. Monitoring efforts will be conducted with SARA and USACE personnel. See Appendix C for a draft copy of the Monitoring and Adaptive Management Plan.

OPERATION, MAINTENANCE, REPAIR, REPLACEMENT, REHABILITATION (OMRR&R)

The non-Federal sponsor is responsible for the OMRR&R of the completed project. SWF will update the existing SACIP OMRR&R plan which also includes management strategies for sustainable riverine ecosystem management. SWF will provide the updated plan upon successful completion of the project (or a representative portion thereof) construction, prior to turning over the project to the non-Federal sponsor for OMRR&R. OMRR&R of the proposed restoration project is comprised of the structural integrity of the riffle structures, cross vane structures, and recreation facilities. Based on a survey of other riparian ecosystem recreation studies, OMRR&R costs are estimated at $1,895 per acre, yielding a total cost of $420,690 for WSC. It is assumed that after five years, plantings and structures would become self-sustaining and OMRR&R costs would decrease by half for the remainder of the planning horizon. Annualized OMRR&R costs for the ecosystem restoration components is estimated to be $248,095. For the recreation component, annualized OMRR&R is estimated to be $39,000.

PILOT CHANNEL, RIFFLE STRUCTURES, ROCK CROSS VANES, POOLS, AND SLACKWATER

Routine maintenance will include periodic inspection, repair of localized erosion, removal of excess sediment and debris, and replacement of dislodged riprap and rock. Structures within the creeks will help to maintain the pilot channel alignment during flood events.

RIPARIAN MEADOW AND RIPARIAN WOODY VEGETATION

Selected mowing within the restoration area may be required periodically to maintain the FRM capability of the project, but is not required for the restoration. These costs should be significantly reduced with the restoration project in place since mowing would be limited for ecosystem restoration management measures.

Some vegetation loss will likely occur during years 3-5 of the project, particularly if the area experiences a significant flood event. This potential loss of habitat is mitigated by the use of seedlings for tree and shrub plantings. Seedlings are more likely to withstand flood forces while root systems become firmly established. An increase in debris is expected during and after flood events. The removal of this debris is accounted for in the OMRR&R estimate.

RECREATION FEATURES

Trails and creek crossings will require periodic inspection, repairing minor cracks and scaling, and clearing of debris. Comfort stations will require periodic cleaning and trash removal. It is expected that picnic tables, benches, water fountains, and signage will require nominal funding for repair and replacement.

TOTAL PROJECT COST AND COST SHARING

Since all lands required for the proposed project are within the existing ROW for the previously constructed SACIP, total project cost as shown in Table 11 for the recommended plan includes utility relocations, channels and canals, fish and wildlife, and recreation facilities as well as planning, engineering, and design, and construction management. Utility relocations include the demolition and reconstruction of water, and waste water lines as necessary to construct, operate, and maintain the proposed project. Channels and canals include excavation, grading, construction materials for the rock cross vane and riffle structures, and armoring. Fish and wildlife includes the removal of the top six inches of soil, ripping to a depth of 12-18 inches, herbicide, compost material, seeds, planting, and provisions for short-term watering. Recreation facilities include walk, jog, and bike trails, shade structures, signage, benches, water fountains, picnic tables, and trash receptacles. Planning, engineering, and design is the cost to complete the DDR, P&S, and PPA, and to award the construction contract(s). Construction management reflects the costs to oversee the construction of the proposed project, and complete the Operation and Maintenance Manual.

Restoration project features are cost shared 65% Federal and 35% non-Federal. The non-Federal share includes the value of all easements, rights of way, relocations, and disposal areas required for the recommended plan. In the event this value is less than 35% of the total project cost, a cash contribution is required to make the non-Federal share at least 35%.

Recreation project features are cost shared 50% Federal and 50% non-Federal. The non-Federal share is provided in cash prior to the fiscal year in which it will be expended.

Table 11 displays a summary of the cost sharing for the proposed project.

PROJECT IMPLEMENTATION SCHEDULE

Table 12 displays a draft project implementation schedule. The final schedule will be coordinated and approved by the non-Federal sponsor and included in the PED PMP.

FINANCIAL PLAN AND CAPABILITY ASSESSMENT

Total financial obligation of the non-Federal sponsor during project implementation is estimated to be $18.8 million. The annual obligation for OMRR&R is estimated at $286 thousand.

Table 12 displays the estimated non-Federal sponsor financial obligation by fiscal year assuming PED commences October 1, 2014.

The statement of financial capability is based on information provided by SARA, and SARA's description of its capability to meet the non-Federal financial obligations for the recommended plan.

Table 11. Total Project First Cost and Cost Share Summary of the Recommended Plan for the Westside Creeks

October 2012 Prices (000's)			
Feature	**Federal**	**Non-Federal**	**Total**
Ecosystem Restoration			
Utility Relocations		$3,109	$3,109
Channels and Canals	$13,658		$13,658
Fish and Wildlife	$19,481		$19,481
Monitoring and Adaptive Management	520	280	800
Planning, Engineering & Design	$3439	$1,146	$45,344
Construction Management	$4,511		$4,511
Unadjusted total	**$41,609**	**$4,535**	**$46,144**
Adjustment to achieve 65/35	$(11,615)	$11615	
Subtotal ER	**$29,994**	**$16,150**	**$46,144**
Recreation			
Recreation Facilities	$3,863		$3,863
Preconstruction, Engineering & Design	$545	$182	$727
Construction Management	$715		$715
Unadjusted total	**$5,123**	**$182**	**$5,305**
Adjustment to achieve 65/35	$(2,471)	$2,471	
Subtotal Recreation	**$2,652.5**	**$2,652.5**	**$5,305**
Total Cost Apportionment	**$32,646**	**$18,803**	**$51,449**
Cost Percentage	**63%**	**37%**	**100%**

Table 12. Westside Creeks Proposed Project Implementation Schedule and Funding ($000)

	Total	2014	2015	2016	2017	2018	2019	2020
Federal ER								
Planning Engineering and Design	$3,505	$2,927	$578					
Utility Relocations								
Channels and Canals	$10,904			$8,089	$704	$704	$704	$704
Fish and Wildlife	$12,425			$9,245	$795	$795	$795	$795
Construction Managements	$2,790			$571	$763	$555	$555	$347
Monitoring and Adaptive Management	$520							
Total Federal ER	**$30,144**	**$2,927**	**$578**	**$17,905**	**$2,262**	**$2,054**	**$2,054**	**$1,846**
Non-Federal ER								
Planning Engineering and Design	$1,091	$1,091						
Utility Relocations	$3,143			$3,143				
Channels and Canals	$5,858			$3,547	$578	$578	$578	$578
Fish and Wildlife	$4,126			$2,970	$289	$289	$289	$289
Construction Managements	$1,733			$404	$520	$289	$231	$289
Monitoring and Adaptive Management	$180							
Total Non-Federal ER	**$16,131**	**$1,091**	**$0**	**$10,064**	**$1,387**	**$1,156**	**$1,098**	**$1,156**
Federal REC								
Planning Engineering and Design	$603	$603						
Recreation Facilities	$1,967					$1,733	$118	$116
Construction Management	$367			$98	$81	$86	$55	$46
Total Federal REC	**$2,937**	**$603**		**$98**	**$81**	**$1,820**	**$173**	**$162**
Non Federal REC								
Planning Engineering and Design	$201	$201						
Recreation Facilities	$2,311					$2,022	$144	$144
Construction Management	$425			$90	$92	$97	$83	$73
Total Non Federal REC	**$2,937**	**$201**		**$90**	**$92**	**$2,109**	**$228**	**$217**
Total Federal	$33,081	$3,530	$578	$18,003	$2,343	$3,873	$2,227	$2,007
Total Non-Federal	$19,068	$1,292	0	$10,154	$1,479	$3,265	$1,325	$1,373
Total	**$52,149**	**$4,822**	**$578**	**$28,157**	**$3,822**	**$7,138**	**$3,552**	**$3,380**

Typically, based upon past SACIP projects, SARA serves as the local sponsor working with the City of San Antonio and Bexar County to identify funding strategies to meet local funding requirements. Past SACIP projects including two flood tunnels and the Mission Reach project have been funded through Interlocal Agreements as approved by the City, County and SARA governing bodies.

A previous source of funding for Bexar County has been an ad valorem flood tax collected from property owners in Bexar County. The County, with past projects has obligated itself to meet debt service requirements through an Interlocal Agreement. SARA, on these past projects, as would be the case today if this strategy is chosen, is required to secure authorizations from the County prior to proceeding with design and construction. Following approval, the County commits the appropriations to support the authorization requested. Funding authorizations and appropriations, especially for construction, may be secured in phases over the life of the project. SARA has issued debt incrementally over the life of the project as needed to fund the County's approved appropriations for the project.

In the past, the City of San Antonio has utilized various sources of funding when participating as a local funding entity. These funding sources have included the City's Capital Improvement Program supported by general obligation bonds, revenue bonds, special revenue funds, and other funds managed by the City. As with the County, SARA has been required to request authorization to proceed with design and construction of the project. Following approval, the City appropriates the required funds. Funding authorizations and appropriations, especially for construction, may be secured in phases over the life of the project. SARA invoices the City for actual expenses to be paid from the City's funding.

SARA is also exploring implementing a revenue strategy authorized under Chapter 49 of the Texas Water Code that would allow SARA to fund Capital Improvement Projects such as the Westside Creeks Restoration Project. Texas Water Code 49.107 authorizes a water district, following an affirmative election of certified voters of the district, to “levy and collect a tax for operation and maintenance purposes, including funds for planning, constructing, acquiring, maintaining, repairing, and operating all necessary land, plants, works, facilities, improvements, appliances, and equipment of the district and for paying costs of proper services, engineering and legal fees, and organization and administrative expenses.” If voters in SARA’s district approve the Chapter 49 tax, another local financing tool will be available to consider for use in implementing the WSC Restoration Project.

Coordinated and financed projects within the Westside Creeks Restoration Project study area include the City of San Antonio Linear Creekways Project that will be providing hike and bike recreation trails in the study area, Bexar County’s San Pedro Creek Restoration Project and the City of San Antonio and Bexar County Proposed Improvements to Elmendorf Lake. The implementation of these area projects demonstrate the commitment local government entities have in improving and restoring the Westside Creeks.

Based on the review of the financial capabilities and plan, it is reasonable to expect sufficient resources will be available to satisfy the non-Federal financial obligations of the recommended plan.

VIEW OF THE LOCAL SPONSOR

SARA, on behalf of the City of San Antonio and Bexar County, is identified as the non-Federal sponsor. SARA, City of San Antonio, and Bexar County support the recommended plan and intend to participate in its implementation. A letter of support stating this intent is included in Appendix N.

VIEWS OF RESOURCE AGENCIES

The USFWS and TPWD are supportive of the recommended plan. The recommended plan fulfills a number of their missions and objectives. TPWD has been involved in the data collection and model development for the study, and provided input throughout the study. Letters from these agencies announcing their support for the recommended plan are expected once the public review period is complete.

ENVIRONMENTAL OPERATING PROCEDURES

The Westside Creeks Ecosystem Restoration Project incorporates environmental sustainability by returning channelized streams into more a more naturally functioning riverine systems to create aquatic habitats and balanced sediment flows. The project balances ecosystem restoration and flood risk management within an existing flood risk management project by restoring habitat without increasing the existing flood risk. The plan was consistent with all applicable laws and policies, and the Corps and its non-Federal sponsors continued to meet our corporate responsibility and accountability for the project in accordance with those laws and policies. The study team used appropriate ways and means to assess cumulative impacts to the environment through the National Environmental Policy Act and the use of engineering models, environmental surveys and coordination with natural resource agencies. As a result of employing a risk management and systems approach throughout the life cycle of the project, the project design evolved to address as many concerns as possible with no mitigation required to address adverse impacts.

CHIEF OF ENGINEERS CAMPAIGN PLAN

In 2006, the Chief of Engineers released 12 Actions for Change, as set of actions that the Corps of Engineers will focus on to transform its priorities, process and planning. These Actions for Change are organized into four groupings. The Westside Creeks Ecosystem Restoration study addresses the Chief of Engineers Campaign Plan, as described below.

EFFECTIVELY IMPLEMENT A COMPREHENSIVE SYSTEMS APPROACH

The Westside Creeks study considered the study area as interconnected environmental, hydraulic, economic and community system. Each of these elements was important and the study strived to find balance within this system by maximizing the environmental habitat possible while ensuring there were no induced flood risk form the project.

RISK INFORMED DECISION MAKING

At each level of decision making, the Westside Creeks PDT considered what risk existed, what new risks may have been created, and what actions could be taken to minimize these risk to both planning and costs. Risks and risk reduction were continuously discusses with the vertical team at each decision point.

COMMUNICATION OF RISK TO THE PUBLIC

In addition to four public meetings, the Westside Creeks PDT spoke at oversight board committees in the communities to describe the project and discuss the studies impact on existing flood risk measures.

PROFESSIONAL AND TECHNICAL EXPERTISE

As a pilot study, the Westside Creek Study pressed each discipline to identify more cost effective and timely ways to reach technically sound decisions with minimal risk. Throughout the plan formulation process, each discipline exercised professional judgment in apply risk informed decision making .

CONCLUSIONS

The Fort Worth District recommends the approval and implementation of the NER/NED Plan as described in this chapter. The following conclusions are based on the study findings in connection with the General Re-evaluation Report and Integrated Environmental Assessment.

- The recommended plan is a multi-objective project consisting of ecosystem restoration features and recreation features which do not adversely affect the performance of the existing flood risk management project.
- A significant need is identified to warrant implementation of ecosystem restoration measures and construction of recreation facilities for these project purposes.
- The recommended plan consists of 222 acres of riparian vegetation, and 6.5 miles of pilot channel with 147 riffle-pool-run segments and 144 slackwater areas. The average annual habitat gain for the restoration area is 101 Avian Community Units.
- The total restoration project cost is estimated at $45.3 million. The annual cost is $2.1 million at the 2013 Federal Discount Rate of 3.75%. The annual cost for the last habitat unit gained is $19 thousand.
- The total recreation project cost is $5.3 million, which increases the Federal share of the project cost by 9.0%. The annual cost is $282 thousand at the 2013 Federal Discount Rate of 3.75%.
- Monitoring and Adaptive Management costs are estimated at $800 thousand.
- The San Antonio River Authority is identified as the non-Federal sponsor for the implementation of the recommended plan. Federal and non-Federal cost apportionments for the recommended restoration plan are estimated at $30 million and $16.2 million, respectively. Federal and non-Federal cost apportionments for the recommended recreation plan are estimated at $2.7 million each.
- The potential to impact cultural resources under this alternative are minimal due to previous activities conducted at the site and the shallow depth of most proposed ground disturbing activities. To minimize the impacts to resources that may be encountered during construction, an archeological monitor would be on site to identify cultural resources should they be discovered. The monitor would assess the significance of the resource and mitigate for impacts before ground disturbing activities would be allowed to continue in the vicinity. In this way, no significant impacts for the implementation of the action alternatives would be expected.
- The recommended plan will cause no long term adverse environmental impacts within the study area. A draft Finding of No Significant Impact (FONSI) has been prepared and is included in the documentation for the General Re-evaluation Report and Integrated Environmental Assessment. Distribution of the report, including the draft FONSI, was made available for public review and comment in July/August 2013.
- The recommended plan is supported by the San Antonio River Authority, City of San Antonio, Bexar County, U.S. Fish and Wildlife Service, Texas Parks and Wildlife Department, and the Westside Creeks Restoration Oversight Committee.

The San Antonio Channel Improvement Project, Westside Creeks Ecosystem Restoration Recommended plan:

- fulfills the USACE restoration mission,
- is in accordance with the USACE Civil Works Strategic Plan,
- is in accordance with the USACE Environmental Operating Principles,
- is in compliance with USACE restoration and recreation policies,
- is technically sound,
- is sustainable though the application of geomorphologic principles for sediment transport, hydraulic modeling, native vegetation species survivability, and synergistic effects,
- restores biological and environmental resources that were present prior to the construction of the SACIP,
- restores limiting habitat for neotropical migratory bird species,
- complements other Federal, state, and local restoration programs and projects,
- demonstrates ecosystem restoration and recreation co-exists effectively with the existing SACIP purpose of flood risk management,
- provides connection to adjacent restored and preserved habitats within the San Antonio River Watershed,
- restores the creeks to a more natural structure and function resulting in the greatest practicable sinuosity, slope gradient, velocity, and sediment transport while maintaining the current effectiveness of the flood risk management function of the SACIP, and
- is supported by U.S. Fish and Wildlife Service, and Texas Parks and Wildlife Department, as well as having widespread local support.

Should there be a mention here of the USACE Campaign plan? I realize that this project is in accordance with the USACE EOPs, but it also demonstrates compliance with 2a and 2b of the Campaign plan to deliver integrated, sustainable, water resource solutions in a collaborative manner. Also, it's possible that the EOPs should be spelled out here with a short description of how this project embraces these EOPs.

RECOMMENDATION

I propose the ecosystem and recreation features identified as the recommended plan in the San Antonio Channel Improvement Project, General Re-evaluation Report and Environmental Assessment, Westside Creeks, San Antonio, Texas, proceed with implementation in accordance with the cost sharing provisions set forth in this report.

This recommendation is made with the provision that, prior to project implementation, the non-Federal sponsor shall enter into a binding agreement with the Secretary of the Army to perform the items of local cooperation, as specified in this document.

The recommendations contained herein reflect the information available at this time, and current Department of the Army, and U.S. Army Corps of Engineer policies governing formulation of individual projects. The recommendations do not reflect the program and budget priorities inherent to the formulation of a national Civil Works construction program, not the perspective of higher review levels within the Executive Branch of the U.S. Government. Consequently, the recommendations may be modified before they are transmitted to Congress as proposals for implementation funding. However, prior to transmittal to Congress, the sponsor, the State, interested Federal agencies, and other interested parties will be advised of any modifications, and be afforded the opportunity to comment further.

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Charles H. Klinge

Colonel, U.S. Army Corps of Engineers

District Engineer

Date ________________________

DRAFT FINDING OF NO SIGNIFICANCE IMPACT

At the request of the San Antonio River Authority, and under authority of section 335 of the Water Resources Development Act of 2000, the Fort Worth District Corps of Engineers conducted a re-evaluation study to include the purposes of ecosystem restoration and recreation in the flood control project authorized by section 203 of the Flood Control Act of 1954, as modified. Study results are presented in an integrated General Re-evaluation Report and Environmental Assessment (EA).

Seven alternative plans, including the "no action", were examined to identify the National Ecosystem Restoration (NER) Plan. The NER Plan would balance sediment transport and native woody vegetation in San Pedro, Apache, and Alazán Creeks, and native herbaceous aquatic and riparian vegetation in Martinez Creek. The restoration would include 222 acres of riverine habitat corridor including riparian meadow and woody vegetative habitat with 6.5 miles of natural channel design pilot channel. Incorporating the recreation component (NED Plan) with the NER Plan results in the recommended plan for the WSC project. The San Antonio River Authority, as the local sponsor for this study, fully supports the recommended plan

The recommended plan would have no effect on federally listed threatened and endangered resources. The recommended plan would impact waters of the United States and subject to provisions of Section 404 of the Clean Water Act. Restoration activities would meet the terms and conditions of Nationwide Permit (NWP) 27, Wetland and Riparian Restoration and Creation Activities. The State of Texas issued a water quality certificate for NWP 27 and, therefore, no further coordination is required under Section 404.

The proposed project is located within the flood control channel of the Westside Creeks, and requires siting within the floodplain to meet its intended purpose. The project has been formulated to not induce or increase flood damages; therefore, the proposed project is in compliance with Executive Order 11988, Floodplain Management. The proposed project would neither adversely impact nor result in loss of wetland areas so the project is in compliance with Executive Order 11990.

In accordance with 36 CFR Part 800.6(b), should adverse impacts to any cultural or historic resources throughout the project corridor be unavoidable, an appropriate mitigation plan will be sought in consultation with the Texas Historical Commission and other interested parties and agencies, and fully implemented prior to project construction. Cultural resources compliance issues for the project area are being addressed through on-going consultation with the Texas State Historic Preservation Office (SHPO) in accordance with Section 106 of the National Historic Preservation Act.

Based on a review of the information, it is determined that the implementation of the Proposed Action is not a major federal action, which would significantly affect the quality of the human environment within the meaning of Section 102(2)(c) of the National Environmental Policy Act of 1969, as amended. Therefore, the preparation of an Environmental Impact Statement is not required.

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CHARLES H. KLINGE
Colonel, EN
Commanding

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Date

CHAPTER 6: PUBLIC INVOLVEMENT

This chapter discusses consultation and coordination that has or will occur during preparation of this document. This includes contacts made during development of the proposed action, other alternatives considered, and writing of the GRR and EA.

AGENCY COORDINATION

Copies of agency coordination letters are presented in Appendix N. Formal and informal coordination has been and will continue to be conducted with the following agencies:

- U.S. Army Corps of Engineers,
- State Historic Preservation Office,
- U.S. Fish and Wildlife Service,
- Environmental Protection Agency, Region 6 Office
- Texas Parks and Wildlife Department,
- Texas Commission on Environmental Quality
- Federal Aviation Administration
- Texas Historical Commission
- Animal and Plant Health Inspection Service of the U.S. Department of Agriculture
- Comanche Nation NAGPRA
- Kiowa Tribe of Oklahoma
- Mescalero Apache Tribe
- Tonkawa Tribe of Oklahoma

TPWD and USFWS were involved throughout the study process. They participated in initial brainstorming and problem identification and provided comments throughout the WSC study process. TPWD also participated in the data collection and field surveys and contributed in the development of the AIBI model.

PUBLIC INFORMATION AND REVIEW

A scoping meeting was conducted in July 2012. Due to the nature of the community, two meetings were conducted to ensure a location was provided that was convenient to all residents and business owners in the study area. Seventy-seven public comments have been received to date. Keys concerns from the public include the return of recreation opportunities to the creeks, safety, and the return of ecological habitats. Multiple State and Federal agencies were invited to attend these meetings. Those that chose to attend included TCEQ, EPA, and USGS.

In accordance with NEPA, a 30-day review period of the GRR, integrated EA, and Draft FONSI will be provided via a Notice of Availability, posting of the document on the Fort Worth District Website (www.swf.usace.army.mil), and a local mailing (Appendix N).

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ACRONYMS

ACE- Annual Chance Exceedance
ADA- American Disabilities Act
AIBI – Avian Index of Biotic Integrity
APE- Area of Potential Effects
APHIS - Animal and Plant Health Inspection Service
ASTM - American Society of Testing and Materials
ATR- Agency Technical Review
BCRs-Bird Conservation Regions
CE/ICA- Cost Effective-Incremental Cost Analysis
CEQ- Council of Environmental Quality
City- City of San Antonio
City HPO- City of San Antonio Historic Preservation Office
CPS – CPS Energy, owner of electric and gas distribution lines for the City of San Antonio
CWA – Clean Water Act
DFIRM- Digital Flood Insurance Rate Maps
EA- Environmental Assessment
EDR - Environmental Data Resources, Incorporated
EO - Executive Order
EPA- Environmental Protection Agency
ER- Engineering Regulation
ERDC- Engineering Research and Development Center
ESA – Environmental Site Assessment
ESRI- Environmental Systems Research Institute
FAA – Federal Aviation Administration
FCA- Flood Control Act
FEMA- Federal Emergency Management Agency
FEMA VAP- Federal Emergency Management Agency Voluntary Acquisition Program
FIS- Flood Insurance Study
FONSI- Finding of no Significant Impact
FPPA - Farmland Protection Policy Act
FRM- Flood Risk Management
FWCA – Fish and Wildlife Coordination Act
GED- General Equivalency Degree
GIS- Geographic Information Systems
GRR- General Re-evaluation Report
HEC- Hydrologic Engineering Center
HKHC- Healthy Kids, Healthy Communities
HTRW- Hazardous, Toxic, and Radioactive Waste
IBI- Index of Biological Integrity
IHD- Index of Human Disturbance
Ka- Austin Chalk
Kan- Anacacho Limestone

Kn- Navarro Group
Kta- Taylor Marl
LID- Low Impact Development
MOA – Memorandum of Agreement
NAAQS- National Ambient Air Quality Standards
NABCI- North American Bird Conservation Initiative
NCD- Natural Channel Design
NED- National Economic Development
NEPA- National Environmental Policy Act
NER- National Ecosystem Restoration
NER- National Environmental Restoration
NHPA – National Historic Preservation Act
NOAA- National Oceanic and Atmospheric Administration
NPDES - National Pollutant Discharge Elimination System
NRC- National Research Council
NRCS- Natural Resource Conservation Service
NRHP- National Register of Historic Places
OMRRR- Operation, Maintenance, Repair, Rehabilitation, and Replacement
OSE- Other Social Effects
OWPR- Office of Water Project Review
P&G- Principals and Guidelines
PDT- Project Delivery Team
PED- Pre-construction Engineering and Design
PGN – Engineering Regulation 1105-2-100, Planning Guidance Notebook
PMP- Project Management Plan
RAS- River Analysis Software
RE- Real Estate
ROE- Rights of Entry
ROW- Right of Way
RTHL- Recorded Texas Historic Landmarks
SACIP - San Antonio Channel Improvement Project
SAL- State Archeological Landmarks
SAPRSSP - San Antonio Park and Recreation System Strategic Plan
SARA- San Antonio River Authority
SAWS- San Antonio Water Systems
SHPO- State Historic Preservation Officer
SWPPP - Storm Water Pollution Prevention Plan
TCEQ- Texas Commission on Environmental Quality
THC- Texas Historical Commission
TPDES - Texas Pollutant Discharge Elimination System
TPWD- Texas Parks and Wildlife Department
TRM – Turf Reinforcement Mat
TSP- Tentatively Selected Plan
TWP- The Wills Point

TX- Texas
USACE- United States Army Corps of Engineers
USFWS- United States Fish and Wildlife Service
USGS- United States Geological Survey
WRDA- Water Resources Development Act
WSC- Westside Creeks (encompasses San Pedro Creek, Martinez Creek, Alazán Creek, and Apache Creek)
WCROC- Westside Creeks Restoration Oversight Committee

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WESTSIDE CREEKS ECOSYSTEM RESTORATION

Appendix A: Geomorphology

GEOMORPHOLOGY APPENDIX

INTRODUCTION

PURPOSE

The San Antonio River Authority (SARA) contracted with Michael Baker Jr., Inc. (Baker) in February 2012 to develop a preliminary bankfull pilot channel design and plan form for the West Side Creeks project (WSC) as part of the SARA Stream Restoration Program. The project is in support of the Ecosystem Restoration (ER) feasibility study being conducted by the US Army Corp of Engineers Fort Worth District (USACE) for WSC. The purpose of this report is to describe project objectives, provide a general overview of the WSC project reaches and corresponding watersheds, describe the methodology of the preliminary plan form design process, and summarize the assumptions of the resulting preliminary design parameter values. Preliminary cost estimates associated with the proposed in-stream structures for each WSC project reach are also provided.

OBJECTIVES

The following objectives were outlined for WSC by USACE:

- *Objective 1* – Restore, to the extent practicable, a sustainable dynamic riverine ecosystem providing habitat for aquatic and riparian dependent migratory and native resident bird species in the WSC study area.
- *Objective 2* – Maximize, to the extent practicable, recreation benefits along WSC compatible in scope and scale of the project's ecosystem restoration objective and consistent with national, regional, and local recreation goals.

Baker incorporated the USACE objectives to develop the preliminary bankfull pilot channel design and base plan form for WSC using natural channel design (NCD) principles. NCD is an applied technique that can be employed to help restore various ecologic functions to impaired stream systems. These primary functions are categorized as hydrology, hydraulic, geomorphic, physiochemical, and biological. The restoration of hydraulic and geomorphologic functions provides a framework for restoring other related functions and ultimately determines the functional lift potential and project success.

BASIN OVERVIEW

The WSC include approximately 14 miles of channel of the following creeks:

- San Pedro Creek (approximately 3.8 miles)
- Apache Creek (approximately 4.2 miles)
- Alazan Creek (approximately 3.3 miles)
- Martinez Creek (approximately 2.8 miles)

The WSC are generally located west to northwest of downtown San Antonio, TX except for San Pedro Creek which is located south of downtown. The WSC are nested tributaries, all predominantly flowing south or southeast and converging with one another, eventually flowing into San Pedro Creek which drains into the San Antonio River.

The WSC are all drained by highly urbanized, impervious watersheds composed primarily of medium to high density residential areas with some commercial and industrial land uses. These developed watersheds are considered to be built-out and have been so for many decades (AECOM, 2011). Drainage area and percent impervious area for the WSC project watersheds are presented in Table 1.

Table 1.Watershed Drainage Areas and Imperviousness

WSC	Drainage Area (sq mi)	Impervious Area (%)
San Pedro Creek	44.9	68
Apache Creek	40.3	66
Alazan Creek	17.5	71
Martinez Creek	7.2	73

The WSC are flood conveyance channels, typically confined by dense urban infrastructure bordering both terraces which serve as flood control boundaries. They are characterized by oversized, grass-lined trapezoidal channels with limited floodplain access, and an inadequate buffer comprised primarily by herbaceous grasses that provide no stream cover and marginal habitat value. These channels are actively maintained and have been severely manipulated and channelized several decades ago by USACE for flood conveyance. Concrete-lined channels within the WSC project area include the majority of Apache Creek and the upstream half of the San Pedro Creek project reach beginning at Camp Street, where portions of channel have been culverted beneath parking lots and roads. Hydrology within the watersheds has been historically altered by flood control structures and extensive stormwater drainage networks. The upstream project limits for Apache, and Alazan Creeks consist of flood control structures with impounded water from an Elmendorf Lake, and Woodlawn Lake respectively.

METHODOLOGY

EXISTING CONDITIONS

Development of design criteria and the preliminary base plan form for WSC was exclusively achieved by analysis and remote sensing of pre-existing digital data provided primarily by SARA using a combination of GIS, CAD, and Google Earth. Site visits for ground-truthing of existing data, or collection of additional field data was not scoped for this project. Data provided by SARA was compiled and inventoried. The following datasets were integral to the methodology for the WSC preliminary design process:

- Existing SARA concept plan for WSC and related GIS layers (basin delineations, hydrography, project corridor boundary)
- Current aerial photography
- Utility crossings
- 2005 contours, TINs, local survey data
- HEC-RAS models and DFIRM data

- East Salitrillo Creek mini-regional curve
- Harris County, Texas regional curve (Harris County Flood Control District, 2009)
- North Carolina regional curves (Urban and Rural Piedmont), (Harman et al., 1999)

The data listed above was used to perform a desktop review of the WSC watersheds and riparian corridor conditions, and to aid in reach delineation and preliminary design approach for the project reaches. Drainage area, land use and impervious area were calculated for each creek and cross-referenced with the WSC concept plan. The drainage areas were delineated to the downstream terminus and used in relation with regional curves to appropriately size a stable bankfull pilot channel for each WSC reach. Watershed land use and imperviousness data helped to assess the extent of urban influence on the stormwater runoff regime and the potential for channel enlargement (when sizing the design channel); larger magnitude peak discharges can occur from smaller magnitude storm events as a result of increased drainage density and conveyance efficiency (from extensive paved surfaces and stormwater infrastructure) inherent to highly developed urban areas.

Existing HEC-RAS models were analyzed for each WSC project reach using cross-sectional and longitudinal profile data. Channel geometry and alignments were reviewed to identify potential relocation opportunities within the existing riparian corridors. Culvert crossings, stormwater outfall locations, utilities and infrastructure, and areas of limited channel or floodplain confinement were identified throughout the corridor as part of a constraints analysis. Each of the four creeks were subdivided into distinct project reaches based upon changes in potential design approach dictated by a combination of the above mentioned variables, namely drainage area, modeled discharge, and available geomorphic floodplain width.

BANKFULL VERIFICATION

The term “bankfull” discharge or dominant discharge represents a breakpoint between processes of channel formation and floodplain development. It is this channel forming flow that fills the channel to the top of its banks and at a point where the water begins to overflow onto the active floodplain (Leopold et al., 1964). This discharge, along with the range of flows that make up an annual hydrograph, governs the shape and size of the active channel. Bankfull discharge is associated with a momentary maximum flow that has an average recurrence interval range of 1.1 – 1.8 years as determined by using a flood frequency analysis (Dunne and Leopold, 1978).

The bankfull elevation or bankfull stage is typically estimated first in the field by identifying geomorphic indicators within the stream channel. These indicators usually include the top of the bank in stable riffle sections, consistent high scour marks in incised sections, and depositional bar areas. However, WSC channels have been severely manipulated and channelized for flood conveyance and geomorphic indicators are unlikely; thus field visits were precluded from this scope of work for the preliminary base plan form design.

For preliminary design plan purposes, detailed cross-section data were extracted from the HEC-RAS models and then compared with regional curve data in order to relate bankfull channel dimensions (dependent variables) such as cross-sectional area, width, mean depth, and discharge versus the drainage area (independent variable). Regional curves can be a useful tool for applying NCD methodology when estimating bankfull channel dimensions for developed and/or ungaged watersheds within the same hydro-physiographic province.

The East Salitrillo Creek mini-regional curve data were used to help compare these hydraulic geometry relationships. Baker and SARA team members originally developed the curve for a stream restoration project in Converse, TX. After identifying stable channels within the watershed, the team performed detailed cross-sectional surveys at each stable riffle identified. Using the cross-sectional dimensions and overall channel slope, bankfull discharge was estimated using Manning's equation. The team then performed site searches to identify stable USGS gage stations within the same hydro-physiographic province to estimate velocity and discharge ranges. The water surface elevations at both the cross-section and the gage station were recorded and the curve was later revised by others after incorporating the additional gage station analysis based on peak discharges.

Additionally, published Harris County TX, NC regional curve data (urban and rural piedmont), and the WSC concept plan data sets/regression curves were compared as converging lines of evidence to appropriately size the bankfull pilot channel to carry the bankfull discharge. Flows larger than bankfull were also validated to determine adequate floodplain widths necessary to transport these flows. Although evaluating regional curve data and hydrologic and hydraulic (H&H) models can be a useful comparison exercise, they do not replace the need for field calibration and verification of bankfull stage and discharge to determine design channel dimensions. Since the hydrology within this area has been historically altered by flood control structures and extensive stormwater networks, a more robust and comprehensive geomorphic field assessment and modeling analysis is recommended to effectively compare the hydrologic calculations with the bankfull discharge predicted by the regional curve for subsequent design phases.

EVALUATION OF PRELIMINARY RESTORATION GOALS AND ALTERNATIVE NCD APPROACHES

Before proceeding with the design criteria development for WSC, preliminary restoration goals and alternative NCD approaches were evaluated to ensure fulfillment of restoration objectives outlined by USACE in Section 1.2.

To achieve these objectives, the following NCD components were considered to maximize the natural functionality of the riparian corridors for improving water quality, habitat, and recreation while minimizing flood impacts to surrounding areas:

- Create geomorphically stable conditions for the channels by determining a bankfull pilot plan form and dimension;
- Improve and restore hydrologic connections between the low flow channels and their geomorphic floodplains;
- Improve water quality by establishing native buffer vegetation for nutrient and sediment removal from stormwater runoff and by stabilizing stream banks to reduce bank erosion and sediment contribution from larger flows;
- Improve aquatic and terrestrial (reptiles, mammals, birds) riparian habitat along the corridor channels by introducing desirable native buffer vegetation; and
- Improve in-stream habitat (fish, benthic macroinvertebrates) by providing a more diverse bed form with riffles and pools, create deeper pools and areas of water re-aeration, and provide woody debris for habitat.

The first step using a NCD design approach was to define the preliminary channel alignment and determine bankfull pilot channel widths. It was imperative to review existing channel geometry and identify potential pattern relocation opportunities and lateral constraints before moving ahead to the next design phase. The low valley/channel slopes of WSC warrants the dissipation of flow energies through riffle-pool sequences in meandering stream geometry that would minimize near bank stresses by allowing higher storm flows to spread out onto the active floodplain.

However, based on stable reference reach ratios and successful past projects, meandering streams must have adequate belt-widths to function properly. For example, a new pattern or minimal channel relocation could be introduced along Martinez Creek between Fredericksburg Road and Calubera Road, but suggested design Meander Width Ratios (Wblt/Wbkf) for meandering streams (Rosgen ‘C’ or ‘E’ stream type) range from 3.5 to 8 times the riffle width, which is not feasible unless property buyouts are initiated and extensive floodplain and terrace side slope excavation is permitted. Therefore, due to urban channel confinements and lateral constraints caused by roads and utilities within the WSC riparian corridors, relocation of the existing channels to re-establish meandering stream geometry was not recommended. Such constraints can severely limit restoration success, construction feasibility, and increase project risk in terms of geomorphic stability.

Instead, an alternative NCD approach was chosen to dissipate flow energies vertically and reduce lateral bank erosion via a nested step-pool stream system. This approach utilizes in-stream structures by centering in-channel flows away from steam banks while maximizing the geomorphic floodplain through excavating bankfull benches. This is defined as a Rosgen Priority Level 3 approach and is recommended to maximize functional lift. Reconnecting and/or creating wider floodplains throughout the WSC riparian corridors will also provide better opportunities for water quality improvements (BMP’s) by way of increased sediment and nutrient filtering through floodwater retainage during over bank flows, capturing and treating stormwater runoff by providing stormwater wetland complexes, installing plunge pools at outfall locations, and establishing native buffer vegetation to improve bird nesting and foraging habitat.

In addition to creating a geomorphic floodplain, restoration efforts would also consist of removing any concrete lined bed/banks and installing in-stream structures along with bioengineering methods. In-stream structures are constructed from natural materials, predominantly large rock and wood and consist of cross vanes, constructed riffles, rock vanes, and double wing deflectors which are installed to control the elevation (vertical stability) of the stream bed, provide bank protection, and improve habitat for aquatic life. Bioengineering methods or “soft armoring” measures would provide lateral (steambank) stability and help propagate native buffer vegetation. Examples of bioengineering techniques include: erosion control matting, geolifts, brush mattresses, live staking, fascines, and native vegetation transplants.

DEVELOP DESIGN CRITERIA

After selecting the general restoration approach based on project objectives, design criteria were then developed so that channel pattern, bankfull dimensions, and representative longitudinal profiles could be determined for each reach. Developing appropriate design criteria is a critical pathway to successful planning, restoration design, and final construction implementation.

After sizing the preliminary bankfull pilot channel, floodprone area widths (width at elevation twice the bankfull maximum depth) and meander belt widths (straight-line distance from the outermost bends of the channel) were measured and compared with existing channel slopes throughout the project corridors using a combination of existing HEC-RAS longitudinal profiles and cross-sections, local survey data, 2005 contour data, and current aerial photography. This analysis validated that entrenchment ratios (ER = floodprone area width divided by the bankfull riffle width) would be within an acceptable range to support the design steam type, and minimum floodplain bench widths could be achieved for stability and constructability purposes, even with some sections only having minimal floodprone area widths due to lateral constraints.

The existing channel slopes were then used to determine pool-to-pool spacing and pool lengths by comparing reference reach parameters and design parameter ratios used for similar stream types and successful restoration designs. Once these features and facet slopes were determined, in-stream structures, such as roack cross-vanes, were placed in locations that would not interfere with existing infrastructure while meeting the design criteria requirements previously mentioned.

SEDIMENT TRANSPORT CONSIDERATIONS

The geomorphic approach for the WSC project reaches based on natural channel design principals includes consideration of sediment transport. A geomorphically stable channel with riffle/run/ pool complexes serve several purposes including energy dissipation and providing aquatic habit. Proper dimensioning of the bankfull channel and floodprone areas, as well as pool-to-pool spacing, is critical to the maintain sediment transport capabilities of the channels so that they do no aggrade or degrade overtime.

Additionally, the proposed in-stream structures, such as cross vanes, serve several purposes including:

- creating and maintaining the scour pools (as part of the riffle/run/pool complexes);
- providing grade control at the downstream end of riffles and,
- providing bank protection by conveying flows (all flow including flood flows) towards the center of the channel.

The proposed cross-vanes structures will consist of at least two rock vanes sufficiently sized to remain in place during flood events. A detailed geomorphic assessment, including sediment transport analysis, will be conducted during the final design phase to refine the bankfull channel dimensions and pool-to-pool spacing, in-stream structure selections, and sizing of the riffle material.

VEGETATION CONSIDERATIONS

Riparian buffer vegetation provides the necessary stabilization of slopes and stream banks to reduce erosion while increasing shade for wildlife and aesthetics, and to moderate water temperatures. Turf establishment is the first priority for site stabilization and rapid revegetation. Once the site is stabilized with turf and permanent coverage has been established, native woody (trees and shrubs) and herbaceous vegetation (grasslands and wildflowers) may be introduced within the corridor to meet the specific needs and goals of the WSC project.

Native plant species should be established throughout the bankfull pilot channel banks, geomorphic floodplain, and transitional upland areas; and plant selection must consider onsite conditions such as wetness, drought, backwater, etc. Taller canopy trees could to be planted in transitional & upland areas throughout the corridor, but should not be planted within the geomorphic floodplain, utility easements or on side slopes steeper than 3:1. The Appendix contains a typical corridor section detail for reference in illustrating the above-mentioned vegetation buffer planting considerations. Refer to the USACE H&H modeling analysis section for specific planting details and proposed vegetation densities.

Long-term buffer maintenance of the WSC riparian corridor must address safety concerns, debris removal for flood conveyance, selective cutting/pruning activities, invasive species control, and include educating workers to the sensitivity of wetland habitats that are both planted and propagated through natural colonization.

SUMMARY OF RESULTS

Deliverables and supporting data for WSC project reaches are provided in the Appendix and include the following:

- Summary table of preliminary design criteria and parameter values;
- Typical corridor section detail;
- Preliminary workmaps illustrating the base plan form design approach;
- Preliminary plan sheets containing bankfull pilot channel alignment, typical sections, representative longitudinal profiles, and in-stream structure locations and details.

A preliminary construction cost estimate was prepared for work related to installing in-stream structures as shown on the base plan form design and typical details (see Table 2 below). Calculating rough costs for in-stream structure installation is a worthwhile exercise during the preliminary design phase for planning a project budget. Typical costs involved with installing in-stream structures include equipment, labor, and materials. It is important to emphasize that these cost estimates are to be used only as a guideline since fluctuating material prices, contractor experience, and installation procedures can heavily influence overall construction costs. Factors that affect installation costs include site accessibility for crews and heavy equipment, local labor/equipment/material rates, and the distance over which boulders must be transported. For example, installing a cross vane structure in a larger channel requires longer vane arms. This proves more costly because it requires larger boulders, additional stone, and increased installation and material haul times. For the purposes of this report, costs assumptions related to installing in-stream structures included stone materials (price per tonnage quotes from two local quarries), standard labor rates, and estimated construction time (using equipment rates) required along each WSC reach, but excluded additional channel excavation and incidental grading costs.

Table 2. In-stream Structure Cost Estimates

Site	*Proposed Length (LF)	Total Structures	**Cost Estimate	Cost / LF
San Pedro Creek	12,676	51	$1,379,000	$109
Apache Creek	4520	16	$448,000	$99
Alazan Creek	17,211	79	$1,269,000	$74
Martinez Creek	14,715	0	$0	$0
TOTAL	49,122	146	$3,096,000	$63

*Restoration/Enhancement activities include in-stream structures, bioengineering, sloping banks, floodplain excavation, streambank and riparian buffer planting.

**Cost for installing in-stream structures includes materials, labor, and construction time, but excludes additional channel excavation and grading costs.

As previously mentioned the resulting preliminary data from this study should only be used for planning purposes and are not for detailed design. A more comprehensive evaluation of design approach/criteria are necessary and should include field calibration and verification of bankfull stage, a geomorphic field assessment and survey, mapping of potential site constraints (utilities and infrastructure), and additional H&H modeling. It is expected that further design modifications would be made during the next design phase once additional information was obtained.

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WESTSIDE CREEKS ECOSYSTEM RESTORATION

Appendix B: Hydrology and Hydraulics

HYDROLOGY AND HYDRAULICS APPENDIX

STUDY PURPOSE

The Westside Creeks feasibility study was conducted under the re-evaluation of the San Antonio Channel Improvement Project (SACIP) authorized in 1954. Construction of the SACIP project was completed in 1986. This is a multi-purpose study to address opportunities relating to flood risk management and ecosystem restoration by designing a pilot channel with pools, riffles and runs to enhance water features as well as adding tree plantings within the flood banks. The local sponsor for this project is the San Antonio River Authority (SARA). SARA contracted the development of the "Concept Restoration Plan", completed in 2011. The study is currently Planning Step 3, Formulating Alternative Plans.

STUDY AUTHORITY

> WRDA 2000, SEC. 335. SAN ANTONIO CHANNEL, SAN ANTONIO, TEXAS.
>
> The project for flood control, San Antonio channel, Texas, authorized by section 203 of the Flood Control Act of 1954 (68 Stat. 1259) as part of the comprehensive plan for flood protection on the Guadalupe and San Antonio Rivers in Texas, and modified by section 103 of the Water Resources Development Act of 1976 (90 Stat. 2921), is further modified to include environmental restoration and recreation as project purposes.

STUDY AREA

The study area is located entirely within Bexar County, Texas and encompassed with the San Antonio River watershed. The San Pedro watershed, a sub watershed to the San Antonio River watershed, covers the western portion of the downtown San Antonio, Texas as well as areas to the west and south. The headwaters of the San Pedro watershed are located northwest of downtown San Antonio with the mouth being at the confluence with the San Antonio River south of downtown. This study focuses on segments of the Alazan, Apache, Martinez and San Pedro Creeks, also known as the Westside Creeks (WSC), contained within the authorized and constructed SACIP. Martinez Creek flows into Alazan Creek, which flows into Apache Creek, which in turn flows into San Pedro Creek. The study area is approximately 5.3 miles long and 2.5 miles wide at the widest point. The size of the study area is approximately 7410 acres, or 12 square miles. Elevations within the study area range from 558 to 732 feet. On the following pages, Figure 1 identifies the constructed SACIP, and Figure 2 identifies the Westside Creeks study area within the San Antonio River Watershed.

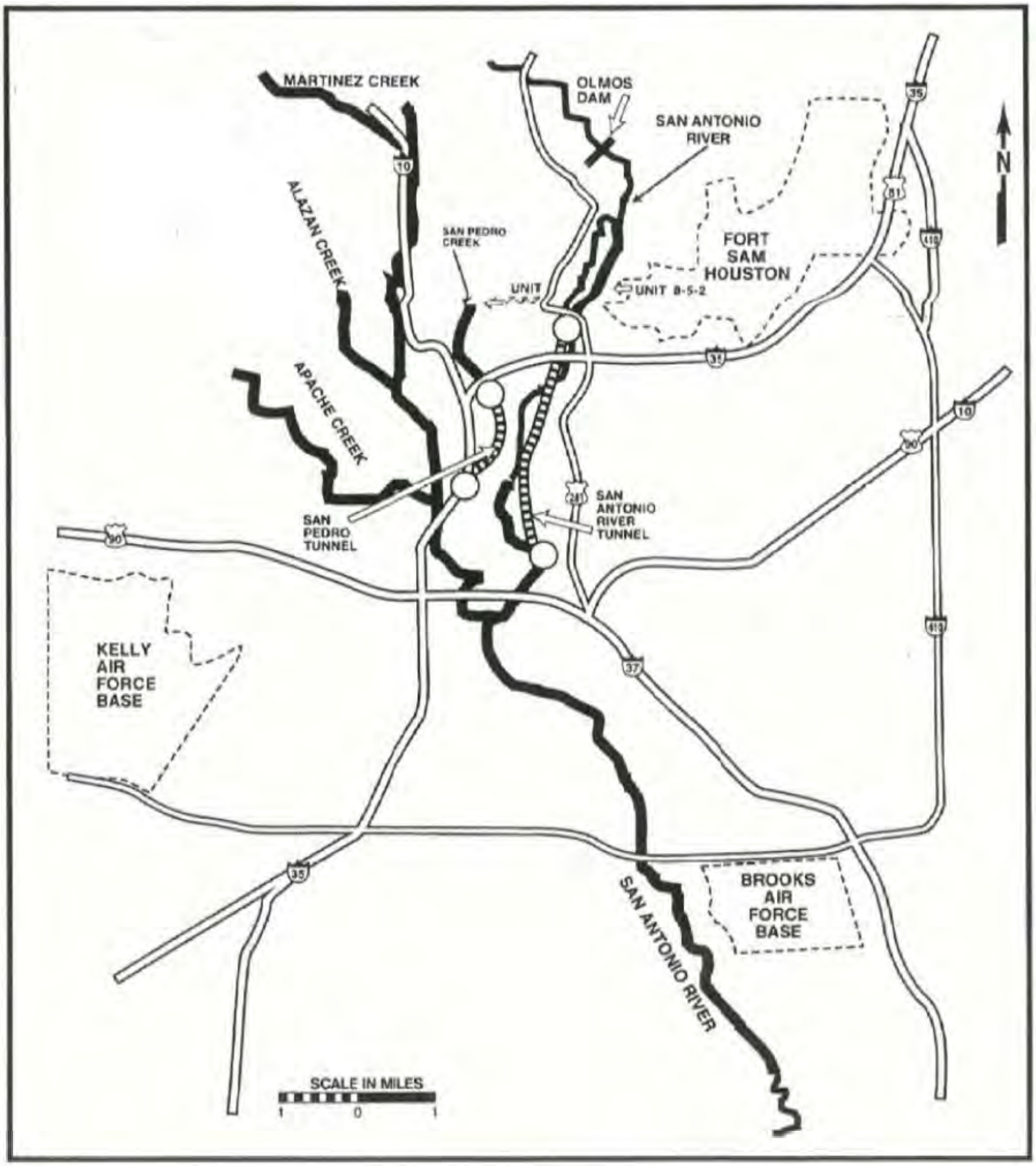

Figure 1 - SACIP Authorized & Constructed Project

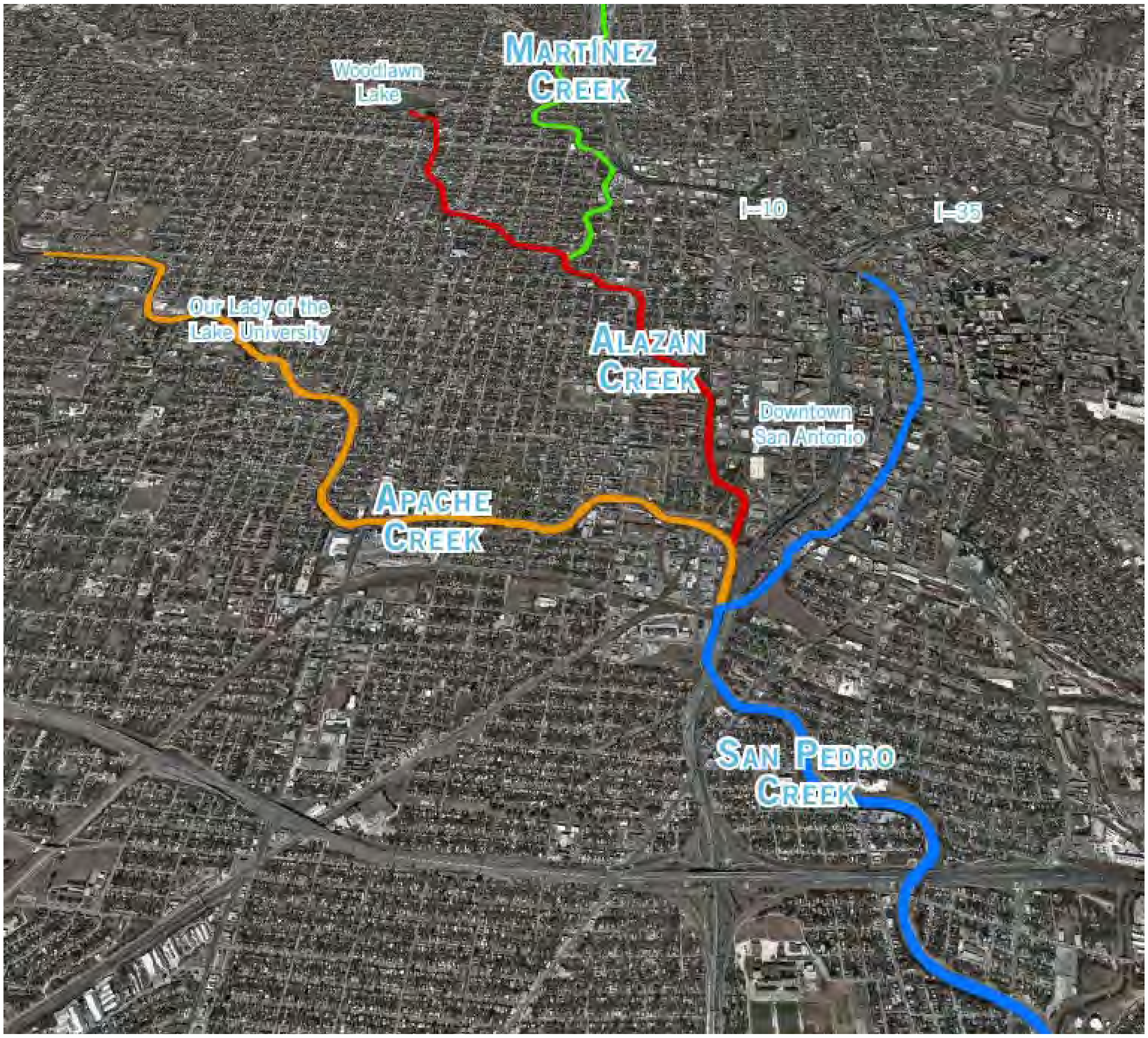

Figure 2. Westside Creeks Project Location

CLIMATE

Bexar County has a modified subtropical climate, predominately continental in winter and marine in summer. San Antonio is situated between a semi-arid climate to the west, and a wetter, more humid area to the east. This results in large variations in the monthly and annual precipitation amounts. Median annual rainfall is slightly less than 29 inches over a 141 year record (1871-2012). The range varies from 10 inches in 1917 to 52 inches in 1973. Mean rainfall is slightly over 29 inches. January is typically the driest month with an average of 1.61 inches of precipitation, and a median of 1.01 inches. May is the wettest month with a median of 3.48 inches and a mean of 2.84 inches of precipitation. The 30 year normals calculated beginning in 1921 and carrying forward to 2010 range from 27.5 inches in 1941-1970 to 32.9 inches in 1971-2000 (Refer to Figure 3). The most recent 30 year normal (1981-2010) is 32.27 inches. On average, the heaviest rains fall in May, September, and October. The wettest month on record is October 1998 in which San Antonio received over 18 inches of rainfall. The rain event occurring October 17-18, 1998 is the event of record, exceeding the 1% Annual Chance Exceedance for this area according to the United States Geological Survey (USGS). The driest months are usually December through March, and July. However, rainfall is sporadic, so the wettest or driest month in any one year may occur in any season and vary greatly from year to year. Small hail is frequent with springtime thunderstorms, though it has been known to occur in other seasons. Measurable snowfall usually occurs once every 3 to 4 years, with snowfall as high as 2-4 inches occurring about once every 10 years.

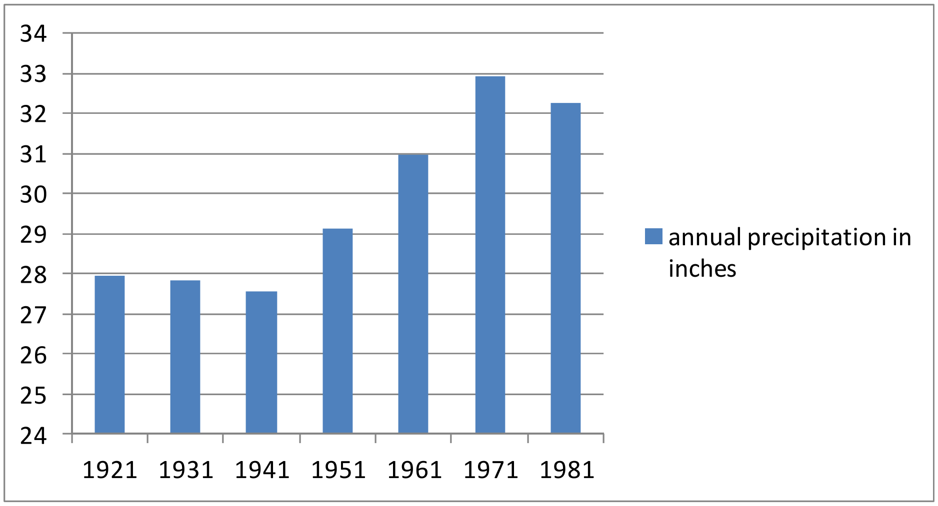

Figure 3. 30 Year Normal Average Annual Precipitation in Inches

The mean and median annual temperature over a 127 year period (1885-2012) is 69.1°F, with normal temperatures ranging from a mean/median daily high of 84°F in July and August to an mean/median daily high of 52° F in January Refer to Figure 4). Mild weather prevails most of the winter, with freezing temperatures only occurring approximately 20 days per year. The coldest low of record was 0˚F on January 31, 1949. Temperature levels can vary as much as 40-50 degrees in a day allowing for 100 degree winter temperatures as experienced 21 February 1996 and 6 March 1991. Summers are usually long and hot with daily maximum temperatures over 90˚F roughly 80% of the time. The highest temperature of record is 111˚F on 5 September 2000. Occasionally, cool fronts move through the area dropping overnight lows into the 50's and 60's for a cooling period that only lasts a day or two.

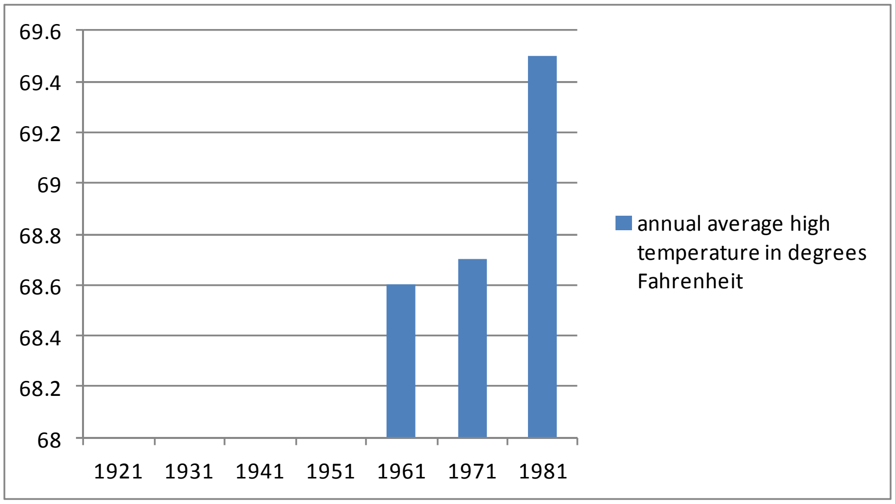

Figure 4. 30 Year Normal Average Annual High Temperature in Degrees Fahrenheit

FLOOD HISTORY

There have been 189 flood events in Bexar County between May 1993 and May 2011, of which 19 of these affected the WSC study area. The three most influential events are documented below:

October16-18, 1998 – SACIP prevented an estimated $296 Million (1998 dollars) in damages for this event of record. The following account is taken from the USGS, NOAA website:

> In advance of a very slow-moving upper level trough of low pressure over West Texas, a cold front drifted slowly southeastward into West Central Texas during the evening of Friday, October 16th. Deep moisture was in place across South Central Texas as the two systems approached, being fed at the mid and upper levels by two nearly stationary hurricanes, Madeline near the tip of Baja Mexico, and Lester, anchored just off Acapulco, Mexico, and in the low levels by a strong flow from the Gulf of Mexico. A very moisture-rich environment was in place across South Central Texas as the event developed. Near 3 am CST, with the cold front still west of San Angelo, scattered showers and thunderstorms began to break out over Bexar County beneath the mid and upper level moisture plume. They quickly became widespread as a low level rain-cooled boundary formed along the south and east edge of the county. It was upon this boundary that subsequent showers and thunderstorms continued to form. By 6 am CST, rainfall of up to 4 inches had been reported in Western Bexar County. By 8 am CST that morning, heavy rain continued over Bexar County. Amounts at this time were approaching 8 inches. The heavy rain continued through the morning period.
>
> All rivers, creeks and streams along and east of a San Antonio to Austin line remained at or above flood stage from Saturday, October 17th through Sunday, October 18th, with a majority continuing to flood through Monday, October 19th. On Tuesday, October 20th and Wednesday, October 21st, flooding was confined to rivers, streams and creeks along and east of a LaGrange-Gonzales-Karnes City line.
>
> This event broke rainfall records across South Central Texas, producing 18 floods of record in South Central Texas streams. October became the wettest of any month in climate records for San Antonio since 1885. October 17th became the wettest day and wettest 24-hour period in San Antonio climatic records, nearly doubling both previous records. Rivers across the area reached or exceeded record stage heights, resulting in widespread flooding in the flood plains of streams, creeks and rivers. Rainfall amounts on October 17 and 18th from northern Bexar County to southeast Kendall County, most of Comal County and southern Hays County ranged from 15 to 22 inches. Damage and destruction to livestock and agriculture, roads and bridges and both public and private property and buildings significantly exceeded that of previous flooding. Thousands to tens of thousands of livestock were killed, as nearly 3000 homes were destroyed and another 8000 or so homes were damaged. Nearly 1000 mobile homes were destroyed and another 3000 were damaged. Twenty-five people drowned as a direct result of the flooding in October in South Central Texas.

September 27, 1946 – This was the worst flood since the flood of 1921 hit San Antonio.

> Damage was estimated to be 2.1 million in 1946 dollars with a death toll of six. A total of 6.74 inches of rain fell on the city in a 12-hour period. Some hotels experienced 3-4 feet of water in their lobbies. It is estimated that 700-1200 people were displaced by the floods. Fort Sam Houston ordered 400 soldiers to duty to help with rescue and recovery efforts. North of San Antonio sits Olmos Dam (built 22 years prior) with a height of 52 feet. Water reached the 37 foot mark according to Fire and Police Commissioner P. L. Anderson. The dam is credited with saving lives and preventing even more damage. Two bridges on West Houston Street Bridge crossing over Alazan Creek were both destroyed. Other bridges were damaged as well. While an event frequency was not estimated at the time, later work indicated that this was something more frequent than a 1% Annual Chance Exceedance Probability. This event precipitated the USACE study that resulted in the authorization of the SACIP, which was designed to the transposed 1946 storm.

September 10, 1921 - Flood waters claimed the lives of 51 people and left behind an estimated $3.7 million in property damage.

> Water rose suddenly as precipitation ranged from 6.1-8 inches over a 48 hour period. Water along River Avenue was reportedly 8 feet deep. Parts of the city were under water by 10-15 feet. Rain in the Olmos Valley, north of San Antonio, flooded the San Antonio River. The flood waters of the San Antonio River joined with the already flooded Alazan and San Pedro Creeks on the west side of San Antonio and inundated a large part of the business section as well as residential areas. Flood waters, mainly from the San Antonio River and Alazan Creek, inundated an area approximately two miles long by one half mile wide which included the business section along River Avenue as well as the Westside. In some areas of San Antonio, rushing walls of water were described as 10-30 feet high.

STUDY FOCUS

As a result of the identified resource significance and flood risk, the study documented in this report formulates for ecosystem restoration only. However in recognition of the residual flood risk, the ecosystem restoration formulation will remain cognizant of the water surface elevations such that the functionality of the existing flood risk management project remains intact.

FLOOD RISK

This study takes place within the footprint of an existing FRM project. The existing FRM project was designed to capture the 1946 flood. The existing FRM project does not contain the 1% ACE flood according to the FEMA flood maps. The PDT performed a sensitivity analysis to determine if the residual flooding issue warrants Federal participation consistent with USACE policy. The HEC-RAS model for existing conditions calculated the 1% ACE water surface elevations at each cross section throughout each reach for each of the four creeks. These elevations were provided to calculate the depths of flooding at structures and were calculated using floor corrections ranging from 1.5 feet to 3 feet to obtain a range of finished floor elevations. In GIS, using outlined rooftops, topography and these estimated flood depths, the PDT determined that while the repercussions to specific neighborhood segments are significant to that portion of the population affected, the flood risk to the study area as a whole will not support a USACE flood risk management solution.

CONSTRAINTS

Constraints are restrictions that limit the planning process. Universal constraints apply to every USACE planning study. They include USACE guidance, regulations, policies and authorities or are defined by laws and regulations of the Federal, State and/or local governments. Study-specific constraints are unique to a specific planning study, and are statements of potential issues that the study team should work to avoid while formulating alternative plans. The following constraint is applicable to this study.

- Avoid increasing water surface elevations as established by the DFIRM mapping completed for FEMA, effective date 29 September 2010.

ASSUMPTIONS

Assumptions are made to help reduce scope to the appropriate level of detail for the plan formulation and analysis consistent with the new planning paradigm. The following is a list of the critical assumptions used in the development of the Project Management Plan (PMP), the selection of measures, and the combination of measures reflected in the alternatives for detailed analysis:

- The study applies to approximately 14 miles of creeks within the San Antonio Channel Improvement Project, but no changes will be made to the San Pedro Creek hydraulic model upstream of the San Pedro tunnel outlet (covers approximately 1.4 miles).
- Right of Way expansion will be considered only for areas where the San Antonio Watershed Master Plan has indicated the potential for expansion. If any of the locations identified for Right-of-Way expansion are utilized, the planning level study will assume that a slope geometry no steeper than 4H:1V will be required and will consult the geotechnical engineers to confirm whether a flatter slope is recommended given the information currently known.
- All existing and future without project conditions hydrology and hydraulic modeling completed by the sponsor is sufficient to proceed through the feasibility study phase of the project. This includes the assumption that all the required hydraulic structures such as bridges, drop inlets, outfalls, detention areas, and bypass channels are included in the models as well as the accuracy of all utility crossings, bridge surveys and property boundaries.
- The use of Manning’s “n” roughness coefficients for proposed woody vegetation zones from the Mission Reach SACIP document will be used throughout the hydraulic model.
- No trees will be placed within the flood banks (side slope banks of the FRM study) within 100 feet upstream or downstream of bridges.
- All material defined in the hydraulic model under all bridge crossings will consist of concrete in order to protect the integrity of the bridge. The bankfull pilot channel is configured as a trapezoidal channel with 1 on 2.5 side slopes, a bottom width which varies from 15 feet to 45 feet, a top width which varies from 25 feet to 67 feet, and a depth which varies from 2 feet to 5 feet. The bankfull pilot channel will consist of native grasses and the bridge piers which line up in the bankfull pilot channel will be protected.
- All excavation quantities will be determined by the use of the hydraulic model.
- No pools, riffles, and runs will be designed in the hydraulic model in order to expedite the planning and modeling process.

HYDROLOGY

The contributing watershed area for the Westside Creeks is highly developed, with extensive residential areas, and some retail and industrial zoning. Contributing Watershed Areas include:

- Alazan Creek, 17.5 square miles;
- Apache Creek, 40.3 square miles;
- Martinez Creek, 7.3 square miles; and
- San Pedro Creek, 44.9 square miles

As the result of the community’s efforts to mitigate frequent flooding conditions and to provide improved storm water management practices for the area, a significant transformation was accomplished in the 1960s and '70s, changing the channels from natural to widened and rectified drainage systems. Through a comprehensive channelization project, the USACE transformed the natural creeks into efficient drainage channels for the purposes of conveying flood waters out of the neighborhoods as quickly as possible. The project was based on the volume of water that occurred in the 1946 flood. The channelization is effective and for many years has provided adequate protection for the area. In many areas, the floodplain was subsequently filled to allow for additional urban development. These changes resulted in creeks that are far from their natural state.

The flooding that had impacted residents and businesses along the Westside Creeks was reduced as a result of the channelization and other modifications that were constructed in the 1960s and '70s; however, additional development in the area adjacent to the creeks as well as within the upstream portions of the contributing watershed has increased impervious cover (see Figure 5 for existing impervious cover) resulting in greater volumes of storm water runoff. In addition, improved technology to better capture topography and land use to simulate the effects of rain events on the creeks have led to the creation of updated engineering models. These updated models indicate that the existing channelized creeks will not contain the 1% ACE event.

For the purposes of this restoration analysis, the hydrology was derived from 2 different sources. The first was an estimation of the 1.5-year design discharges through empirical methods, such as regression analysis of gauge data that was developed by the USGS for the urban areas of Austin, TX, which was assumed to be a close approximation for the San Antonio urban watersheds, since no local urban equations have been developed. The 1.5-year discharges calculated by these equations were utilized to develop stable bankfull channel designs for the Westside Creeks.

For analysis of the water surface elevations that could be expected during a 1% ACE (100-yr) event, discharges were used that matched those developed for the FEMA Flood Insurance Study (Bexar County FIS, Sept 2010). The Flood Insurance Study/DFIRM flows include a diversion in the upstream flows on San Pedro Creek, accounting for the bypass tunnel which discharges back into San Pedro Creek just downstream of El Paso Street.

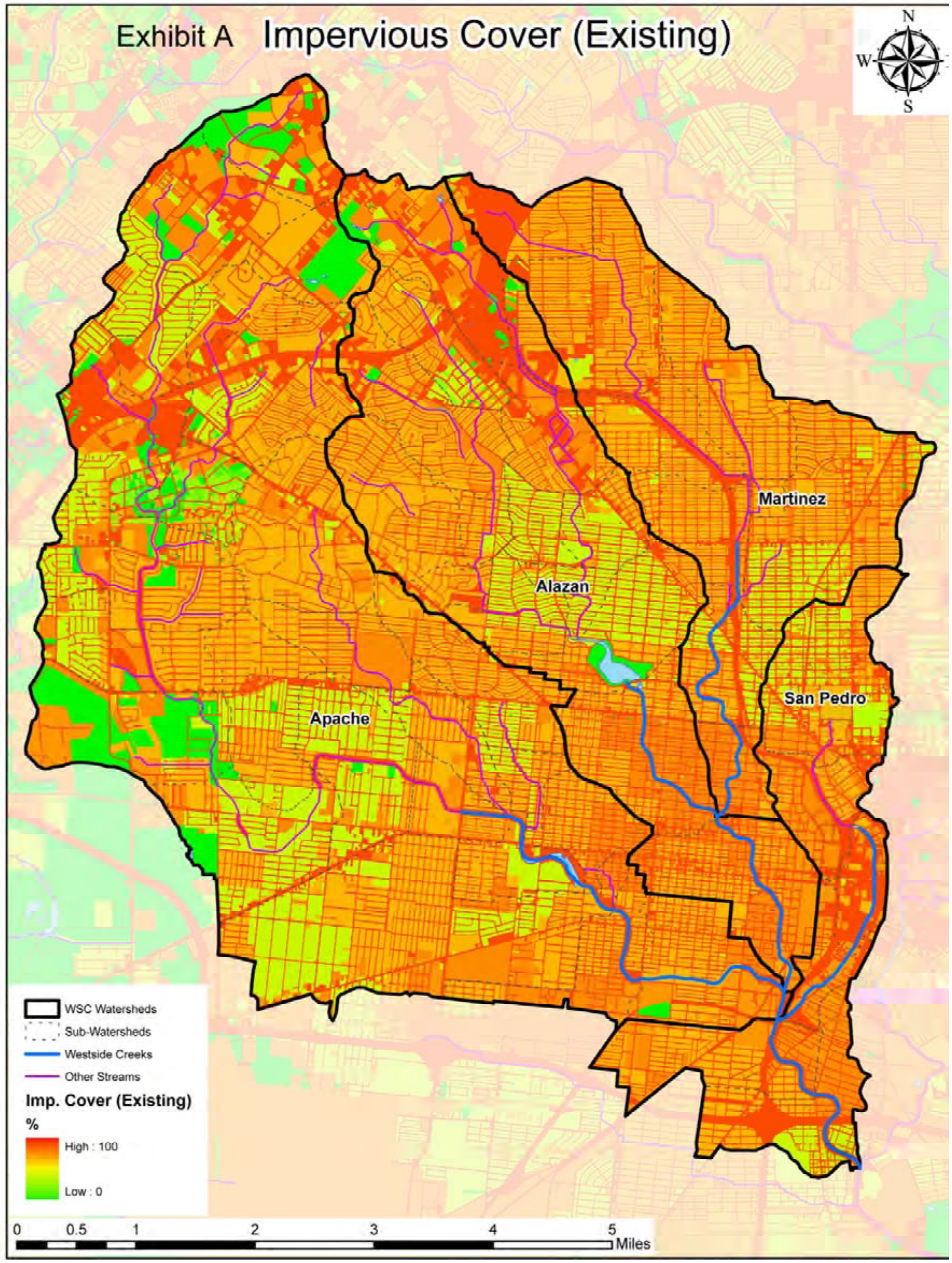

Figure 5. Existing Conditions Impervious Cover

Studies have found that the bankfull discharge is typically associated with a 67% Annual Chance Exceedance (ACE) or 1.5-year return period flow (US Army Corps of Engineers, 2001); however, this can vary greatly given differing hydrologic and geologic parameters.

Several methods were compared to determine the correct bankfull discharge on each stream reach and are described in more detail as follows:

San Antonio and the Westside Creeks project locations fall within the Texas Hydrologic Region 5 according to the USGS (USGS, 1997) (Table SCD-1 and Table SCD-2). There are two sets of regression equations for Region 5: one set for locations with less than 32 square miles of contributing drainage areas, and the second for locations with more than 32 square miles of contributing drainage area. The 75% ACE discharge was calculated by plotting the Region 5 discharges and using a power-trend line for each stream. It was determined that the Region 5 regression equations were underestimating discharges because the equations do not account for urbanization.

The Austin Urban Regional Regression Equations (USGS Report 94-4002) yield discharges for the 50% to 1% ACE (2- to 100- year) recurrence intervals. The equation’s inputs are contributing drainage area and total percent impervious of the contributing basin. The equations are applicable to sites with drainage areas of 2 to 20 square miles. Apache Creek’s and San Pedro Creek’s drainage areas fall outside the range of drainage areas recommended for the equations; however, the equations were used for this analysis because they yielded results that were comparable to the effective discharges.

The effective FIS discharges for return periods of the 10%, 2%, and 1% return intervals were plotted. Since there are no effective discharges for low flows (less than 10-year return periods), the shape of the regression curve was shifted and fitted to the FIS data in order to estimate the 75% ACE discharges. When compared to the 75% ACE discharges yielded from the Austin Urban Regional Regression Equations, the shifted effective FIS discharges were in the same range.

When comparing the effective FIS discharges to the discharges calculated using the regression equations, it was determined that the interpolated Austin Urban Regional Regression Equations yielded the best results.

At this conceptual level of study, the bankfull discharge analysis is limited in terms of methods that could be analyzed. During detailed project design, more methodologies to determine the design discharge should be analyzed. Frequency analyses should be performed on local USGS stream gages as another source of data to compare. Also, discharge analyses from previous studies in the area should be compared to the design discharge. Data could be developed to produce discharges for return periods less than the 10% ACE using the effective FIS hydrology model. This information would be used to refine the 75% ACE discharge; however, further analysis should also be conducted to determine the appropriate return period to use in the final design. Studies of the appropriate return interval to be used for urban areas in other Texas cities have been closer to the 90-95% ACE return interval.

HYDRAULICS

EXISTING CONDITIONS

The evolution of the Westside Creeks over the last half-century is largely due to shifts in urbanization and in flood control and maintenance practices. Earlier cross sections depict a more natural stream, consisting of a baseflow channel, a wider channel and a large floodplain. Straightening and channelization of the creeks yielded grass-lined trapezoidal channels (that delineate most of the creeks), dramatic concrete banks and underground bypass tunnels (San Pedro Creek). The channel substrate consists of unfractured Cretaceous limestone that covers the Edwards Group limestone and is overlaid by a thin soil cap. The high intensity precipitation coupled with urbanized, rocky terrain, makes the Westside Creeks prone to flash floods which rise and fall in rapid response to storms.

While long-time area residents recall base flow that was perennial (continual), site inspections and anecdotal reports indicate that base flow for most of the Westside Creeks has been reduced to either intermittent (during wet periods of the year only) or ephemeral (only immediately following storm events). There is no gauge data available to accurately determine the current base flow category for the Westside Creeks.

MODELING METHODOLOGY FOR FEMA

The study streams for existing conditions were completed for the Bexar County Hydraulic and Mapping Technical Support Data Notebook (TSDN) which consisted of streams located in the Upper San Antonio River Watershed that were identified by the San Antonio River Authority (SARA) and the Federal Emergency Management Agency (FEMA). The San Antonio River and San Pedro Creek hydraulic models were combined into one model and the work was completed by Pape-Dawson Engineering, Inc and submitted to FEMA December 2006. Apache Creek, Alazan Creek, and Martinez Creek models were completed by Halff and Associates and submitted to FEMA in May 2007. All base work maps were generated from 2005 aerial 2 foot topographic data.

The detailed hydraulic study for FEMA consists of hydraulic models based on detailed survey information that will produce new base flood elevations. Hydraulic structure information was obtained from precise and detailed field surveys of all bridges and culverts. As-built plans were not needed, since detailed survey information was available. This includes the collection of existing ground, structure and underwater elevations.

The Environmental Systems Research Institute (ESRI) ArcMap, Version 9.0, along with the HEC-GeoRAS Version 3.1 were used for the integration of geospatial data into the United States Army Corps of Engineers' (USACE), Hydrologic Engineering Center River Analysis System (HEC-RAS), Version 3.1.2. HEC-RAS, accepted by FEMA for hydraulic analysis, performs one-dimensional hydraulic calculations to model the water surface elevations. HEC-GeoRAS along with the 3D Analyst and Spatial Analyst extensions was used to create the stream centerline and cross sections that were imported into HEC-RAS.

The locations for cross sections were identified to capture the critical hydraulic features within a study reach. The cross sections were spaced to achieve target spacing of not more than 1000 feet between the cross sections in rural areas and spacing of 500 feet or less in urban areas, as recommended in the Hydrologic and Hydraulic modeling guidelines set by SARA. The spacing of cross sections was reduced as necessary to model significant hydraulic features. The cross sections were extended to the limits of the topographic data on both sides of the stream. The location of the tributaries contributing to the study streams was also considered for choosing appropriate cross section locations.

All existing bridges and culverts in the studied reaches were modeled in HEC-RAS in order to determine their affect on water surface profiles and the resulting floodplain. The culvert dimensions were obtained from field survey measurements. The Federal Highway Administration (FHWA) chart and scale numbers were appropriately chosen based on the observed culvert entrance designs from field visits. The upstream invert elevations and the hydraulic widths were obtained from approximate survey methods. Bridges were also modeled using the information obtained from approximate surveys. The approximate bridge survey included obtaining pier shapes and dimensions, upstream invert elevations, deck thickness, channel top and bottom widths, distance between the toes of the abutments and the hydraulic widths.

The effective flow areas were identified around the bridges and culverts by defining the limits of ineffective flow per the HEC-RAS modeling standards. Ineffective flow areas were delineated in HEC-RAS to identify areas of a cross section in which the flow of water is not effectively conveyed.

Hydraulic models are calibrated using observed high-water marks, measured profiles, and stage information at stream gauges.

Manning’s roughness coefficients were determined from field visits and surveys, and ground and aerial photographs. Typical Manning’s roughness coefficients used in the HEC-RAS models were based on Table 1 “Manning’s Roughness Coefficients”, of the San Antonio River Basin Regional Modeling Standards for Hydrology and Hydraulics Models Floodplain Mapping, and are represented in the table below. The United States Geological Survey Water-supply Paper 2339, “Guide for Selecting Manning’s Roughness Coefficients for Natural Channels and Flood Plains,” was also referenced. The energy loss coefficients at cross sections, bridges and culverts were chosen as recommended in the HEC-RAS manual.

Table 1. Guide for Selecting Manning’s Roughness Coefficients for Natural Channels and Floodplains

Channel Description	**Average n Value**	**Minimum n Value**	**Maximum n Value**
Concrete Lined Channel	0.015	0.010	0.020
Grass Lined Channel with regular maintenance	0.035	0.030	0.040
Gravel or Outcropping Stone Channel with some Vegetation	0.045	0.040	0.050
Grass Lined Channel without recent maintenance	0.050	0.045	0.055
Vegetated Channel with trees, little or no underbrush	0.055	0.050	0.060
Natural Channel with trees, moderate underbrush	0.075	0.070	0.080
Natural Channel with trees, dense underbrush	0.090	0.085	0.095
Natural Channel with dense trees and dense underbrush	0.100	0.100	0.100
Overbank Description			
Pasture	0.045	0.035	0.055
Trees, little or no underbrush, scattered structures	0.070	0.060	0.075
Dense vegetation, multiple fences and structures	0.085	0.075	0.100
Buildings inundated by floodplains	0.085	0.075	0.100

WITHOUT-PROJECT CONDITIONS

The existing conditions hydraulic models for San Pedro Creek, Apache Creek, Alazan Creek and Martinez Creek were all provided to the Corps as separate models. . For this study, these individual stream models were all combined into a dendritic system hydraulic model to properly account for tributary confluence impacts. The Hydrologic Engineering Center River Analysis System (HEC-RAS), Version 4.1 was used for this analysis. Martinez Creek flows into Alazan Creek, which flows into Apache Creek, which flows into San Pedro Creek which flows into the San Antonio River. All models are connected with junctions at each confluence. All flows in this model remain unchanged from the existing condition models, as well as most parameters. The modeling includes the 10%, 2%, 1%, and the 0.2% Annual Exceedance Probability (AEP) flood events based on peak discharges.

WITH-PROJECT CONDITIONS

The development of proposed plans for restoration of Westside Creeks required the development of hydraulic models to determine the water surface elevation impacts due to implementation of the bankfull pilot channel and placement of woody vegetation zones. The water surface profiles for With-Project conditions were then compared to the water surface profiles for Without-Project conditions to determine the impacts and ensure that “hydraulic neutrality” was maintained with respect to the existing FRM performance of the floodway at the 1% AEP flood level. Using the Without-Project HEC-RAS models as a base, the geometry configuration of the proposed bankfull pilot channel was input and subsequently woody vegetation zones were modeled by means of changes in Manning’s roughness coefficients associated with proposed vegetation zones. To facilitate the hydraulic modeling for the woody vegetation zones, a previously prepared Manning’s roughness guide was used to guide the selection of Manning’s roughness coefficients for the woody vegetation zones. This guide is referred to as the “Memorandum for Assigning Manning’s “n” Values for Vegetation Associations”. The document was used for the prior USACE ecosystem restoration study for the San Antonio River Mission Reach Project in San Antonio. The memorandum was developed specifically for the purpose of woody vegetation design and was coordinated extensively with the USACE, the local sponsor, the San Antonio River Authority (SARA), the sponsor’s A/E, the City of San Antonio, and Bexar County.

SENSITIVITY ANALYSIS

The design team (PDT) tested the hydraulic model with a sensitivity analysis, which involved the placement of different types of woody vegetation configurations into the model. The initial assumption of undertaking this sensitivity analysis was to reduce the number of iterations, thus reducing the time and cost associated with the hydraulic modeling effort for this pilot study. Through discussion and professional judgment, hydraulic engineers and biologists agreed that a planting regime could be developed such that the hydraulic affects of planting riparian meadow would be insignificant. The sensitivity analysis helped define how the placement of additional woody vegetation would affect the water surface elevations for each creek. A representative stream segment (sensitivity reach) was selected for each of the four creeks. Selection of the reach was based on obtaining a stream segment representative of the entire creek in terms of a constant slope with similar number of bridge crossing. The resulting assumption is that, while some variation is expected, the results for the sensitivity reach are generally representative of the model behavior for the entire creek.

Three configurations, shown below, were tested using woody vegetation densities of 30 trees per acre (manning's roughness coefficient of 0.055) and 70 trees per acre (manning's roughness coefficient of 0.085). For purposes of the analysis, continuous placement of the woody vegetation along the entire sensitivity reach was placed within the model for each creek. Each of the configurations tested resulted in a computed water surface elevation, which was compared to the existing conditions water surface elevations.

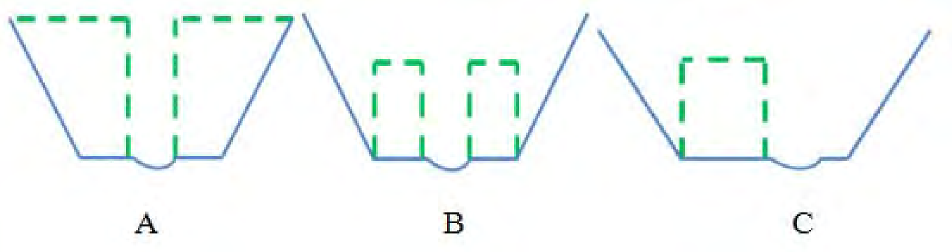

Figure 6. Tree Vegetation Configurations used for the Sensitivity Analysis

Configuration A - Consists of woody vegetation from the top edges of the bankfull pilot channel to the top of the flood banks on both sides of the existing creek. This is the maximum extent of vegetation within the existing Right of Way (ROW) for the SACIP flood control channel. This configuration has the largest surface area for the increase in roughness values and therefore, as expected, the largest adverse affect on water surface elevation. The average increase in the water surface elevation ranged between 3.0 to 6.0 feet based on the 1% ACE flood event for each creek.

Configuration B – Consists of woody vegetation from the top edge of the bankfull pilot channel along the invert, to the toe of the flood banks on both sides of the existing creek. Configuration B has a lesser impact than Configuration A. This configuration provides a significant coverage of woody vegetation along the entire invert, which surrounds the bankfull pilot channel, with significant increase on the water surface elevations. The average increase in the water surface elevation ranged between 1.7 to 4.0 feet based on the 1% ACE flood event for each creek.

Configuration C – Consists of woody vegetation from the top edge of the bankfull pilot channel along the invert, to the toe of the left flood bank of the existing creek. This configuration had the lease amount of impact on the water surface elevation. The average increase in the water surface elevation ranged between 0.9 to 2.3 feet based on the 1% ACE flood event for each creek.

Table 2. Water Surface Increases due to Tree Vegetation Configurations used for the Sensitivity Analysis

Vegetation Configuration	30 stems per acre (n-Value = 0.055)	70 stems per acre (n-value = 0.085)
A	+ 3.0 feet	+ 6.0 feet
B	+ 1.7 feet	+ 4.0 feet
C	+ 0.9 feet	+ 2.3 feet

Each configuration listed in Table 2 represents the average results of the woody vegetation placement for a particular reach for each of the four creeks. These results are used only as a guide to help determine how sensitive the model behaved in this particular reach and will vary in the final model analysis. Each cross section of the working model, starting from the downstream end of the project and working upstream, will depend on the specific excavation amount necessary to place the bankfull pilot channel. Therefore, it is anticipated that placement of a diverse mix of woody vegetation and riparian meadow in combination with the excavation necessary for placement of the bankfull pilot channel will be accomplished without any increases in water surface elevation.

DETAILED MODELING DESCRIPTION

A geomorphology study, completed by Baker and Associates used a reference reach and a regression equation analysis to develop the approximate dimensions for a bankfull pilot channel (Refer to the Geomorphology Appendix). This analysis has estimated uncertainties for design channel flow between 20-30 percent. This uncertainty was assumed consistent with the level of design analysis required at his stage of this study and the assumed cost risk associated with the bankfull pilot channel sizing. More detailed hydrologic analysis for the pilot channel sizing is recommended as the project moves into the detailed design phase. The bankfull pilot channel is configured as a trapezoidal channel with 1 on 2.5 side slopes, a bottom width which varies from 15 feet to 45 feet, a top width which varies from 25 feet to 67 feet, and a depth which varies from 2 feet to 5 feet. The bankfull pilot channel consists of native grasses and the bridge piers which line up in the bankfull pilot channel will be protected. This bankfull pilot channel was placed into the model for all four creeks at the existing invert elevation. The following discussion will define the placement of this bankfull pilot channel into each creek separately. In reaches where the bankfull pilot channel cannot be placed at the invert elevation, required excavation will be necessary to avoid the use of adding earth fill quantities to each creek. Even though pools, riffles and runs are assumed to be an intricate part of the bankfull pilot channel final design, these structures were not placed into the model in order to expedite the hydraulic analysis for this pilot study utilizing the new paradigm.

The FRM project floodway channel side slopes are to remain unmodified in most locations. The proposed bankfull pilot channel benches contact the toe of the floodway channel side slopes in some locations, in which case, the existing slope is to be maintained. All models have assumed roughness values for concrete channel paving under all bridge crossings, except for the bankfull pilot channel, in order to provide protection and maintain the integrity of the bridge structure. All models for design of the bankfull pilot channel initially included trees on the left bench with a density of 30 trees per acre. For a final detailed description of the placement of trees, refer to the Environmental Appendix.

SAN PEDRO CREEK

San Pedro Creek study reach began at the junction with the San Antonio River and continued to just upstream of Camp Street with a total study length of 12,676 feet. The starting water surface elevation for San Pedro Creek at the junction with San Antonio River was based on the 1% ACE flood elevation of the San Antonio River model, elevation 595.98 feet. The downstream channel bottom elevation with the bankfull pilot channel in place is 570.29 feet. The upstream invert elevation is 619.34 feet. The top of bank elevations range from 598.79 feet downstream to 632.79 feet upstream.

Water surface elevations with the woody vegetation in place, for the 1% ACE flood event, range from 595.98 feet at the downstream end to 634.89 feet at the upstream end of the study reach.

Flows for the 1% ACE flood event are approximately 6,896 cfs at the upstream, increasing to 49,312 at the confluence with San Antonio River.

The placement of the bankfull pilot channel was accomplished in two reaches, Reach 3 and Reach 4, using the dimensions provided by the geomorphology study. The bankfull pilot channel was placed into the model at or below the existing invert of the flood control channel. The excavation required for this placement, in most cases, allowed for additional flood space, and provided opportunities for the placement of trees with various densities. The sensitivity of the model for each reach determined the densities of trees to be placed onto the benches of the bankfull pilot channel.

REACH 4 – JUNCTION WITH SAN ANTONIO RIVER TO RIVER STATION 95+00

Reach 4 began at the junction with San Antonio River, and continued upstream to the junction with Apache Creek. The bankfull pilot channel for this reach has a bottom width of 44.7 feet with side slope of 1V on 2.5H, a depth of 4.5 feet and a top width of 67.1 feet. From the junction with the San Antonio River to Station 50+48, the bankfull pilot channel is placed at the existing channel invert elevation, with banks on either side of the bankfull pilot channel. The resulting water surface elevation is lower than the existing condition water surface elevation by an average of 3 to 4 inches before the placement of trees on the benches. From Station 50+48 to 95+00, the bankfull pilot channel is placed below the existing invert elevation by an average of 1 to 2 feet, with banks on both sides of the bankfull pilot channel. The resulting water surface elevation is lower than the existing condition water surface elevation by an average of 4 to 8 inches before the placement of trees on the benches.

REACH 3 - RIVER STATION 95+00 TO 126+76

Reach 3 began at Station 95+00 and continues to the upstream end of the project at Station 126+76. The bankfull pilot channel for this reach has a bottom width of 14.7 feet with side slope of 1V on 2.5H, a depth of 1.7 feet and a top width of 21.8 feet. The bankfull pilot channel is placed below the existing invert elevation by an average of 2 to 4 feet, with very narrow banks on both sides of the bankfull pilot channel. The resulting water surface elevation is lower than the existing condition water surface elevation by an average of 12 to 16 inches before the placement of trees on the benches.

APACHE CREEK

Apache Creek study reach began at the junction with San Pedro Creek continuing upstream to Southwest 19th Street with a total study length of 14,344 feet. The downstream channel bottom elevation with the bankfull pilot channel in place is 601.63 feet. The upstream invert elevation is approximately 635.13 feet. The top of bank elevations range from 629.02 feet downstream to 652.59 feet upstream.

Water surface elevations with woody vegetation in place, for the 1% ACE flood event, range from 628.17 feet at the downstream end to 657.97 feet at the upstream end of the study reach. Flows for the 1% ACE flood event, range from 21,229 cfs, at the Elmendorf Lake Dam, increasing to 46,726 cfs at the confluence with San Pedro Creek.

According to the geomorphology study, Apache Creek has three reaches. The placement of the bankfull pilot channel was accomplished in only two of these three reaches, Reach 3 and Reach 4, using the dimensions provided by the geomorphology study. The bankfull pilot channel was placed into the model at or below the existing invert of the flood control channel. The excavation required for this placement, in most cases, allowed for additional flood space, and provided opportunities for the placement of trees with various densities. The sensitivity of the model for each reach determined the densities of trees to be placed onto the benches of the bankfull pilot channel.

This channel contains significantly more concrete within the flood banks than any of the other three creeks studied. The base flow channel of Apache is predominantly concrete. The largest challenge was trying to provide native grasses and remove the concrete from the existing pilot channel without creating a rise in the water surface elevation. As a result, Reach 2 and part of Reach 3 contained too much concrete to effectively place a bankfull pilot channel.

REACH 4 – JUNCTION WITH SAN PEDRO CREEK TO RIVER STATION 13+00

Reach 4 began at the junction with San Pedro Creek, and continued upstream to River Station 13+00, which is at the junction with Alazan Creek. The bankfull pilot channel for this reach has a bottom width of 41.6 feet with side slope of 1V on 2.5H, a depth of 4.2 feet and a top width of 62.4 feet. From the junction with San Pedro Creek to Station 13+00, the bankfull pilot channel is placed at the existing channel invert elevation, with banks on either side of the bankfull pilot channel. The resulting water surface elevation is lower than the existing condition water surface elevation by an average of 2 to 3 inches before the placement of trees on the benches.

REACH 3 - RIVER STATION 13+00 TO 124+69 (SOUTH HAMILTON AVENUE)

Reach 3 began at Station 13+00 and continued upstream to River Station 124+69. The bankfull pilot channel extends up into this reach to station 42+70, 688 feet upstream of South Brazos Street. Modeling of the bankfull pilot channel further upstream in this reach was attempted but the various models' outputs indicated a water surface elevation increase. The bankfull pilot channel for this reach has a bottom width of 33.8 feet with side slope of 1V on 2.5H, a depth of 3.4 feet and a top width of 50.7 feet. The bankfull pilot channel was placed below the existing invert elevation by an average of 2 to 3 feet, with very narrow banks on both sides of the bankfull pilot channel. The resulting water surface elevation is lower than the existing condition water surface elevation by an average of 0.02 to 0.04 inches before the placement of trees on the benches.

REACH 2 - RIVER STATION 124+69 (SOUTH HAMILTON AVENUE) TO RIVER STATION 143+44 (SOUTH OF 19TH STREET)

Reach 2 began at Station 124+69 and continued upstream to River Station 143+44. Modeling of the bankfull pilot channel further upstream into this reach was attempted but the various models' outputs indicated an increase of the water surface elevation.

ALAZAN CREEK

Alazan Creek study reach began at the junction with Apache Creek and continued upstream to the outlet of Woodlawn Lake Dam with a total study length of 17,571 feet. The starting water surface elevation for Alazan Creek at the junction with Apache Creek is an elevation of 630.34 feet. The downstream channel bottom elevation with the bankfull pilot channel in place is 605.06 feet. The upstream invert elevation is 661.21feet. The top of bank elevations range from 628.07 feet downstream to 679.64 feet upstream.

Water surface elevations with the woody vegetation in place, for the 1% ACE flood event, range from 630.34 feet at the downstream end to 672.53 feet at the upstream end of the study reach.

Flows for the 1% ACE flood event are 18,331 cfs at the upstream, increasing to 38,745 at the confluence with Apache Creek.

The placement of the bankfull pilot channel was accomplished in two reaches, Reach 1 and Reach 2, using the dimensions provided by the geomorphology study. The bankfull pilot channel was placed into the model at or below the existing invert of the flood control channel. The excavation required for this placement, in most cases, allowed for additional flood space, and provided opportunities for the placement of trees with various densities. The sensitivity of the model for each reach determined the densities of trees to be placed onto the benches of the bankfull pilot channel.

Reach 2 – Junction with Apache Creek to River Station 96+27 (Junction with Martinez Creek)

Reach 2 began at the junction with Apache Creek, and continued upstream to River Station 96+27, which is at the junction with Martinez Creek. The bankfull pilot channel for this reach has a bottom width of 30.6 feet with side slope of 1V on 2.5H, a depth of 3.1 feet and a top width of 45.9 feet. From the junction with Apache Creek to Station 96+27, the bankfull pilot channel is placed at the existing channel invert elevation, with banks on either side of the bankfull pilot channel. The resulting water surface elevation is lower than the existing condition water surface elevation by an average of 2 to 3 inches before the placement of trees on the benches.

Reach 1 – River Station 96+27 to River Station 175+71)

Reach 1 began at the junction with Martinez Creek, and continued upstream to River Station 175+71, which is at the outlet of Woodlawn Lake. The bankfull pilot channel for this reach has a bottom width of 24.2 feet with side slope of 1V on 2.5H, a depth of 2.4 feet and a top width of 36.2 feet. From the junction with Martinez Creek to Station 175+71, the bankfull pilot channel is placed at the existing channel invert elevation, with banks on either side of the bankfull pilot channel. The resulting water surface elevation is lower than the existing condition water surface elevation by an average of 2 to 3 inches before the placement of trees on the benches.

MARTINEZ CREEK

Martinez Creek study reach began at the junction with the Alazan Creek and continued to just downstream of West Hildebrand Avenue with a total study length of 14,726 feet. The starting water surface elevation for Martinez Creek at the junction with Alazan Creek is 656.69 feet. The downstream channel bottom elevation with the bankfull pilot channel in place is 633.79 feet. The upstream invert elevation is 682.97 feet. The top of bank elevations range from 646.14 feet downstream to 696.27 feet upstream.

Water surface elevations with the woody vegetation in place, for the 1% ACE flood event, range from 656.69 feet at the downstream end to 697.72 feet at the upstream end of the study reach. Flows for the 1% chance flood event are approximately 8,229 cfs at the upstream, increasing to 17,823 at the confluence with Alazan Creek.

The placement of the bankfull pilot channel was accomplished in three reaches, Reach 1, Reach 2, and Reach 3, using the dimensions provided by the geomorphology study. The bankfull pilot channel was placed into the model at or below the existing invert of the flood control channel. The excavation required for this placement, in most cases, allowed for additional flood space, and provided opportunities for the placement of trees with various densities. The sensitivity of the model for each reach determined the densities of trees to be placed onto the benches of the bankfull pilot channel.

REACH 3 – JUNCTION WITH ALAZAN CREEK TO RIVER STATION 46+53

Reach 3 began at the junction with Alazan Creek, and continued upstream to River Station 46+53, which is at Culebra Avenue Bridge crossing. The bankfull pilot channel for this reach has a bottom width of 22.3 feet with side slope of 1V on 2.5H, a depth of 2.2 feet and a top width of 33.4 feet. The bankfull pilot channel is placed at the existing channel invert elevation, with banks on either side of the bankfull pilot channel. The resulting water surface elevation is lower than the existing condition water surface elevation by an average of 2 to 3 inches before the placement of trees on the benches.

REACH 2 - RIVER STATION 46+53 TO RIVER STATION 122+65 (I-10 BRIDGE)

Reach 2 began at Station 46+53 and continued upstream to the I-10 Bridge at River Station 122+65. The bankfull pilot channel extends up into this reach to station 122+65 immediately upstream of the I-10 Bridge. The bankfull pilot channel for this reach has a bottom width of 21.7 feet with side slope of 1V on 2.5H, a depth of 2.2 feet and a top width of 32.6 feet. The bankfull pilot channel was placed below the existing invert elevation by an average of 2 to 3 feet, with wider banks on both sides of the bankfull pilot channel. The resulting water surface elevation is lower than the existing condition water surface elevation by an average of 4 to 6 inches before the placement of trees on the benches.

REACH 1 - RIVER STATION 122+65 (I-10 BRIDGE) TO RIVER STATION 147+26 (W. HILDEBRAND AVENUE)

Reach 1 began at Station 122+65 and continued upstream to W. Hildebrand Avenue at River Station 147+26. The bankfull pilot channel extends up into this reach to station 147+26 which is the upstream limit at the downstream face of the W. Hildebrand Avenue Bridge. The bankfull pilot channel for this reach has a bottom width of 21.0 feet with side slope of 1V on 2.5H, a depth of 2.1 feet and a top width of 31.5 feet. The bankfull pilot channel was placed below the existing invert elevation by an average of 2 to 3 feet, with wider banks on both sides of the bankfull pilot channel. The resulting water surface elevation is lower than the existing condition water surface elevation by an average of 3 to 4 inches before the placement of trees on the benches.

SUMMARY AND CONCLUSION

The Hydraulic modeling process was completed using the Geomorphology stream data defining the sizes of each pilot channel for all four creeks for the Westside Creeks Pilot Study. The data utilized in the study was the most up-to-date and the water surface elevations computed for each alternative met the criteria of not allowing the water surface elevation to exceed those published in the 2010 DFIRM.

WESTSIDE CREEKS ENVIRONMENTAL RESTORATION

Appendix C: Natural Resources

NATURAL RESOURCES APPENDIX

INTRODUCTION

The Natural Resources appendix was developed to provide technical and policy support information utilized in the development of the feasibility report. This appendix provides information that documents historic conditions, future without project conditions, known planning constraints and opportunities to develop plans that would meaningfully restore modern historic ecosystem conditions to the streams and realated riparian habitats of the study area. This appendix describes the estimation of environmental benefits and the plan formulation of the WSC ecosystem restoration study.

Havard (1885) describes the San Antonio River Valley as containing “masses of luxuriant timber spread over the valley, thick shrubbery of various shades of green covers the uplands, and a sward of thin but nutritious grass carpets the ground…Largest and most conspicuous of trees along the river is the lordly pecan, attaining here an enormous size, and the cottonwood.” Havard describes an extremely rich and diverse aquatic ecosystem in the San Antonio streams including yellow pond-lily (*Nuphar lutea*), water pennyworts (*Hydrocotyle prolifera, H. umbellata*), Carolina fanwort (*Cabomba caroliana*), watercress (*Nasturtium officinale*), arrow-heads (*Sagittaria lancifolia, S. latifolia*), brookweeds (*Samolus valerandi, S. ebracteatus*), water hemlock (*Cicuta maculata*), monkey-flowers (*Mimulus glabratus, M. luteus*), and several species of pondweed (*Potomogeton* spp.). Beckham (1887) provides further insight into the historic morphology of the San Antonio river and its tributaries writing “These (San Antonio) springs or fountains unite to form a river, which, after winding through the town in a very tortuous course, is joined some distance below by the San Pedro, a large creek having a source of supply similar to that of the river.”

The aquatic and terrestrial organisms that depended on the aquatic and riparian habitats were equally diverse. The presence of numerous springs and streams along the Balcones Escarpment and the convergence of the Edwards Plateau, South Texas Brush, and Blackland Prairies ecological regions have long been recognized as providing valuable habitat for many wildlife species in the San Antonio area, particularly birds (Beckham, 1887; Attwater, 1892; Quinlan and Holleman, 1918; Griscom, 1920). The evolutionary ‘development’ of the Central Flyway along these resources is probably no accident given the immense historic productivity these habitats must have provided.

Although the Westside Creeks aquatic ecosystem had been previously affected by the urbanization of Bexar County and the encroachment on the riparian habitats, the San Antonio Channel Improvements Project (SACIP) constructed between 1957 and1988 by the Corps of Engineers eradicated any semblance of the streams Havard and Beckham described almost 130 years ago. The SACIP straightened approximately 35 miles of the San Antonio River and its tributaries in the San Antonio area and converted the aquatic and riparian habitats to maintained grass-lined channels to reduce flood risk. By straightening the tortuous watercourses, water velocities increased leading to increased erosion and sedimentation downstream, thereby disrupting the substrate composition of the highly impacted aquatic habitats that remained. The homogeneous, shallow pilot channel that replaced the sinuous natural pool, riffle, and run habitats resulted in increased water temperatures and lower dissolved oxygen concentrations. Additionally, the loss of overstory vegetation that once shaded the creeks exasperated these effects resulting in the severe aquatic habitat conditions existing today.

Although the flood risk management measures initiated by the SACIP were a needed response to damaging floods that occurred in San Antonio in the 1940's and 1950's, the actions resulted in unconsidered consequences for fish and wildlife that are dependent on these regionally scarce aquatic and riparian habitats.

The purpose of Civil Works ecosystem restoration is to restore significant ecosystem function, structure, and dynamic processes that have been degraded (USACE, 1999). In an effort to return aquatic and riparian habitat structural and functional benefits to the SACIP riverine ecosystem, San Antonio River Authority (SARA) and the United States Army Corps of Engineers (USACE) have already partnered to restore approximately 9 miles of these habitats with the implementation of Eagleland and Mission Reach projects located on the San Antonio River. This WSC study assesses the benefits of restoring 13 miles of aquatic and riparian habitat along previously channelized tributary streams to the San Antonio River.

EXISTING CONDITIONS

The channelization of the Westside Creeks has caused degradation of the riverine environment resulting in the loss of an aquatic environment supporting native aquatic species. The existing WSC floodways resemble typical trapezoidal shaped floodways with concrete slab and block armoring interspersed throughout. Vegetation is maintained to heights of approximately six inches or less. Linked to the aquatic degradation is the loss of native riparian vegetation species, which in addition to being vital to the aquatic environment, supports native residential and migratory, game and nongame wildlife species. The extent of the degradation is so severe that it is impossible to separate the components of the riverine environment, aquatic versus riparian, to prioritize restoration measures. Virtually no vestige of a natural, complete, native riverine environment remains upon which to add only a few restoration measures and expect significant improvements. The loss of historical native riparian vegetation has resulted in the loss of the necessary components for the life cycle of the numerous insect species, which are the vital cornerstone of the riverine prey base for the native aquatic and riparian-dependent insectivore species. The imbalance in the predator/prey relationship has assisted in the invasion of non-native invasive species into the aquatic and riparian habitats.

Specific details of the WSC existing environmental conditions and potential impacts of the WSC study on these resources are described in the main report (Chapters 2 and 4).

RESOURCE SIGNIFICANCE

In compliance with the Council of Environmental Quality (CEQ) National Environmental Policy Act (NEPA) regulations (40 CFR 1500.1(b), 1501.7(a)(2) and (3), and 1502.2(b)), guidance for USACE ecosystem restoration projects (P&G) require the identification of significant resources and attributes that are likely to be affected by one or more of the alternative plans (U.S. Water Resources Council, 1983). "Significant" is defined as "likely to have a material bearing on the decision-making process" (Apogee Research, Inc., 1996). Resource significance is determined by the importance and non-monetary value of the resource based on institutional, public, and technical recognition in the study area. The P&G defines these significance criteria as:

- **Institutional Recognition**: The importance of the resource or attribute is acknowledged in the laws, adopted plans, and other policy statements of public agencies or private groups.
- **Public Recognition:** The resource or attribute is considered important by some segment of the general public.

- **Technical Recognition:** The importance of the resource or attribute is based on scientific or technical knowledge or judgment of critical resource characteristics.

In January, 2011, the USACE and the Assistant Secretary of the Army (Civil Works)(ASA(CW)) initiated a study to improve the efficiency and effectiveness of the pre-authorization study process (USACE, 2011). The Westside Creeks Ecosystem Restoration study has been designated as one of the pilot programs to assess the efficacy of the new pre-authorization study paradigm. One of the implementation measures identified by the study was the determination of Federal interest and level of Federal investment early in the study process. The new paradigm also requires alternative development and assessment beyond the National Economic Development (NED) and the National Ecosystem Restoration (NER) alternatives and the use of multi-criteria decision analysis in the selection of a “preferred” plan. Therefore, the identification of significant resources in the study area may provide additional criteria to include in a multi-criteria decision making analysis.

INSTITUTIONAL RECOGNITION

Significance based on institutional recognition means that the importance of the environmental resource is acknowledged in the laws, adopted plans, and other policy statements of public agencies or private groups. The institutional recognition of resource significance for the Westside Creeks Study area is demonstrated by the following laws, policies, treaties, plans, and cooperative agreements established for the conservation and protection of these environmental resources.

ENDANGERED SPECIES ACT

The Endangered Species Act of 1973 (ESA), as amended, "provides a means whereby the ecosystems upon which endangered and threatened species depend may be conserved, and to provide a program for the conservation of these species." The Department of the Interior, acting through the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service is responsible for the protection of federally threatened and endangered species in the U.S. The ESA prohibits the take of listed animals and the interstate or international trade in listed plants and animals without a permit. The USFWS also maintains a list of Candidate species consisting of species where there is information that warrants proposing them for listing under ESA, but listing them is precluded due to higher priority species. On October 6, 2011, five mussel species were added to the Federal list of Candidate species, three of which historically occurred in the San Antonio River Basin, but no longer occur within the WSC. The only Federally listed species that may move through the area as an extremely rare transient is the Whooping Crane (Table 1) (USFWS, 2011a; USFWS, 2011b).

TEXAS STATE THREATENED AND ENDANGERED SPECIES

In 1973, the Texas legislature authorized the Texas Parks and Wildlife Department (TPWD) to establish a list of fish and wildlife that are endangered or threatened with statewide extinction. In 1988, the Texas legislature added the authority for TPWD to establish a list of threatened and endangered plant species for the state. TPWD regulations prohibit the taking, possession, transportation, or sale of any state endangered or threatened animal species without the issuance of a permit (TPWD Code §68.015). In addition, the commercial sale, possession for commercial sale, or the sale of all or part of an endangered, threatened, or protected plant from public land is prohibited (TPWD Code §88.008).

Table 1 presents the state-listed rare, threatened, and endangered species that are known to occur in Bexar County (TPWD, 2011a) with the potential of these species to utilize aquatic and riparian habitats within the study area. Table 1 also identifies species of significance that may benefit from the proposed Westside Creeks study.

Table 1. Rare, Threatened, and Endangered Species

Common Name	Scientific Name	State Listing[1]	Utilizes Aquatic/ Riparian Habitats	Habitat within Westside Creeks Study Area
Birds				
American Peregrine Falcon	*Falco peregrines anatum*	ST	Yes	Yes[2]
Arctic Peregrine Falcon	*Falco peregrines tundrius*	SOC	Yes	Yes[2]
Interior Least Tern	*Sterna antillarum athalassos*	SE	Yes	Yes[2]
White-faced Ibis	*Plegadis chihi*	ST	Yes	Yes[2]
Whooping Crane	*Grus americana*	FE/SE	Yes	Yes[2,3]
Wood Stork	*Mycteria americana*	ST	Yes	Yes[2]
Zone-tailed Hawk	*Buteo albonotatus*	ST	Yes	Yes[2]
Mammals				
Cave myotis bat	*Myotis velifer*	SOC	No	Yes[4]
Ghost-faced bat	*Mormoops megalophylla*	SOC	No	Yes[4]
Mollusks				
Creeper (squawfoot)	*Strophitus undulatus*	SOC	Yes	Yes
Golden orb	*Quadrula aurea*	FC/ST	Yes	Yes
Reptiles				
Texas garter snake	*Thamnophis sirtalis annectens*	SOC	Yes	Yes
Texas indigo snake	*Drymarchon melanurus erebennus*	ST	Yes	Yes[3]
Timber/Canebrake rattlesnake	*Crotalus horridus*	ST	Yes	Yes[3]
Plants				
Big red sage	*Salvia pentstemenoides*	SOC	Yes	Yes
Correll’s false dragon-head	*Physostegia correllii*	SOC	Yes	Yes

[1] SE – State-listed Endangered; FC –Candidate for Federal Listing; ST – State-listed Threatened; SOC – State Species of Concern

[2] Potential migrant

[3] Study area is at the limits of known range

[4] Potential foraging area

FISH AND WILDLIFE CONSERVATION ACT OF 1956

The Fish and Wildlife Conservation Act (FWCA) of 1956 encourages all Federal agencies to utilize their statutory and administrative authority to conserve and promote the conservation of nongame fish and wildlife and their habitats.

FISH AND WILDLIFE COORDINATION ACT OF 1958

The Fish and Wildlife Coordination Act of 1934, as amended, recognizes the contribution of wildlife resources to the nation. The USFWS and TPWD have committed to dedicate time and resources to coordinate with USACE to develop, refine, and assess a set of measures that will ultimately yield identification of a preferred plan meeting the delivery team objectives for riverine habitat restoration that have significant environmental outputs for fish and wildlife resources. The USFWS and TPWD have previously stated that the Mission Reach segment of the San Antonio Restoration Project is great example of how the two objectives of flood control and habitat restoration can be integrated together, and believe that a similar coordinated effort can be used to accomplish environmental restoration benefits while maintaining the current level of flood protection offered by the existing flood control structures. The habitats that would be restored with implementation of the eventual recommended plan will meet intent and provisions of the Fish and Wildlife Coordination Act by recognizing the vital contribution of wildlife resources to San Antonio, south-central Texas, and the Nation. Institutional significance is demonstrated by the extreme interest, commitment, and recognition given to this study by the USFWS and TPWD. The Act recognizes that incremental losses to flowing waters and their associated riparian habitats have become cumulatively important to nationally recognized resources and that mitigation of those losses is within the national interest. Similarly the restoration of these habitats could be shown to be incrementally nationally significant.

MIGRATORY BIRD TREATY ACT

The United States has recognized the critical importance of this shared resource by ratifying international, bilateral conventions for the conservation of migratory birds. These migratory bird conventions impose substantive obligations on the U.S. for the conservation of migratory birds and their habitats, and through the Migratory Bird Treaty Act, the U.S. has implemented these migratory bird conventions with respect to the U.S. The Migratory Bird Treaty Act prohibits the taking, possessing, importing/exporting, selling, and transporting of any listed migratory bird, its parts, nest, or eggs. Included in the protection provided by this act are all North American diurnal birds of prey, except bald and golden eagles which are provided protection under the Bald and Golden Eagle Protection Act. A list of bird species known to occur in Bexar County, including migratory birds protected under the Migratory Bird Treaty Act, are presented in Attachment 1.

NORTH AMERICAN BIRD CONSERVATION INITIATIVE

The North American Bird Conservation Initiative (NABCI) is a trinational declaration of intent between the U.S., Canada, and Mexico to strengthen cooperation on the conservation of North American birds throughout their ranges and habitats. The U.S. NABCI Committee is coalition of government agencies, private organizations, and bird initiatives in the United States comprised of representatives from the following entities:

- U.S. Fish and Wildlife Service
- Natural Resources Conservation Service
- Bureau of Land Management

- Department of Defense
- National Park Service
- U.S. Geological Survey
- U.S. Forest Service
- Farm Service Agency
- Wildlife Management Institute
- Association of Fish and Wildlife Agencies
- National Flyway Council
- Partners in Flight
- Association of Joint Venture Management Boards
- National Audubon Society
- The Nature Conservancy
- American Bird Conservancy
- Ducks Unlimited
- Waterbird Conservation for the Americas
- U.S. Shorebird Conservation Plan
- North American Waterfowl Management Plan
- Migratory Shorebird and Upland Game Bird Working Group
- Resident Game Bird Working Group

The NABCI divided North America into 67 ecologically distinct Bird Conservation Regions (BCRs) based on similar bird communities, habitats, and resource management issues. The Westside Creek study area is located near the intersection of three BCRs: Oaks and Prairies (BCR 21), Edwards Plateau (BCR 20), and Tamaulipan Brushlands (BCR 36). Because of the proximity of the study area to each of these BCRs, the avian community and habitats exhibit characteristics of each region.

OAKS AND PRAIRIES BCR 21

The Oaks and Prairie BCR encompasses over 45 million acres of Texas and Oklahoma encompassing the Blackland Prairie Ecoregion and the Cross Timbers Ecoregion. These ecoregions represent the southernmost extent of “true” prairies and the westernmost extent of deciduous forest in North America.

EDWARDS PLATEAU BCR 20

The Edwards Plateau BCR is demarcated by the Balcones Fault on the south and east boundary of the BCR and grades into the Great Plains and Chihuahuan Desert to the west and north. The Edwards Plateau BCR includes the eastern ranges for more arid, desert species as the region trends to more mesic climes provided in the prairie regions.

TAMAULIPAN BRUSHLANDS BCR 36

The Tamaulipan Brushlands BCR encompasses most of south Texas west of the Gulf Coastal Plains and extends into northeastern Mexico. The BCR provides habitat representing the northernmost extent of several tropical species ranges and the southernmost extent to numerous North American species.

NORTH AMERICAN WATERFOWL MANAGEMENT PLAN

Established in 1986, the North American Waterfowl Management Plan (NAWMP) is an international plan to reverse the downward trend in waterfowl populations. The goal of the plan is to protect, restore, and enhance wetland habitat and increase waterfowl population numbers. An update to the plan in 1998 was signed by the United States, Canada, and Mexico and lists wetland, aquatic systems, grassland, forest, and riparian areas as habitats critical to waterfowl. Thirty-six Important Waterfowl Habitat Areas have been identified by the USFWS, three of which are represented within Texas, and include east Texas, the gulf coast, and the playa lakes region. Central Texas, including the San Antonio area, provides a critical link between the three priority waterfowl habitat areas. The USFWS states that conservation efforts should include national and regional planning for both migratory and endemic waterfowl species. Between 1986 and 2009, $4.5 billion was invested to secure, protect, restore, enhance and manage 15.7 million acres of waterfowl priority landscapes in North America. The NAWMP was updated again in 2004 and NAWMP Science Support Team (NSST) prioritized conservation needs for waterfowl species based on socioeconomic importance of the species, the species population trend, and the vulnerability of the population to decline (NAWMP, 2004). Conservation priority designations in the NAWMP (High, Moderately High, Moderate, and Moderately Low) reflect the conservation need during the breeding and/or nonbreeding seasons. Species that are considered High and Moderately High conservation priorities were included in the Conservation Guild of the Avian IBI. Table 2 identifies waterfowl species known to occur in Bexar County that are considered priority species by the NSST for each BCR in the Westside Creeks study area.

Table 2. Waterfowl Conservation Priority Species (NSST, 2004) Known to Occur in Bexar County (Brierly and Engelman, 2004)

Species	Bird Conservation Region (BCR)		
	Oaks and Prairies	Edwards Plateau[1]	Tamaulipan Brushland
High			
Canada Goose	X		
Moderately High			
American Wigeon	X		
Blue-winged Teal	X		
Bufflehead			
Canvasback	X		
Common Goldeneye	X		
Gadwall	X		X
Green-winged Teal	X		
Northern Shoveler	X		
Redhead	X		X
Ring-necked Duck	X		
Wood Duck	X		

[1] No waterfowl species were listed in the 2004 update of the NAWMP

NORTH AMERICAN WATERBIRD CONSERVATION PLAN

The Waterbird Conservation for the Americas (WCA) initiative was established in 1998 to address threats to waterbirds and their habitats. The goal of the WCA is sustain and restore waterbird populations and breeding, migratory, and nonbreeding habitats in North America, Central America, and the Caribbean. The WCA identified and ranked the conservation concern for waterbird species throughout North America by BCRs as Highly Imperiled, High Concern, Moderate Concern, Low Concern, Not Currently At Risk, and Information Lacking (Kushlan et al., 2002). Species with significant population declines and either low populations or some other high risk factor were designated as Highly Imperiled species. Declining species of High Concern species are declining and have some potential threat as well, and Moderate Concern species are either declining with moderate threats or distributions, stable with known or potential threats and moderate to restricted distributions, or small risk with relatively restricted distributions. Because these three conservation statuses are defined by declining populations, they were included in the Conservation Bird Guild for the Avian IBI.

Table 3. WCA (2002) Conservation Status Waterbirds within BCRs of Bexar County (Brierly and Engelman, 2004)

	Bird Conservation Region (BCR)		
Species	**Oaks and Prairies**	**Edwards Plateau**	**Tamaulipan Brushland**
High Concern			
Black Skimmer			X
Gull-billed Tern			X
Least Tern	X	X	
Little Blue Heron	X	X	X
Snowy Egret	X		X
Tricolored Heron			X
Moderate Concern			
White Pelican			X
Anhinga	X		X
Black-crowned Night-heron	X	X	X
Bonaparte’s Gull	X		X
Eared Grebe	X	X	X
Forster’s Tern	X		X
Neotropic Cormorant	X		X
Roseate Spoonbill			X
White Ibis			X
Yellow-crowned Night-heron	X		

SHOREBIRD CONSERVATION PLAN

The U.S. Shorebird Conservation Plan is a partnership of state and federal agencies and non-governmental conservation organizations. The Shorebird Conservation Plan developed the plan to protect and restore shorebird populations and their migratory, breeding, and nonbreeding habitats. The plan categorizes the conservation concern and risk for North American shorebirds into five categories: 1) species not at risk, 2) species of low concern, 3) species of moderate concern, 4) species of high concern, and 5) highly imperiled species (Brown et al., 2001). Because the Highly Imperiled, High Concern, and Moderate Concern have declining populations and/or some level of conservation risk identified, they were included in the Conservation Guild in the Avian IBI model. These species are presented in Table 4 for shorebirds that are known to occur in Bexar County.

Table 4. North American Shorebird Conservation Plan Species of Concern (Brown et al., 2001) for BCRs of Bexar County (Brierly and Engelman, 2004)

	Bird Conservation Region (BCR)		
Species	**Oaks and Prairies**	**Edwards Plateau**	**Tamaulipan Brushland**
Highly Imperiled			
Long-billed Curlew			X
Mountain Plover			X
Piping Plover			X
Snowy Plover			X
Species of High Concern			
American Woodcock	X		
Marbled Godwit			X
Red Knot			X
Ruddy Turnstone			X
Sanderling			X

	Bird Conservation Region (BCR)		
Species	**Oaks and Prairies**	**Edwards Plateau**	**Tamaulipan Brushland**
Short-billed Dowitcher			X
Solitary Sandpiper			X
Western Sandpiper	X		
Whimbrel			X
Wilson’s Plover			X
Species of Moderate Concern			
American Avocet			X
Black-bellied Plover			X
Dunlin	X		X
Greater Yellowlegs			X
Killdeer	X	X	X
Least Sandpiper	X	X	X
Lesser Yellowlegs			X
Stilt Sandpiper			X
Willet			X

USFWS BIRDS OF CONSERVATION CONCERN

The 1988 amendment to (Public Law 100-653, Title VIII) to the FWCA directs the USFWS to identify migratory nongame bird species, subspecies, and populations that would become candidates for listing under the ESA if additional conservation actions are not implemented. In response to this mandate, the USFWS (2008) compiled a list of Birds of Conservation Concern (BCC) on three scales: the BCRs, USFWS Regions, and a National scale. The USFWS utilized the conservation assessment scores in the Partners in Flight North American Landbird Conservation Plan (Rich et al., 2004), the United States Shorebird Conservation Plan (Brown et al., 2001; USSCP, 2004), and the North American Waterbird Conservation Plan (Kushlan et al., 2002) to identify abundance, population trends, distribution, threats, and the importance of an area to a species to identify Birds of Conservation Concern for each BCR (Table 5).

Table 5. USFWS (2008) Birds of Conservation of Concern and Species Known to Occur Bexar County (Brierly and Engelman, 2004)

	Bird Conservation Region (BCR)		
Species	**Oaks and Prairies**	**Edwards Plateau**	**Tamaulipan Brushland**
Little Blue Heron	X		
Swallow-tailed Kite	X		
Bald Eagle	X(b)	X(b)	
Harris’ Hawk			X
Swainson’s Hawk			X
Peregrine Falcon	X(b)	X(b)	
Snowy Plover			X(c)
Mountain Plover		X(nb)	X(nb)
Lesser Yellowlegs			X(nb)
Solitary Sandpiper			X(nb)
Upland Sandpiper	X	X(nb)	
Long-billed Curlew	X(nb)	X(nb)	X(nb)
Hudsonian Godwit	X(nb)		
Buff-breasted Sandpiper	X(nb)		
Gull-billed Tern			X
Green Parakeet			X(d)

Species	Bird Conservation Region (BCR)		
	Oaks and Prairies	Edwards Plateau	Tamaulipan Brushland
Elf Owl			X
Burrowing Owl			X
Buff-bellied Hummingbird			X
Red-headed Woodpecker	X		
Scissor-tailed Flycatcher	X		
Loggerhead Shrike	X		
Bell’s Vireo	X(c)		X(c)
Verdin			X
Curve-billed Thrasher			X
Sprague’s Pipit	X(nb)		X(nb)
Tropical Parula			X
Swainson’s Warbler	X		
Summer Tanager			X
White-collared Seedeater			X
Cassin’s Sparrow			X
Rufous-crowned Sparrow		X	
Lark Bunting			X(nb)
Henslow’s Sparrow	X(nb)		
Harris’ Sparrow	X(nb)	X(nb)	
McCown’s Longspur		X(nb)	
Smith’s Longspur	X(nb)		
Chestnut-collared Longspur		X(nb)	X(nb)
Varied Bunting			X
Painted Bunting			X
Dickcissel			X
Orchard Oriole	X	X	
Hooded Oriole			X
Altamira Oriole			X
Audubon’s Oriole			X

(b) ESA delisted, (c) non-listed subspecies or population of Threatened or Endangered species, (d) MBTA protection uncertain or lacking, (nb) non-breeding in this BCR

PARTNERS IN FLIGHT

Partners in Flight (PIF)is a cooperative partnership between federal, state, and local government agencies, philanthropic foundations, professional organizations, conservation groups, industry, academia, and private individuals. Federal agency partners include the following:

- Federal Agencies
    - U.S. Geological Survey
    - National Park Service
    - Bureau of Land Management
    - U.S. Fish and Wildlife Service
    - Department of Defense
    - U.S. Forest Service
    - U.S. Environmental Protection Agency
    - Natural Resources Conservation Service
    - U.S. Army Corps of Engineers
    - U.S. Department of State

- State Wildlife Resource Agencies
- Non-governmental Organizations
- Private Industry

The goals of PIF are to create a coordinated network of conservation partners to secure sufficient commitment and resources to implement and support scientifically-based landbird conservation plans at multiple scales. In an effort to prioritize conservation needs, PIF assessed the conservation vulnerability for landbird species and assigned a scores to each species based on biological criteria such as population size, breeding distribution, non-breeding distribution, threats to breeding habitats, threats to non-breeding areas, and population trends (Panjabi et al., 2005). In addition to providing conservation scores for each species on a continental scale, scores are also calculated for each BCR. Based on the conservation scores, appropriate conservation action categories are assigned to each species depending on the threat of extinction (Table 6). These conservation actions are required for improving or maintaining the current population status of the species.

Table 6. PIF Conservation Action Categories (Punjab et al. 2005) and Species Known to Occur in Bexar County (Brierly and Engelman, 2004)

Conservation Action Category	Vulnerability Risk	BCR		
		Oaks & Prairies	Edwards Plateau1	Tamaulipan[2]
Critical Recovery	Species subject to very high regional threats. Critical recovery actions are needed to prevent likely extirpation or to reintroduce a species that has been extirpated.	Swallow-tailed Kite Black-capped Vireo Yellow Warbler Golden-cheeked Warbler	Black-capped Vireo Yellow Warbler Golden-cheeked Warbler Common Yellowthroat	Bell's Vireo Common Yellowthroat
Immediate Management	Species subject to high regional threats and large population declines. Conservation action is needed to reverse or stabilize significant, long-term population declines. Lack of action may result in extirpation of species.	Loggerhead Shrike Bell's Vireo	Montezuma Quail Painted Bunting	Scaled Quail Buff-bellied Hummingbird Summer Tanager Painted Bunting Hooded Oriole Bullock's Oriole Audubon's Oriole
Management Attention	Species subject to moderate regional threats and moderate to large declines OR subject to high regional threats but no large decline. Management or other conservation actions are required to reverse or stabilize significant, long-term population declines or mitigate threats.	Northern Bobwhite Yellow-billed Cuckoo Common Nighthawk Chimney Swift Red-headed Woodpecker Great Crested Flycatcher Scissor-tailed Flycatcher Summer Tanager Cassin's Sparrow Field Sparrow Lark Sparrow Painted Bunting Eastern Meadowlark Bullock's Oriole Baltimore Oriole	Northern Bobwhite Harris' Hawk Yellow-billed Cuckoo Bell's Vireo Canyon Wren Cassin's Sparrow Rufous-crowned Sparrow Field Sparrow Lark Sparrow Dickcissel Orchard Oriole	Northern Bobwhite Harris' Hawk Swainson's Hawk White-tailed Hawk Green Parakeet Yellow-billed Cuckoo Golden-fronted Woodpecker Verdin Cactus Wren Curve-billed Thrasher Cassin's Sparrow Lark Sparrow Pyrrhuloxia Dickcissel Orchard Oriole Altamira Oriole
Planning and Responsibility	Species are of continental concern, but not regional concern. Long-term planning actions are required to ensure sustainable populations are maintained.	Swainson's Hawk Inca Dove Purple Martin Carolina Chickadee Prothonotory Warbler Kentucky Warbler Dickcissel	Scaled Quail Black-chinned Hummingbird Black-crested Titmouse Bewick's Wren	Inca Dove Common Ground-dove Greater Roadrunner Eastern Screech-owl Elf Owl Ladder-backed Woodpecker Couch's Kingbird Scissor-tailed Flycatcher Chihuahuan Raven Cave Swallow Long-billed Thrasher Olive Sparrow

[1] Swainson's Warbler has been reported for Bexar County; however, these reports are unconfirmed. Therefore, these species are not included in this analysis.

[2] The Hook-billed Kite, Tropical Parula, White-collared Seedeater, and Varied Bunting have been reported for Bexar County; however, these reports are unconfirmed. Therefore, these species are not included in this analysis.

DOD PARTNERS IN FLIGHT

The Department of Defense PIF program consists of a cooperative network of natural resources personnel from military installations across the U.S. DoD PIF works collaboratively with other avian conservation initiatives to conserve migratory and resident bird species and their habitat on DoD lands. In addition, DoD PIF works beyond installation boundaries to facilitate cooperative partnerships, determine the current status of bird populations, and prevent the listing of additional birds as threatened or endangered. In this effort, the DoD PIF has developed a list of species of concern for bird's utilizing DoD lands (Table 7).

Table 7. DoD PIF (2011) Priority Species

Species
Northern Bobwhite
Swallow-tailed Kite
Bald Eagle
Northern Goshawk
Golden Eagle
Prairie Falcon
King Rail
Snowy Plover
Wilson's Plover
Mountain Plover
Upland Sandpiper
Long-billed Curlew
Buff-breasted Sandpiper
Gull-billed Tern
Least Tern
Western Yellow-billed Cuckoo
Burrowing Owl
Common Nighthawk
Chuck-will's-widow
Whip-poor-will
Red-headed Woodpecker
Olive-sided Flycatcher
Loggerhead Shrike
Cactus Wren
Sprague's Pipit
Blue-winged Warbler
Golden-winged Warbler
Prairie Warbler
Cerulean Warbler
Swainson's Warbler
Kentucky Warbler
Grasshopper Sparrow
Baird's Sparrow
Henslow's Sparrow
Harris' Sparrow
Painted Bunting
Dickcissel
Eastern Meadowlark
Rusty Blackbird

NATIONAL AUDUBON SOCIETY AND THE AMERICAN BIRD CONSERVANCY

In 2007, the Audubon Society and the American Bird Conservancy published the Watchlist 2007 (Butcher et al., 2007) documenting a Red-list of bird species in the U.S. that were rapidly declining in numbers and/or had very small populations or limited ranges, and faced major conservation threats and a Yellow-list of bird species that were either declining or rare. Watchlist 2007 includes 15[1] Red-listed species and 39 Yellow-listed species that can be found in Bexar County (Brierly and Engleman, 2004)(Table 8).

Table 8. Bexar County Bird Species on Watchlist 2007

Red-list Species	Yellow-list Species	
Snowy Plover	American Black Duck	Lucifer Hummingbird
Piping Plover	Mottled Duck	Calliope Hummingbird
Mountain Plover	Montezuma Quail	Rufous Hummingbird
Long-billed Curlew	Reddish Egret	Allen’s Hummingbird
Buff-breasted Sandpiper	Harris’ Hawk	Red-headed Woodpecker
Green Parakeet	Swainson’s Hawk	Olive-sided Flycatcher
Bell’s Vireo	Ferruginous Hawk	Willow Flycatcher
Black-capped Vireo	American Golden-plover	Wood Thrush
Sprague’s Pipit	Wilson’s Plover	Curve-billed Thrasher
Golden-winged Warbler	Whimbrel	Blue-winged Warbler
Golden-cheeked Warbler	Hudsonian Godwit	Prairie Warbler
Cerulean Warbler	Marbled Godwit	Bay-breasted Warbler
Baird’s Sparrow	Red Knot	Prothonotory Warbler
Henslow’s Sparrow	Short-billed Dowitcher	Worm-eating Warbler
Audubon’s Oriole	American Woodcock	Kentucky Warbler
	Wilson’s Phalarope	Canada Warbler
	Elf Owl	Painted Bunting
	Short-eared Owl	Dickcissel
	White-throated Swift	Rusty Blackbird
	Buff-bellied Hummingbird	

EXECUTIVE ORDER 13186 (MIGRATORY BIRDS)

The importance of migratory non-game birds to the nation is embodied in numerous laws, executive orders, and partnerships. The Fish and Wildlife Conservation Act demonstrates the Federal commitment to conservation of non-game species. Amendments to the Act adopted in 1988 and 1989 direct the Secretary to undertake activities to research and conserve migratory non-game birds. Executive Order 13186 directs Federal agencies to promote the conservation of migratory bird populations, including restoring and enhancing habitat. Migratory Non-game Birds of Management Concern is a list maintained by the USFWS. The list helps fulfill a primary goal of the USFWS to conserve avian diversity in North America. Additionally, the USFWS' Migratory Bird Plan is a draft strategic plan to strengthen and guide the agency's Migratory Bird Program. The proposed ecosystem restoration would contribute directly to the U.S. Fish and Wildlife Service Migratory Bird Program goals to protect, conserve, and restore migratory bird habitats to ensure long-term sustainability of all migratory bird populations. Rangewide protection, restoration and enhancement of terrestrial and aquatic habitats and landscapes are crucial to maintain and conserve migratory birds (USFWS 2003).

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[1] The Whooping Crane, Swainson’s Warbler, and McCown’s Longspur have been reported for Bexar County; however, these reports are unconfirmed. Therefore, these species are not included in this analysis.

Because the Westside Creeks study area support species of concern and their habitats which are addressed in numerous avian joint ventures, conservation organizations, and interagency and international cooperative plans, their institutional significance is recognized from both a regional, national, and international perspective. Aquatic and riparian ecosystem restoration of the Westside Creeks study area would support the goals of each of these plans and cooperative initiatives as the degraded habitat within the study area would increase the quality of breeding, foraging, wintering, and migration habitats for numerous bird species. Institutional significance is further supported as the restored habitats would support many of the species of concern identified in the tables above.

The four following laws and policies further add to the identification of Institutional Significance:

WATER RESOURCES DEVELOPMENT ACT OF 1986

The restored ecosystem functions that would be provided by the eventual recommended plan for the Westside Creeks study can be considered significant by the USACE because the restoration of these functions meet with the spirit of the Water Resources Development Act of 1986.

WATER RESOURCES DEVELOPMENT ACT OF 1990

Section 307(a) of the Water Resources Development Act of 1990 established an interim goal of no overall net loss of wetlands in the U.S. and set a long-term goal to increase the quality wetlands, as defined by acreage and function. The WSC ecosystem restoration study would not result in the loss of wetlands and waters of the U.S. as the proposed study would restore the ecological and hydraulic function to the WSC.

EXECUTIVE ORDER 13112 (INVASIVE SPECIES)

Executive Order 13112 recognizes the significant contribution native species make to the well-being of the Nation's natural environment and directs Federal agencies to take preventive and responsive action to the threat of non-native species invasion and to provide restoration of native species and habitat conditions in ecosystems that have been invaded. As the WSC study would replace non-native vegetation with site-specific native vegetation, it would be in compliance with Executive Order 13112.

TEXAS SENATE BILL 2

In Texas, Senate Bill 2, 77th Legislature of Texas recognizes the San Antonio River basin as a critical fish and wildlife resource. This bill requires the TPWD, the Texas Water Development Board (TWDB), the Texas Commission on Environmental Quality (TCEQ), and other agencies to establish an interagency instream flow program to determine conditions necessary to support a sound ecological environment. TPWD is a stakeholder in the planning of the WSC ecosystem restoration and the WSC ecosystem restoration study would restore fish and wildlife resources associated with the WSC.

PUBLIC RECOGNITION

Significance based on public recognition means that some segment of the general public recognizes the importance of an environmental resource. Public recognition is evidenced by people engaged in activities that reflect an interest in or concern for a particular resource. Recognition of public significance for the Westside Creeks study area can best be demonstrated by the actions of the SARA and the Westside Creeks Oversight Committee (WSCOC). The WSCOC consists of representatives of 20 local community organizations organized in 2008. Building on successes with the San Antonio River Improvements Project, SARA held public workshops between April, 2009 and February, 2010 to seek community participation in the development of a conceptual restoration plan for Westside Creeks (SARA, 2011). During the planning process, stakeholders representing Westside Creek area residents and neighborhood associations, service organizations, elected and government officials, schools and universities participated in the WSCOC, four sub-committees representing each of the four Westside Creek watersheds, and public workshops.

The proposed Westside Creeks Study makes a significant contribution to a larger watershed conservation and restoration effort being implemented by Bexar County, City of San Antonio (CoSA), and SARA. The above entities have made commitments to improving habitat across the entire San Antonio River watershed within Bexar County. The following is a brief listing for some of the recent, current, ongoing, and future projects for the watershed.

- Cibolo Creek, Leon Creek, Salado Creek, Eagleland, and Olmos Creek Studies: partnership studies with USACE to identify ecosystem restoration opportunities within the San Antonio River watershed.
- On-going community input for restoration of other tributaries of the San Antonio River.
- City of San Antonio's Creekways program: $20 million invested in the purchase and preservation the riparian zone of Salado and Leon Creeks.
- City of San Antonio's Proposition 3: Provides funding to purchase lands located in the Edwards Aquifer recharge zone, including creeks and riparian habitats. Approximately $45 million dollars is available for this effort, and thousands of acres have already been purchased.
- Bexar County, SARA, and CoSA spend a great deal for river/creek debris clean-up. CoSA maintains two fulltime crews, and SARA is spending millions to develop water quality models throughout the basin to quantify water quality benefits produced by natural creek systems.
- San Antonio River, Mission Reach: $83.6 million (including $27.5 million in lands, easements, rights-of-way, relocations and disposal areas) was invested in the Mission Reach project by SARA and other non-federal entities in addition to the $121.7 million federal share.

TECHNICAL RECOGNITION

Significance based on technical recognition requires identification of critical resource characteristics such as scarcity, representativeness, status and trends, connectivity, critical habitat, and biodiversity. Therefore, technical recognition of resources varies across geographic areas and spatial scale. The institutional section of this document provides evidence supporting the technical significance of the resources, specifically the scarcity, status, and trends of the resources. Further support for the technical significance of resources in the Westside Creeks Study area is documented in the following sections.

Scarcity. Nationally, the loss of aquatic and riparian habitats is widely recognized. Historically, approximately one percent of the western landscape was comprised of riparian habitats.

Status and Trends. Over the last 100 years, approximately 95-percent of riparian habitat has been converted by river channelization, water impoundments, agricultural practices, and urbanization (Krueper, 1995). As a result, freshwater animal species are disappearing five times faster than terrestrial animals due, partially, to the widespread physical alteration of rivers (Ricciardi and Rasmussen 1999). Of 860,000 river miles within the United States, approximately 24 percent have been impacted by channelization, impoundment, or navigation. The USFWS estimates 70-percent of the riparian habitats nationwide have been lost or altered, and 50-percent of all listed threatened or endangered species depend on rivers and streams for their continued existence. In some geographic areas, loss of natural riparian vegetation is as much as 95-percent indicating that riparian areas are some of the most severely altered landscapes in the country (NRCS 2002). The National Research Council (NRC) has stated that restoration of riparian functions along America's water bodies should be a national goal (NRC 2002). Urban riparian buffers are the framework for healthy streams and water quality and provide greenways that improve the quality of life for citizens (Okay 2000).

Physical, Chemical and Biologic interaction. One of the most important functions of both intermittent and ephemeral headwater streams that have been unaltered and have normal function is the collection and processing of organic material such as leaves, woody debris, and detritus. Microorganisms in the headwater stream systems consume the organic material, converting it into the primary bioavailable food source for aquatic species downstream. Intermittent and ephemeral streams are able to biotransform organic matter more efficiently than perennial streams because larger pieces of organic materials may not be as easily transported downstream at lower or infrequent flows. Therefore, more organic material is retained in the headwater streams extending the time that microorganisms can convert the material to bioavailable carbon and modulating water quality to prevent excess organic matter from degrading downstream systems (Cappiella and Fraley-McNeal, 2007). In addition, headwater streams play a disproportionately large role in the transformation of nitrogen, converting up to 50-percent of the nitrogen introduced from the watershed (Peterson et al., 2001), thereby improving water quality.

Biodiversity. It is because of the intermittent flows of these streams that biodiversity in headwater streams and their associated riparian areas is higher than in perennial systems downstream. This biodiversity includes primary producers (diatoms, cyanobacteria, red algae, and green algae), decomposers (bacteria, and fungi), insects, invertebrates (mollusks, crustaceans, and other invertebrates), fishes, amphibians, reptiles, birds and mammals, some of which are entirely restricted to intermittent streams. Many other species utilize headwater stream habitats seasonally as spawning and nursery areas, foraging areas, refugia habitats from predators and competitors, thermal refuge, and travel corridors (Meyer et al., 2007).

Connectivity. Potential management actions could include the reestablishment of riparian woodland and shrubland habitats, as well as riparian grassland habitats in strategic locations throughout the study area. The establishment of native woody and herbaceous riparian vegetation would provide significant benefit to the movement of aquatic species throughout the study area and would play a role in the aquatic species ability to move into newly restored upstream habitats. During baseflow conditions, fish from the San Antonio River and lower reaches of the Westside Creeks do not have the ability to emigrate up or down long stretches of the creeks. This is the historic condition of the San Pedro Creek and native fish species have adapted to the situation. In addition, the historical riparian habitats along Alazan, Apache, and Martinez Creeks would have maintained stream flows longer into the season than the current conditions allow. During flooding events, fish move along the margins of the creeks, where velocities are slower, in order to migrate up and downstream between the various aquatic habitats. Currently, because of the trapezoidal shape of the channel and the lack of proper riparian vegetational structure, velocities along the margins of the river can be too swift for fish movement during floods. Riparian trees serve many purposes when inundated including slowing the flood waters along the margins, which makes fish movement possible and provides a velocity refugia from the higher velocity water. Additionally, the structure added by the trees and the woody and herbaceous understory provides cover from predation during movement up and downstream. It is important that the riparian corridor be continuous from the water's edge to the top of the channel banks in order to maximize the benefits provided with respect to cover and migration along floodwater margins.

Typical of arid and semiarid areas in the western U.S., the mean monthly and annual evaporation rates exceed the highly variable precipitation rates in the San Antonio area (Table 9). As the ratio of precipitation to evaporation decreases, the contrast between the mesic riparian habitats associated with perennial flow and the adjacent upland habitats increases. For intermittent streams, this contrast decreases from the perennial end of the water availability continuum to the ephemeral until eventually blending into the upland end of the continuum. This relationship underscores the importance of arid and semiarid riparian ecosystems compared to riparian ecosystems in wetter or more humid climates where the distinction between upland and riparian habitats may be less defined.

Table 9. Mean Precipitation and Evaporation Rates for Bexar County (TWDB, 2011)

Month	Mean Precipitation (in)	Mean Evaporation (in)
January	1.78	2.19
February	2.05	2.53
March	1.96	3.84
April	2.72	4.55
May	3.76	4.98
June	3.49	6.42
July	2.22	7.33
August	2.47	7.11
September	3.59	5.42
October	3.44	4.45
November	2.22	2.99
December	1.84	2.25
Annual	**31.53**	**54.05**

Although riparian habitats comprise a relatively small portion of the overall landscape in arid and semiarid regions, riparian ecosystems substantially influence hydrologic, geomorphic, and ecological processes (Shaw and Cooper, 2008). Because soils in riparian habitats adjacent to intermittent and ephemeral streams have higher moisture content, they support more abundant vegetation than adjacent uplands. This vegetation provides breeding, nesting, and foraging habitat, cover, and wildlife travel corridors that are not available in adjacent upland habitats. Parameters influencing migrant passerine bird use in riparian habitats include habitat preferences of the bird, niche diversity and plant species composition, location and accessibility of habitat, and quality of adjacent habitat (Stevens et al., 1977). Avian species, in particular, are more dependent on riparian habitats in semiarid environments than other organisms (Levick et al., 2008). In fact, riparian bird populations may not be significantly affected by the impacts of urbanization as long as the riparian ecosystem remains in good condition (Oneal and Rotenberry, 2009).

Based on an analysis of more than 21,000 plant and animal species, the Nature Conservancy ranked biodiversity within the 50 states and the District of Columbia (Stein, 2002). According to the Nature Conservancy, four states exhibit exceptional levels of biodiversity, with Texas ranked 2nd overall and ranked 1st for diversity of birds and reptiles. Unfortunately, Texas ranks 4th in the number of extinctions, and is ranked 11th overall for the number of species at risk. Following is a listing of Texas rankings (out of 51) for the percentage of species at risk. Those listings in bold type are significant to the recommended ecosystem restoration of the San Antonio River.

- Bird Diversity at Risk 6th
- Amphibian Diversity at Risk 7th
- Freshwater Fish Diversity at Risk 8th

Mammal Diversity at Risk	9th
Reptile Diversity at Risk	9th
Vascular Plant Diversity at Risk	11th

TPWD released the Texas Conservation Action Plan (TPWD, 2011b) for comment in June 2011 identifying Species of Greatest Conservation Need (SGCN) for ecoregions throughout the state, including the Blackland Prairie, Edwards Plateau, and South Texas ecoregions (Attachment 2). Included in the list of SGCN for these ecoregions are several species that would benefit from aquatic and riparian ecosystem restoration measures within the Westside Creeks Study Area (Table 10). Aquatic species such as spiny softshell turtle, slider, Texas shiner, alligator gar, and blue sucker would benefit from the reconnection of fragmented aquatic habitats. Riparian SGCN such as the swamp rabbit, Strecker's chorus frogs Bell's Vireo, Louisiana Waterthrush would also benefit from the restoration of riparian grassland, shrubland, and woodland habitats. In addition, species that rely on riparian corridors for foraging habitat, including bat SGCN such as the Brazilian free-tailed bat and ghost-faced bat, would benefit from the improved habitat for forage species.

Table 10. TPWD Species of Greatest Conservation Need

Species	Scientific Name	Global/State Ranking	Blackland Prairies	Edwards Plateau	South Texas Plains
Birds					
Wood Stork	*Mycteria americana*	G4/SHB,S2N	X		
Northern Harrier	*Circus cyaneus*	G5/S2B,S3N	X	X	X
Common Black-hawk	*Buteogallus anthracinus*	G4G5/S2B		X	X
Harris's Hawk	*Parabuteo unicinctus*	G5/S3B		X	X
Zone-tailed Hawk	*Buteo albonotatus*	G4/S3B		X	
Golden Eagle	*Aquila chrysaetos*	G5/S3B		X	
American Golden-plover	*Pluvialis dominica*	G5,S3	X		
Mountain Plover	*Charadrius montanus*	G3/S2	X		X
American Woodcock	*Scolopax minor*	G5/S2B,S3N	X		
Chuck-will's-widow	*Caprimulgus carolinensis*	G5/S3S4B	X	X	
Red-headed Woodpecker	*Melanerpes erythrocephalus*	G5/S3B	X		
Scissor-tailed Flycatcher	*Tyrannus forficatus*	G5/S3B	X	X	X
Loggerhead Shrike	*Lanius ludovicianus*	G4/S4B	X	X	X
Bell's Vireo	*Vireo bellii*	G5/S3B	X	X	X
Sprague's Pipet	*Anthus spragueii*	G4/S3N	X	X	X
Kentucky Warbler	*Oporornis formosus*	G5/S3B	X		
Grasshopper Sparrow	*Ammodramus savannarum*	G5/S3B	X	X	X
Henslow's Sparrow	*Ammodramus henslowii*	G4/S2S3N,SXB	X		
Amphibians and Reptiles					
Texas indigo snake	*Drymarchon melanurus erebennus*	G4/S3		X	X
Cagle's map turtle	*Graptemys caglei*	G3/S1	X	X	
Alligator snapping turtle	*Macrochelys temminckii*	G3G4/S3	X		
Strecker's chorus frog	*Pseudacris streckeri*	G5/S3	X	X	
Texas garter snake	*Thamnophis sirtalis annectans*	G5/S2	X	X	
Fish					
Blue sucker	*Cycleptus elongates*	G3G4/S3	X		
Headwater catfish	*Ictalurus lupus*	G3/S2		X	X

[1] Global Conservation Ranking/State Conservation Ranking

GX/SX – Presumed Extinct; not located despite intensive searches and virtually no likelihood of discovery
GH/SH – Missing; known from only historical occurrences but still some hope of discovery
G1/S1 – Critically Imperiled; At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, 0r other factors
G2/S2 – Imperiled; At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors
G3/S3 – Vulnerable; At moderate risk of extinction due to restricted range , relatively few populations (often 80 or fewer), recent and widespread declines, or other factors
G4/S4 – Apparently Secure; Uncommon but not rare; some cause for long-term concern due to declines or other factors
G5/S5 – Secure; Common, widespread and abundant
G#G#/S#S# - Range Rank; A numeric range rank (e.g. G2G3/S2S3) is used to indicate the range of uncertainty in the status of a species.
B – Breeding; Conservation status referes to the breeding population of the species
N – Nonbreeding; Conservation status refers to the non-breeding population of the species

The national and state trend for habitat loss is even more pronounced within Bexar County and the study area. An analysis of tree cover within the San Antonio region reveals tree loss trends in three distinct analysis areas. As might be expected, the most dramatic loss of tree cover occurs within the City of San Antonio. The city has had its heavy tree cover (areas with greater than 50-percent canopy) decline by nearly 39 percent from 63,522 acres in 1985 to 38,753 acres in 2001. The greater San Antonio Area, including Bexar County and surrounding suburbs saw its heavy tree cover drop from 26 percent to 20 percent; areas with medium density canopy (20-49-percent) had the most significant percentage change, from 6 percent in 1985 to 3 percent by 2001 – a loss of approximately 43 percent; areas with light tree canopy (less than 20-percent tree cover) expanded from 69 percent in 1985 to 77 percent in 2001 (American Forests, 2002). Further, the introduction of exotic plant and animal species has had a substantial effect on riparian areas, leading to displacement of native species and the subsequent alteration of ecosystem properties (NRC 2002). Problematic non-native woody and herbaceous plant species are found throughout the study area. Local elimination of these species has been recommended by the USFWS (2004). This *trend* in the loss of habitat and species is expected to continue unless proactive restoration measures are taken. Between 2000 and 2020, the Bexar County population is projected to grow up to 49-percent. Of all the attributes of natural land in south Texas, wildlife habitat is the most endangered by human growth pressures.

The species benefiting from the restoration are also significant for a number of reasons. First, the restored aquatic habitat provides the opportunity for native fish populations to return to the Westside Creeks within the study area. Fish assemblages are strongly influenced by instream habitat, which in turn is strongly influenced by the riparian zone (Paller, et al. 2000). Annual fish surveys conducted by SARA between 1998 and 2003 of the San Antonio River below the study area show that the percentage of non-native species is consistently 200-300 percent higher (15-57 percent non-native) than below the floodway (2-17 percent non-native). A fish survey conducted for the San Antonio River Mission Reach segment by the U.S. Army Corps of Engineers, Engineering and Research Design Center (ERDC) found 25 percent of the total number identified species were non-native. Sixty-four percent of the native species component of the Mission Reach aquatic community was tolerant of degraded habitat. Therefore, 89 percent of the fishes surveyed within the Mission Reach project area are comprised of introduced species or native species tolerant of degraded conditions.

It has been demonstrated that habitat is the limiting factor in the return of native fish to the study area. As water quality in the river has improved through better wastewater treatment, an increase in the number of pollution-intolerant fish species such as stone rollers and longear sunfish in the San Antonio River downstream of the study area has been observed. The resource agencies believe the number of native fish will increase throughout the study area after implementation of the restoration project.

As evidenced by the numerous conservation and management cooperatives established to address adverse impacts to avian populations in North America, migratory birds are of great ecological value and contribute immensely to biological diversity. Bexar County provides essential feeding and resting habitat for migratory birds and is located in the heart of the Central Flyway. Over 300 species of birds are listed as Nearctic-Neotropical migrants in North America, and over 98-percent of those have been recorded in Texas. Therefore, of the more than 600 species of birds documented in Texas, 54-percent are neotropical species which depend on Texas to provide nesting or migration habitats. Many of these species are specifically dependent on south central Texas riparian areas. Neotropical migratory birds have been declining in numbers for several decades. Initially, the focus of conservation for this important group of birds was focused on breeding habitat and wintering grounds; however, recently it has been recognized that the loss, fragmentation, and degradation of migratory stop-over habitat is potentially the greatest threat to the survival and conservation of neotropical birds. In arid areas of the United States, stop-over sites are restricted to small defined habitats along shelter belts, hedgerows, desert oases and riparian corridors. The riparian corridors of south central Texas provide an opportunity for the birds to replenish fat reserves, provide shelter from predators and water for re-hydration prior to continuing, what is for most neotropicals, a trip of over 1000 miles one-way. During the fall migration, the San Antonio area is located towards the end of the long flight, and therefore, provides the vital link between having enough fat reserves to complete the trip or perish.

The Oak and Prairies BCR supports over 25-percent of the global breeding population of Painted Buntings and Scissor-tailed Flycatchers. In addition, the riverine and riparian habitats in the BCR provide habitat for numerous other bird species including Bell’s Vireo and the Red-headed Woodpecker (TPWD, 2007).

Conservation priorities identified by the Oak and Prairies and Rio Grande Joint Ventures (TPWD, 2006; TPWD, 2007) that are applicable to the study area include:

- Riparian corridors, especially where above-ground stream flow occurs;
- Habitat fragmentation;
- Alteration of hydrologic regimes;
- Invasive plants;
- Urban development; and
- Limited water resources.

Desirable habitat for migratory waterfowl and neotropical migrants is limited in the San Antonio Area. A high percentage of all neotropical migrant species require woodlands of various densities and structure. Woodland habitats in San Antonio are primarily limited to only those that occur along waterways. In addition, many species of waterfowl require riparian grassland and parkland areas for foraging, cover, and nesting habitats. Potential restoration measures would increase riverine habitat (riparian and aquatic) required by many bird species living in or migrating through Bexar County, including many of the bird species of concern noted in the previous tables.

The study area is centrally located between two areas where migratory birds, including migratory waterfowl are heavily concentrated, Mitchell Lake and Brackenridge Park. The Mitchell Lake Wildlife Refuge, located approximately 9.5 miles from the southern end of the study area, has had over 300 species of birds recorded, many of which are migratory waterfowl, and is one of the most heavily birded locations in Bexar County. The other area of heavy use is located just 6 miles from the northern end of the study area is Brackenridge Park. In Brackenridge Park, there is a small remnant of quality riparian habitat along the San Antonio River. This area has also recorded a large number of neotropical migrant species and represents the other heavily birded locations in Bexar County. In addition, previously constructed ecosystem restoration projects at the Mission Reach and Eagleland reaches of the San Antonio River have increased the quantity and quality of migratory bird habitat near the study area (Lee Marlowe, personal communication). During site surveys of the Westside Creeks study area, several migratory species were observed, including great egret, belted kingfisher, great blue heron, double-crested cormorant, mallard, white-winged dove, and others. The Westside Creeks Restoration Study, which connects to the Mission Reach segment of the San Antonio River and is located to the west of Mitchell Lake and Brackenridge Park migratory bird habitats, would increase the amount of highly used, but scarce habitat along a proven migratory bird stop-over corridor.

Aquatic and riparian habitats are dynamic and relatively rare systems in South Texas, most of which are defined by highly variable and intermittent flows. The number of naturally functioning aquatic and riparian habitats are decreasing nationwide, and the loss of these habitats is much more significant in South Texas due to the limited availability of aquatic and riparian habitats in the region. The effect of the loss of aquatic and riparian habitats in South Texas is especially significant for migrating birds utilizing the Central Flyway which are dependent on these habitats. Potentially compounding the loss of riparian habitats in the immediate future, are the number of Conservation Reserve Program lands throughout the Great Plains in the Central Flyway that will be coming out of the program and will potentially be converted back to croplands.

Bird migration is a physically demanding activity that places extreme energy demands on birds. Compounding these energy requirements, the migration bookends the breeding and reproduction season of the birds where the energy demands approach those needed for migration. Energy reserves may be severely depleted for many bird species as they have flown non-stop over the Gulf of Mexico. In order to fuel migration energy demands, productive foraging and resting stop over habitats must be found along the migration corridor. Aquatic and riparian habitats are some of the most productive and diverse ecosystems in North America, especially in the arid southwest, and therefore are heavily utilized by migrating birds. Historically, the aquatic and riparian habitats in the San Antonio area would have been one of the first productive stopover habitats for northbound migratory birds after the Texas coast along the southeastern side of the arid South Texas plains.

The WSC study will analyze the benefits of restoring the structure and function of aquatic and riparian habitats within the study area. The benefits analyzed will be those associated with the energy resources that are provided by these types of habitat that are needed for migrating birds as well as benefits for wintering and resident birds. As the energy reserves for the birds can encompass all taxa, one may consider the birds as a biomarker of the true health of the aquatic and riparian ecosystem in the San Antonio area.

HABITAT EVALUATIONS

Aquatic and riparian habitat assessments were conducted to assess existing habitat conditions and to base future net benefits to the riverine habitat resulting from the proposed ecosystem restoration measures. Aquatic habitat structure, water quality, and fish community parameters were collected to compare the WSC with the reference streams (Medio Creek and the Medina River) that were utilized in the Avian point count surveys. The Avian point count surveys were conducted to assess the utilization of the WSC habitats by migratory birds (breeding, wintering, and migrating) compared to the reference streams. By modeling avian community and habitat parameters as they are influenced by the level of human disturbances inherent in the WSC and Medio Creek compared to the more pristine Medina River, we can quantify the habitat benefits realized by the implementation of the proposed restoration measures.

AQUATIC HABITAT ASSESSMENT

Fish community sampling efforts were made at 15 locations: Alazan Creek (2), Apache Creek (3), Martinez Creek (2), San Pedro Creek (3), Medio Creek (3), and the Medina River (2). At each stream, 2-3 stations per location with 1-4 habitats (pool, riffle, run, or glide) were sampled at each station for a total of 34 fish community samples. Twenty-eight sites were sampled by seine once during the period 11-12 April 2012. Six units were also sampled by electrofishing. A detailed description of each sample station and general sampling conditions is provided inAttachment 3.

EXISTING HABITAT CONDITIONS

Of the 34 samples from representative macrohabitat units were taken at 15 the stations, 2,955 individuals representing 23 species of fishes were captured. The number of species documented varied across stations, gear types and between habitats. Seining efforts, both sizes combined, documented 1-9 species per unit ($\bar{x}$ (mean) = 3.7 species) with two units (pool and riffle) at Apache Creek yielding no catch. Electrofishing efforts produced 2-9 species ($\bar{x}$= 3.9) per sampled unit. The number of species varied between waterbodies with combined efforts on Alazan Creek yielding 2 species ($\bar{x}$ = 2); San Pedro Creek, 1-4 species ($\bar{x}$ = 2.2), Apache Creek, 2-5 species ($\bar{x}$ = 2.3); Martinez Creek, 1-4 species ($\bar{x}$ = 2.7); Medina River, 3-9 species ($\bar{x}$ = 5.9) and Medio Creek, 4-9 species ($\bar{x}$ = 6.4). Combined sampling efforts by macrohabitat unit varied as well with pool units yielding 2-5 species ($\bar{x}$ = 2.75) followed by riffle, 1-9 species ($\bar{x}$ = 3.7); glide, 1-7 species ($\bar{x}$ = 3.7); run, 1-9 species ($\bar{x}$ = 4.5) and backwater, 6-7 species ($\bar{x}$ = 6.7).

Species diversity between habitat types was differed by waterbody where total number of species was typically lower at Westside Creek stations. Indicators of urban stream conditions include a flashier hydrograph, elevated concentrations of nutrients and contaminants, altered channel morphology, and reduced biotic richness, with increased dominance of tolerant species (Walsh et al. 2005). Water quality analyses reflect these types of symptoms in Westside Creeks, but comparison to the Reference streams indicates that restoration will provide benefits. Fish assemblages associated with Westside Creeks were correlated with reduced structural variables (vegetation, overstory), larger substrates including rip-rap, higher water temperatures, and shallower water (reduced depth and wetted perimeter). The type of fish assemblage (tolerant and more invasive species) reflects these degraded habitat conditions. Reference streams suggest that restoration measures will have a positive benefit to native fishes as the restoration would increase habitat diversity and cover for food items required to support a greater diversity of fishes. Additionally, increasing overstory and stream riparian cover, along with greater depths and water velocity, were shown to result in higher richness and diversity of the fish assemblage. The fisheries, instream, and stream bank habitat analysis indicates that restoration of habitat conditions of Westside Creek would provide ecological benefits to the overall aquatic community including fish and wildlife species that make up the interrelated food web of the stream basins.

RIPARIAN HABITAT ASSESSMENT

Frey (1977) defined biotic integrity as "…the capability of supporting and maintaining a balanced integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region." Assessing the health and monitoring changes of habitats due to anthropogenic activities in an effort to evaluate the biotic integrity of each component of the ecosystem can be complex and unwieldy. However, by identifying biological indicators of habitat quality and their community level response over a range of anthropogenic and natural stressors, we can infer a level of biotic integrity to the system as a whole. Karr (1981) developed an Index of Biotic Integrity (IBI) to assess the ecosystem integrity of streams using a multimetric fish community model. The IBI approach to assessing ecosystem health has since been applied on six continents and with freshwater, marine, and terrestrial organisms (Karr, 2005; Crewe and Timmermans, 2005).

The composition and structure of the avian community has been used as an indicator of anthropogenic impacts and habitat quality of forests and riparian habitats (Adamus, 1995; Brooks et al., 1998; Bryce et al., 2002; Larsen et al., 2010; Larsen et al., 2012; O'Connell et al. 2000). Methods for applying the IBI process to avian communities in an effort to assess and monitor riparian ecosystems in response to anthropogenic activities have been proposed (U.S. EPA, 2002) and tested (Crewe and Timmermans, 2005; Guilfoyle et al., 2009; Wakeley et al., 2003; Wakeley et al. 2004). The Westside Creeks Avian IBI model expands off the work of Wakeley et al. and Guilfoyle et al. in an effort to characterize the existing biotic integrity of the Westside Creeks and project future biotic integrity of the creeks resulting from different combinations of ecosystem restoration measures for the Westside Creeks Ecosystem Restoration study.

The purpose of the Avian IBI model is to quantify the effects of human alterations to avian habitats. By correlating an anthropogenic index, or Index of Human Disturbance (IHD), to an avian diversity metric, the Avian IBI can model existing conditions over a range of habitat disturbances. The resulting model can be used to predict the potential future conditions and benefits resulting from proposed habitat restoration measures on the Westside Creeks. The Avian IBI model has been approved for the San Antonio River Basin .

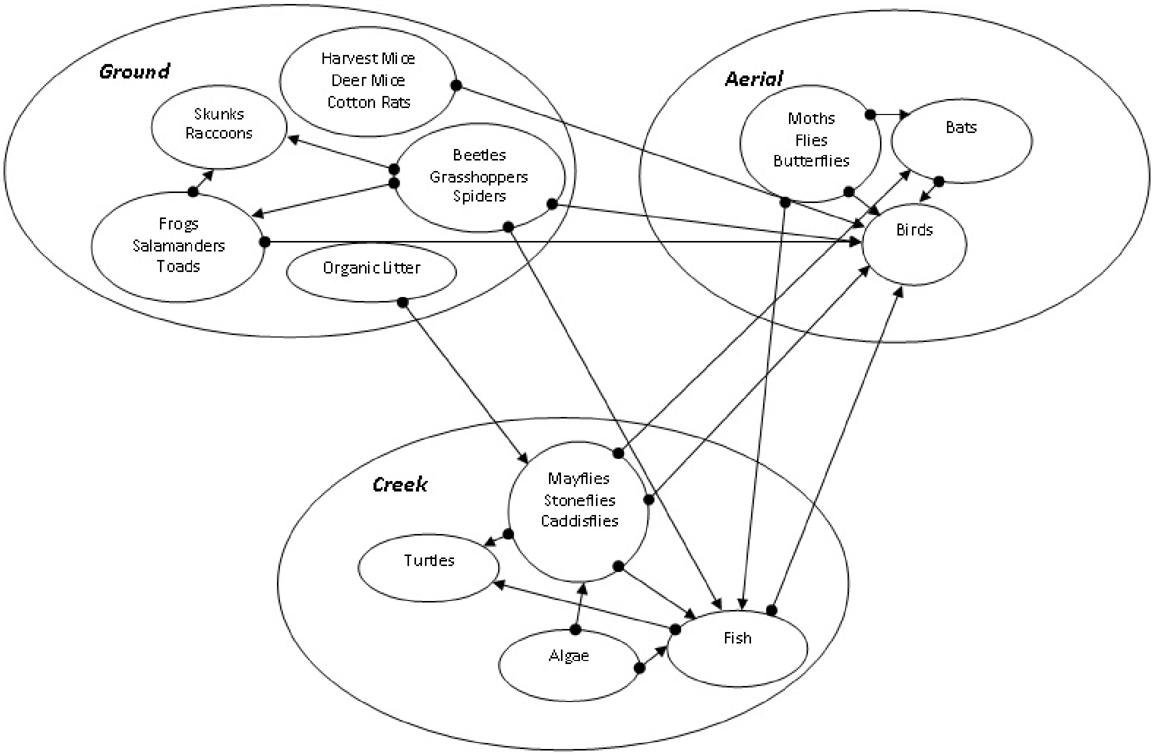

Figure 1. Food Web for Riverine Systems

Other ecological benefits not recognized by the Avian IBI model such as increased invertebrate, amphibian, fish, and mammal diversity can be used to provide further justification for determining a tentatively selected plan. When examining the trophic pyramid in Figure 2. Ecological Trophic Levels, the Avian IBI model is primarily looking at the increase of diversity on the tertiary and secondary consumers, i.e. the top of the pyramid. The benefits attribute to the aquatic and riparian ecosystem components with the largest diversity and biomass are unrecognized. Because the interpolation of benefits to primary producers and consumers is not linear, the benefits of the restoration measures affect exponentially more organisms than the Avian IBI alone accounts for. Therefore, the Avian IBI is used as a habitat quality metric to develop habitat inputs into the IWR Planning Suite’s Cost Effective/Incremental Cost Analysis software and the qualitative indicators of biomass and foodweb interactions will be used to assess the justification of the costs of one alternative to the next.

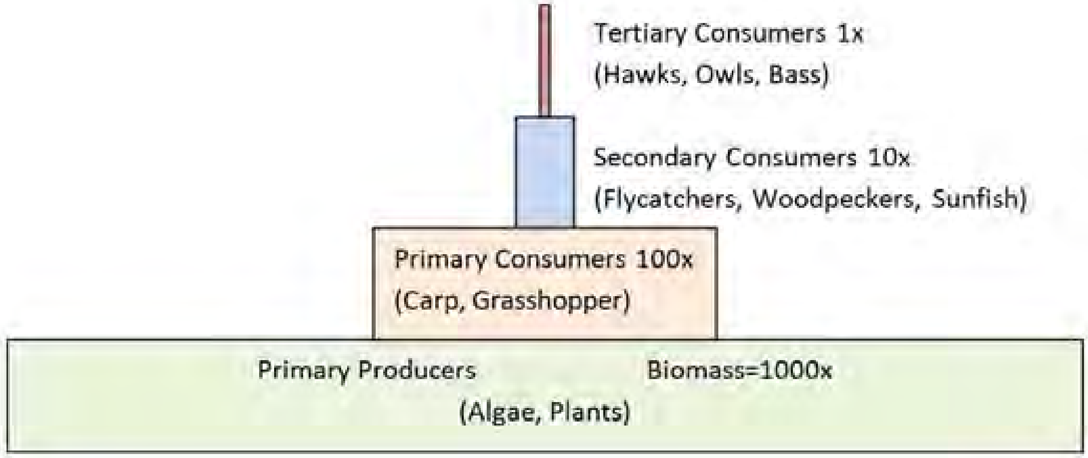

Figure 2. Ecological Trophic Levels

PROCEDURES

SARA, TPWD, and USACE biologists and local birding experts conducted avian point count following Hamel et al., 1996 with one modification; birds were spatially categorized with respect to the creek, floodway and neighborhood instead of with respect to specified radii from the point.

Six permanent avian point count survey stations were established on each of the four Westside Creeks and the two reference reaches (Figure 3 and Figure 4). Each point count station was marked with a lathe stake and the GPS location was recorded.

Each avian point count station was sampled bi-weekly from 22 February to 31 May 2012 and from 13 August to 7 October 2012. Each sampling session began at sunrise and was completed within five hours of sunrise. Sampling sessions were scheduled for days when weather forecasts predicted no precipitation and wind speeds below 15 miles per hour. Three teams of two each sampled two creeks each sampling session. Each team was comprised of a birder with specific expertise on central Texas bird species (Attachment 3) and a data recorder. Each point count station was sampled for seven minutes with notations on the datasheet designating whether the bird was first seen within the first three minutes, the next two minutes, or the last two minutes. Flushed birds were recorded if it was determined that the birds flushed in response to the team approaching the point count station.

The number of birds seen and/or heard during each sampling session was recorded by species and the location of the bird in relation to the creek was documented. Each bird was documented as utilizing the creek habitat, floodway/floodplain habitat, the neighborhood or areas outside of the floodplain, or was documented as a flyover. Birds were tracked on field datasheets with a schematic of the floodway/floodplain enabling the recorder to track the location of each bird identified to minimize the double counting of a bird (Attachment 4). At the end of the sampling session, the data from the field data sheets were reviewed and transcribed to data summary sheets immediately upon the return from the field.

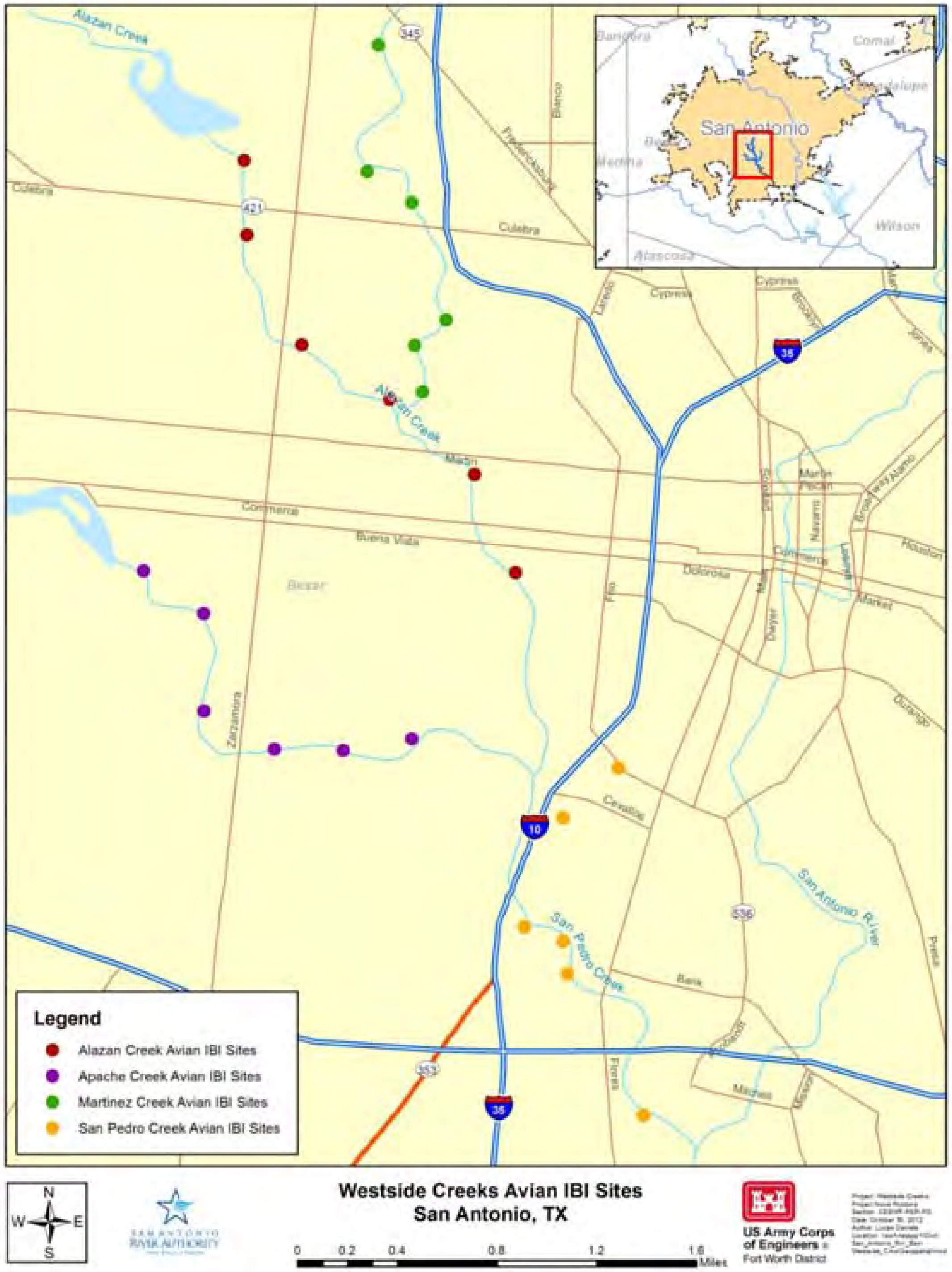

Figure 3: Avian IBI Sites for the Westside Creeks

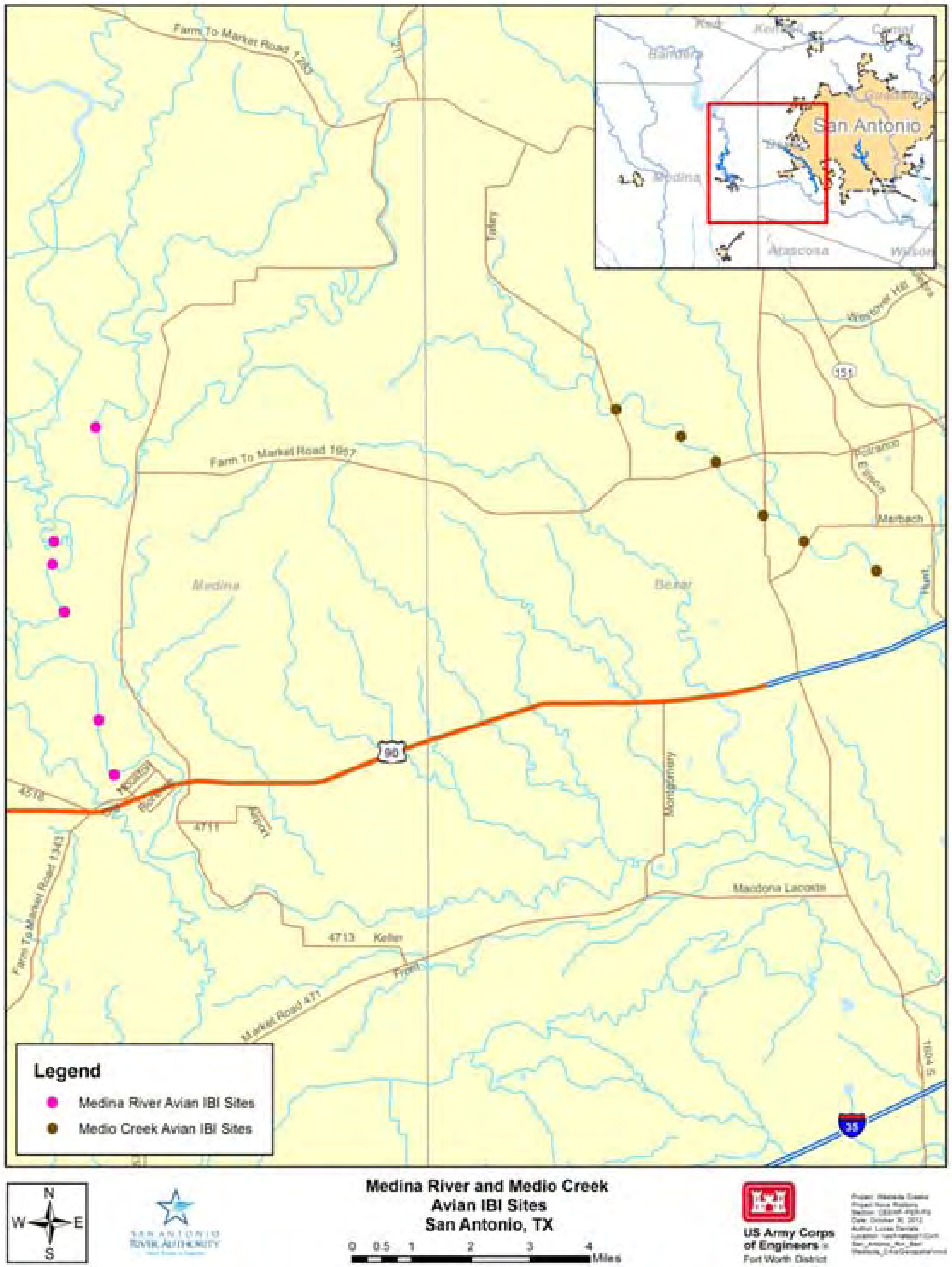

Figure 4: Avian IBI Sites for the Reference Reaches

At each avian point count station, habitat conditions were assessed over three scales: at a site specific, creek, and watershed level. The vegetation structure, species composition, and anthropogenic development of each site were characterized to calculate the site specific component of the IHD. For each creek, the level of human disturbance (channelization, concrete armoring, etc.) was quantified to calculate the creek component of the IHD. Finally, the USGS North American Land Use Cover GIS data for Bexar and Medina Counties were used to quantify a watershed scale estimate of human disturbance as the third component of the IHD for each site.

Details of the avian community and IHD calculations and derivation of the Avian IBI is described in more detail in the WSC Avian IBI model certification documentation.

EXISTING HABITAT CONDITIONS

To quantify the value of the existing habitat conditions, the Avian IBI will be used to quantify the diversity of the avian community within the WSC study area. The Avian IBI will utilize habitat-specific features that can be incorporated into measures to improve avian habitat within WSC. Due to the multiple coefficients used to calculate the the lowest score for the Avian IBI, attributable to absolutely no usable avian habitat, is 0.0. Due to the urban land uses and hydraulic constraints, the highest Avian IBI score possible for the WSC is 3.4.

Table 11. Avian IBI Scores for Westside Creeks

Point Count Station	Avian IBI	Mean Avian IBI for Creek
Alazan		**0.919491**
1	0.956594	
2	0.995982	
3	0.861292	
4	0.921665	
5	0.897996	
6	0.883416	
Apache		**0.939846**
2	1.079253	
3	0.953086	
4	0.971056	
5	0.883244	
6	0.927655	
7	0.824784	
Martinez		**0.920196**
1	0.885287	
2	0.839975	
3	0.916872	
4	0.918972	
5	1.056488	
6	0.903579	
San Pedro		**0.913683**
1	0.772167	
2	0.947887	
3	0.993473	
4	0.892162	
5	0.897693	
6	0.978719	

The avian IBI was then multiplied by the acreage of the study area for each creek to obtain the existing condition avian community units (ACU) of each creek (Table 12).

Table 12: Existing Avian Community Units for the WSC Study Area

Creek	Acres	Avian IBI	Avian Community Units
San Pedro	67.35	0.9137	61.54
Apache	34.02	0.9398	31.97
Alazan	70.35	0.9195	64.69
Martinez	50.26	0.9202	46.53

FUTURE WITHOUT PROJECT CONDITIONS

Because the WSC study area is located within the existing SACIP project area, the future without-project condition for aquatic and riparian habitat would continue to be equivalent to the existing conditions. As continued mowing and maintenance of the floodway would continue to minimize the habitat value of the floodway, the Index of Human Disturbance and Avian IBI scores would fluctuate with yearly rainfall and management actions but on average remain the unchanged over the next 75 years. In order to maintain the existing flood protection, any woody vegetation invading the floodway would have to be removed and the invasive non-native Bermudagrass and Johnsongrass would continue to dominate the herbaceous vegetation. Sedimentation and erosion problems would also persist throughout the next 75 years, requiring frequent maintenance to keep flood conveyance within existing expected conditions.

ALTERNATIVE DEVELOPMENT

USACE only participates in detailed analysis of ecosystem restoration alternatives for areas that show a probable federal interest and fall within the USACE authorized mission. Because of this constraint, the WSC study area is smaller in size than the construction limits of the SACIP as follows:

- San Pedro Creek –The study area is bounded by Camp St, just downstream of the San Pedro tunnel outlet and continues to the confluence with the San Antonio River.
- Apache Creek – The upstream end of the study area is at the dam at Elmendorf Lake, and extends downstream to the confluence with San Pedro Creek.
- Alazán Creek – The upstream study area limit is set at the dam for Woodlawn Lake, and continues downstream to the confluence with Apache Creek.
- Martinez Creek – The upstream end of the study area is set at Hildebrand Avenue, and continues downstream to the confluence with Alazán Creek.

Bridge modifications were considered to increase conveyance and allow for concrete removal to provide additional opportunities for restoration measures. The PDT determined early that full scale removal and reconstruction of bridges represented an unacceptable cost in relationship to the scale of potential benefits. A sensitivity analysis was conducted to determine the rough order of magnitude change in water surface elevation that might result from modifying only the bridge abutments. Through the analysis the PDT determined the change in water surface elevation (0.1-0.2 feet) was not sufficient to allow for the increased roughness and slower velocities that would result from concrete removal. Furthermore, there are geotechnical risks associated with altering the existing abutments which the PDT found to be unacceptable. The alteration of the abutments would necessitate increased costs for geotechnical remediation, raising the same concerns as full scale removal and replacement of bridges; therefore, costs would not be proportionate to the potential benefits.

This study area is highly urbanized, making acquisition of additional right-of-way (ROW) relatively expensive. The result is a general desire to stay within the existing ROW to keep costs scaled relative to the achievable restoration benefits. However, some publicly owned lands, which typically cost less to acquire, were considered for ROW expansion. These lands are adjacent to the creeks, and include public parks and/or excavated lands acquired between 2002-2004 by FEMA in response to the October 1998 flood event. The public lands considered include:

- Portions of Mario-Farias Park at the confluence of Martinez and Alazán;
- City property adjacent to Elmendorf Lake downstream of General McMullen, evacuated as part of the FEMA VAP;
- Portions of Amistad Park on Apache, downstream of Navidad; and
- City property adjacent to Martinez Creek, between Magnolia and Craig Place, evacuated as part of the FEMA VAP.

Considerations regarding topography, surrounding land use, and hydraulics resulted in dropping all but the city property adjacent to Martinez Creek from further formulation efforts. The ROW expansion adjacent to Martinez Creek, because of the low floodway banks in this area, is deemed to be a suitable location for a small scale off channel wetland area.

Major portions of Apache are currently reinforced with concrete. It would be extremely costly to excavate and complete the geotechnical remediation necessary to remove the concrete, while maintaining hydraulic neutrality and geotechnical stability needed to ensure the continued performance of the existing FRM project. The team briefly considered abandoning all efforts to restore the pilot channel on this creek, however, the addition of a pilot channel to Apache Creek is important when considering the study area and watershed as a connected ecosystem. Analyses were completed to determine the sensitivity of the water surface elevations to removal of lesser sections of concrete. The areas for concrete removal were further refined to occur only in areas of low risk for geotechnical stability issues. Ultimately the project delivery team (PDT) determined the most acceptable way to implement the pilot channel on Apache was to limit the continuous pilot channel measure to the lower third (0.8 miles) of Apache Creek. This results in the Apache Creek pilot channel being the shortest of the four pilot creek increments but still provides a system approach to the pilot channel network.

After the screening process discussed above, a final list of potential management measures was developed for each creek. These are the measures which will be carried forward for input into the IWR Planning Suite to be compared as standalone alternatives or in combination with other measures in a cost-effective incremental cost analysis (CE/ICA). Each of the measures below was evaluated against the Avian Index of Biotic Integrity to determine the level of benefit that might be derived, as well as the cost to implement each measure. The cost and benefit evaluation values for each individual measure and/or combination of measures to be compared in the CE/ICA were established. Below is a brief discussion of the cost elements for each measure and how each measure addresses the ecosystem restoration objective for WSC. Unless otherwise noted, each measure is implementable on each creek independent of whether implemented on the other creeks.

No Action: The no action measure would result in no additional costs beyond the current annual expenditure for regular operation and maintenance of the existing FRM channel features. The

WSC floodway would continue to be maintained using the existing maintenance and management plans. The no action measure does not address the ecosystem restoration objective, but is included during the comparison of action measures.

Riparian Meadow (RM): The change from non-native herbaceous vegetation to a restored native riparian meadow and aquatic vegetation would be a hydraulically neutral action. The riparian meadow measure can be implemented as a standalone alternative. Restoration of the riparian meadow and aquatic vegetation would partially address the restoration objective for WSC by providing some increased vertical structure diversity in the aquatic and riparian habitat, some increased insect biomass production, and some increased allochthonous material input to the aquatic habitat. Cost components for establishment of a native riparian meadow and aquatic vegetation include: 1) removal of top 6 inches of existing soil to remove the non-native seed bank; 2) ripping to a depth of 12-18 inches to reduce compaction and provide an acceptable strata for deep root growth; 3) incorporation of compost material into the top 2-4 inches to promote germination and sustained growth; 4) planting a diverse mix of native riparian meadow seeds; 5) the planting of aquatic, wetland, and riparian seedlings, and; 6) provisions for short-term watering to aid in quick establishment of ground cover of the exposed floodway slopes. As riparian meadow was historically a principle component of the riverine system of the WSC and the foundation of aquatic and riparian habitats, the riparian meadow management measure was determined to be the first increment of restoration.

Pilot Channel (PC): The pilot channel measure supports the ecosystem restoration objective by addressing the problems associated the increased bed slope and loss of aquatic habitat structures which occurred as a direct result of the channelization for flood risk management purposes. Specifically, the pilot channel measure would restore a balanced sediment transport function to the aquatic system as well as restore pool-riffle complexes within the creek. The restored sediment transport function in combination with restored habitat structure results in riffle and pool habitats with appropriate substrates to support the historic aquatic functions of the riverine system. Cost components for establishment of the pilot channel include: excavation, grading, rock constructed in-channel features, armoring, and utility relocation. The pilot channel measure will require a larger amount of excavation and ground disturbing activity. Since re-establishment of ground cover will be required due to the extensive ground disturbance, it seems logical that native plants would be utilized. Therefore, it was assumed that the pilot channel measure would be implemented in combination with the riparian meadow measure.

Riparian Woodland (30, 70): The riparian woodland measure supports the ecosystem restoration objective by addressing the problems of lack of aquatic shading, reduced allochthonous material inputs, lack of stratification of vertical structure, lack of terrestrial shading, and lack of soft and hard mast diversity which occurred as a direct result of the channelization for flood risk management purposes. Specifically, the riparian woodland measure would restore shading and provide the necessary organic inputs to drive the function of the riverine ecosystem. Cost components for the establishment of the riparian woodlands include: 1) spot treatment herbicide to remove herbaceous competition in the immediate area around the seedling; 2) purchase of seedlings in a diverse mix of native riparian woodland species; 3) planting of seedlings, and; 4) provisions for short term watering to aid in quick establishment. Implementation of the riparian woodland measure requires that hydraulic capacity within the floodway be increased to accommodate the added hydraulic roughness of trees. Implementation of the pilot channel measure would gain some hydraulic capacity through the required excavation to implement that measure. Therefore, it was determined that implementation of the riparian woodland measure would be dependent upon implementation of the pilot channel measure first.

Slackwater (SW): The slackwater measure supports the ecosystem restoration objective by addressing the loss of aquatic habitat structure resulting from channelization. Slackwater areas will include the addition small embayment features to the natural stream design channel increasing the heterogeneity of the physical habitat structure of the pilot channel. This measure would restore natural velocity refugia and increase length of the shoreline boundary, facilitating the accumulation of organic materials and restoring vital micro-habitats necessary for the function of the riverine ecosystem. Cost components for the establishment of slackwater include excavation, grading, armoring, and utility relocation. Implementation of the slackwater measure would require mobilization of equipment and staging sites for each location. Since the measure is so similar in nature to that of the pilot channel, which is continuous, requiring singular mobilization but multiple staging sites, significant cost reduction for this measure would be experienced by combining the slackwater work with the pilot channel work.

Wetland (WL): The wetland measure supports the ecosystem restoration objective by addressing the loss of aquatic habitat structure resulting from channelization. The measure would restore uniquely productive microhabitats through the accumulation of organic materials. Cost components for the establishment of wetland include real estate acquisition, excavation, grading, armoring, planting a diverse mixture of wetland vegetation, and provisions for short term actions to aide in establishment. Implementation of the wetland measure would require ensuring a consistent if intermittent source of water. The nearest source is Martinez Creek, but modifications to the existing channel would be required. For this reason the team determined the wetland measure would only implemented in combination with the pilot channel measure.

Utilizing the list of final management measures above, a set of incrementally combined plans for each creek was developed. By projecting future herbaceous, shrub, and overstory percent canopy cover and channel conditions for the acreage of restored habitats under each alternative, Avian IBI scores were calculated for each measure over a period of 75 years, with indexes estimated for 1 year following construction; 15 years following construction, 25 years following construction, 50 years following construction, and 75 years following construction. A period of 75 years was chosen to allow the maturing of the riparian woody vegetation so that full benefits can be captured. The respective Avian IBI scores were then multiplied by acreage to get the Avian Community Units for each measure in each of the reference years. Tables 13 through 17 show the calculation of these Avian Community Units. Using the annualizer module in the IWR Planning Suite software, these environmental outputs were annualized. By utilizing a 75-year period, the project benefits can be modeled as plateauing around the 50-year time period thereby accounting for the time required for the woody vegetation to mature. Table 18. Average Annual ABI, shows the data entered into the annualizer module and the resulting average annual avian community units for each measure. In performing the annualization, linear interpolation was used for the calculation (Table 19).

Table 13. Calculation of Total Avian Community Units for Year 1

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
San Pedro Creek	Riparian Meadow	1.11	67.35	74.77										74.77
	Riparian Meadow + Pilot Channel	1.16	67.35	78.18										78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.16	50.24	58.32	1.16	17.11	19.86							78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.16	50.24	58.32	1.16	9.14	10.61	1.16	7.97	9.25				78.18
	Riparian Meadow + Pilot Channel + Slackwater	1.21	67.35	81.59										81.59
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.21	50.24	60.9	1.21	17.11	20.73							81.59
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.21	50.24	60.9	1.21	9.14	11.07	1.21	7.97	9.66				81.59
Alazán Creek	Riparian Meadow	1.15	70.35	80.82										80.82
	Riparian Meadow + Pilot Channel	1.20	70.35	84.39										84.39
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	58.02	69.60	1.20	12.33	14.79							84.39
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	58.02	69.60	1.20	7.86	9.42	1.20	4.47	5.36				84.39
	Riparian Meadow + Pilot Channel + Slackwater	1.25	70.35	87.95										87.95
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	1.25	58.02	72.54	1.25	12.33	15.41							87.95
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	58.02	72.54	1.25	7.86	9.83	1.25	4.47	5.59				87.95
Martinez Creek	Riparian Meadow	1.15	50.56	58.08										58.08
	Riparian Meadow + Pilot Channel	1.20	50.56	60.64										60.64
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	41.77	50.10	1.20	8.79	10.54							60.64
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	41.77	50.10	1.20	5.03	6.03	1.20	3.76	4.51				60.64

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
	Riparian Meadow + Pilot Channel + Slackwater	1.25	50.56	63.20										63.20
	Riparian Meadow + Pilot Channel + Wetland	1.20	50.56	60.64							1.45	5.20	7.54	68.18
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	1.25	50.56	63.20							1.45	5.20	7.54	70.74
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.25	41.77	52.21	1.25	8.79	10.99							63.20
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	41.77	52.21	1.25	5.03	6.29	1.25	3.76	4.70				63.20
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	1.20	41.77	50.10	1.20	8.79	10.54			0.00	1.45	5.20	7.54	68.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	1.20	41.77	50.10	1.20	5.03	6.03	1.20	3.76	4.51	1.45	5.20	7.54	68.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	1.25	8.79	10.99			0.00	1.45	5.20	7.54	70.74
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	1.25	5.03	6.29	1.25	3.76	4.70	1.45	5.20	7.54	70.74
Apache Creek	Riparian Meadow	1.09	34.02	37.20										37.20
	Riparian Meadow + Pilot Channel	1.11	34.02	37.73										37.73
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.11	27.22	30.19	1.11	6.80	7.54							37.73
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.11	27.22	30.19	1.11	2.00	2.22	1.11	4.80	5.32				37.73
	Riparian Meadow + Pilot Channel + Slackwater	1.13	34.02	38.27										38.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.13	27.22	30.62	1.13	6.80	7.65							38.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.13	27.22	30.62	1.13	2.00	2.25	1.13	4.80	5.40				38.27

Table 14. Calculation of Total Avian Community Units for Year 15

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
San Pedro Creek	Riparian Meadow	1.11	67.35	74.77										74.77
	Riparian Meadow + Pilot Channel	1.16	67.35	78.18										78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.16	50.24	58.31	1.65	17.11	28.17							86.49
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.16	50.24	58.31	1.65	9.14	15.04	2.00	7.97	15.95				89.31
	Riparian Meadow + Pilot Channel + Slackwater	1.21	67.35	81.59										81.59
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.21	50.24	60.86	1.70	17.11	29..04							89.90
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.21	50.24	60.86	1.70	9.14	15.51	2.05	7.97	16.35				92.73
Alazán Creek	Riparian Meadow	1.15	70.35	80.82										80.82
	Riparian Meadow + Pilot Channel	1.20	70.35	84.39										84.38
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	58.02	69.60	1.69	12.33	20.78							90.38
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	58.02	69.60	1.69	7.86	13.25	2.04	4.47	9.12				91.96
	Riparian Meadow + Pilot Channel + Slackwater	1.25	70.35	87.95										87.95
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	1.25	58.02	72.54	1.74	12.33	21.40							93.94
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	58.02	72.54	1.74	7.86	13.64	2.04	4.47	9.12				95.30
Martinez Creek	Riparian Meadow	1.15	50.56	58.08										58.08
	Riparian Meadow + Pilot Channel	1.20	50.56	60.64										60.64
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	41.77	50.09	1.69	8.79	14.81							64.91
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	41.77	50.09	1.69	5.03	8.48	2.04	3.76	7.67				66.24

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
	Riparian Meadow + Pilot Channel + Slackwater	1.25	50.56	63.20										63.20
	Riparian Meadow + Pilot Channel + Wetland	1.20	50.56	60.64							1.45	5.20	7.54	68.18
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	1.25	50.56	63.20							1.45	5.20	7.54	70.74
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.25	41.77	52.21	1.74	8.79	15.26							67.47
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	41.77	52.21	1.74	5.03	8.73	2.09	3.76	7.86				68.80
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	1.20	41.77	50.09	1.69	8.79	14.81				1.45	5.20	7.54	72.44
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	1.20	41.77	50.09	1.69	5.03	8.48	2.04	3.76	7.67	1.45	5.20	7.54	73.78
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	1.74	8.79	15.26				1.45	5.20	7.54	75.01
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	1.74	5.03	8.73	2.09	3.76	7.86	1.45	5.20	7.54	76.34
Apache Creek	Riparian Meadow	1.09	34.02	37.20										37.20
	Riparian Meadow + Pilot Channel	1.11	34.02	37.73										37.73
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.11	27.22	30.19	1.59	6.80	10.85							41.04
	Riparian Meadow + Pilot Channel + Woody Vegetation 70 stems per acre)	1.11	27.22	30.19	1.59	2.00	3.19	1.95	4.80	9.36				42.74
	Riparian Meadow + Pilot Channel + Slackwater	1.13	34.02	38.27										38.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.13	27.22	30.63	1.61	6.80	10.95							41.58
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.13	27.22	30.63	1.61	2.00	3.22	1.97	4.80	9.43				43.28

Table 15. Calculation of Total Avian Community Units for Year 25

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
San Pedro Creek	Riparian Meadow	1.11	67.35	74.77										74.77
	Riparian Meadow + Pilot Channel	1.16	67.35	78.18										78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.16	50.24	58.32	2.01	17.11	34.35							92.67
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.16	50.24	58.32	2.01	9.14	18.35	2.48	7.97	19.77				96.44
	Riparian Meadow + Pilot Channel + Slackwater	1.21	67.35	81.59										81.59
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.21	50.24	60.86	2.06	17.11	35.21							96.08
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.21	50.24	60.86	2.06	9.14	18.81	2.53	7.97	20.17				99.85
Alazán Creek	Riparian Meadow	1.15	70.35	80.82										80.82
	Riparian Meadow + Pilot Channel	1.20	70.35	84.39										84.39
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	58.02	69.59	2.05	12.33	25.23							94.83
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	58.02	69.59	2.05	7.86	16.08	2.52	4.47	11.26				96.94
	Riparian Meadow + Pilot Channel + Slackwater	1.25	70.35	87.95										87.95
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	1.25	58.02	72.54	2.10	12.33	25.86							98.39
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	58.02	72.54	2.10	5.86	16.48	2.57	4.47	11.49				100.50
Martinez Creek	Riparian Meadow	1.15	50.56	58.08										58.08
	Riparian Meadow + Pilot Channel	1.20	50.56	60.64										60.64
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	41.77	50.10	2.05	8.79	17.98							68.08
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	41.77	50.10	2.05	5.03	10.29	2.52	3.76	9.47				69.86
	Riparian Meadow + Pilot Channel + Slackwater	1.25	50.56	63.20										63.20

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
	Riparian Meadow + Pilot Channel + Wetland	1.20	50.56	60.64							1.45	5.20	7.54	68.17
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	1.25	50.56	63.20							1.45	5.20	7.54	70.74
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.25	41.77	52.21	2.10	8.79	18..43							70.65
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	41.77	52.21	2.10	5.03	10.55	2.57	3.76	9.66				72.42
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	1.20	41.77	50.09	2.05	8.79	17.99				1.45	5.20	7.54	75.62
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	1.20	41.77	50.09	2.05	5.03	10.29	2.52	3.76	9.47	1.45	5.20	7.54	77.40
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	2.10	8.79	18.43				1.45	5.20	7.54	78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	2.10	5.03	10.55	2.57	3.76	9.66	1.45	5.20	7.54	79.96
Apache Creek	Riparian Meadow	1.09	34.02	37.20										37.20
	Riparian Meadow + Pilot Channel	1.11	34.02	37.73										37.73
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.11	27.22	30.19	1.96	6.80	13.30							43.49
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.11	27.22	30.19	1.96	2.00	3.91	2.43	4.80	11.66				45.76
	Riparian Meadow + Pilot Channel + Slackwater	1.13	34.02	38.27										38.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.13	27.22	30.62	1.97	6.80	13.41							44.03
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.13	27.22	30.62	1.97	2.00	3.94	2.44	4.80	11.73				46.30

Table 16. Calculation of Total Avian Community Units for Year 50

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
San Pedro Creek	Riparian Meadow	1.11	67.35	74.77										74.77
	Riparian Meadow + Pilot Channel	1.16	67.35	78.18										78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.16	50.24	58.32	2.48	17.11	42.44							100.76
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.16	50.24	58.32	2.48	9.14	22.67	3.02	7.97	24.03				105.02
	Riparian Meadow + Pilot Channel + Slackwater	1.21	67.35	81.59										81.59
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.21	50.24	60.86	2.53	17.11	43.31							104.17
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.21	50.24	60.86	2.53	9.14	23.13	3.07	7.97	24.44				108.43
Alazán Creek	Riparian Meadow	1.15	70.35	80.82										80.82
	Riparian Meadow + Pilot Channel	1.20	70.35	84.39										84.39
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	58.02	69.60	2.52	12.33	31.06							100.66
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	58.02	69.60	2.52	7.86	19.80	3.05	4.47	13.65				103.05
	Riparian Meadow + Pilot Channel + Slackwater	1.25	70.35	87.95										87.95
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	1.25	58.02	72.54	2.57	12.33	31.69							104.22
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	58.02	72.54	2.57	7.86	20.20	3.10	4.47	13.88				106.61
Martinez Creek	Riparian Meadow	1.15	50.56	58.08										58.08
	Riparian Meadow + Pilot Channel	1.20	50.56	60.64										60.64
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	41.77	50.10	2.52	8.79	22.14							72.24
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	41.77	50.10	2.52	5.03	12.67	3.05	3.76	11.48				74.25
	Riparian Meadow + Pilot Channel + Slackwater	1.25	50.56	63.20										63.20
	Riparian Meadow + Pilot Channel + Wetland	1.20	50.56	60.64							1.45	5.20	7.54	68.18
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	1.25	50.56	63.20							1.45	5.20	7.54	70.74
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.25	41.77	52.21	2.57	8.79	22.59							74.80
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	41.77	52.21	2.57	5.03	12.93	3.10	3.76	11.67				76.81

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	1.20	41.77	50.10	2.52	8.79	22.14				1.45	5.20	7.54	79.78
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	1.20	41.77	50.10	2.52	5.03	12.67	3.05	3.76	11.48	1.45	5.20	7.54	81.79
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	2.57	8.79	22.59				1.45	5.20	7.54	82.33
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	2.57	5.03	12.93	3.10	3.76	11.67	1.45	5.20	7.54	84.35
Apache Creek	Riparian Meadow	1.09	34.02	37.20										37.20
	Riparian Meadow + Pilot Channel	1.11	34.02	37.73										37.73
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.11	27.22	30.19	2.43	6.82	16.52							46.71
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.11	27.22	30.19	2.43	2.00	4.86	2.96	4.80	14.23				49.28
	Riparian Meadow + Pilot Channel + Slackwater	1.13	34.02	38.27										38.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.13	27.22	30.62	2.44	6.82	16.62							47.24
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.13	27.22	30.62	2.44	2.00	4.89	2.98	4.80	14.30				49.82

Table 17. Calculation of Total Avian Community Units for Year 75

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
San Pedro Creek	Riparian Meadow	1.11	67.35	74.77										74.77
	Riparian Meadow + Pilot Channel	1.16	67.35	78.18										78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.16	50.24	58.32	2.48	17.11	42.44							100.76
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.16	50.24	58.32	2.48	9.14	22.67	3.02	7.97	24.03				105.02
	Riparian Meadow + Pilot Channel + Slackwater	1.21	67.35	81.59										81.59
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.21	50.24	60.86	2.53	17.11	43.31							104.17
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.21	50.24	60.86	2.53	9.14	23.13	3.07	7.97	24.44				108.43
Alazán Creek	Riparian Meadow	1.15	70.35	80.82										80.82
	Riparian Meadow + Pilot Channel	1.20	70.35	84.39										84.39
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	58.02	69.60	2.52	12.33	31.06							100.66
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	58.02	69.60	2.52	7.86	19.80	3.05	4.47	13.65				103.05
	Riparian Meadow + Pilot Channel + Slackwater	1.25	70.35	87.95										87.95
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	1.25	58.02	72.54	2.57	12.33	31.69							104.22
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	58.02	72.54	2.57	7.86	20.20	3.10	4.47	13.88				106.61
Martinez Creek	Riparian Meadow	1.15	50.56	58.08										58.08
	Riparian Meadow + Pilot Channel	1.20	50.56	60.64										60.64
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	41.77	50.09	2.52	8.79	22.14							72.24
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	41.77	50.09	2.52	5.03	12.67	3.05	3.76	11.48				74.25
	Riparian Meadow + Pilot Channel + Slackwater	1.25	50.56	63.20										63.20
	Riparian Meadow + Pilot Channel + Wetland	1.20	50.56	60.64							1.45	5.20	7.54	68.18

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	1.25	50.56	63.20							1.45	5.20	7.54	70.74
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.25	41.77	52.21	2.57	8.79	22.59							74.80
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	41.77	52.21	2.57	5.03	12.93	3.10	3.76	11.67				76.81
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	1.20	41.77	50.09	2.52	8.79	22.14				1.45	5.20	7.54	79.78
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	1.20	41.77	50.09	2.52	5.03	12.67	3.05	3.76	11.48	1.45	5.20	7.54	81.79
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	2.57	8.79	22.59				1.45	5.20	7.54	82.34
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	2.57	5.03	12.93	3.10	3.76	11.67	1.45	5.20	7.54	84.35
Apache Creek	Riparian Meadow	1.09	34.02	37.20										37.20
	Riparian Meadow + Pilot Channel	1.11	34.02	37.73										37.73
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.11	27.22	30.19	2.43	6.80	16.52							46.71
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.11	27.22	30.19	2.43	2.00	4..86	2.96	4.80	14.23				49.28
	Riparian Meadow + Pilot Channel + Slackwater	1.13	34.02	38.27										38.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.13	27.22	30.62	2.44	6.80	16.62							47.25
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.13	27.22	30.62	2.44	2.00	4.89	2.98	4.80	14.30				49.82

Table 18. Average Annual ABI

Stream	Measure	Year						Average Annual Avian Community Units
		0	1	15	25	50	75	
San Pedro Creek	Riparian Meadow	61.54	74.77	74.77	74.77	74.77	74.77	74.27
	Riparian Meadow + Pilot Channel	61.54	78.18	78.18	78.18	78.18	78.18	77.66
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	61.54	78.18	86.49	92.67	100.76	100.76	93.66
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	61.54	78.18	89.32	96.44	105.02	105.02	97.12
	Riparian Meadow + Pilot Channel + Slackwater	61.54	81.59	81.59	81.59	81.59	81.59	81.05
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	61.54	81.59	89.90	96.08	104.17	104.17	97.05
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	61.54	81.59	92.73	99.85	108.43	108.43	100.51
Alazán Creek	Riparian Meadow	64.69	80.82	80.82	80.82	80.82	80.82	80.28
	Riparian Meadow + Pilot Channel	64.69	84.39	84.39	84.39	84.39	84.39	83.83
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	64.69	84.39	90.38	94.83	100.66	100.66	95.35
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	64.69	84.39	91.96	96.94	103.05	103.05	97.30
	Riparian Meadow + Pilot Channel + Slackwater	64.69	87.95	87.95	87.95	87.95	87.95	87.36
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	64.69	87.95	93.94	98.39	104.22	104.22	98.89
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	64.69	87.95	95.30	100.50	106.61	106.61	100.80
Martinez Creek	Riparian Meadow	46.53	58.08	58.08	58.08	58.08	58.08	57.69
	Riparian Meadow + Pilot Channel	46.53	60.64	60.64	60.64	60.64	60.64	60.24
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	46.53	60.64	64.91	68.08	72.24	72.24	68.46
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	46.53	60.64	66.24	69.86	74.25	74.25	70.09
	Riparian Meadow + Pilot Channel + Slackwater	46.53	63.20	63.20	63.20	63.20	63.20	62.78
	Riparian Meadow + Pilot Channel + Wetland	46.53	68.18	68.18	68.18	68.18	68.18	67.73
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	46.53	70.74	70.74	70.74	70.74	70.74	70.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	46.53	63.20	67.47	70.65	74.80	74.80	71.00
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	46.53	63.20	68.80	72.42	76.81	76.81	72.63
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	46.53	68.18	72.45	75.62	79.78	79.78	75.94
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	46.53	68.18	73.78	77.40	81.79	81.79	77.58
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	46.53	70.74	75.01	78.18	82.34	82.34	78.49
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	46.53	70.74	76.34	79.96	84.35	84.35	80.12
Apache Creek	Riparian Meadow	31.97	37.20	37.20	37.20	37.20	37.20	36.92
	Riparian Meadow + Pilot Channel	31.97	37.73	37.73	37.73	37.73	37.73	37.48
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	31.97	37.73	41.04	43.49	46.71	46.71	43.84
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	31.97	37.73	42.74	45.76	49.28	49.28	45.93
	Riparian Meadow + Pilot Channel + Slackwater	31.97	38.27	38.27	38.27	38.27	38.27	38.02
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	31.97	38.27	41.58	44.03	47.25	47.25	44.38
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	31.97	38.27	43.28	46.30	49.82	49.82	46.46

Environmental restoration benefits are calculated by subtracting the future without-project avian community units from the with-project average annual avian community units. The resulting benefits are then used, along with annual costs, to identify cost effective plans and perform incremental cost analysis. The calculation of benefits (outputs) is shown in Table 19.

Table 19: Calculation of Ecological Benefits by Creek and Measure

		Future Without Project			Future With Project		
Stream	**Plan**	**Avian IBI**	**Acres**	**Avian Community Unit**	**Acres**	**Average Annual Avian Community Unit**	**Benefits Average Annual Avian Community Units (Output)**
San Pedro Creek	Riparian Meadow	0.913683	67.35	61.53655	67.35	74.27136	12.73481
	Riparian Meadow + Pilot Channel	0.913683	67.35	61.53655	67.35	77.65872	16.12217
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	0.913683	67.35	61.53655	67.35	93.65845	32.1219
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	0.913683	67.35	61.53655	67.35	97.12074	35.58419
	Riparian Meadow + Pilot Channel + Slackwater	0.913683	67.35	61.53655	67.35	81.04609	19.50954
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	0.913683	67.35	61.53655	67.35	97.04702	35.51047
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	0.913683	67.35	61.53655	67.35	100.5093	38.97276
Alazán Creek	Riparian Meadow	0.919491	70.35	64.68619	70.35	80.28135	15.59516
	Riparian Meadow + Pilot Channel	0.919491	70.35	64.68619	70.35	83.82717	19.14098
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	0.919491	70.35	64.68619	70.35	95.35475	30.66856
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	0.919491	70.35	64.68619	70.35	97.29697	32.61078
	Riparian Meadow + Pilot Channel + Slackwater	0.919491	70.35	64.68619	70.35	87.36366	22.67746
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	0.919491	70.35	64.68619	70.35	98.89363	34.20744
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	0.919491	70.35	64.68619	70.35	100.799	36.11277
Martinez Creek	Riparian Meadow	0.920196	50.56	46.52511	50.56	57.69275	11.16764
	Riparian Meadow + Pilot Channel	0.920196	50.56	46.52511	50.56	60.23575	13.71064
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	0.920196	50.56	46.52511	50.56	68.45646	21.93135
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	0.920196	50.56	46.52511	50.56	70.08925	23.56414
	Riparian Meadow + Pilot Channel + Slackwater	0.920196	50.56	46.52511	50.56	62.77875	16.25364
	Riparian Meadow + Pilot Channel + Wetland	0.920196	50.56	46.52511	55.76	67.72526	21.20015

		Future Without Project			Future With Project		
Stream	**Plan**	**Avian IBI**	**Acres**	**Avian Community Unit**	**Acres**	**Average Annual Avian Community Unit**	**Benefits Average Annual Avian Community Units (Output)**
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	0.920196	50.56	46.52511	55.76	70.26826	23.74315
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	0.920196	50.56	46.52511	50.56	70.99986	24.47475
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	0.920196	50.56	46.52511	50.56	72.63278	26.10767
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	0.920196	50.56	46.52511	55.76	75.9433	29.41819
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	0.920196	50.56	46.52511	55.76	77.57538	31.05027
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	0.920196	50.56	46.52511	55.76	78.48657	31.96146
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	0.920196	50.56	46.52511	55.76	80.12042	33.59531
Apache Creek	Riparian Meadow	0.939846	34.02	31.97356	34.02	36.92178	4.948216
	Riparian Meadow + Pilot Channel	0.939846	34.02	31.97356	34.02	37.47876	5.505194
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	0.939846	34.02	31.97356	34.02	43.84279	11.86922
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	0.939846	34.02	31.97356	34.02	45.92924	13.95568
	Riparian Meadow + Pilot Channel + Slackwater	0.939846	34.02	31.97356	34.02	38.01507	6.041507
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	0.939846	34.02	31.97356	34.02	44.37816	12.4046
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	0.939846	34.02	31.97356	34.02	46.46449	14.49093

To conduct the CE/ICA analysis, these environmental restoration benefits (increase in with-project average annual avian community units) and annual costs (expressed in thousands of dollars) were entered into IWR Planning Suite, resulting in an an array of Best Buy Plans for the study that provide ecological benefits to migratory birds and other biotic components utilizing the WSC.

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ATTACHMENT 1: BIRD SPECIES OCCURRING IN BEXAR COUNTY (BRIERLY AND ENGELMAN, 2004)

Common Name	Scientific Name	Season				Breeding Habitat[1]
		Spring	Summer	Fall	Winter	
Anatidae						
Black-bellied Whistling Duck	*Dendrocygna autumnalis*	C	C	C	C	X
Fulvous Whistling Duck	*Dendrocygna bicolor*	R	V	V	V	
Greater White-fronted Goose	*Anser albifrons*	V		R	R	
Snow Goose	*Chen caerulescens*	R		R	R	
Ross' Goose	*Chen rossii*				R	
Canada Goose	*Branta canadensis*	R		U	U	
Tundra Swan	*Cygnus columbianus*				V	
Wood Duck	*Aix sponsa*	F	F	F	F	X
Gadwall	*Anas strepera*	C	R	C	C	X
American Wigeon	*Anas Americana*	C	R	C	C	
American Black Duck	*Anas rubripes*				V	
Mallard	*Anas platyrhynchos*	U	U	U	U	X
Mottled Duck	*Anas fulvigula*	R	R	R	R	
Blue-winged Teal	*Anas discors*	C	R	C	F	X
Cinnamon Teal	*Anas cyanoptera*	U	V	U	U	X
Northern Shoveler	*Anas clypeata*	C	R	C	C	X
Northern Pintail	*Anas acuta*	C	R	C	C	
Green-winged Teal	*Anas crecca*	C	R	C	C	
Canvasback	*Aythya valisineria*	U	V	U	U	
Redhead	*Aythya americana*	U	R	U	U	
Ring-necked Duck	*Aythya collaris*	U	R	U	F	
Greater Scaup	*Aythya marila*	V	V	R	R	
Lesser Scaup	*Aythya affinis*	C	R	C	C	
Surf Scoter	*Melanitta perspicillata*			V	V	
White-winged Scoter	*Melanitta fusca*	V		V	V	
Black Scoter[2]	*Melanitta americana*				V	
Long-tailed Duck	*Clangula hyemalis*			V	V	
Bufflehead	*Bucephala albeola*	C	V	C	C	
Common Goldeneye	*Bucephala clangula*	V		R	R	
Hooded Merganser	*Lophodytes cucullatus*	R		F	F	
Common Merganser	*Mergus merganser*				V	
Red-breasted Merganser	*Mergus serrator*	V		R	R	
Masked Duck	*Nomonyx dominicus*	V				
Ruddy Duck	*Oxyura jamaicensis*	C	R	C	C	X
Odontophoridae						
Scaled Quail	*Callipepla squamata*	V	V	V	V	X[3]
Northern Bobwhite	*Colinus virginianus*	F	C	F	U	X
Montezuma Quail	*Cyrtonyx montezumae*		V		V	X[3]
Phasianidae						
Wild Turkey	*Meleagris gallopavo*	R	R	R	R	X
Gaviidae						
Red-throated Loon[2]	*Gavia stellata*			V	V	

Common Name	Scientific Name	Season				Breeding Habitat[1]
		Spring	Summer	Fall	Winter	
Pacific Loon[2]	*Gavia pacifica*			V	V	
Common Loon	*Gavia immer*	V	V	R	R	
Podicipedidae						
Least Grebe	*Tachybaptus dominicus*	U	R	U	F	X
Pied-billed Grebe	*Podilymbus podiceps*	C	C	C	C	X
Horned Grebe	*Podiceps auritus*			R	R	
Red-necked Grebe	*Podiceps grisegena*				V	
Eared Grebe	*Podiceps nigricollis*	C	R	C	C	X[3]
Western Grebe	*Aechmophorus occidentalis*	R	V	V	R	
Hydrobatidae						
Band-rumped Storm-petrel	*Oceanodroma castro*		V			
Ciconiidae						
Wood Stork	*Mycteria americana*	V	R	R		
Fregatidae						
Magnificent Frigatebird	*Fregata magnificens*		V	V		
Phalacrocoracidae						
Neotropic Cormorant	*Phalacrocorax brasilianus*	U	C	C	U	
Double-crested Cormorant	*Phalacrocorax auritus*	C	R	C	C	
Anhingidae						
Anhinga	*Anhinga anhinga*	R	R	R	R	X[3]
Pelecanidae						
American White Pelican	*Pelecanus erythrorhynchos*	C	C	C	C	
Brown Pelican	*Pelecanus occidentalis*	R	R	R	R	
Ardeidae						
American Bittern	*Botaurus lentiginosus*	R		R	R	
Least Bittern[4]	*Ixobrychus exilis*	U	U	U		X
Great Blue Heron	*Ardea Herodias*	C	U	C	C	
Great Egret	*Ardea alba*	C	C	C	C	X
Snowy Egret	*Egretta thula*	F	C	F	U	X
Little Blue Heron	*Egretta caerulea*	F	F	F	R	X
Tricolored Heron	*Egretta tricolor*	R	F	F	R	
Reddish Egret	*Egretta rufescens*		V	V		
Cattle Egret	*Bubulcus ibis*	C	C	C	U	X
Green Heron	*Butorides virescens*	C	C	C	R	X
Black-crowned Night-heron	*Nycticorax nycticorax*	C	F	C	C	X
Yellow-crowned Night-heron	*Nyctanassa violacea*	C	C	C	R	X
Threskiornithidae						
White Ibis	*Eudocimus albus*	R	R	R	V	
Glossy Ibis	*Plegadis falcinellus*	V	V			
White-faced Ibis	*Plegadis chihi*	F	U	F	R	X[3]
Roseate Spoonbill	*Platalea ajaja*	R	U	U	R	
Cathartidae						
Black Vulture	*Coragyps atratus*	C	C	C	C	X
Turkey Vulture	*Cathartes aura*	C	C	C	C	X
Pandionidae						
Osprey[4]	*Pandion haliaetus*	F	U	U	F	

		Season				Breeding Habitat[1]
Common Name	**Scientific Name**	**Spring**	**Summer**	**Fall**	**Winter**	
Accipitridae						
Hook-billed Kite[2]	*Chondrohierax uncinatus*			V		
Swallow-tailed Kite	*Elanoides forficatus*	V	V	V		
White-tailed Kite	*Elanus leucurus*	V	R	R	V	
Mississippi Kite	*Ictinia mississippiensis*	U	R	U		
Bald Eagle	*Haliaeetus leucocephalus*	V		V	R	
Northern Harrier	*Circus cyaneus*	C	V	C	C	
Sharp-shinned Hawk	*Accipiter striatus*	F	V	F	F	
Cooper’s Hawk	*Accipiter cooperii*	F	V	F	F	X
Northern Goshawk	*Accipiter gentilis*		V		V	
Common Black-hawk	*Buteogallus anthracinus*			V	V	
Harris’ Hawk	*Parabuteo unicinctus*	U	U	U	U	X
Red-shouldered Hawk	*Buteo lineatus*	F	F	F	F	X
Broad-winged Hawk	*Buteo platypterus*	U		R		
Swainson’s Hawk[4]	*Buteo swainsoni*	F	U	F	V	X
White-tailed Hawk	*Buteo albicaudatus*	V	V	V	V	
Zone-tailed Hawk	*Buteo albonotatus*	R		R	R	X[3]
Red-tailed Hawk	*Buteo jamaicensis*	C	F	C	C	X
Ferruginous Hawk	*Buteo regalis*	R		R	U	
Rough-legged Hawk	*Buteo lagopus*	V		V	R	
Golden Eagle	*Aquila chrysaetos*	R		R	R	
Falconidae						
Crested Caracara	*Caracara cheriway*	F	F	F	F	X
American Kestrel	*Falco sparverius*	C	R	C	C	
Merlin	*Falco columbiarius*	R		R	R	
Peregrine Falcon	*Falco peregrines*	R		R	R	
Prairie Falcon	*Falco mexicanus*	V			V	
Rallidae						
King Rail	*Rallus elegans*	V	V		V	X[3]
Virginia Rail	*Rallus limicola*	V		V	R	
Sora[4]	*Porzana carolina*	U		U	F	
Purple Gallinule	*Porphyrio martinica*	R	R	R		X
Common Gallinule[4]	*Gallinula galeata*	F	C	F	F	X
American Coot	*Fulica americana*	C	U	C	C	X
Gruidae						
Sandhill Crane	*Grus canadensis*	R	V	R	R	
Whooping Crane[2]	*Grus americana*			V		
Charadriidae						
Black-bellied Plover	*Pluvialis squatarola*	R	V	R	V	
American Golden-plover	*Pluvialis dominica*	R	V	R	R	
Snowy Plover	*Charadrius nivosus*	R	R	R	V	
Wilson’s Plover	*Charadrius wilsonia*		V	V		
Semipalmated Plover	*Charadrius semipalmatus*	U	U	U	R	
Piping Plover	*Charadrius melodus*	V	V	R	V	
Killdeer	*Charadrius vociferous*	C	C	C	C	X
Mountain Plover	*Charadrius montanus*	V		V	V	
Recurvirostridae						

Common Name	Scientific Name	Season				Breeding Habitat[1]
		Spring	Summer	Fall	Winter	
Black-necked Stilt	*Himantopus mexicanus*	C	C	C	R	X
American Avocet	*Recurvirostra americana*	C	U	U	R	X
Jacanidae						
Northern Jacana	*Jacana spinosa*		V			X
Scolopacidae						
Spotted Sandpiper	*Actitis macularius*	C	U	C	C	
Solitary Sandpiper	*Tringa solitaria*	U	U	U	U	
Greater Yellowlegs	*Tringa melanoleuca*	C	U	C	U	
Willet	*Tringa semipalmata*	R	V	R		
Lesser Yellowlegs	*Tringa flavipes*	C	U	C	U	
Upland Sandpiper	*Bartramia longicauda*	U	R	U		
Whimbrel	*Numenius phaeopus*	R	V	V		
Long-billed Curlew	*Numenius americanus*	R	V	R		
Hudsonian Godwit	*Limosa haemastica*	R	V			
Marbled Godwit	*Limosa fedoa*	V	R	V		
Ruddy Turnstone	*Arenaria interpres*	R	R	R		
Red Knot	*Calidris canutus*	V				
Sanderling	*Calidris alba*	R	R	R		
Semipalmated Sandpiper	*Calidris pusilla*	U	U	U		
Western Sandpiper	*Calidris mauri*	C	U	C	R	
Least Sandpiper	*Calidris minutilla*	C	F	C	C	
White-rumped Sandpiper	*Calidris fuscicollis*	U	V	U		
Baird's Sandpiper	*Calidris bairdii*	C	V	C	V	
Pectoral Sandpiper	*Calidris melanotos*	F	U	F	V	
Dunlin	*Calidris alpina*	R	V	R	R	
Curlew Sandpiper[2]	*Calidris ferruginea*	V				
Stilt Sandpiper	*Calidris himantopus*	F	V	F	R	
Buff-breasted Sandpiper	*Tryngites subruficollis*	R	R	R	R	
Ruff	*Philomachus pugnax*	V	V	V	V	
Short-billed Dowitcher	*Limnodromus griseus*	R	V	R		
Long-billed Dowitcher	*Limnodromus scolopaceus*	C	F	C	U	
Wilson's Snipe	*Gallinago delicata*	C	V	C	C	
American Woodcock	*Scolopax minor*	V			R	
Wilson's Phalarope	*Phalaropus tricolor*	C	U	C	R	
Red-necked Phalarope	*Phalaropus lobatus*	V	V	V		
Laridae						
Black-legged Kittiwake	*Rissa tridactyla*			V	R	
Sabine's Gull	*Xema sabini*			V		
Bonaparte's Gull	*Chroicocephalus philadelphia*	R		R	C	
Little Gull[2]	*Hydrocoloeus minutes*				V	
Laughing Gull	*Leucophaeus atricilla*	R	R	R	R	
Franklin's Gull	*Leucophaeus pipixcan*	F	R	F	V	
Mew Gull[2]	*Larus canus*				V	
Ring-billed Gull	*Larus delawarensis*	C	R	C	C	
California Gull	*Larus californicus*	V		V	V	
Herring Gull	*Larus argentatus*	R	V	R	U	
Lesser Black-backed Gull[2]	*Larus fuscus*				V	
Glaucous Gull[2]	*Larus hyperboreus*				V	

Common Name	Scientific Name	Season				Breeding Habitat[1]
		Spring	Summer	Fall	Winter	
Sooty Tern	*Onychoprion fuscatus*		V	V		
Bridled Tern[2]	*Onychoprion anaethetus*		V			
Least Tern	*Sternula antillarum*	R	R	R		
Gull-billed Tern	*Gelochelidon nilotica*	V		V		
Caspian Tern	*Hydroprogne caspia*	R	V	R	V	
Black Tern	*Chlidonias niger*	U	U	U		
Common Tern	*Sterna hirundo*	R	V	R		
Forster's Tern	*Sterna forsteri*	C	R	U	C	
Royal Tern	*Thalasseus maximus*		V	V		
Black Skimmer	*Rynchops niger*	R	R	R	V	
Stercorariidae						
Parasitic Jaeger	*Stercorarius parasiticus*		V	V		
Long-tailed Jaeger	*Stercorarius longicaudus*		V			
Columbidae						
Rock Pigeon[5]	*Columbia livia*	C	C	C	C	X
Eurasian Collared-dove[5]	*Streptopelia decaocto*	R	R	R	R	
White-winged Dove	*Zenaida asiatica*	C	C	C	C	X
Mourning Dove	*Zenaida macroura*	C	C	C	C	X
Inca Dove	*Columbina inca*	C	C	C	C	X
Common Ground-dove	*Columbina passerina*	F	F	F	U	X
Psittacidae						
Monk Parakeet[4,5]	*Myiopsitta monachus*	R	R	R	R	X
Green Parakeet	*Aratinga holochlora*	V	V	V	V	
Cuculidae						
Yellow-billed Cuckoo	*Coccyzus americanus*	C	C	C	V	
Black-billed Cuckoo	*Coccyzus erythropthalmus*	R	V	R		
Greater Roadrunner	*Geococcyx californianus*	F	F	F	F	
Groove-billed Ani[4]	*Crotophaga sulcirostris*	R	U	U		
Tytonidae						
Barn Owl	*Tyto alba*	U	U	U	U	X
Strigidae						
Western Screech-owl[2]	*Megascops kennicottii*				V	
Eastern Screech-owl	*Megascops asio*	U	U	U	U	X
Great Horned Owl	*Bubo virginianus*	U	U	U	U	X
Snowy Owl[2]	*Bubo scandiacus*				V	
Elf Owl	*Micrathene whitneyi*	V	V			
Burrowing Owl	*Athene cunicularia*	V		V	R	
Barred Owl	*Strix varia*	U	U	U	U	X
Long-eared Owl	*Asio otus*	R		V	R	
Short-eared Owl	*Asio flammeus*	R		R	R	
Caprimulgidae						
Lesser Nighthawk	*Chordeiles acutipennis*	U	U	U		X
Common Nighthawk	*Chordeiles minor*	C	C	C		X
Common Pauraque[2]	*Nyctidromus albicollis*				V	
Common Poorwill	*Phalaenoptilus nuttallii*	R	V	R	V	X
Chuck-will's-widow	*Caprimulgus carolinensis*	F	F	F		X
Whip-poor-will	*Caprimulgus vociferus*	U		R	V	

Common Name	Scientific Name	Season				Breeding Habitat[1]
		Spring	Summer	Fall	Winter	
Apodidae						
Chimney Swift	*Chaetura pelagica*	C	C	C	V	X
White-throated Swift	*Aeronautes saxatalis*				V	
Trochilidae						
Green Violet-ear	*Colibri thalassinus*	V				
Broad-billed Hummingbird[2]	*Cyananthus latirostris*	V				
Buff-bellied Hummingbird	*Amazilia yucatanensis*	V	V	R	V	
Magnificent Hummingbird[2]	*Eugenes fulgens*	V				
Lucifer Hummingbird	*Calothorax Lucifer*		V			
Ruby-throated Hummingbird	*Archilochus colubris*	C	R	C	V	
Black-chinned Hummingbird	*Archilochus alexandri*	C	C	C	V	X
Anna’s Hummingbird	*Calypte anna*			R	R	
Calliope Hummingbird	*Stellula calliope*	V	V			
Broad-tailed Hummingbird	*Selasphorus platycercus*	R	V	R		
Rufous Hummingbird	*Selasphorus rufus*	R	R	U	U	
Allen’s Hummingbird	*Selasphorus sasin*		V	V	V	
Alcedinidae						
Ringed Kingfisher	*Megaceryle torquata*			V	V	
Belted Kingfisher	*Megaceryle alcyon*	C	U	C	C	X[3]
Green Kingfisher	*Chloroceryle americana*	U	U	U	U	X
Picidae						
Red-headed Woodpecker	*Melanerpes lewis*	V	V	R	R	X[3]
Golden-fronted Woodpecker	*Melanerpes aurifrons*	C	C	C	C	X
Red-bellied Woodpecker	*Melanerpes carolinus*	V			V	
Yellow-bellied Woodpecker	*Sphyrapicus varius*	U		U	U	
Red-naped Sapsucker[2]	*Sphyrapicus nuchalis*			V		
Ladder-backed Woodpecker	*Picoides scalaris*	C	C	C	C	X
Downy Woodpecker	*Picoides pubescens*	R	R	R	R	X
Hairy Woodpecker[2]	*Picoides villosus*				V	
Northern Flicker	*Colaptes punctigula*	F		F	F	
Pileated Woodpecker	*Dryocopus pileatus*		V			X[3]
Tyranidae						
Olive-sided Flycatcher	*Contopus cooperi*	U	R	U		
Greater Pewee	*Contopus pertinax*				V	
Western Wood-Pewee	*Contopus sordidulus*	R		R		
Eastern Wood-Pewee	*Contopus virens*	C	U	U		X
Yellow-bellied Flycatcher	*Empidonax flaviventris*	U	R	U		
Acadian Flycatcher	*Empidonax virescens*	C	F	F		X[3]
Alder Flycatcher	*Empidonax alnorum*	U	R	U		
Willow Flycatcher	*Empidonax traillii*	U	R	U		
Least Flycatcher	*Empidonax minimus*	C	R	U		
Cordilleran Flycatcher	*Empidonax occidentalis*		V			
Black Phoebe	*Sayornis nigricans*	V		V	R	
Eastern Phoebe	*Sayornis phoebe*	C	U	C	C	X
Say’s Phoebe	*Sayornis saya*	R		R	F	
Vermilion Flycatcher[4]	*Pyrocephalus rubinus*	F	R	F	C	X[3]
Ash-throated Flycatcher	*Myiarchus cinerascens*	C	F	U	F	X
Great Crested Flycatcher	*Myiarchus crinitus*	C	C	F		X

Common Name	Scientific Name	Season				Breeding Habitat[1]
		Spring	Summer	Fall	Winter	
Brown-crested Flycatcher	*Myiarchus tyrannulus*	U	U	R		X
Great Kiskadee	*Pitangus sulphuratus*			V		
Couch's Kingbird	*Tyrannus couchii*	U	U	U	U	X
Cassin's Kingbird[2]	*Tyrannus vociferans*			V		
Western Kingbird	*Tyrannus verticalis*	C	C	F	V	X
Eastern Kingbird	*Tyrannus tyrannus*	F	R	R		X[3]
Scissor-tailed Flycatcher	*Tyrranus forficatus*	C	C	C	V	X
Laniidae						
Loggerhead Shrike	*Lanius ludovicianus*	C	F	C	C	X
Vireonidae						
White-eyed Vireo	*Vireo griseus*	C	C	C	F	X
Bell's Vireo	*Vireo bellii*	F	F	U	V	X
Black-capped Vireo	*Vireo atricapilla*	R	R			X
Yellow-throated Vireo	*Vireo flavifrons*	R	R	R	V	X[3]
Plumbeous Vireo	*Vireo plumbeus*	V	V			
Blue-headed Vireo	*Vireo solitaries*	C		C	U	
Hutton's Vireo[4]	*Vireo huttoni*	R	R	R	R	X
Warbling Vireo	*Vireo gilvus*	U		U		
Philadelphia Vireo	*Vireo philadelphicus*	U	V	U		
Red-eyed Vireo	*Vireo olivaceus*	F	R	R		X
Corvidae						
Green Jay	*Cyanocorax yncas*	V	V	V	V	X[3]
Blue Jay	*Cyanocitta cristata*	C	C	C	C	X
Western Scrub-jay	*Aphelocoma californica*	C	C	C	C	X
American Crow	*Corvus brachyrhynchos*	C	C	C	C	X
Chihuahuan Raven	*Corvus cryptoleucus*		V			
Common Raven	*Corvus corax*	U	U	U	U	X
Alaudidae						
Horned Lark	*Eremophila alpestris*		V	R	R	
Hirundinidae						
Purple Martin	*Progne subis*	C	C	U	V	X
Tree Swallow	*Tachycineta bicolor*	F	U	F	R	X[3]
Violet-green Swallow[2]	*Tachycineta thalassina*			V		
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	F	U	F	V	X
Bank Swallow	*Riparia riparia*	U	U	U	V	
Cliff Swallow	*Petrochelidon pyrrhonota*	C	C	C	V	X
Cave Swallow	*Petrochelidon fulva*	C	C	C	C	X
Barn Swallow	*Hirundo rustica*	C	C	C	R	X
Paridae						
Carolina Chickadee	*Poecile carolinensis*	C	C	C	C	X
Tufted Titmouse	*Baeolophus bicolor*				V	
Black-crested Titmouse	*Baeolophus atricristatus*	C	C	C	C	X
Remizidae						
Verdin	*Auriparus flaviceps*	F	F	F	F	X
Aegithalidae						
Bushtit	*Psaltriparus minimus*	R	R	R	R	X
Sittidae						

Common Name	Scientific Name	Season				Breeding Habitat[1]
		Spring	Summer	Fall	Winter	
Red-breasted Nuthatch	*Sitta canadensis*	R		R	R	
White-breasted Nuthatch	*Sitta carolinensis*	V			R	
Certhidae						
Brown Creeper	*Certhia americana*	R		R	R	
Troglodytidae						
Cactus Wren	*Campylorhynchus brunneicapillus*	U	U	U	U	X
Rock Wren	*Salpinctes obsoletus*	R	R	R	R	X[3]
Canyon Wren	*Catherpes mexicanus*	U	U	U	U	X
Carolina Wren	*Thryothorus ludovicianus*	C	C	C	C	X
Bewick’s Wren	*Thryomanes bewickii*	C	C	C	C	X
House Wren	*Troglodytes aedon*	C		C	C	
Winter Wren	*Troglodytes hiemalis*	R		R	R	
Sedge Wren	*Cistothorus platensis*			R	R	
Marsh Wren	*Cistothorus palustris*	F		F	F	
Polioptilidae						
Blue-gray Gnatcatcher	*Polioptila caerulea*	C	U	F	F	X
Black-tailed Gnatcatcher	*Polioptila melanura*	V		V	V	
Regulidae						
Golden-crowned Kinglet	*Regulus satrapa*	R		R	R	
Ruby-crowned Kinglet	*Regulus calendula*	C		C	C	
Turdidae						
Eastern Bluebird	*Sialia sialis*	U	R	U	F	X
Western Bluebird	*Sialia mexicana*			V	V	
Mountain Bluebird	*Sialia currucoides*	V			V	
Townsend’s Solitaire	*Myadestes townsendi*	V			V	
Veery	*Catharus fuscescens*	R		V	V	
Gray-cheeked Thrush	*Catharus minimus*	R		V	V	
Swainson’s Thrush	*Catharus ustulatus*	F	V	U	R	
Hermit Thrush	*Catharus guttatus*	F		F	F	
Wood Thrush	*Hylocichla mustelina*	U		U	R	
American Robin	*Turdus migratorius*	F	R	F	F	X
Mimidae						
Gray Catbird	*Dumetella carolinensis*	F		U	R	
Northern Mockingbird	*Mimus polyglottos*	C	C	C	C	X
Sage Thrasher	*Oreoscoptes montanus*	V		V	R	
Brown Thrasher	*Toxostoma rufum*	U		U	U	
Long-billed Thrasher	*Toxostoma longirostre*	F	F	F	F	X
Curve-billed Thrasher	*Toxostoma curvirostre*	F	F	F	F	X
Sturnidae						
European Starling[5]	*Sturnus vulgaris*	C	C	C	C	X
Motacillidae						
American Pipit	*Anthus rubescens*	C	V	F	C	
Sprague’s Pipit	*Anthus spragueii*	R		V	U	
Bombycillidae						
Bohemian Waxwing[2]	*Bombycilla garrulous*				V	
Cedar Waxwing	*Bombycilla cedrorum*	C		R	C	

Common Name	Scientific Name	Season				Breeding Habitat[1]
		Spring	Summer	Fall	Winter	
Ptilogonatidae						
Phainopepla	*Phainopepla nitens*	V		V		X[3]
Calcariidae						
Lapland Longspur	*Calcarius lapponicus*				F	
Chestnut-collared Longspur	*Calcarius ornatus*	V		V	R	
Smith's Longspur[2]	*Calcarius pictus*				V	
McCown's Longspur[2]	*Rhynchophanes mccownii*	V		V	R	
Parulidae						
Ovenbird	*Seiurus aurocapilla*	U		R	V	
Worm-eating Warbler	*Helmitheros vermivorum*	R		V		
Louisiana Waterthrush	*Parkesia motacilla*	U	V	R		
Northern Waterthrush	*Parkesia noveboracensis*	F	V	R	V	
Golden-winged Warbler	*Vermivora chrysoptera*	R		V		
Blue-winged Warbler	*Vermivora cyanoptera*	R		V		
Black-and-white Warbler	*Mniotilta varia*	C	U	F	U	X
Prothonotory Warbler	*Protonotaria citrea*	U	R	V		
Swainson's Warbler[2]	*Limnothlypis swainsonii*	V				
Tennessee Warbler	*Oreothlypis peregrine*	U		R		
Orange-crowned Warbler	*Oreothlypis celata*	C		C	C	
Nashville Warbler	*Oreothlypis ruficapilla*	C		C	R	
Connecticut Warbler	*Oporornis agilis*	V		V		
MacGillivray's Warbler	*Geothlypis tolmiei*	U	V	R		
Mourning Warbler	*Geothlypis philadelphia*	U	R	R		
Kentucky Warbler	*Geothlypis formosa*	U	V	V	V	X[3]
Common Yellowthroat	*Geothlypis trichas*	C		C	C	
Hooded Warbler	*Setophaga citrina*	U		R	V	
American Redstart	*Setophaga ruticilla*	F	V	U	V	
Cape May Warbler	*Setophaga tigrina*	V		V		
Cerulean Warbler	*Setophaga cerulea*	R		V		
Northern Parula	*Setophaga americana*	U	V	V	V	X
Tropical Parula[2]	*Setophaga pitiayumi*		V			
Magnolia Warbler	*Setophaga magnolia*	C	V	R		
Bay-breasted Warbler	*Setophaga castanea*	U		R		
Blackburnian Warbler	*Setophaga fusca*	F	V	R		
Yellow Warbler	*Setophaga petechia*	F	V	F	V	X[3]
Chestnut-sided Warbler	*Setophaga pensylvanica*	U	V	R	V	
Blackpoll Warbler	*Setophaga striata*	R				
Black-throated Blue Warbler	*Setophaga caerulescens*	V		V	V	
Palm Warbler	*Setophaga palmarum*	V		R	R	
Pine Warbler	*Setophaga pinus*	R		R	U	
Yellow-rumped Warbler	*Setophaga coronata*	C		C	C	
Yellow-throated Warbler	*Setophaga dominica*	R		V	V	
Prairie Warbler	*Setophaga discolor*			V		
Black-throated Gray Warbler	*Setophaga nigrescens*	V		V	V	
Townsend's Warbler	*Setophaga townsendi*			V	V	
Golden-cheeked Warbler	*Setophaga chrysoparia*	F	F			X
Black-throated Green Warbler	*Setophaga virens*	C	V	F	R	
Rufous-capped Warbler[2]	*Basileuterus rufifrons*				V	

Common Name	Scientific Name	Season				Breeding Habitat[1]
		Spring	Summer	Fall	Winter	
Canada Warbler	*Cardellina canadensis*	U		R	V	
Wilson’s Warbler	*Cardellina pusilla*	C	V	F	R	
Yellow-breasted Chat	*Icteria virens*	C	U	U	V	X
Emberizidae						
White-collared Seedeater[2]	*Sporophila torqueola*				V	
Olive Sparrow	*Arremonops rufivirgatus*	R	R	R	R	
Green-tailed Towhee	*Pipilo chlorurus*	R		R	R	
Spotted Towhee	*Pipilo maculatus*	C		C	C	
Eastern Towhee	*Pipilo erythrophthalmus*	R		R	U	
Rufous-crowned Sparrow	*Aimophila ruficeps*	F	F	F	U	X
Canyon Towhee[2]	*Melozone fusca*	R	R	R		X[3]
Cassin’s Sparrow	*Peucaea cassinii*	F	R	R	R	X
American Tree Sparrow[2]	*Spizella arborea*				V	
Chipping Sparrow	*Spizella passerina*	C	R	U	C	X
Clay-colored Sparrow	*Spizella pallida*	F		F	R	
Field Sparrow	*Spizella pusilla*	C	R	U	C	X
Vesper Sparrow	*Pooecetes gramineus*	C		C	C	
Lark Sparrow	*Chondestes grammacus*	F	F	F	F	X
Black-throated Sparrow	*Amphispiza bilineata*	U	U	U	U	X[3]
Lark Bunting	*Calamospiza melanocorys*	R	V	R	U	
Savannah Sparrow	*Passerculus sandwichensis*	C	V	C	C	
Grasshopper Sparrow	*Ammodramus savannarum*	F	U	U	F	X
Baird’s Sparrow	*Ammodramus bairdii*	V			V	
Henslow’s Sparrow	*Ammodramus henslowii*	V			V	
Le Conte’s Sparrow	*Ammodramus leconteii*	V		V	R	
Fox Sparrow	*Passerella iliaca*	R		R	U	
Song Sparrow	*Melospiza melodia*	F		F	C	
Lincoln’s Sparrow	*Melospiza lincolnii*	C	V	C	C	
Swamp Sparrow	*Melospiza Georgiana*	U		U	F	
White-throated Sparrow	*Zonotrichia albicollis*	C		F	C	
Harris’ Sparrow	*Zonotrichia querula*	R		R	U	
White-crowned Sparrow	*Zonotrichia leucophrys*	C		C	C	
Golden-crowned Sparrow[2]	*Zonotrichia atricapilla*				V	
Dark-eyed Junco	*Junco hyemalis*	U		R	U	
Cardinalidae						
Hepatic Tanager	*Piranga flava*	V	V	V	V	
Summer Tanager	*Piranga rubra*	F	F	U	R	
Scarlet Tanager	*Piranga olivacea*	U		V		
Western Tanager	*Piranga ludoviciana*	R		R	V	
Northern Cardinal	*Cardinalis cardinalis*	C	C	C	C	X
Pyrrhuloxia	*Cardinalis sinuatus*	F	F	F	F	X
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	U		R	V	
Black-headed Grosbeak	*Pheucticus melanocephalus*	R	V	R	R	
Blue Grosbeak	*Passerina caerulea*	C	F	U	V	X
Lazuli Bunting	*Passerina amoena*	R		V	V	
Indigo Bunting	*Passerina cyanea*	F	U	F	V	X
Varied Bunting[2]	*Passerina versicolor*	V				
Painted Bunting	*Passerina ciris*	C	C	U	V	X

Common Name	Scientific Name	Season				Breeding Habitat[1]
		Spring	Summer	Fall	Winter	
Dickcissel	*Spiza americana*	C	F	R	V	X
Icteridae						
Bobolink	*Dolichonyx oryzivorus*	V		V		
Red-winged Blackbird	*Agelaius phoeniceus*	C	C	C	C	X
Eastern Meadowlark	*Sturnella magna*	C	F	C	C	X
Western Meadowlark	*Sturnella neglecta*	R		R	F	
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	U	R	U	R	
Rusty Blackbird	*Euphagus carolinus*	R			R	
Brewer's Blackbird[4]	*Euphagus cyanocephalus*	U		U	C	
Common Grackle	*Quiscalus quiscula*	U	V	U	F	X[3]
Great-tailed Grackle	*Quiscalus mexicanus*	C	C	C	C	X
Bronzed Cowbird	*Molothrus aeneus*	U	U	U	R	X
Brown-headed Cowbird	*Molothrus ater*	C	C	C	C	X
Orchard Oriole	*Icterus spurious*	F	F	U		X
Hooded Oriole	*Icterus cucullatus*	R	R	R	V	
Bullock's Oriole	*Icterus bullockii*	C	C	U	R	X
Altamira Oriole	*Icterus gularis*		V	V	V	
Audubon's Oriole	*Icterus graduacauda*	V			V	
Baltimore Oriole	*Icterus galbula*	C	U	U	R	
Scott's Oriole	*Icterus parisorum*	R	R	R	V	X
Fringillidae						
Purple Finch	*Carpodacus purpureus*	R		R	R	
House Finch	*Carpodacus mexicanus*	C	C	C	C	X
Red Crossbill	*Loxia curvirostra*	V		V	V	
Pine Siskin	*Spinus pinus*	R		R	R	
Lesser Goldfinch	*Spinus psaltria*	U	U	U	U	X
American Goldfinch	*Spinus tristus*	C		C	C	
Evening Grosbeak	*Coccothraustes vespertinus*	V			V	
Passeridae						
House Sparrow[5]	*Passer domesticus*	C	C	C	C	X

C-Common; F-Fairly Common; U-Uncommon; R-Rare; V-Very Rare

[1] Documented breeding in Bexar County

[2] Status uncertain, siting not independently verified

[3] Historical breeding record

[4] Localized populations

[5] Non-native species

ATTACHMENT 2: TPWD SPECIES OF CONCERN

Species	Specific Epithet	Global/State Ranking	Blackland Prairies	Edwards Plateau	South Texas Plains
Mammals					
Pallid bat	*Antrozous pallidus*	G5/S5		X	X
Elliot's short-tailed shrew	*Blarina hylophaga plumblea*	G5T1Q/S1	X		
Nelson's pocket mouse	*Chaetodipus nelsoni*	G5/S?			X
Hog-nosed skunk	*Conepatus leuconotus*	G5/S4		X	X
Townsend's big-eared bat	*Corynorhinus townsendii*	G4T4/S3S4?		X	
Black-tailed prairie dog	*Cynomys ludovicianus*	G5T3/S3		X	
Ord's kangaroo rat	*Dipodomys ordii parvabullatus*	G5/S4			X
Big brown bat	*Eptesicus fuscus*	G5/S5		X	
Attwater's pocket gopher	*Geomys attwateri*	G4/S4	X		X
Texas pocket gopher	*Geomys personatus davisi*	G4T2/S2			X
Strecker's pocket gopher	*Geomys streckeri*	G4T1/S1			X
Frio pocket gopher	*Geomys texensis bakeri*	G2QT2/S2		X	X
Llano pocket gopher	*Geomys texensis texensis*	G3T2/S2		X	
Jaguarundi	*Herpailurus yaguarondi*	G4/S1			X
Southern yellow bat	*Lasiurus ega*	G5/S1			X
Ocelot	*Ocelot*	G4/S1			X
River Otter	*Lutra canadensis*	G5/S4	X	X	
Ghost-faced bat	*Mormoops megalophylla*	G4/S2		X	X
Long-tailed weasel	*Mustela frenata*	G5/S5	X	X	X
Black-footed ferret	*Mustela nigripes*	G1/SH		X	
Southeastern myotis	*Myotis austroriparius*	G3G4/S3	X		
Cave myotis	*Myotis velifer*	G5/S4	X	X	X
White-nosed coati	*Nasua narica*	G5/S2?		X	X
Mink	*Neovision vison*	G5/S4			X
Desert shrew	*Notiosorex crawfordii*	G5/S4			X
Big free-tailed bat	*Nyctinomops macrotis*	G5/S3			X
Coues rice rat	*Oryzomys couesi aquaticus*	G5T3?/S2			X
Canyon bat	*Parastrellus hesperus*	G5/S5		X	
Tricolored bat	*Perimyotis subflavus*	G5/S5		X	
Mountain lion	*Puma concolor*	G5/S2	X	X	X
Eastern mole	*Scalopus aquaticus*	G5/S5			X
Western spotted skunk	*Spilogale gracilis*	G5/S5		X	X
Eastern spotted skunk	*Spilogale putorius*	G4T/S4	X	X	X
Swamp rabbit	*Sylvilagus aquaticus*	G5/S5	X	X	
Brazilian free-tailed bat	*Tadarida brasiliensis*	G5/S5	X	X	X
American badger	*Taxidea taxus*	G5/S5	X	X	X
Black bear	*Ursus americanus*	G5/S3	X	X	
Swift fox	*Vulpes velox*	G3/S3?		X	
Birds					
Mottled Duck	*Anas fulvigula*	G4/S4B			X
Northern Pintail	*Anas acuta*	G5/S3B,S5N	X		X
Scaled Quail	*Callipepla squamata*	G5/S4B			X
Northern Bobwhite	*Colinus virginianus*	G5/S4B	X	X	X
Montezuma Quail	*Cyrtonyx montezumae*	G4G5/S3B		X	
Greater Prairie-chicken	*Tympanicus cupido*	G4/S1B	X		
Wild Turkey	*Meleagris gallopavo*	G5/S5B	X	X	X
Least Bittern	*Ixobrychus exilis*	G5/S4B	X		
Snowy Egret	*Egretta thula*	G5/S5B	X		
Little Blue Heron	*Egretta caerulea*	G5/S5B	X		
Green Heron	*Butorides virescens*	G5/S5B	X		
Wood Stork	*Mycteria americana*	G4/SHB,S2N	X		

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Mississippi Kite	*Ictinia mississippiensis*	G5/S4B	X		
Hook-billed Kite	*Chondrohierax uncinatus*	G4/S2			X
Bald Eagle	*Haliaeetus leucocephalus*	G5/S3B,S3N	X		
Northern Harrier	*Circus cyaneus*	G5/S2B,S3N	X	X	X
Common Black-hawk	*Buteogallus anthracinus*	G4G5/S2B		X	X
Harris's Hawk	*Parabuteo unicinctus*	G5/S3B		X	X
Red-shouldered Hawk	*Buteo lineatus*	G5/S4B	X	X	X
Gray Hawk	*Buteo nitidus*	G5/S2B			X
Swainson's Hawk	*Buteo swainsoni*	G5/S4B			X
Zone-tailed Hawk	*Buteo albonotatus*	G4/S3B		X	
Golden Eagle	*Aquila chrysaetos*	G5/S3B		X	
American Golden-plover	*Pluvialis dominica*	G5,S3	X		
Mountain Plover	*Charadrius montanus*	G3/S2	X		X
American Woodcock	*Scolopax minor*	G5/S2B,S3N	X		
Least Tern	*Sternula antillarum*	G4/S3B	X		X
Green Parakeet	*Aratinga holochlora*	G3/S3			X
Red-crowned Parrot	*Amazona viridigenalis*	G2/S2			X
Ferruginous Pygmy-owl	*Glaucidium brasilianum*	G5/S3B			X
Burrowing Owl	*Athene cunicularia*	G4/S3B			X
Short-eared Owl	*Asio flammeus*	G5/S4N	X		
Chuck-will's-widow	*Caprimulgus carolinensis*	G5/S3S4B	X	X	
Red-headed Woodpecker	*Melanerpes erythrocephalus*	G5/S3B	X		
Pileated Woodpecker	*Dryocopus pileatus*	G5/S4B	X		
Northern Beardless-tyrannulet	*Camptostoma imberbe*	G5/S3B			X
Scissor-tailed Flycatcher	*Tyrannus forficatus*	G5/S3B	X	X	X
Loggerhead Shrike	*Lanius ludovicianus*	G4/S4B	X	X	X
Bell's Vireo	*Vireo bellii*	G5/S3B	X	X	X
Black-capped Vireo	*Vireo atricapilla*	G3/S2B		X	
Carolina Chickadee	*Poecile carolinensis*	G5/S5B	X	X	
Bewick's Wren	*Thryomanes bewickii*	G5/S5B	X		
Sedge Wren	*Cistothorus platensis*	G5/S4	X		
Wood Thrush	*Hylocichla mustelina*	G5/S4B	X		
Sprague's Pipet	*Anthus spragueii*	G4/S3N	X	X	X
Tropical Parula	*Parula pitiayumi*	G5/S3B		X	X
Golden-cheeked Warbler	*Dendroica chrysoparia*	G2/S2B		X	
Yellow-throated Warbler	*Dendroica dominica*	G5/S4B	X	X	
Prothonotory Warbler	*Protonotaria citrea*	G5/S5B	X		
Swainson's Warbler	*Limnothlypis swainsonii*	G5/S4	X		
Louisiana Waterthrush	*Seiurus motacilla*	G5/S4B	X	X	
Kentucky Warbler	*Oporornis formosus*	G5/S3B	X		
Cassin's Sparrow	*Aimophila cassinii*	G5/S4B		X	X
Rufous-crowned Sparrow	*Aimophila ruficeps*	G5/S4B		X	
Field Sparrow	*Spizella pusilla*	G5/S5B	X	X	
Grasshopper Sparrow	*Ammodramus savannarum*	G5/S3B	X	X	X
Lark Sparrow	*Chondestes grammacus*	G5/S4B	X	X	X
Henslow's Sparrow	*Ammodramus henslowii*	G4/S2S3N,SXB	X		
Le Conte's Sparrow	*Ammodramus leconteii*	X	X	X	
Harris's Sparrow	*Zonotricha querula*	G5S4	X	X	
McCown's Longspur	*Calcarius mccownii*	G5/S4	X		
Smith's Longspur	*Calcarius pictus*	X	X		
Summer Tanager	*Piranga rubra*	G5/S5B	X	X	X

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Painted Bunting	*Passerina ciris*	G5/S4B	X	X	X
Dickcissel	*Spiza americana*	G5/S4B	X	X	X
Eastern Meadowlark	*Sturnella magna*	G5/S5B	X	X	X
Rusty Blackbird	*Euphagus carolinus*	G4/S3	X		
Orchard Oriole	*Icterus spurious*	G5S4B	X	X	X
Amphibians & Reptiles					
Woodhouse's toad	*Anaxyrus woodhousii*	G5/SU	X	X	
Smooth softshell turtle	*Apalone mutica*	X	X	X	
Spiny softshell turtle	*Apalone spinifera*	X	X	X	X
Common snapping turtle	*Cheylydra serpentine*	X	X	X	
Black-striped snake	*Coniophanes imperialis*				X
Western diamondback rattlesnake	*Crotalus atrox*	S4	X	X	X
Timber rattlesnake	*Crotalus horridus*	G4/S4	X		
Reticulate collared lizard	*Crotaphytus reticulatus*	G3/S2			X
Texas indigo snake	*Drymarchon melanurus erebennus*	G4/S3		X	X
Cascade Caverns salamander	*Eurycea latitans*	G3/S1		X	
San Marcos salamander	*Eurycea nana*	G1/S1		X	
Georgetown salamader	*Eurycea naufragia*	G1/S1		X	
Texas salamander	*Eurycea neotenes*	G1/S2		X	
Blanco River Springs salamander	*Eurycea pterophila*	G2/S2		X	
Texas blind salamander	*Eurycea rathbuni*	G1/S1		X	
Blanco blind salamander	*Eurycea robusta*	G1Q/S1		X	
Barton Springs salamander	*Eurycea sosorum*	G1/S1		X	
Jollyville Plateau salamander	*Eurycea tonkawae*	G1/S2S3		X	
Comal blind salamander	*Eurycea tridentifera*	G1/S1		X	
Austin blind salamander	*Eurycea waterlooensis*	G1/S1		X	
Texas tortoise	*Gopherus berlandieri*	G4/S2*		X	X
Cagle's map turtle	*Graptemys caglei*	G3/S1	X	X	
Texas map turtle	*Graptemys versa*	G4/SU	X	X	
Western hognosed snake	*Heterodon nasicus*	X	X	X	X
Plateau earless lizard	*Holbrookia lacerata lacerata*	S2		X	
Southern earless lizard	*Holbrookia lacerata subcaudalis*	X			X
Northern earless lizard	*Holbrookia propinqua propinqua*	SX			X
Sheep frog	*Hypopachus variolosus*	G5/S2			X
White-lipped frog	*Leptodactylus variolosus*	G5/S1			X
Northern cat-eyed snake	*Leptodeira septentrionalis septentrionalis*	G5T5/S2			X
Concho water snake	*Nerodia paucimaculata*	G2/S2		X	
Black-spotted newt	*Notophthalmus meridionalis*	G1/S1 or S2?			X
Alligator snapping turtle	*Macrochelys temminckii*	G3G4/S3	X		
Western slender glass lizard	*Ophisaurus attenuates*	X	X	X	
Texas horned lizard	*Phrynosoma cornutum*	G4G5/S4	X	X	X
Strecker's chorus frog	*Pseudacris streckeri*	G5/S3	X	X	
Rio Grande cooter	*Pseudemys gorzugi*	S2			X
Texas blind snake	*Rena dulcis*	X			X

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Mexican burrowing toad	*Rhinophrynus dorsalis*	G5/S2			X
Rio Grande siren (large form)	*Siren sp.*	GNRQ/S2			X
Massasagua	*Sistrurus catenatus*	X	X	X	X
Mexican blackhead snake	*Tantilla atriceps*	X			X
Eastern box turtle	*Terrapene carolina*	G5/S3	X	X	
Ornate box turtle	*Terrapene ornate*	G5/S3	X	X	X
Texas garter snake	*Thamnophis sirtalis annectans*	G5/S2	X	X	
Red-eared slider	*Trachemys scripta*	X	X	X	X
Freshwater Fishes					
American eel	*Anguilla rostrata*	G4/S5	X	X	X
Alligator gar	*Atractosteus spatula*	X	X		X
Blue sucker	*Cycleptus elongates*	G3G4/S3	X		
Rio Grande blue sucker	*Cycleptus sp.*	X			X
Plateau shiner	*Cyprinella lepida*	G1G2/S1S2		X	X
Proserpine shiner	*Cyprinella proserpina*	G3/S2		X	X
Nueces River shiner	*Cyprinella sp.*	G1G2Q/S1S2		X	X
Devils River pupfish	*Cyprinodon eximius ssp.*	X		X	X
Manantial roundnose minnow	*Dionda argentosa*	G2/S2		X	X
Devil’s River minnow	*Dionda diaboli*	G1/S1		X	X
Guadalupe roundnose minnow	*Dionda nigrotaeniata*	G4/S4		X	
Nueces roundnose minnow	*Dionda serena*	G2/S2		X	X
Fountain darter	*Etheostoma fonticola*	G1/S1	X		
Rio Grande darter	*Etheostoma grahami*	G2G3/S2		X	X
San Felipe gambusia	*Gambusia clarkhubbsi*	G1/S1			X
Clear Creek gambusia	*Gambusia heterochir*	G1/S1		X	
Blotched gambusia	*Gambusia senilis*	G3G4/SX			X
Rio Grande silvery minnow	*Hybognathus amarus*	G1G2/SX			X
Headwater catfish	*Ictalurus lupus*	G3/S2		X	X
Silver chub	*Macryhbopsis storeriana*	X	X		
Guadalupe bass	*Micropterus treculii*	G3/S3	X	X	
Texas shiner	*Notropis amarus*	X			X
Blackspot shiner	*Notropis atrocaudalis*	X	X		
Red River shiner	*Notropis bairdi*	X	X		
Tamaulipas shiner	*Notropis braytoni*	X			X
Small-eye shiner	*Notropis buccula*	G2Q/S2	X		
Ironcolor shiner	*Notropis chalybaeus*	X	X		
Rio Grande shiner	*Notropis jemezanus*	X			X
Sharpnose shiner	*Notropis oxyrhynchus*	G3/S3	X		
Chub shiner	*Notropis potteri*	G4/S3	X		
Silverband shiner	*Notropis shumardi*	X	X		
Guadalupe darter	*Percina apristis*	X	X	X	
Paddlefish	*Polyodon spathula*	G4/S3	X		
Longnose dace	*Rhinichthys cataractae*	X			X
Widemouth blindcat	*Satan eurystomus*	G1/S1	X		
Toothless blindcat	*Trogloglanis pattersoni*	G1/S1	X		
Invertebrates					
A cave obligate amphipod	*Allotexiweckelia hirsuta*	G2G3/S2?*		X	
An aquatic mite	*Almuerzothyas n. sp.*	G1*/S1*		X	
A katydid	*Amblycorypha uhleri*	G2G3*/S2?*		X	
A mining bee	*Andrena scotoptera*	G1*S1*			X
Rio Grande gold	*Aphonopelma moderatum*	G2G3*/S2?*			X

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tarantula					
A cave obligate pseudoscorpion	*Apocheiridium reddelli*	G1G2/S1*		X	
A katydid	*Arethaea ambulator*	G2G3*/S2?*		X	
Rio Grande thread-legged katydid	*Arethaea phantasma*	G2?*/S2?*			X
Golden-winged dancer	*Argia rhoadsi*	G2G3/S2?*		X	
An aquatic mite	*Arrenurus n. sp.*	XG1*/S1*		X	
A cave obligate amphipod	*Artesia subterranean*	G1G2/S1?*		X	
Texas Austrotinodes caddisfly	*Austrotinodes texensis*	G2/S2		X	X
A mayfly	*Baetodes alleni*	G1G2/S1?*		X	
Balcones ghostsnail	*Balconorbis uvaldensis*	G1G2/S1*		X	
A cave obligate beetle	*Batrisodes cryptotexanus*	G1G2/S1*		X	
A cave obligate beetle	*Batrisodes dentifrons*	G2*/S1*		X	
A cave obligate beetle	*Batrisodes fanti*	G1G2*/S1*		X	
A cave obligate beetle	*Batrisodes feminiclypeus*	G1G2*/S1*		X	
A cave obligate beetle	*Batrisodes gravesi*	G2*/S2*		X	
A cave obligate beetle	*Batrisodes grubbsi*	G1G2/S1*		X	
A cave obligate beetle	*Batrisodes incisipes*	G1G2*/S1*		X	
A cave obligate beetle	*Batrisodes pekinsi*	G1G2*/S1*		X	
A cave obligate beetle	*Batrisodes reyesi*	G2G3/S2*		X	
A cave obligate beetle	*Batrisodes shadeae*	G1G2*/S1*		X	
A cave obligate beetle	*Batrisodes texanus*	G1G2/S1		X	
A cave obligate beetle	*Batrisodes venyivi*	G1G2/S1		X	
A cave obligate beetle	*Batrisodes wartoni*	G1G2*/S1		X	
American bumblebee	*Bombus pensylvanicus*	GU/SU*	X	X	X
Sonoran bumblebee	*Bombus sonorus*	GU/SU*		X	X
Variable cuckoo bumblebee	*Bombus variabilis*	GU/SU*		X	
A cave obligate isopod	*Brackenridgia reddelli*	G2G3/S2?*		X	
A mayfly	*Caenis arwini*	G1G3/S2?*		X	X
A cave obligate shrimp	*Calathaemon holthuisi*	G1G2/S1?*		X	
Holzenthal’s Philopotamid caddisfly	*Chimarra holzenthali*	G1G2/S1	X		
A cave obligate pseudoscorpion	*Chitrella elliotti*	G1G2/S1*		X	
A cave obligate spider	*Cicurina bandera*	G2G3/S2*		X	
Bandit Cave spider	*Cicurina bandida*	G1G2/S1		X	
Robber Baron Cave meshweaver	*Cicurina baronia*	G1G2/S1		X	
A cave obligate spider	*Cicurina barri*	G1G2/S1*		X	
A cave obligate spider	*Cicurina browni*	G1G2/S1*		X	
A cave obligate spider	*Cicurina caliga*	G1G2*/S1*		X	
A cave obligate spider	*Cicurina cavern*	G1G2/S1*		X	
A cave obligate spider	*Cicurina coryelli*	G1G2/S1*		X	
A cave obligate spider	*Cicurina elliotti*	G2G3/S2*		X	
A cave obligate spider	*Cicurina ezelli*	G1G2/S1*		X	
A cave obligate spider	*Cicurina gruta*	G1G2/S1*		X	
A cave obligate spider	*Cicurina holsingeri*	G1G2/S1*		X	
A cave obligate spider	*Cicurina hoodensis*	G1G2*/S1*		X	
A cave obligate spider	*Cicurina machete*	G1G2/S1*		X	
Madla Cave meshweaver	*Cicurina madla*	G1G2/S1		X	
A cave obligate spider	*Cicurina mckenziei*	G1G2/S1*		X	
A cave obligate spider	*Cicurina medina*	G1G2/S1*		X	
A cave obligate spider	*Cicurina menardia*	G1G2/S1*		X	
A cave obligate spider	*Cicurina mixmaster*	G1G2*/S1*		X	

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A cave obligate spider	*Cicurina obscura*	G1G2/S1*		X	
A cave obligate spider	*Cicurina orellia*	G1G2/S1*		X	
A cave obligate spider	*Cicurina pablo*	G1G2/S1*		X	
A cave obligate spider	*Cicurina pastura*	G1G2/S1*		X	
A cave obligate spider	*Cicurina patei*	G1G2/S1*		X	
A cave obligate spider	*Cicurina porter*	G1G2/S1*		X	
A cave obligate spider	*Cicurina puentecilla*	G1G2/S1*		X	
A cave obligate spider	*Cicurina rainesi*	G1G2/S1*		X	
A cave obligate spider	*Cicurina reclusa*	G1G2/S1*		X	
A cave obligate spider	*Cicurina reddelli*	G1G2/S1*		X	
A cave obligate spider	*Cicurina russelli*	G1G2/S1*		X	
A cave obligate spider	*Cicurina sansaba*	G1G2/S1*		X	
A cave obligate spider	*Cicurina selecta*	G1G2/S1*		X	
A cave obligate spider	*Cicurina serena*	G1G2/S1*		X	
A cave obligate spider	*Cicurina sheari*	G1G2/S1*		X	
A cave obligate spider	*Cicurina sprousei*	G1G2/S1*		X	
A cave obligate spider	*Cicurina stowersi*	G1G2/S1*		X	
A cave obligate spider	*Cicurina suttoni*	G1G2/S1*		X	
A cave obligate spider	*Cicurina travisae*	G1G2/S1*		X	
A cave obligate spider	*Cicurina troglobia*	G1G2/S1*		X	
A cave obligate spider	*Cicurina ubicki*	G1G2/S1*		X	
A cave obligate spider	*Cicurina uvalde*	G1G2/S1*		X	
A cave obligate spider	*Cicurina venefica*	G1G2/S1*		X	
Braken Canyon Bat Cave meshweaver	*Cicurina venii*	G1G2/S1		X	
Government Canyon Bat Cave meshweaver	*Cicurina vespera*	G1G2/S1		X	
A cave obligate spider	*Cicurina vibora*	G1G2/S1*		X	
Warton Cave meshweaver	*Cicurina wartoni*	G1/S1		X	
A cave obligate spider	*Cicurina waters*	G1G2/S1*		X	
Cazier's tiger beetle	*Cincindela cazieri*	G2/S2		X	
A bee	*Coelioxys piercei*	G1*/S1*		X	
A lichen moth	*Cisthene conjuncta*	G1Q/S1Q*		X	
A cellophane bee	*Colletes bumeliae*	G1*/S1*		X	
A cellophane bee	*Colletes saritensis*	G1*/S1*		X	
Comal Springs diving beetle	*Comaldessus stygius*	G1/S1		X	
Brownsville meadow katydid	*Conocephalus resacensis*	G2?*/S2?*			X
A scarab beetle	*Cotinus boylei*	G2*/S2*	X		
Horseshoe liptooth	*Daedalochila hippocrepis*	G1/S1		X	
Percosius skipper	*Decinea percosius*	G1G3/S1S3*			X
Acacia fairy shrimp	*Dendrocephalus acacioidea*	G1/S1*			X
A katydid	*Dichopetala catinata*	G1?*/S1?*		X	
Gladiator short-winged katydid	*Dichopetala gladiator*	G2?*/S2?*			X
A katydid	*Dichopetala seeversi*	G1*/S1*		X	
A cave obligate pseudoscorpion	*Dinocheirus cavicolus*	G2G3/S2*		X	
A cave obligate spider	*Eidmennella nastuta*	G2G3/S2*		X	
A cave obligate spider	*Eidmennella reclusa*	G1G2/S1*		X	
A cave obligate copepod	*Elaphoidella n. sp.*	G1*/S1*		X	
Glossy wolfsnail	*Euglandina texasiana*	G1G2/S1S2*			X
Tamaulipan clubtail	*Gomphus gonzalezi*	G2/S2*			X
Edwards Aquifer diving beetle	*Haideoporus texanus*	G1G2/S1		X	
Comal Springs riffle	*Heterelmis comalensis*	G1/S1		X	

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beetle					
Fern Bank Springs riffle beetle	*Heterelmis sp.*	G1*/S1*		X	
Fessenden Springs riffle beetle	*Heterelmis sp.*	G1*/S1*		X	
Devils River Springs riffle beetle	*Heterelmis sp.*	G1*/S1*		X	X
A cuckoo bee	*Holcopasites jerryozeni*	G1*/S1*		X	
New Braunfels Holospira	*Holospira goldfussi*	G2G3/S2?*		X	
A cave obligate amphipod	*Holsingerius samacos*	G1G2/S1?*		X	
Clear Creek amphipod	*Hyalella texana*	G1/S1		X	
A caddisfly	*Hydroptila melia*	G2G3/S2?*		X	
A cave obligate amphipod	*Ingofiella n. sp.*	G1G2*/S1*		X	
Texas fatmucket	*Lampsilis bracteata*	G1/S1*		X	
A mayfly	*Latineosus cibola*	G1G2/S1?*			X
A cave obligate pseudoscorpion	*Leucohya texana*	G1G2/S1*		X	
A cave obligate isopod	*Lirceolus bisetus*	G1G2/S1*		X	
A cave obligate isopod	*Lirceolus hardeni*	G2G3/S2?*		X	
A cave obligate isopod	*Lirceolus pilus*	G2G3/S2?		X	
Texas troglobitic water slater	*Lirceolus smithii*	G1G2/S1		X	
A cave obligate beetle	*Lymantes nadineae*	G1*/S1*		X	
A mining bee	*Macrotera parkeri*	G1G2*/S1S2*		X	
A mining bee	*Macrotera robertsi*	G1*/S1*		X	
Comal siltsnail	*Marstonia comalensis*	G1/S1		X	
A leaf-cutting beetle	*Megachile parksi*	G1*/S1*			X
A cave obligate isopod	*Mexistenasellus coahuila*	G2G3/S2?*		X	
A cave obligate amphipod	*Mexiweckelia hardeni*	G2G3/S2?*		X	
Texas angle-wing	*Microcentrum minus*	G1?*/S1?*			X
Texas urocoptid	*Microceramus texanus*	G2/S2*		X	
Edwards Plateau liptooth	*Millerelix gracilis*	G2G3/S2?*		X	
A narrow-waisted bark beetle	*Myrmecoderus laevipennis*	G1*/S1*		X	
A caddisfly	*Nectopsyche texana*	G1G3/S2?*		X	
Texas minute moss beetle	*Neocylloepus boeseli*	G1G2*/S1*			X
A cave obligate spider	*Neoleptoneta anopica*	G1G2/S1*		X	
A cave obligate spider	*Neoleptoneta bullis*	G1G2*/S1*		X	
A cave obligate spider	*Neoleptoneta concinna*	G1G2/S1*		X	
A cave obligate spider	*Neoleptoneta devia*	G1G2/S1*		X	
Government Canyon Bat Cave spider	*Neoleptoneta microps*	G1G2/S1		X	
Tooth Cave spider	*Neoleptoneta myopica*	G1G2/S1		X	
A cave obligate spider	*Neoleptoneta valverde*	G1G2/S1*		X	
A caddisfly	*Neotrichia juani*	G1/S1*		X	
American burying beetle	*Nicrophorus americanus*	G1/S1	X		
A cave obligate copepod	*Nitocrellopsis texana*	G1*/S1*		X	
A cave obligate springtail	*Oncopodura fenestra*	G2G3/S2?*		X	
A snout moth	*Oxyelophila callista*	G1?*/S1?*		X	

Species	Specific Epithet	Global/State Ranking	Blackland Prairies	Edwards Plateau	South Texas Plains
A caddisfly	*Oxyethira ulmeri*	G2G3/S2?*		X	
A cave obligate shrimp	*Palaemonetes antrorum*	G2G3/S2?*		X	
Texas river shrimp	*Palaemonetes texanaus*	G1G2*/S1?*		X	
A cave obligate amphipod	*Parabogidiella americana*	G2G3/S2?*		X	
A cave obligate amphipod	*Paraholsingerius smaragdinus*	G2G3/S2?*		X	
Pointytop finger clam shrimp	*Paralimnetis texana*	G1/S1*		X	
A cave obligate amphipod	*Paramexiweckelia ruffoi*	G1G2/S1?*		X	
Pedernales oval	*Patera leatherwoodi*	G1/S1*		X	
Daedelus sheildback katydid	*Pediodectes daedelus*	G1?*/S1?*			X
Mitchell’s shieldback katydid	*Pediodectes mitchelli*	G1?*/S1?*			X
Pratt’s shieldback katydid	*Pediodectes pratti*	G1?*/S1?*			X
A mining bee	*Perdita dolanensis*	G1*/S1*		X	
A mining bee	*Perdita fraticincta*	G1*/S1*			X
A mining bee	*Perdita tricincta*	G1*/S1*			X
A snout moth	*Petrophila daemonalis*	G1?*/S1?*		X	
Hueco cavesnail	*Phreatodrobia conica*	G1/S1*		X	
Mimic cavesnail	*Phreatodrobia imitata*	G1/S1		X	
Flattened cavesnail	*Phreatodrobia micra*	G2G3/S2S3		X	
Nymph trumpet	*Phreatodrobia nugax*	G1G2/S1*		X	
Disc cavesnail	*Phreatodrobia plana*	G2/S2*		X	
High-hat cavesnail	*Phreatodrobia punctata*	G2/S2*		X	
Beaked cavesnail	*Phreatodrobia rotunda*	G1G2/S1*		X	
A mayfly	*Plauditus texanus*	G2G3/S1?*		X	
Comanche harvester ant	*Pogonomyrmex comanche*	G2G3*/S2*		X	
Texas hornshell	*Popenaias popeii*	G1/S1			X
Texas heelsplitter	*Potamilus amphichaenus*	G1G2/S1	X		
Salina mucket	*Potamilus metnecktayi*	G1/S1			X
White scrubsnail	*Praticolella candida*	G2/S2*			X
Hidalgo scrubsnail	*Praticolella trimatris*	G2/S2*			X
Nueces crayfish	*Procambarus nueces*	G1/S1			X
Regal burrowing crayfish	*Procambarus regalis*	G2G3/S2?*	X		
Parkhill prairie crayfish	*Procambarus steigmani*	G1G2/S1S2*	X		
A mayfly	*Procloeon distinctum*	G1G3/S2?*		X	
A mining bee	*Protandrena maurula*	G1G2*/S1S2*		X	
A caddisfly	*Protoptila arca*	G1/S1		X	
A mayfly	*Pseudocentroptiloides morihari*	G2G3/S2?*	X		
A tiger moth	*Pygarctia lorula*	G2G3/S2?*		X	
Golden orb	*Quadrula aurea*	G1/S2*		X	X
Smooth pimpleback	*Quadrula houstonensis*	G2/S1S2*		X	
False spike	*Quadrula mitchelli*	GH/SH		X	
Texas pimpleback	*Quadrula petrina*	G2/S1*		X	
A cave obligate beetle	*Rhadine austinica*	G1G2/S1*		X	
A cave obligate beetle	*Rhadine bullis*	G2*/S2		X	
A cave obligate beetle	*Rhadine exilis*	G1/S1		X	
A cave obligate beetle	*Rhadine infernalis*	G2G3/S1		X	
A cave obligate beetle	*Rhadine insolata*	G1G2/S1*		X	
A cave obligate beetle	*Rhadine noctivaga*	G1G2/S1*		X	
A cave obligate beetle	*Rhadine persephone*	G1G2/S1		X	
A cave obligate beetle	*Rhadine reyesi*	G1G2*/S1S2*		X	

Species	**Specific Epithet**	**Global/State Ranking**	**Blackland Prairies**	**Edwards Plateau**	**South Texas Plains**
A cave obligate beetle	*Rhadine russelli*	G1G2/S1*		X	
A cave obligate beetle	*Rhadine speca*	G2*/S2*		X	
A cave obligate beetle	*Rhadine subterranea*	G2*/S2*		X	
A cave obligate amphipod	*Seborgia relicta*	G2G3/S2?*		X	
A cave obligate isopod	*Speocirolana hardeni*	G2G3/S2?*		X	
A cave obligate millipede	*Speodesmus echinourus*	G2G3/S2?*		X	
A cave obligate millipede	*Speodesmus falcatus*	G2*/S2*		X	
A cave obligate millipede	*Speodesmus ivyi*	G2*/S2*		X	
A cave obligate millipede	*Speodesmus reddelli*	G2*/S2*		X	
Sage sphinx	*Sphinx eremitoides*	G1G2/S1?*	X	X	
Manfreda giant-skipper	*Stallingsia maculosus*	G1G2/S1S2			X
Spinyfinger fairy shrimp	*Streptocephalus linderi*	G2/S2*		X	
A cave obligate amphipod	*Stygobromus balconis*	G2G3/S1		X	
Cascade Cave amphipod	*Stygobromus dejectus*	G1G2/S1		X	
Ezell's Cave amphipod	*Stygobromus flagellatus*	G2G3/S1		X	
Devil's Sinkhole amphipod	*Stygobromus hadenoecus*	G1G2/S1		X	
Border Cave amphipod	*Stygobromus limbus*	G1G2/S1*		X	
Long-legged Cave amphipod	*Stygobromus longipes*	G2G3/S1		X	
Neel's Cave amphipod	*Stygobromus n. sp.*	G1G2*/S1*		X	
Devil's River Cave amphipod	*Stygobromus n. sp.*	G1G2*/S1*		X	
Fessenden Cave amphipod	*Stygobromus n. sp.*	G1G2*/S1*		X	
Lost Maples Cave amphipod	*Stygobromus n. sp.*	G1G2*/S1*		X	
San Gabriel Cave amphipod	*Stygobromus n. sp.*	G1G2*/S1*		X	
Peck's Cave amphipod	*Stygobromus pecki*	G1G2/S1		X	
Reddell stygobromid	*Stygobromus reddelli*	G1G2/S1		X	
A cave obligate amphipod	*Stygobromus russelli*	G1G2*/S1*		X	
Comal Springs dryopid beetle	*Stygopamus comalensis*	G1G2/S1		X	
Barton cavesnail	*Stygopyrgus bartonensis*	G1/S1		X	
A mayfly	*Susperatus tonkawa*	G1/S1*	X		
A cave obligate pseudoscorpion	*Tartarocreagris altimana*	G1G2*/S1*		X	
A cave obligate pseudoscorpion	*Tartarocreagris amblyopa*	G1G2*/S1*		X	
A cave obligate pseudoscorpion	*Tartarocreagris attenuata*	G1G2*/S1*		X	
A cave obligate pseudoscorpion	*Tartarocreagris domina*	G1G2*/S1*		X	
A cave obligate pseudoscorpion	*Tartarocreagris grubbsi*	G1G2*/S1*		X	
A cave obligate pseudoscorpion	*Tartarocreagris hoodensis*	G1G2*/S1*		X	
A cave obligate pseudoscorpion	*Tartarocreagris infernalis*	G2G3/S2?*		X	

Species	Specific Epithet	Global/State Ranking	Blackland Prairies	Edwards Plateau	South Texas Plains
A cave obligate pseudoscorpion	*Tartarocreagris intermedia*	G1G2/S1*		X	
A cave obligate pseudoscorpion	*Tartarocreagris proserpina*	G1G2*/S1*		X	
A cave obligate pseudoscorpion	*Tartarocreagris reddelli*	G1G2*/S1*		X	
A cave obligate pseudoscorpion	*Tartarocreagris reyesi*	G1G2*/S1*		X	
Tooth Cave pseudoscorpion	*Tartarocreagris texana*	G1G2/S1		X	
A cave obligate crustacean	*Tethysbaena texana*	G2G3/S2?*		X	
Kretschmarr Cave mold beetle	*Texamaurops reddelli*	G2G3/S1		X	
A bathynellid	*Texanobathynella bowmani*	G2G3/S2?*		X	
Striated hydrobe	*Texapyrgus longleyi*	G1/S1		X	
A cave obligate harvestman	*Texella brevidenta*	G1G2/S1*		X	
A cave obligate harvestman	*Texella brevistyla*	G1G2/S1*		X	
Cokendolpher Cave harvestman	*Texella cokendolpheri*	G1G2/S1		X	
A cave obligate harvestman	*Texella diplospina*	G1G2/S1*		X	
A cave obligate harvestman	*Texella grubbsi*	G1G2/S1*		X	
A cave obligate harvestman	*Texella hardeni*	G1G2/S1*		X	
A cave obligate harvestman	*Texella mulaiki*	G2G3/S2*		X	
Reddell harvestman	*Texella reddelli*	G2G3/S2*		X	
A cave obligate harvestman	*Texella renkesae*	G1G2/S1*		X	
Bone Cave harvestman	*Texella reyesi*	G2G3/S2*		X	
A cave obligate harvestman	*Texella spinoperca*	G1G2*/S1*		X	
A cave obligate amphipod	*Texiweckelia texensis*	G2G3/S2?*		X	
Texas fawnsfoot	*Truncilla macrodon*	G2Q/S1*		X	
A cave obligate pseudoscorpion	*Tyrannochthonius muchmoreorum*	X		X	
A cave obligate pseudoscorpion	*Tyrannochthonius troglodytes*	G1G2/S1*		X	
A caddisfly	*Xiphocentron messapus*	G1G3/S2?*		X	
Plants					
Texas trumpets	*Acleisanthes crassifolia*	G2/S2			X
Wright’s trumpets	*Acleisanthes wrightii*	G2/S2			X
Vasey’s adelia	*Adelia vaseyi*	G3/S3			X
Osage Plains false foxglove	*Agalinis densiflora*	G3/S2	X	X	
Texas amorpha	*Amorpha roemeriana*	G3/S3		X	
Silvery wild-mercury	*Argythamnia argyraea*	G2/S2			X
Prostrate milkweed	*Asclepias prostrata*	G1G2/S1S2			X
Cory’s woolly locoweed	*Astragalus mollissimus var. coryi*	G5T3/S3		X	
Texas milkvetch	*Astragalus reflexus*	G3/S3	X	X	X
Wright’s milkvetch	*Astragalus wrightii*	G3/S3		X	
Star cactus	*Astrophytum asterias*	G2/S1S2			X
Kleberg saltbush	*Atriplex klebergorum*	G2/S2			X

Species	Specific Epithet	Global/State Ranking	Blackland Prairies	Edwards Plateau	South Texas Plains
Anacacho orchid	*Bauhinia lunarioides*	G3/S1		X	X
Texas barberry	*Berberis swaseyi*	G3/S3		X	
Enquist’s sandmint	*Brazoria enquistii*	G2/S2		X	
Gravelbar brickellbush	*Brickellia dentata*	G3G4/S3S4		X	
Narrowleaf brickellbush	*Brickellia eupatorioides var. gracillima*	G5T3/S3		X	
South Texas rushpea	*Caesalpinia phyllanthoides*	G2/S1			X
Two-flower stick-pea	*Calliandra biflora*	G3/S3			X
Oklahoma grass pink	*Calopogon oklahomensis*	G3/S1S2	X		
Basin bellflower	*Campanula reverchonii*	G2/S2		X	
Texas largeseed bittercress	*Cardamine macrocarpa var. texana*	G3T2/S2		X	
Chihuahuan balloon-vine	*Cardiospermum dissectum*	G2G3/S3			X
Canyon sedge	*Carex edwardsiana*	G3G4/S3S4	X	X	
Shinner’s sedge	*Carex shinnersii*	G3?/S2	X		
Spreading leastdaisy	*Chaetopappa effusa*	G3G4/S3S4		X	
Scarlet leather-flower	*Clematis texensis*	G3G4/S3S4		X	
Comal snakewood	*Colubrina stricta*	G2/S1		X	
Crown tickseed	*Coreopsis nuecensis*	G3/S3			X
Runyon’s cory cactus	*Coryphantha macromeris var. runyonii*	G5T2T3/S2S3			X
Nickel’s cory cactus	*Coryphantha nickelsiae*	G2/SH			X
Dallas hawthorn	*Crataegus dallasiana*	G3Q/S3	X		
Turners’ hawthorn	*Crataegus turnerorum*	G3Q/S3		X	
Texabama croton	*Croton alabamensis var. texensis*	G3T2/S2		X	
Tree dodder	*Cuscuta exaltata*	G3/S3	X	X	X
Hall’s prairie-clover	*Dalea hallii*	G3/S3	X	X	
Sabinal prairie-clover	*Dalea sabinalis*	GH/SH		X	
Net-leaf bundleflower	*Desmanthus reticulates*	G3/S3		X	X
Lindheimer’s tickseed	*Desmodium lindheimeri*	G3G4/S1		X	
Don Richard’s spring moss	*Donrichardsia macroneuron*	G1/S1		X	
Topeka purple-coneflower	*Echinacea atrorubens*	G3/S3	X		
Texas claret-cup cactus	*Echinocereus coccineus var. paucispinus*	G5T3/S3		X	
Yellow-flowered alicoche	*Echinocereus papillosus*	G3/S3			X
Fitch’s hedgehog cactus	*Echinocereus reichenbachii ssp. fitchii*	G5T3/S3			X
Black lace cactus	*Echinocereus reichenbachii var. albertii*	G5T1Q/S1			X
Cory’s ephedra	*Ephedra coryi*	G3/S3		X	
Small-headed pipewort	*Eriocaulon koernickianum*	G2/S1		X	
Gregg’s wild-buckwheat	*Eriogonum greggii*				X
Irion County wild-buckwheat	*Eriogonum nealleyi*	G2/S2		X	
Basin wild-buckwheat	*Eriogonum tenellum var. ramosissimum*	G5T3/S3		X	
Low spurge	*Euphorbia peplidion*	G3/S3		X	X
Texas fescue	*Festuca versuta*	G3/S3		X	
Johnston’s frankenia	*Frankenia johnstonii*	G3/S3			X
Watson’s milk-pea	*Galactia watsoniana*	G1/S1		X	
Woolly butterfly-weed	*Gaura villosa ssp. parksii*	G5T3/S3			X
South Texas gilia	*Gilia ludens*	G3/S3		X	X
Texas greasebush	*Glossopetalon texense*	G1/S1		X	

Species	Specific Epithet	Global/State Ranking	Blackland Prairies	Edwards Plateau	South Texas Plains
Dimmit sunflower	*Helianthus praecox ssp. hirtus*	G4T2Q/S2			X
Red yucca	*Hesperaloe parviflora*	G3/S3		X	
Mexican mud-plantain	*Heteranthera mexicana*	G2G3/S1			X
Glass Mountains coral-root	*Hexalectris nitida*	G3/S3	X	X	
Warnock’s coral-root	*Hexalectris warnockii*	G2G3/S2	X	X	
Drummond’s rushpea	*Hoffmannseggia drummondii*	G3/S3			X
Slender rushpea	*Hoffmannseggia tenella*	G1/S1			X
Correll’s bluet	*Houstonia correllii*	G1/S1			X
Greenman’s bluet	*Houstonia croftiae*	G3/S3			X
Greenman’s bluet	*Houstonia parviflora*	G3/S3		X	X
Pygmy prairie dawn	*Hymenoxys pygmea*	G1/S1	X		
Rock quillwort	*Isoetes lithophila*	G2/S2		X	
Piedmont quillwort	*Isoetes piedmontana*	G3/S1		X	
Texas stonecrop	*Lenophyllum texanum*	G3/S3			X
Glandular gay-feather	*Liatris glandulosa*	G3/S3	X		
Plateau loosestrife	*Lythrum ovalifolium*	G3G4/S3S4		X	
St. Joseph’s staff	*Manfreda longiflora*	G2/S2			X
Siler’s huaco	*Manfreda sileri*	G3/S3			X
Walker’s manioc	*Manihot walkerae*	G3/S3			X
Shortcrown milkvine	*Matelea brevicoronata*	G3/S3			X
Plateau milkvine	*Matelea edwardsensis*	G3/S3		X	
Falfurrias milkvine	*Matelea radiata*	GH/SH			X
Arrowleaf milkvine	*Matelea sagittifolia*	G3/S3		X	X
Stanfield’s beebalm	*Monarda punctata var. stanfieldii*	G5T3/S3		X	
Villous muhly	*Muhlenbergia villiflora var. villosa*	G5T3/S2		X	
Longstalk heimia	*Nesaea longipes*	G2G3/S2		X	
Heartleaf evening-primrose	*Oenothera cordata*	G3/S3		X	X
Heller’s marbleseed	*Onosmodium helleri*	G3/S3		X	
Llano butterweed	*Packera texensis*	G2/S2		X	
Bushy whitlow-wort	*Paronychia congesta*	G1/S1			X
McCart’s whitlow-wort	*Paronychia maccartii*	G1/S1			X
Bristle nailwort	*Paronychia setacea*	G3/S3	X		X
Turnip-root scurfpea	*Pediomelum cyphocalyx*	G3G4/S3S4		X	
Rydberg’s scurfpea	*Pediomelum humile*	G1/S1			X
Guadalupe beardtongue	*Penstemon guadalupensis*	G3/S3		X	
Heller’s beardtongue	*Penstemon triflorus ssp. integrifolius*	G3T3/S2		X	
Threeflower penstemon	*Penstemon triflorus ssp. triflorus*	G3T3/S3		X	
Canyon bean	*Phaseolus texensis*	G2/S2		X	
Canyon mock-orange	*Philadelphus ernestii*	G3/S3		X	
Oklahoma phlox	*Phlox oklahomensis*	G3/SH	X		
Hawksworth’s mistletoe	*Phoradendron hawksworthii*	G3/S3		X	
Sand sheet leaf-flower	*Phyllanthus abnormis var. riograndensis*	G5T3/S3			X
Engelmann’s bladderpod	*Physaria engelmannii*	G3/S3	X	X	
Zapata bladderpod	*Physaria thamnophila*	G1/S1			X
Correll’s false dragon-head	*Physostegia correllii*	G2/S2		X	
South Texas yellow clammyweed	*Polanisia erosa ssp. breviglandulosa*	G5T3T4/S3S4B			X
Palmer’s milkwort	*Polygala palmeri*	G3/S2		X	
Parks’ jointweed	*Polygonella parksii*	G2/S2	X		
Stinking rushpea	*Pomaria austrotexana*	G3/S3			X

Species	Specific Epithet	Global/State Ranking	Blackland Prairies	Edwards Plateau	South Texas Plains
Broadpod rushpea	*Pomaria brachycarpa*	G2/S2		X	
Canyon rattlesnake-root	*Prenanthes carrii*	G2/S2		X	
Texas almond	*Prunus minutiflora*	G3G4/S3S4		X	X
Texas peachbush	*Prunus texana*	G3G4/S3S4	X	X	X
South Texas false cudweed	*Pseudognaphalium austrotexanum*	G3/S3			X
Big red sage	*Salvia penstemonoides*	G1/S1		X	
Tobusch fishhook cactus	*Sclerocactus brevihamatus ssp. tobuschii*	G4T3/S3		X	
Large selenia	*Selenia grandis*	G3/S3			X
Jones' selenia	*Selenia jonesii*	G3/S3		X	X
Texas seymeria	*Seymeria texana*	G3/S3		X	
Springrun whitehead	*Shinnersia rivularis*	G2G3/S1		X	
Florida pinkroot	*Spigelia texana*	G3/S3		X	
Bracted twistflower	*Streptanthus bracteatus*	G1G2/S1S2		X	
Broadpod twistflower	*Streptanthus platycarpus*	G3/S3		X	
Sycamore-leaf snowbell	*Styrax platanifolius ssp. platanifolius*	G3T3/S3		X	
Hairy sycamore-leaf snowbell	*Styrax platanifolius ssp. stellatus*	G3T3/S1		X	
Texas snowbells	*Styrax platanifolius ssp. Texanus*	G3T1/S1		X	
Billie's bitterweed	*Tetraneuris turneri*	G3/S3			X
Texas meadow-rue	*Thalictrum texanum*	G2/S2	X		
Burridge greenthread	*Thelesperma burridgeanum*	G3/S3			X
Shinner's rocket	*Thelypodiopsis shinnersii*	G2/S2			X
Ashy dogweed	*Thymophylla tephroleuca*	G2/S2			X
Bailey's ballmoss	*Tillandsia baileyi*	G2G3/S2			X
Buckley's spiderwort	*Tradescantia buckleyi*	G3/S3			X
Granite spiderwort	*Tradescantia pedicellata*	G2Q/S2		X	
Darkstem noseburn	*Tragia nigricans*	G3/S3		X	
Buckley tridens	*Tridens buckleyanus*	G3G4/S3S4		X	
Bigflower cornsalad	*Valerianella stenocarpa*	G3/S3		X	
Edwards Plateau cornsalad	*Valerianella texana*	G2/S2		X	
Small-leaved yellow velvet-leaf	*Wissadula parvifolia*	G1/S1			X
Texas shrimp-plant	*Yeatesia platystegia*	G3G4/S3S4			X
Jones's rainlily	*Zephyranthes jonesii*	G3/S3			X
Texas wild rice	*Zizania texana*	G1/S1	X	X	

[1] Global Conservation Ranking/State Conservation Ranking

GX/SX – Presumed Extinct; not located despite intensive searches and virtually no likelihood of discovery

GH/SH – Missing; known from only historical occurrences but still some hope of discovery

G1/S1 – Critically Imperiled; At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors

G2/S2 – Imperiled; At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors

G3/S3 – Vulnerable; At moderate risk of extinction due to restricted range , relatively few populations (often 80 or fewer), recent and widespread declines, or other factors

G4/S4 – Apparently Secure; Uncommon but not rare; some cause for long-term concern due to declines or other factors

G5/S5 – Secure; Common, widespread and abundant

GNR/SNR – Unranked; Nation or state conservation status not yet assessed

GU/SU – Unrankable; Currently unrankable due to lack of information or due to substantially conflicting information about status or trends

SNA – Secure; Common, widespread, and abundant in the nation or state

? – Inexact Numeric Rank

Q – Questionable Taxonomy; Taxonomic distinctiveness of this entity at the current level is questionable; resolution of this uncertainty may result in change from a species to a subspecies or hybrid, or the inclusion of this taxon, with the resulting taxon having a lower-priority conservation priority

Species	Specific Epithet	Global/State Ranking	Blackland Prairies	Edwards Plateau	South Texas Plains

T# – Infraspecific Taxon; The status of infraspecific taxa (subspecies or varieties) are indicated by a “T-rank” following the species’ global rank.

G#G#/S#S# - Range Rank; A numeric range rank (e.g. G2G3/S2S3) is used to indicate the range of uncertainty in the status of a species.

NP – Not Provided

B – Breeding; Conservation status referes to the breeding population of the species

N – Nonbreeding; Conservation status refers to the non-breeding population of the species

ATTACHMENT 3: WESTSIDE CREEKS AVIAN SURVEY TEAM

Study Lead:
Danny Allen (CESWF)

Lead Birding Expert:
Martin Reid

Birding Experts:
Sheridan Coffee
Tom Collins
Dana Green
Fred Land (CESWF)
Derek Muschalek
Brent Ortego (TPWD)
Richard Redmond
Bobby Shelton (CESWF)

Birding Assistants:
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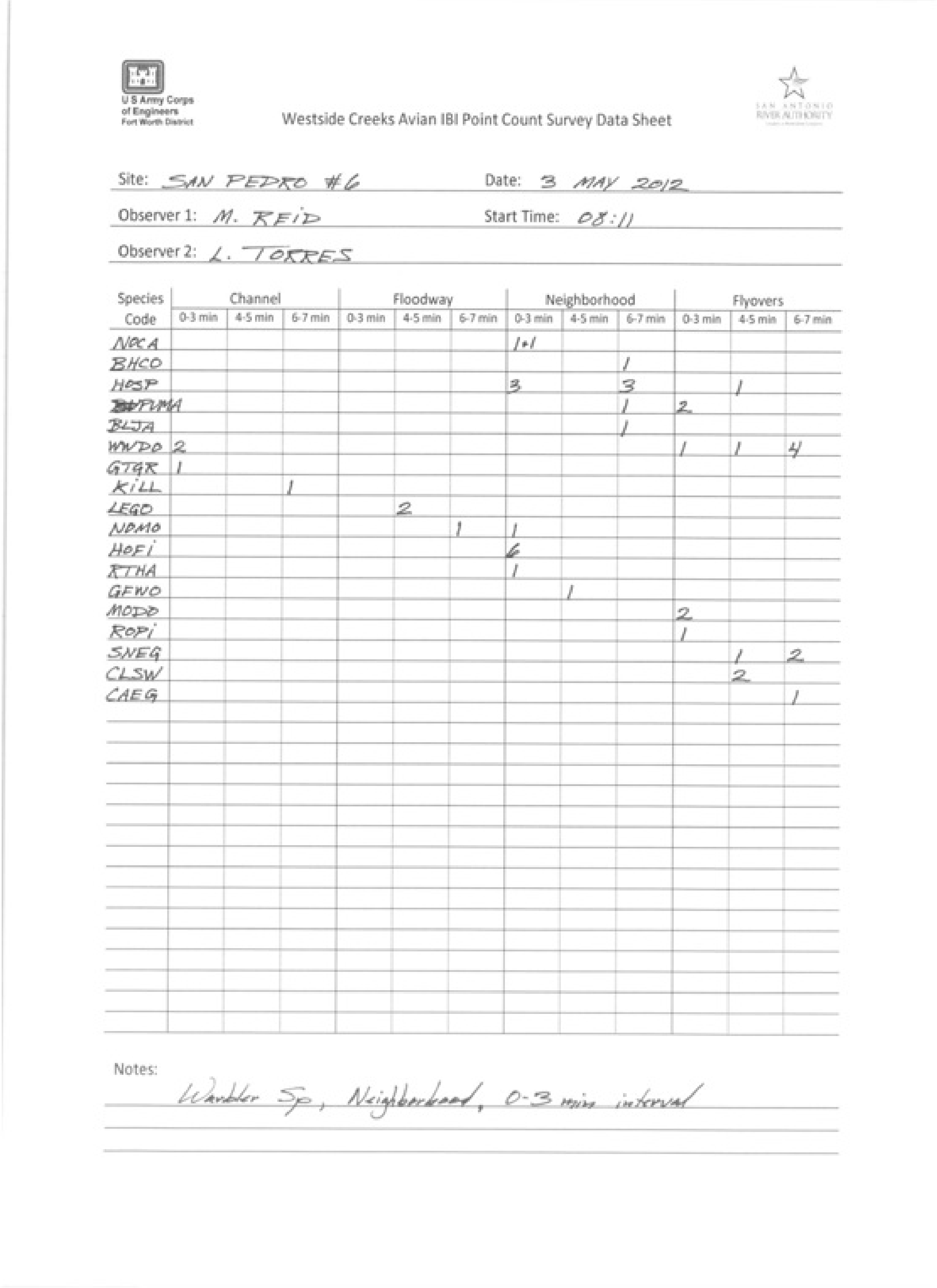
Beth Bendik (TPWD)
Mark Blair (CESWF)
Steven Caparco (CESWF)
Bill Colbert (CESWF)
Cim Howell
Sarah Kervin (CESWF)
Simon Ng (CESWF)
Cliff Shackelford (TPWD)
Leanna Torres (CESWF)
Palani Whiting (SARA)
Susan Wolters (CESWF)

ATTACHMENT 4: AVIAN POINT COUNTY SURVEY DATA SHEET



U S Army Corps
of Engineers
Fort Worth District

Westside Creeks Avian IBI Point Count Survey Data Sheet

SAN ANTONIO RIVER AUTHORITY

Site: SAN PEDRO #6

Date: 3 MAY 2012

Observer 1: M. REID

Start Time: 08:11

Observer 2: L. TORRES

Species Code	Channel			Floodway			Neighborhood			Flyovers		
	0-3 min	4-5 min	6-7 min	0-3 min	4-5 min	6-7 min	0-3 min	4-5 min	6-7 min	0-3 min	4-5 min	6-7 min
NOCA							1+1					
BHCO									1			
HOSP							3		3		1	
PUMA									1	2		
BLJA									1			
WWDO	2									1	1	4
GTGR	1											
KILL			1									
LEGO					2							
NOMO						1	1					
HOFI							6					
RTHA							1					
GFWO								1				
MODO										2		
ROPI										1		
SNEG											1	2
CLSW											2	
CAEG												1

Notes:

Warbler Sp, Neighborhood, 0-3 min interval

ATTACHMENT 5: WESTSIDE CREEKS AQUATIC HABITAT SURVEY

WEST SIDE CREEKS: FISH-HABITAT RELATIONSHIPS

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Engineer Research and Development Center
Environmental Laboratory
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INTRODUCTION

The San Antonio River basin is physically and faunistically distinctive from all other basins of the western Gulf Slope (Conner and Suttkus, 1986). It has the third smallest drainage area (10, 619 km^2) and discharge is low (<<0.1 m^3/km^2), but ionic concentrations (silica, calcium, magnesium, sodium, sulphate, chloride), total dissolved solids, hardness, specific conductance, and pH are the highest. Only 42 native freshwater fishes are documented, but 7 of these are eastern lowland or Mississippi Valley fishes at the southwestern most limits of their distribution. Native fish communities are dominated taxonomically by minnows and darters, including the state-endemic Texas shiner and Texas logperch. Environmentally sensitive ("intolerant") species, however, may constitute low percentages (< 6%) of the total biomass (Gonzales, 1988; Edwards, 2001).

Aquatic communities of the main channel of the San Antonio River are impacted by: urbanization and flood control projects; loss of riparian zone and floodplain habitats (pers. obs.); reduced complexity of instream physical habitat and availability of natural habitat (Gonzales, 1988); elevated nutrient levels (TNRCC, 2002); and burgeoning populations of exotic fishes (Hubbs et al. 1978; Hubbs, 1982; Edwards, 2001). Main channel fish assemblages in 2003 were comprised of 32 species, with diversity and biomass positively correlated with stream depth (Hoover et al., 2004).

Tributaries of the San Antonio River are subject to the same stressors as the main channel, but of possibly greater magnitude (e.g., deforestation), and others including impoundment, altered sediment transport, and elevated water temperatures. Collectively, these factors have reduced water volume, habitat quality, and connectivity among stream reaches, resulting in losses of fish habitat and passage. Conditions are pronounced in the San Pedro Creek drainage in the western San Antonio River Basin, referred to as Westside Creeks. Losses in riparian vegetation (with associated allochthonous inputs) and riffle-pool-run sequences (with associated habitat complexity) prompted a feasibility study to identify non-structural options for habitat restoration that would restore riparian-riverine functions while retaining or enhancing flood control and recreation (USACE, 2011a).

The U.S. Army Corps of Engineers (USACE) Fort Worth District, in partnership with the San Antonio River Authority (SARA) are developing and evaluating ecosystem restoration alternatives to provide recommendations for project implementation. As part of the planning process, the Engineer Research and Development Center, Environmental Laboratory (ERDC-EL) conducted an aquatic survey in Westside Creeks and nearby reference streams in April 2012 with the following goals:

- Provide an aquatic habitat description for each stream
- Describe fish assemblages for each stream
- Identify habitat limitations for Westside Creek reaches
- Recommend potential restoration measures to improve aquatic habitat for Westside Creeks

STUDY AREA

The proposed study includes San Pedro Creek from 1-35 to the confluence with the San Antonio River, Apache Creek from the Elmendorf Lake Dam to the confluence with San Pedro Creek, Alazan Creek from the Woodlawn Lake Dam to the confluence with Apache Creek, and Martinez Creek from Hildebrand Street to the confluence with Alazan Creek. All four creeks are contained within urban San Antonio and comprise the Westside Creeks system (USACE, 2011b).

- Martinez Creek is concrete-lined just above the project limit and is “broken” mid-length by culverts crossing under Interstate 10W. Sedimentation occurs throughout the system and is extensive in some locations. It is tributary to Alazan Creek.
- Alazan Creek is impounded at its upper limit (Woodlawn Lake) and walled on both sides at one location. It is sediment-starved above its confluence with Martinez Creek. Alazan Creek is tributary to San Pedro Creek.
- Apache Creek is impounded at its principal tributary Zarzamora Creek (Elmendorf Lake). The lake is a sediment trap, with 4-6 feet of accumulated sediment, and is stagnant. Water enters the stream from the lake only when overtopped at the weir and banks; sedimentation is extensive downstream to the confluence with the upper reach of Apache Creek. Aeration and water release structures have been proposed for the lake. Apache Creek is tributary to San Pedro Creek.
- San Pedro Creek flows through underground tunnels except at its uppermost and lower most reaches where it receives water from Alazan and Apache Creeks. It is tributary to the San Antonio River.

In addition to the four impacted streams within the project area, two reference streams, with reaches flowing extensively through non-urban areas, were sampled:

- Medio Creek is comparable in size and located directly west of Westside Creeks streams. It is tributary to the Medina River. Riparian forest may be thin or moderate, but is continuous at some reaches.
- Medina River is west and south of the Westside Creeks streams and is impounded in its upper reach (Medina Lake). Riparian forest may be substantial. It is substantially wider than any of the other streams.

Thirty-four collections were made at 15 stations throughout the study area: 2-3 stations/stream, 1-4 habitats/station. Twenty-eight localities or units (i.e., individual habitat at a station) were sampled by seine once during the period 11-12 Apr 2012. Six units were also sampled by electrofishing. Stations were distributed among the following waterbodies: Alazan Creek (2), Apache Creek (3), Martinez Creek (2), Medio Creek (3), Medina River (2) and San Pedro Creek (3). Maps highlighting location of each respective system and geographic location of each sample station are depicted in Figures 5-10. A detailed description of each sample station and general sampling conditions is provided in Attachment 4-1.

METHODS

FIELD METHODS

Physical habitat (stream hydraulics, substrate, and water quality) and fish communities (species-abundance, size structure) were sampled concurrently at discrete habitats (riffles, runs, glides, and pools) within the streams. Fishes were collected by seining or electrofishing within a defined homogenous macrohabitat unit (e.g., pool, run, glide, riffle, backwater) at each sampled station. Because of the small and highly variable size of individual habitats, standard sampling effort was inappropriate and scaled appropriately to the size of each individual locality. Small seines (8' x 10' length; no more than 10 hauls) were used in smaller streams and larger seines (8' x 20-ft length; 5 hauls) in the largest stream (Medina River). Both seines were constructed of 3/16" mesh. In addition, a Smith Root PC 15-B POW backpack electrofisher was used to sample a subset of macrohabitat units to facilitate comparisons of sampling effectiveness between gear types. Effort for electrofishing was recorded as total shocking time (seconds) for each sampled unit. Catch-per-unit-effort (CPUE) for seine samples was computed as number of individuals per seine haul. CPUE for electrofishing samples was computed as number of individuals per second of shocking time, and then standardized to a 60 second period to equate with the amount of time expended for a general seine haul conducted during this project period.

All fish were fixed in 10% formalin except for large specimens which were identified, measured, and released in the field. In the laboratory, preserved fishes were rinsed, sorted, identified, enumerated, and measured (total length to nearest mm). Specimens were preserved in isopropyl alcohol, cataloged, and deposited in the collections of the University of Louisiana at Monroe Museum of Natural History. Catalog numbers are available on request.

Water quality parameters were determined for each river section or macrohabitat unit sampled. Dissolved oxygen (mg/L), pH, conductivity (µS) and water temperature (C) were measured with a Quanta Hydrolab®. Turbidity (NTU) was measured with a Hach 2100P® turbidimeter. River width (m) and sampling distance (m) were measured using a Bushnell® laser rangefinder. Water depth (m, stadia rod) and surface velocity (cm/sec, Marsh-McBirney Flo-Mate) were taken at 5 equidistant points along a cross-sectional transect within the sampled reach. Dominant and sub-dominant substrata were recorded for each transect point following a modified Wentworth scale (Cummins 1962, Bain 1999). Stations were georeferenced using a hand-held Magellan® or Delorme PN40 GPS unit.

ANALYTICAL METHODS

The matrix for the comparison of environmental conditions consisted of 22 variables (Attachment 4-2) including measurements related to water quality (e.g., water temperature, dissolved oxygen, conductivity, pH, turbidity), physical habitat features (water depth, water velocity, stream width), land coverage attributes (percent overstory, shrub, herbaceous, rip-rap) and substrata (dominant, subdominant). Data were transformed (Log[x+1]), normalized and a Euclidean distance matrix was produced before conducting further analyses.

CPUE values in the final species matrix were square root transformed to reduce the influence of the most common species (Clarke and Gorley 2006). No species were excluded due to rarity. Resemblance matrices were created by computing Bray-Curtis similarity indices for each assemblage comparison. Analytical assessments of data structure (biological and environmental matrices) and sample similarity were computed with the procedures in the PRIMER (Plymouth Routines in Multivariate Ecological Research) version 6 statistical package (Clarke and Warwick 2001; Clarke and Gorley 2006).

Non-metric multi-dimensional scaling (MDS) was conducted to provide a graphical presentation of the similarity among samples in a low-dimensional space with those samples (i.e., points on the figure) occurring close together representing samples that are very similar in community composition. The reduction of the original dataset to a low-dimensional space is measured as "stress" and represents the effectiveness of the data reduction technique in depicting the similarity among samples in the original high-dimensional space. Values < 0.05 represent excellent representation of the low-dimensional solution with a value of 0.01 representing a perfect fit; < 0.1 represents a good solution; < 0.2 represents useful 2-dimensional solutions but signals the need for additional analyses to evaluate internal structure within the dataset; and stress values > 0.3 represent solutions that differ little from randomized points (Clarke and Warwick 2001).

An analysis of similarity (ANOSIM) was conducted to assess differences in species assemblages and/or environmental conditions between systems (e.g., Apache Creek and Medina River) or between any *a priori* defined groupings. This analytical approach is analogous to a 1-way ANOVA and assesses the degree of variability in similarity values within treatments in order to establish the strength of differences that may be found between treatments. The test statistic for ANOSIM, R, ranges from 0 to 1. Values close to 0 indicate little difference between groups and values approaching 1 represent complete separation of the groups (Clarke and Warwick 2001).

We calculated similarity percentages (SIMPER) on CPUE values to determine which species or environmental variable contribute to the similarity pattern depicted within groups (i.e., typifying species) as well as those features that contribute to the dissimilarity between groups (i.e., discriminating species). We conducted a hierarchical clustering technique (CLUSTER) on each respective resemblance matrices and incorporated the SIMPROF option to test for significance (alpha = 0.05) of internal structure.

A principal components analysis (PCA) was conducted to assess the relative importance of the measured environmental condition in developing discriminating factors (i.e., combination of environmental variables) for discerning differences between the respective groups of samples.

The BEST (Bio-Env + STepwise) routine was utilized to provide a measure of agreement between structure in the biotic assemblage and any multivariate environmental pattern depicted for the same sampled stations (Clarke and Gorley 2006).

RESULTS AND DISCUSSION

A total of 34 samples from representative macrohabitat units were taken at 15 stations resulting in 2,955 individuals representing 23 species of fishes during efforts conducted 11-12 April 2012 (Table 20). Sampling by seine was the predominant effort with 27 localities sampled with this gear type. The number of hauls varied depending on seine size with the 10' seine ranging 1-10 hauls (**mean** = 6.3; 24 units) and efforts with the 20' seine (3 localities) all consisting of 5 hauls. Seven (7) localities were sampled with both seine and backpack electrofisher (Table 20).

SPECIES RICHNESS

The number of species documented varied across stations, gear types and between habitats. Seining efforts, both sizes combined, documented 1-9 species per unit (**mean** = 3.7 species) with two units (pool and riffle) at Apache Creek yielding no catch. Electrofishing efforts produced 2-9 species (**mean** = 3.9) per sampled unit. The number of species varied between waterbodies with combined efforts on Alazan Creek yielding 2 species (**mean** = 2); San Pedro Creek, 1-4 species (**mean** = 2.2), Apache Creek, 2-5 species (**mean** = 2.3); Martinez Creek, 1-4 species (**mean** = 2.7); Medina River, 3-9 species (**mean** = 5.9) and Medio Creek, 4-9 species (**mean** = 6.4).

Combined sampling efforts by macrohabitat unit varied as well with pool units yielding 2-5 species **(mean** = 2.75) followed by riffle, 1-9 species (**mean** = 3.7); glide, 1-7 species (**mean** = 3.7); run, 1-9 species (**mean** = 4.5) and backwater, 6-7 species (**mean** = 6.7).

General trends in species diversity followed a similar pattern with variation attributed to gear type, waterbody and sampled habitat (Figure 11, 12). Comparative sampling efforts between seine and electrofishing gear generally resulted in greater or equal species diversity occurring with electrofishing efforts (Figure 11) although the mean number of species documented with each gear type was similar. Species diversity between habitat types was confounded by waterbody where total number of species was typically lower at Westside Creek stations. There was a similar pattern of diversity among macrohabitat units based on gear type with electrofishing generally resulting in slightly higher species diversity (Figure 12).

ENVIRONMENTAL CONDITIONS

The results of the MDS for the environmental conditions provided a good solution for a 3-dimensional portrayal of the data (stress = 0.11). The 2-D solution had a slight reduction in fit (stress = 0.16) (Figure 13) but illustrated a distinct separation between stations representing the reference systems (i.e., Medio Creek and Medina River) and the remaining samples in terms of measured habitat features. Sample units from San Pedro and Alazan creeks, along with numerous samples from Apache Creek, illustrated high similarity based on habitat conditions. Sample units from Martinez Creek were distinct from the remaining Westside Creek samples.

The similarity in environmental conditions is depicted well with the results of the CLUSTER analysis (Figure 14) indicating internal structure (i.e., statistically significant differences between clusters) by the SIMPROF analysis (Global Pi = 0.487, p = 0.001). Results of the ANOSIM indicated significant differences between waterbodies in terms of measured environmental conditions (Global R = 0.584, p = 0.001). The difference in habitat between Medio Creek and Medina River was statistically significant, and these two systems also differed from all remaining waterbodies (Table 12). Habitat features for Apache, San Pedro, Alazan and Martinez creek, in most cases, were not statistically different.

The PCA on the environmental variables provided a moderate solution with 78.1% of the variability in measured conditions being accounted for with 5 PC axes. Loadings on each axis were low to moderate with -0.483 reported as the highest overall loading (Table 22). All included variables had loadings > 0.300 except COND, SITE_LNGTH_M, SV_CV, SUB_SECONDARY_MEAN and SUB_SECONDARY_STD. PC axis 1 and 2 had higher loadings of variables generally associated with water quality and land coverage while PC axes 3-5 reflected physical habitat features of the sampled macrohabitat units. Inspection of the plots utilizing the first 2 axes provides a visual interpretation of the data and the relative loadings of each variable along each axis (Figure 15). The length of the trajectory for each variable indicates the strength of that particular variable for discriminating conditions along a particular axis.

Following the inclusion of all 22 environmental variables, the results of the BEST procedure indicated the best solution included 14 variables (Global Rho = 0.955, p = 0.01). The best explanatory variables, in descending order of contribution, included WTEM, COND, PH, TURBID, SV_MEAN, DEPTH_STD, WIDTH_DEPTH_RATIO, WET_PER, SHRUB, RIPRAP, OVR_W, SUB_PRIMARY_MEAN, SUB_SECONDARY_MEAN and SUB_SECONDARY_STD. Variables deemed non-significant in discriminating between sampled macrohabitat units were DO, SITE_LNGTH_M, SV_CV, DEPTH_MEAN, DEPTH_CV, OVRSTRY, HERB and SUB_PRIMARY_STD. Figure 16 depicts the correlations among all 22 environmental variables and illustrates well the lack of discriminating ability of some variables due to their correlative properties.

Using a more simplified approach we conducted a BEST procedure (BioEnv option) to determine which subset of the total suite of environmental variables best describes the pattern depicted in faunal assemblage for two groups (Westside Creeks vs. Reference Creeks) (Table 25). Five variables, in decreasing order of importance (DEPTH_STD, OVRSTRY, SHRUB, RIPRAP, SUB_SECONDARY_MEAN), were included in the best solution (r = 0.510, p= 0.010). Additional solutions with (r = 0.508, 0.502) included the same suite of variables except SHRUB and RIPRAP were replaced by OVR_W in their respective solutions.

All samples were coded based on respective station designation (Westside Creek, reference system [Medina River, Medio Creek]) and subjected to a SIMPER analysis to describe the contribution of each measured environmental variable in discerning differences (i.e., discriminating variables) between the two systems based on habitat conditions. Westside Creek stations were characterized with by no SHRUB, OVRSTRY or OVR_W and high levels of RIPRAP and HERB.

FISH FAUNA

The results of the MDS provided a good solution for a 3-dimensional portrayal of the data (stress = 0.11). The 2-D solution had a slight reduction in fit (stress = 0.17) but is presented instead due to ease of interpretation (Figure 17). Graphically, the MDS depicted a fairly clean separation between samples from the respective systems. In general, the depicted faunal pattern is similar to that portrayed with the environmental conditions of the sampled units (Figure 13).

Results of the SIMPROF indicated internal structure in terms of faunal similarity among the sampled stations (Global Pi = 1.574, p = 0.035) with the CLUSTER analysis (Figure 18) depicting major clusters among the sampled units. For example, the cluster containing sample units from Medio Creek and Medina River were faunistically similar and the inclusive cluster was significantly different from the remaining sample units. Similarly, all sample units from the Westside Creek stations were included within a single cluster that based on group averages was only 12% similar to the samples represented by the reference systems.

The one-way ANOSIM indicated significant fish assemblage differences between the sampled systems (Global R = 0.506, p = 0.001) with Medina River and Medio Creek being significantly different from all remaining systems except for one comparison between Medio and Martinez creeks (p = 0.006; Table 23). The remaining samples from the Westside Creek stations were not faunistically different.

Average faunal similarity (SIMPER analysis) between sample units within each respective waterbody ranged 24.8-43.2%. Westside Creek stations generally had a low number of species overall and samples were generally dominated by Central stoneroller, Common carp and Western mosquitofish. “Typifying species” (*sensu* Clarke and Gorley 2006) for Medio Creek samples included Western mosquitofish, Bluegill, Rio Grande cichlid, Longear sunfish and Red shiner which comprised 90.26% of the within group similarity. Similarly, Medina River samples included Blacktail shiner, Western mosquitofish, Central stoneroller, Rio Grande cichlid and Orangethroat darter which comprised 95.82% of the within group similarity for that system.

The average faunal dissimilarity between waterbodies included in the Westside Creek stations ranged 60.5-74.1% (SIMPER analysis) with most of these differences due to variations in CPUE abundance values for a few dominant species (Table 23, Martinez Creek & San Pedro Creek). In contrast, average dissimilarity between Westside Creek systems and reference systems were attributed in part to differences in species richness between the systems (i.e., 3 versus 7 species) and the differences in CPUE abundances for co-occurring species (i.e., Central stoneroller; Table 23). Overall, Westside Creeks are dominated by tolerant and small-sized invasive species of fish compared to reference streams. Large-bodied invasive fishes, such as suckermouth catfishes and tilapia that dominate the San Antonio River (Hoover et al 2002), were absent from the smaller tributaries suggesting that Westside Creeks are unsuitable for these species. Conversely, tributaries may be source populations for fish uncommon (e.g., Campostoma, logperch) in San Antonio River.

RESTORATION OPPORTUNITIES

Symptoms of the urban stream syndrome include a flashier hydrograph, elevated concentrations of nutrients and contaminants, altered channel morphology, and reduced biotic richness, with increased dominance of tolerant species (Walsh et al. 2005). Our analysis reflects these types of symptoms in Westside Creeks, but comparison to the Reference streams indicates that restoration will provide benefits. Best Analysis (Table 24) indicated certain environmental variables were correlated differently with Westside Creek compared to reference sites. To further illustrate this, an MDS was generated using average values from each waterbody and vectors were plotted showing environmental variables associated with potential restoration measures (Figure 19). Fish assemblages associated with Westside Creeks were correlated with reduced structural variables (vegetation, overstory), larger substrates including rip-rap, higher water temperatures, and shallower water (reduced depth and wetted perimeter). The type of fish assemblage (tolerant and more invasive species) reflect these degraded habitat conditions. Reference streams suggest that certain restoration measures will have a positive benefit to native fishes. Specifically, increasing overstory and stream riparian cover, along with greater depths and water velocity, should result in higher richness and diversity of the fish assemblage. This analysis provides justification to improve habitat conditions of Westside Creek with expected benefits to the overall aquatic community.

ACKNOWLEDGEMENTS

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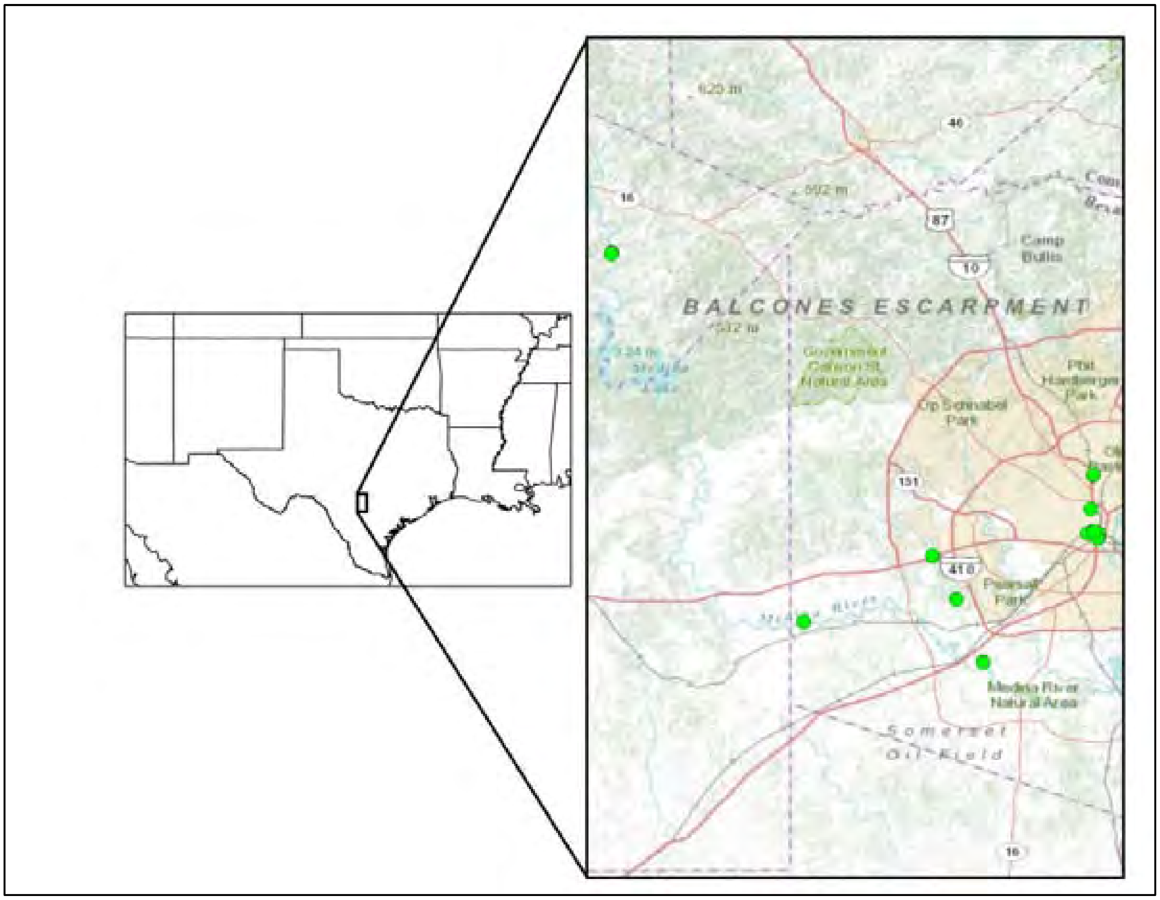


Figure 5. . Broad-scale geographic view depicting the project area within Texas and the relative location of the sampled stations for Westside Creek project.

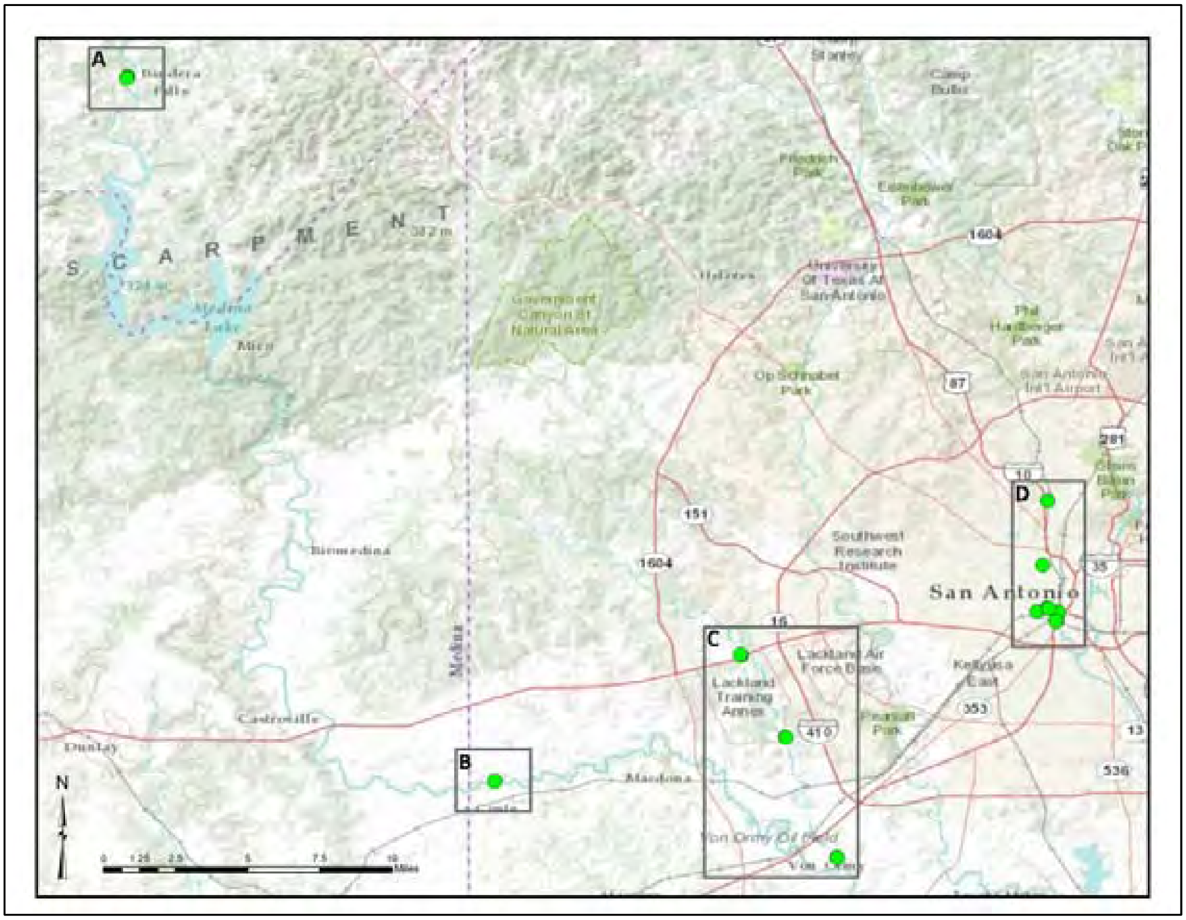


Figure 6. Map depicting the zones (Insets A-D) which include sampled reference waterbodies (Medina River, Inset A and B; Medio Creek, Inset C) and Westside creeks (Inset D).

Figure 7. Detailed view of Inset A (see Figure 2) featuring stations sampled on the upper Medina River

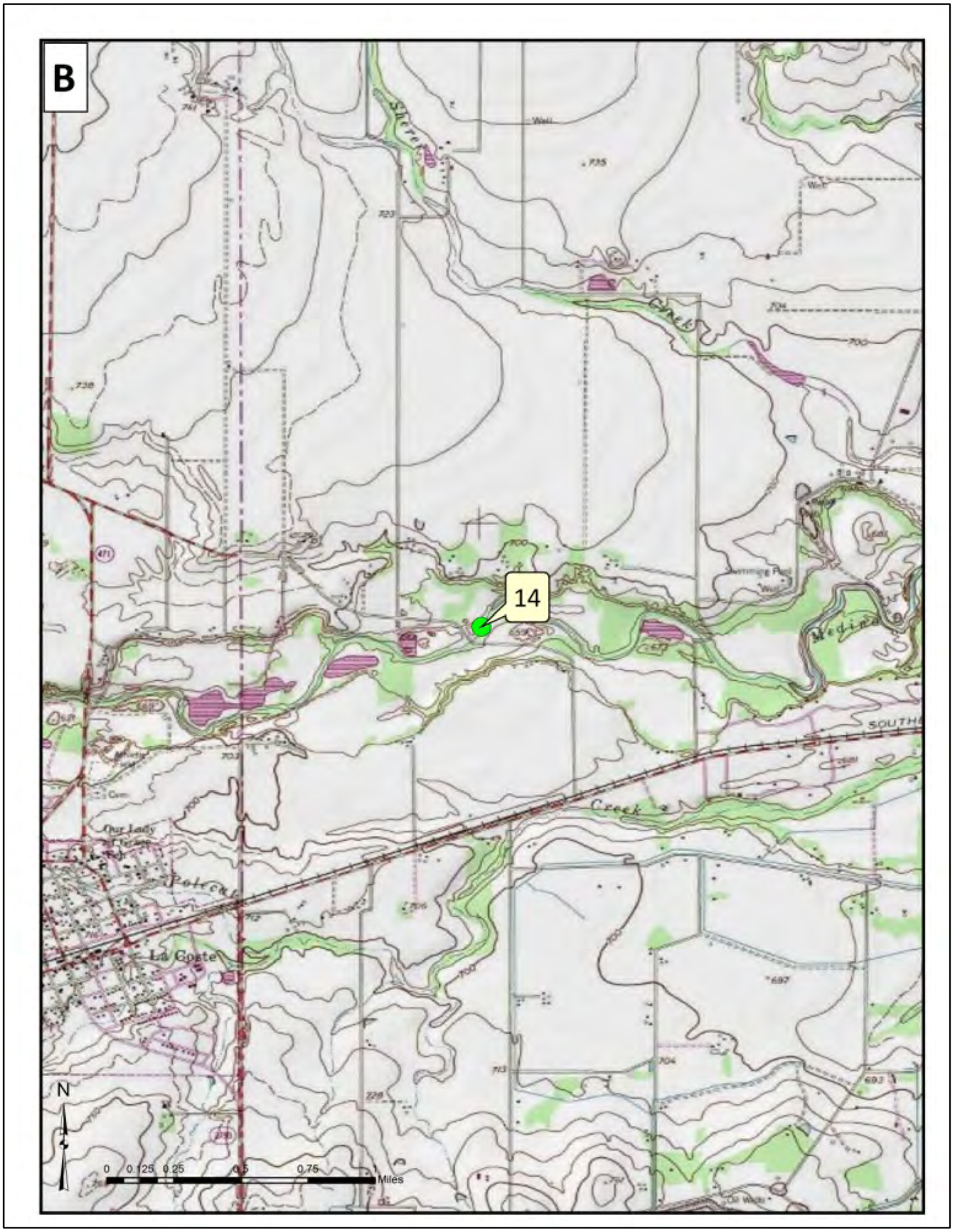


Figure 8. Detailed view of Inset B (see Figure 2) featuring stations sampled on the lower Medina River.

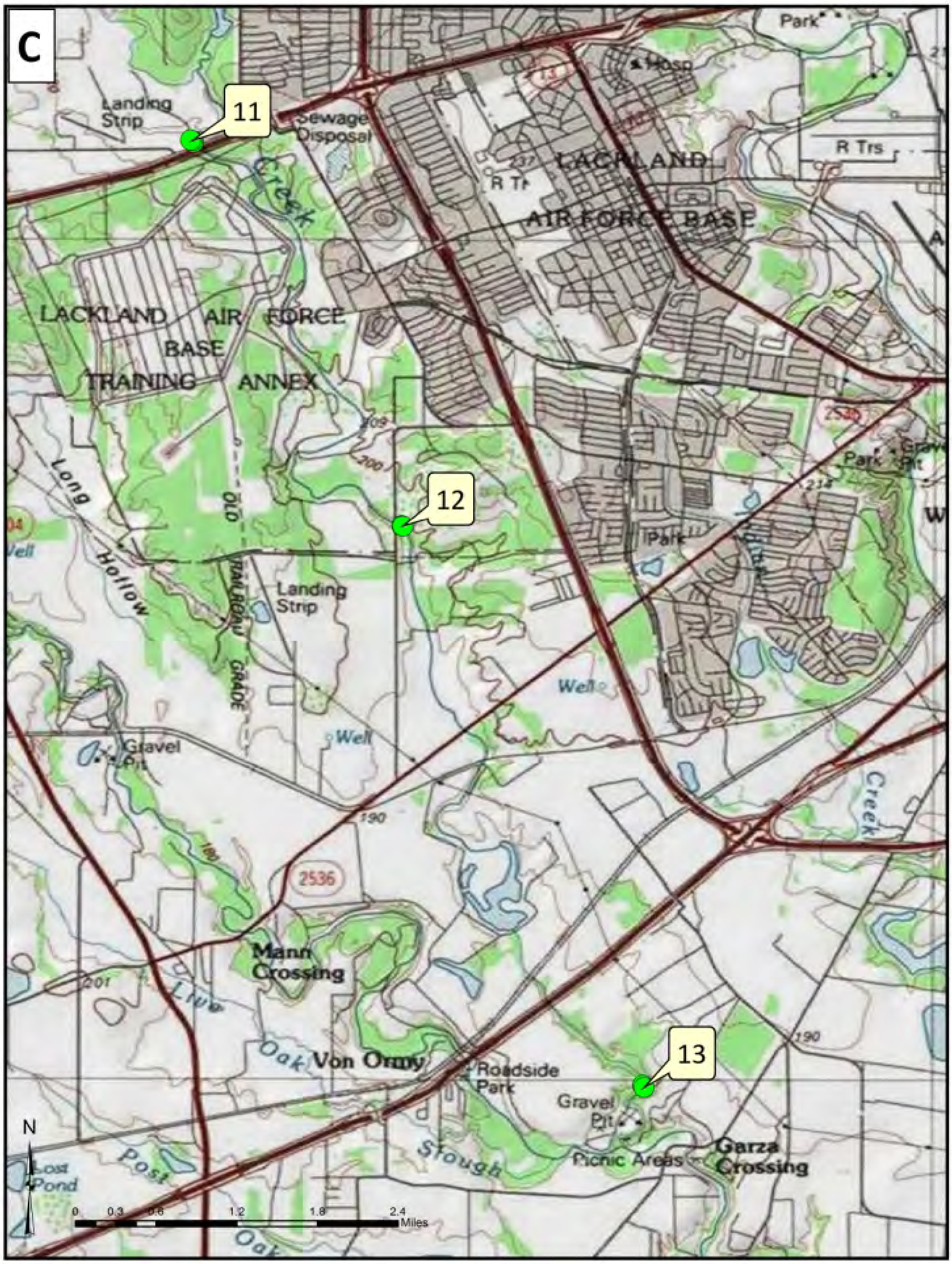


Figure 9. view of Inset C (see Figure 2) featuring stations sampled on Medio Creek

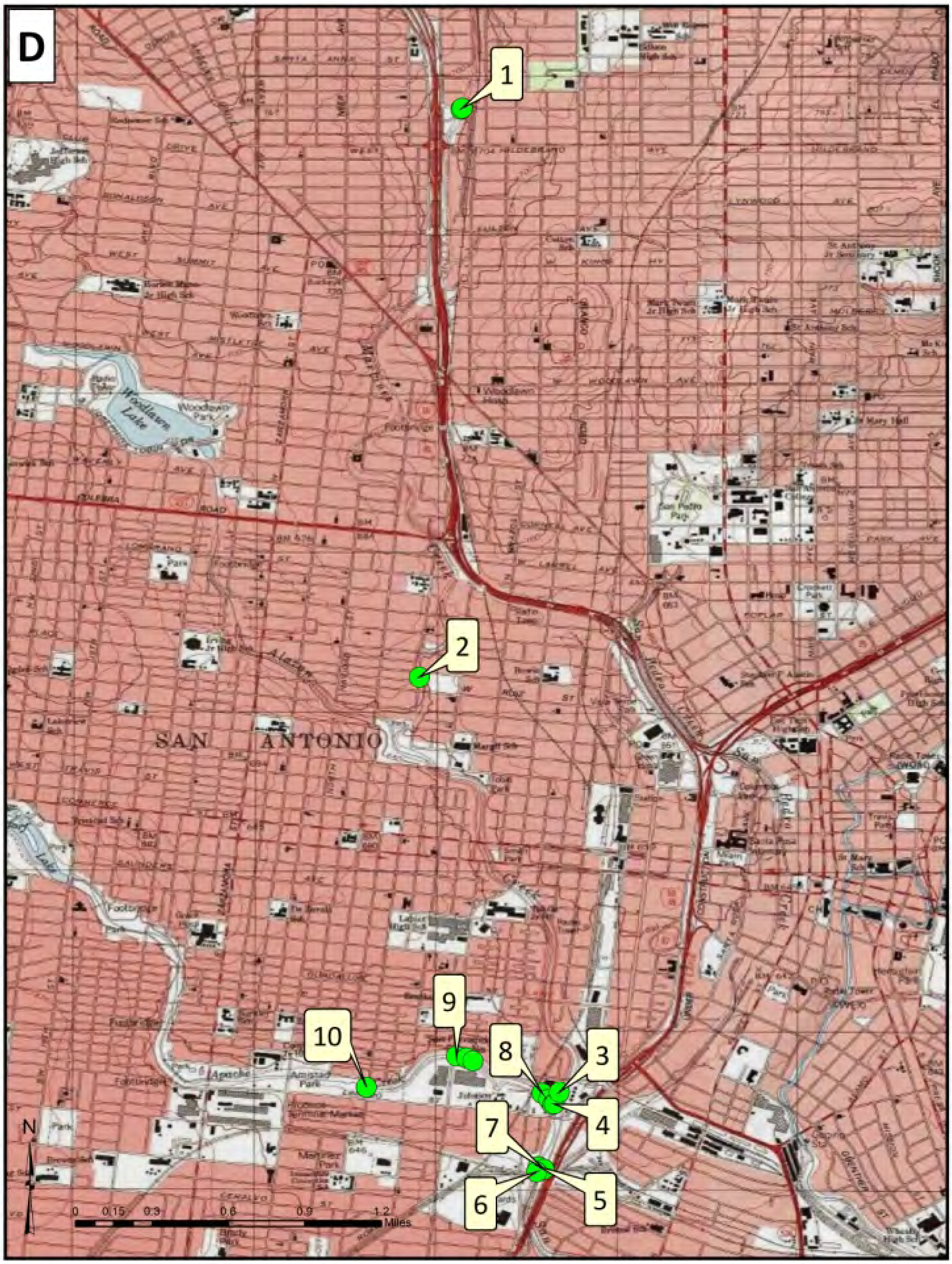


Figure 10. Detailed view of Inset D (see Figure 2) featuring stations sampled on Alazan, Apache, Martinez and San Pedro creeks (Westside Creek project area).

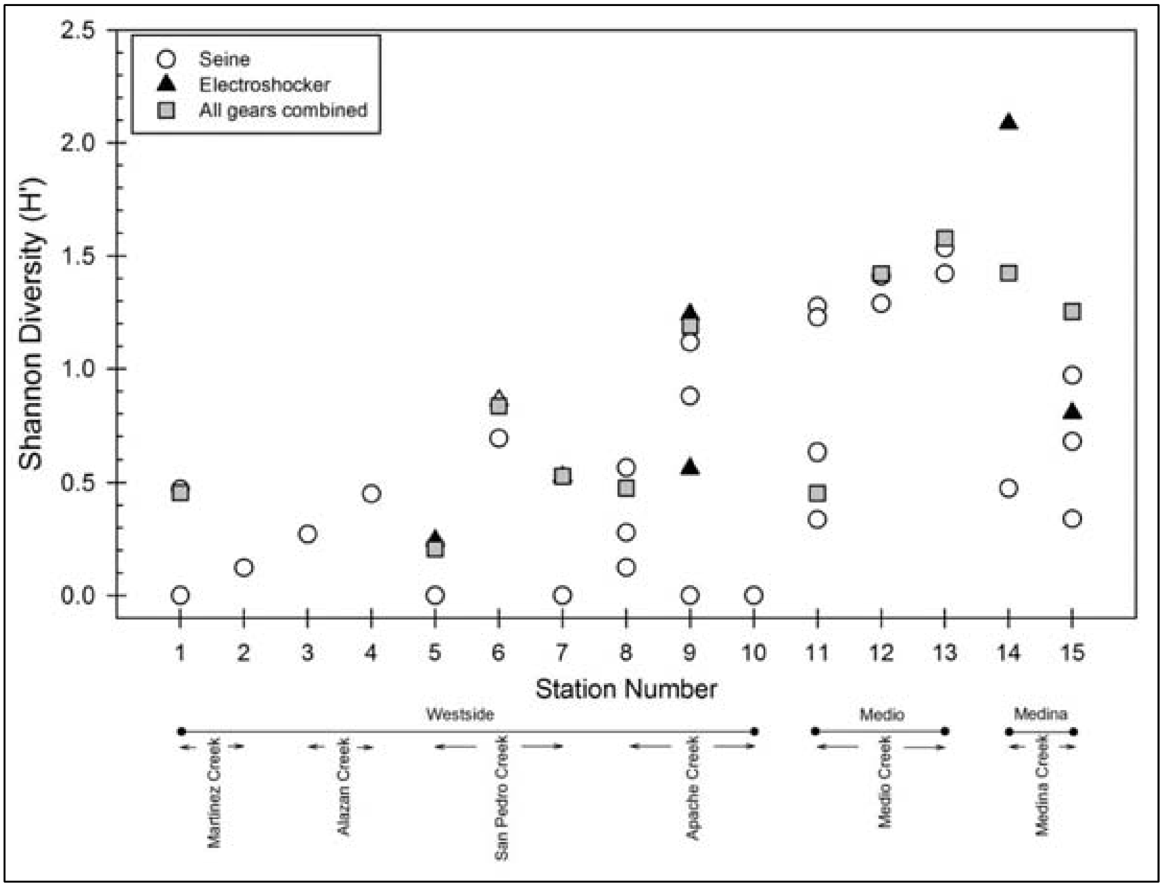


Figure 11. Shannon diversity values based on standardized CPUE for all samples conducted at the 15 stations within the project area with samples coded by gear type.

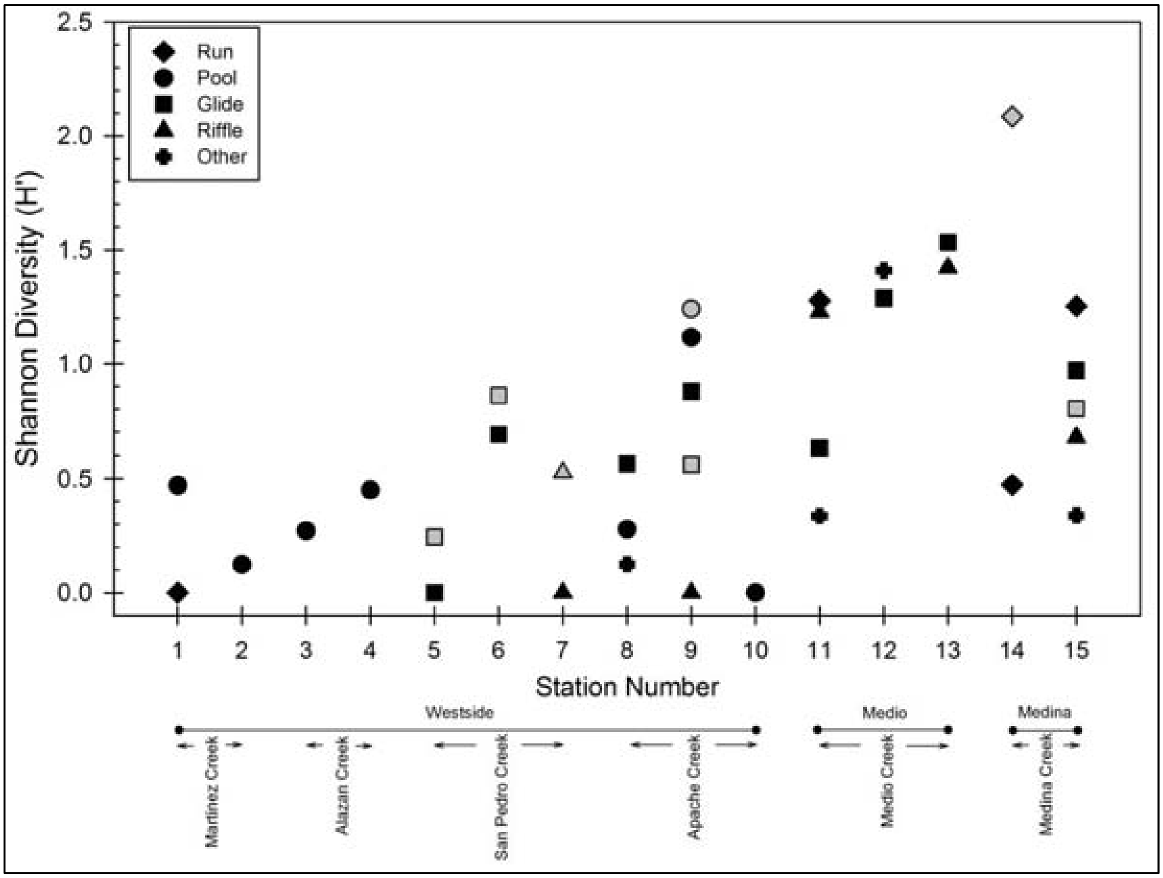


Figure 12. Shannon diversity values based on standardized CPUE for all samples conducted at the 15 stations within the project area with samples coded by sampled habitat. Solid symbols indicate seining efforts; grey symbols represent electrofishing efforts.

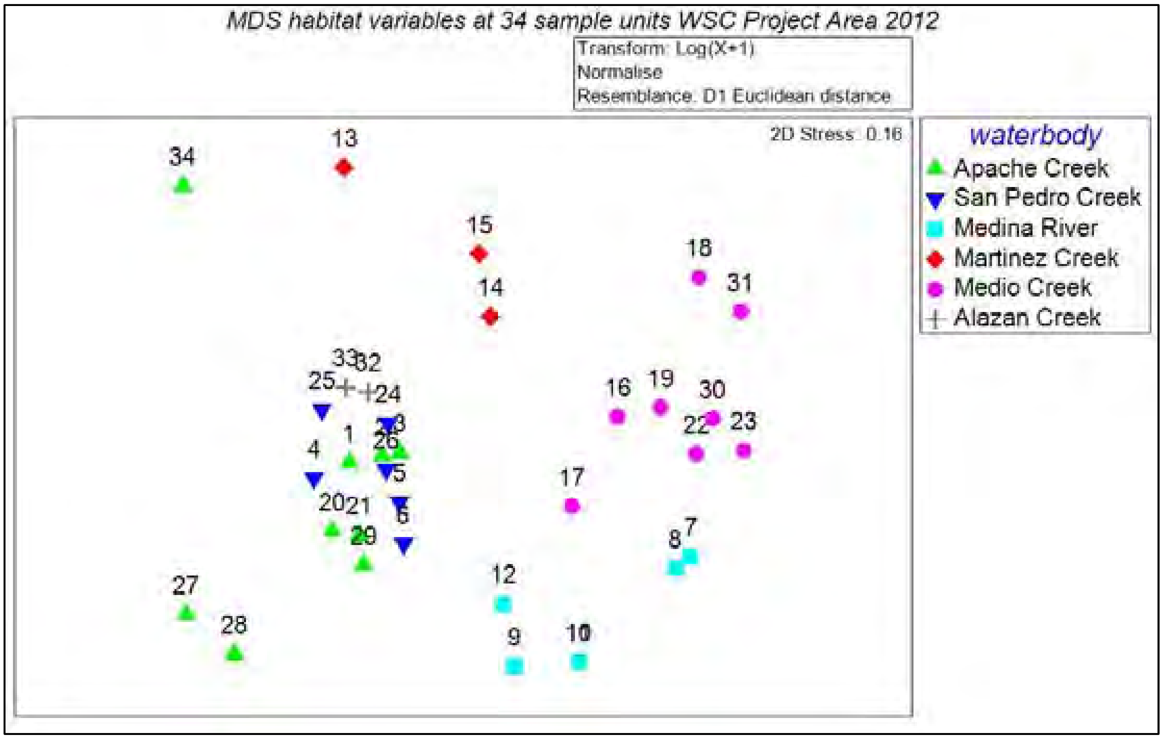


Figure 13. MDS plot of measured habitat variables taken at 34 sampled macrohabitat units distributed across 15 stations within the project area.

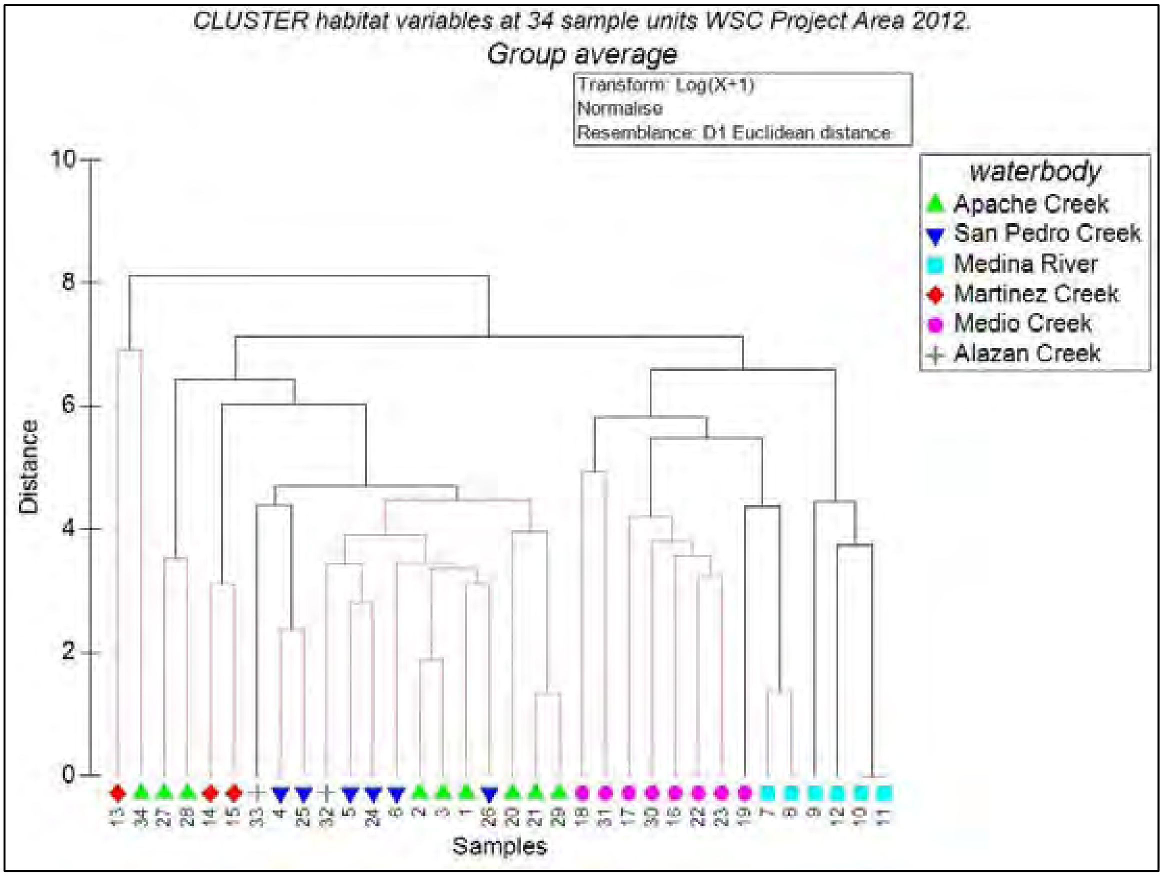


Figure 14. CLUSTER analysis depicting habitat similarity between sampled units across all included waterbodies. Statistically significant clusters are noted by black linkages; non-significant clusters are in red.

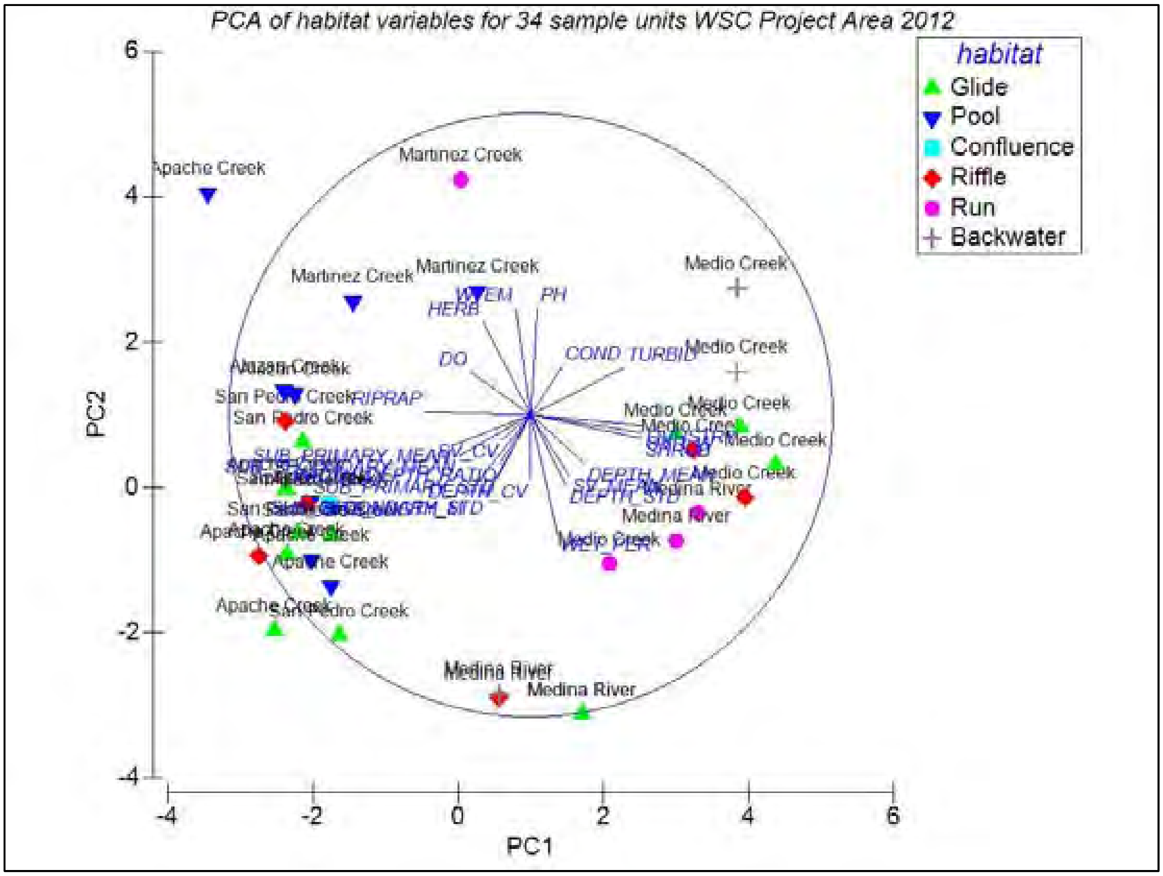


Figure 15. PCA of habitat variables recorded at 34 sampled macrohabitat units. Sample units are coded based on habitat type.

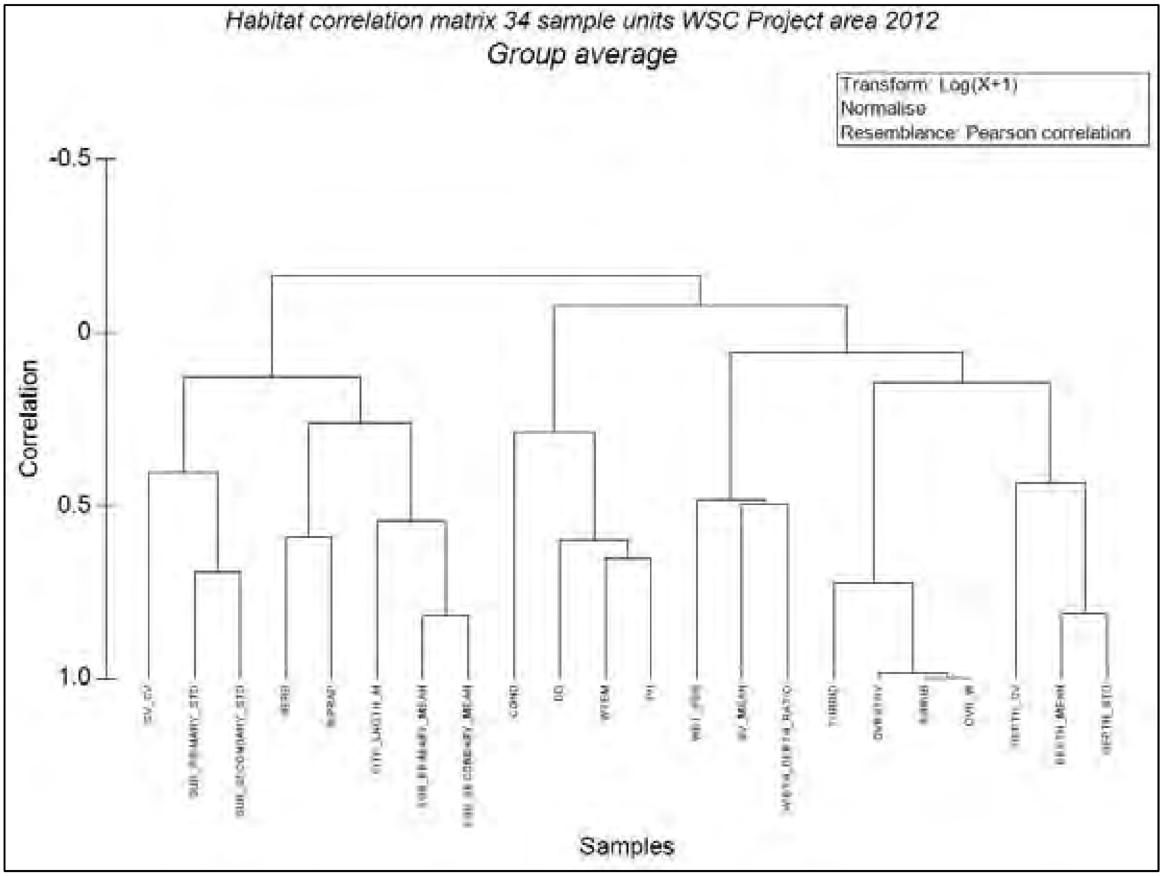


Figure 16. CLUSTER diagram depicting correlation among variables included in the environmental data matrix.

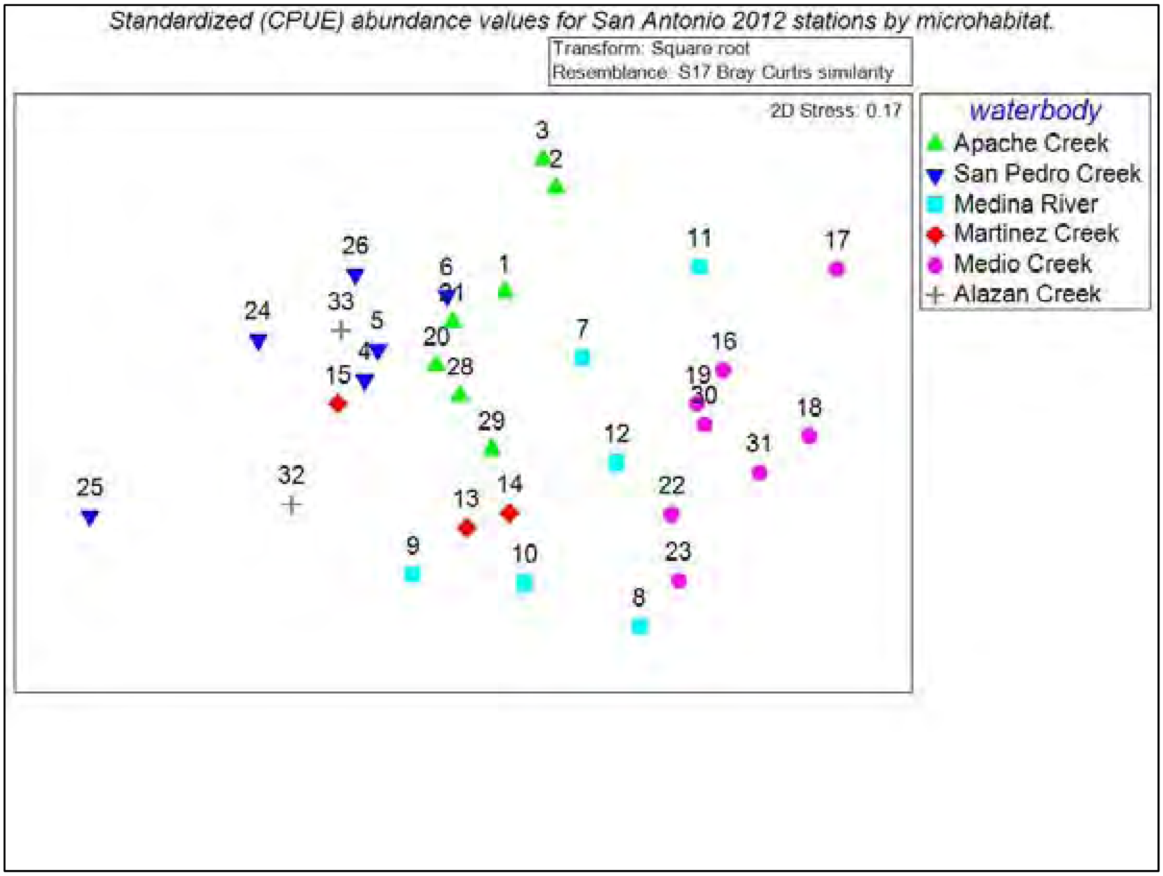


Figure 17. MDS of fish samples conducted at 34 macrohabitat units distributed across 15 stations within the project area.

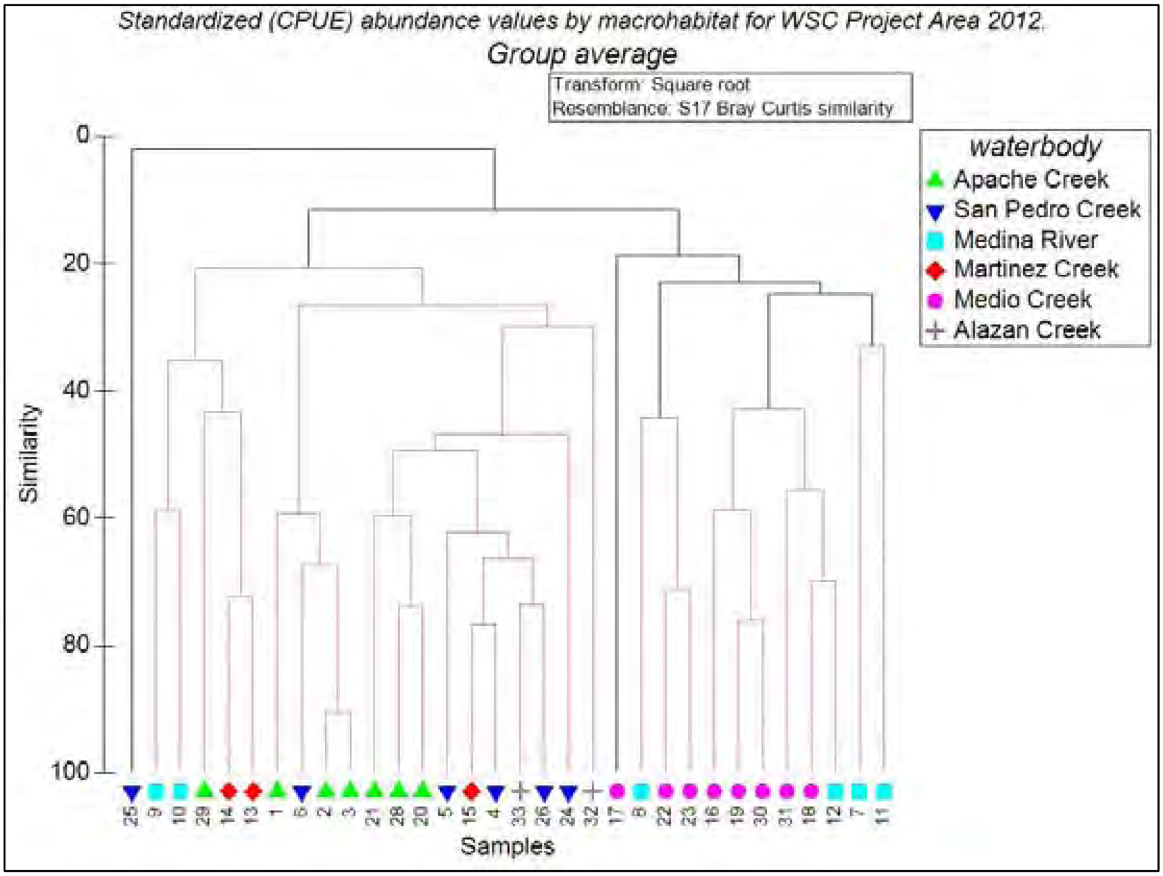


Figure 18. CLUSTER depicting faunal similarity between sampled macrohabitat units. Statistically significant clusters are noted by black linkages; non-significant clusters are in red.

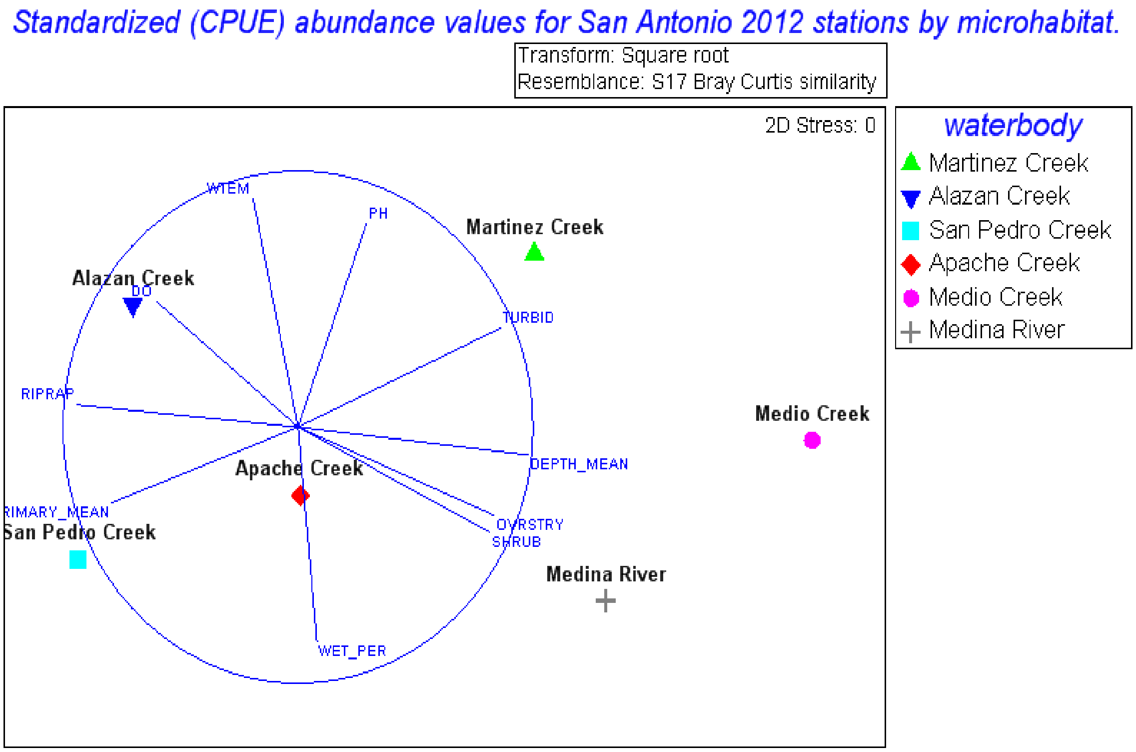
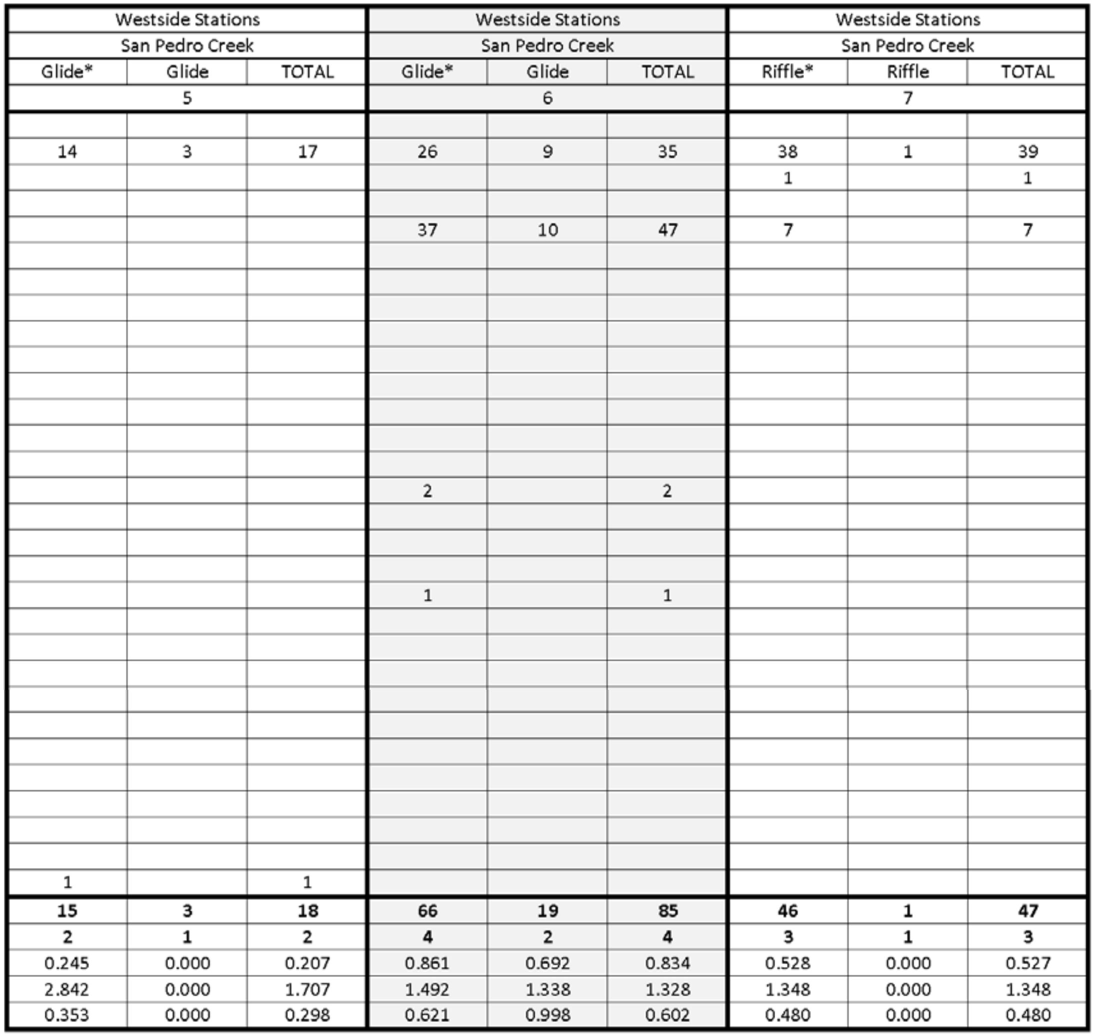


Figure 19. MDS plot of the average resemblance matrix by waterbody with vectors associated with habitat variables.

Table 20. . Species of fishes collected at each of the 15 sample locations within the project area including the specific macrohabitat unit sampled (e.g., glide, riffle, run, pool, backwater). All sampling was conducted with either a 10 or 20' seine; electrofishing samples are noted with an asterisk superscript (i.e., riffle*). Diversity (Shannon H' [Log e]), richness (Margalef d = [S-1]/Log[N]) and eveness (Pielou J' = H'/Log[S]) index values were computed with standardized CPUE values.

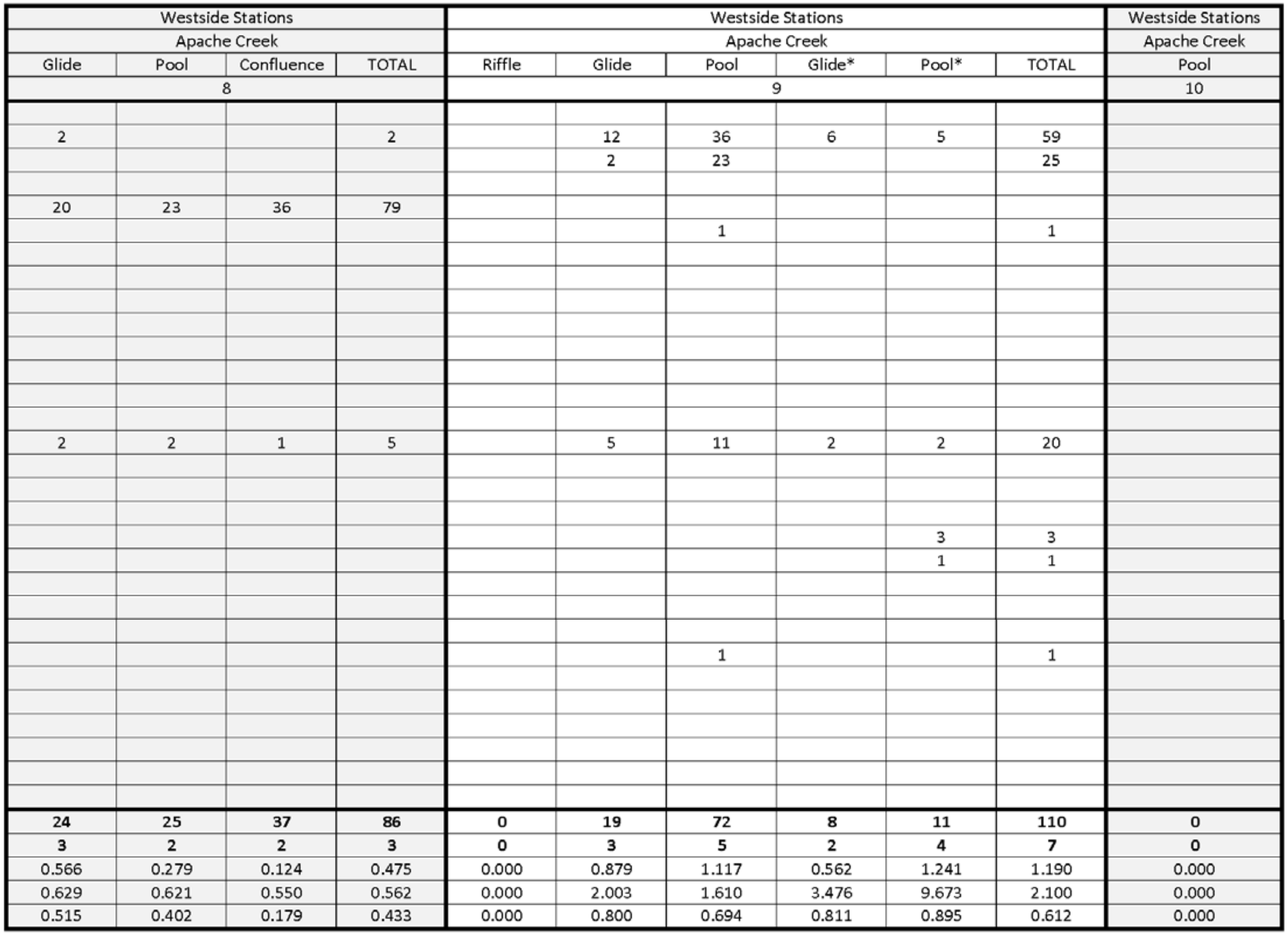
		Westside Stations			Westside Stations	Westside Stations	Westside Stations
		Martinez Creek			Martinez Creek	Alazan Creek	Alazan Creek
		Run	Pool	TOTAL	Pool	Pool	Pool
Scientific Name	Common name	1			2	3	4
Cyprinidae							
Campostoma anomalum	Central stoneroller	15	182	197	418	12	1
Cyprinella lutrensis	Red shiner				5		5
Cyprinella venusta	Blacktail shiner						
Cyprinus carpio	Common carp					1	
Notemigonus crysoleucas	Golden shiner						
Notropis stramineus	Sand shiner						
Notropis volucellus	Mimic shiner						
Pimephales vigilax	Bullhead minnow						
Characidae							
Astyanax mexicanus	Mexican tetra						
Ictaluridae							
Ictalurus punctatus	Channel catfish						
Poeciliidae							
Gambusia affinis	Western mosquitofish		32	32	2		
Poecilia latipinna	Sailfin molly		2	2			
Centrarchidae							
Lepomis auritus	Redbreast sunfish						
Lepomis cyanellus	Green sunfish						
Lepomis gulosus	Warmouth						
Lepomis macrochirus	Bluegill				2		
Lepomis megalotis	Longear sunfish						
Lepomis minitatus	Redspotted sunfish						
Micropterus salmoides	Largemouth bass						
Micropterus treculii	Guadalupe bass						
Percidae							
Etheostoma spectabile	Orangethroat darter						
Percina carbonaria	Texas logperch						
Cichlidae							
Herichthys cyanoguttatus	Rio Grande cichlid						
	TOTAL INDIVIDUALS	**15**	**216**	**231**	**427**	**13**	**6**
	Number of species	**1**	**3**	**3**	**4**	**2**	**2**
	Diversity (H')	0.000	0.471	0.456	0.123	0.271	0.451
	Richness (d)	0.000	0.468	0.462	0.675	1.615	0.558
	Eveness (J')	0.000	0.428	0.415	0.089	0.391	0.650

Table 20 (con't).



Westside Stations			Westside Stations			Westside Stations		
San Pedro Creek			San Pedro Creek			San Pedro Creek		
Glide*	Glide	TOTAL	Glide*	Glide	TOTAL	Riffle*	Riffle	TOTAL
5			6			7		
14	3	17	26	9	35	38	1	39
						1		1
			37	10	47	7		7
			2		2			
			1		1			
1		1						
15	**3**	**18**	**66**	**19**	**85**	**46**	**1**	**47**
2	**1**	**2**	**4**	**2**	**4**	**3**	**1**	**3**
0.245	0.000	0.207	0.861	0.692	0.834	0.528	0.000	0.527
2.842	0.000	1.707	1.492	1.338	1.328	1.348	0.000	1.348
0.353	0.000	0.298	0.621	0.998	0.602	0.480	0.000	0.480

Table 20 (con't).



Westside Stations				Westside Stations						Westside Stations
Apache Creek				Apache Creek						Apache Creek
Glide	Pool	Confluence	TOTAL	Riffle	Glide	Pool	Glide*	Pool*	TOTAL	Pool
8				9						10
2			2		12	36	6	5	59	
					2	23			25	
20	23	36	79							
						1			1	
2	2	1	5		5	11	2	2	20	
								3	3	
								1	1	
						1			1	
24	**25**	**37**	**86**	**0**	**19**	**72**	**8**	**11**	**110**	**0**
3	**2**	**2**	**3**	**0**	**3**	**5**	**2**	**4**	**7**	**0**
0.566	0.279	0.124	0.475	0.000	0.879	1.117	0.562	1.241	1.190	0.000
0.629	0.621	0.550	0.562	0.000	2.003	1.610	3.476	9.673	2.100	0.000
0.515	0.402	0.179	0.433	0.000	0.800	0.694	0.811	0.895	0.612	0.000

Medio Stations					Medio Stations			Medio Stations		
Medio Creek					Medio Creek			Medio Creek		
Glide	Run	Riffle	Backwater	TOTAL	Glide	Backwater	TOTAL	Riffle	Glide	TOTAL
11					12			13		
		1		1	1		1	35	35	70
								5	14	19
								1		1
								1	4	5
			2	2		2	2			
55		17	351	423	35	74	109	12	2	14
			7	7	8	28	36			
	1		1	2						
4	3	3	7	17	2	18	20	1	10	11
		1		1	3	8	11	8	17	25
4	2			6						
		1	1	2	2	10	12			
								1	1	2
3	1	13	6	23	7	3	10	1		1
66	**7**	**36**	**375**	**484**	**58**	**143**	**201**	**65**	**83**	**148**
4	**4**	**6**	**7**	**10**	**7**	**7**	**8**	**9**	**7**	**9**
0.632	1.277	1.228	0.336	0.453	1.289	1.409	1.420	1.422	1.533	1.578
1.422	1.542	3.607	1.243	1.826	3.220	1.892	2.053	4.046	2.426	2.713
0.456	0.921	0.685	0.173	0.197	0.662	0.724	0.683	0.647	0.788	0.718

Table 20 (con't).

Table 20. (concluded).

Medina Stations			Medina Stations					Project Area
Medina River			Medina River					System
Run*	Run	TOTAL	Riffle	Glide	Glide*	Backwater	TOTAL	Site description
14			15					Station No.
3		3	40	140		10	190	973
								108
3	46	49	94	308		1	403	471
								134
								1
				3			3	3
								1
								5
								4
3		3						3
2	2	4		28	2	354	384	995
1		1						46
2		2						2
								6
								1
						10	10	60
	3	3		5		2	7	47
1		1						7
								15
	1	1						3
			2	10	12		24	24
1		1						1
4		4			3	3	6	45
20	**52**	**72**	**136**	**494**	**17**	**380**	**1027**	**2955**
9	**4**	**11**	**3**	**6**	**3**	**6**	**8**	**23**
2.086	0.474	1.424	0.677	0.971	0.804	0.339	1.254	
8.535	1.820	4.883	0.606	1.089	1.962	1.155	1.315	
0.949	0.342	0.594	0.617	0.542	0.732	0.189	0.603	

Table 21. Results from ANOSIM procedure to assess differences in habitat similarity between sampled waterbodies.

```
ANOSIM

Habitat similarity between waterbodies

Global Test
Sample statistic (Global R): 0.584
Significance level of sample statistic: 0.1% (P =[0.001])
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 0

Pairwise Tests
                                      R     Significance     Possible        Actual Number >=
Groups                           Statistic       Level % Permutations  Permutations  Observed
Apache Creek, San Pedro Creek       -0.001          0.446        5005           999       445
Apache Creek, Medina River           0.650          0.001        5005           999         0
Apache Creek, Martinez Creek         0.426          0.055         220           220        12
Apache Creek, Medio Creek            0.775          0.001       24310           999         0
Apache Creek, Alazan Creek          -0.147          0.618          55            55        34
San Pedro Creek, Medina River        0.831          0.002         462           462         1
San Pedro Creek, Martinez Creek      0.821          0.012          84            84         1
San Pedro Creek, Medio Creek         0.957          0.002        3003           999         1
San Pedro Creek, Alazan Creek        0.302          0.179          28            28         5
Medina River, Martinez Creek         0.981          0.012          84            84         1
Medina River, Medio Creek            0.690          0.001        3003           999         0
Medina River, Alazan Creek           0.948          0.036          28            28         1
Martinez Creek, Medio Creek          0.739          0.006         165           165         1
Martinez Creek, Alazan Creek         0.167          0.300          10            10         3
Medio Creek, Alazan Creek            0.970          0.022          45            45         1
```

Table 22. Results from PCA assessment on measured habitat features from 34 sampled macrohabitat units. Loadings highlighted in yellow were considered strong loadings.

PCA

Principal Component Analysis

```
Data worksheet
Name: Data5
Data type: Environmental
Sample selection: All
Variable selection: All

Eigenvalues
PC  Eigenvalues  %Variation  Cum.%Variation
 1         6.64        30.2            30.2
 2         3.52        16.0            46.2
 3         3.06        13.9            60.1
 4         2.53        11.5            71.6
 5         1.43         6.5            78.1

Eigenvectors
(Coefficients in the linear combinations of variables making up PC's)
Variable                 PC1     PC2     PC3     PC4     PC5
WTEM                  -0.050   0.354  -0.262  -0.057  -0.168
DO                    -0.201   0.143  -0.373  -0.092  -0.183
COND                   0.104   0.160  -0.214  -0.181  -0.206
PH                     0.021   0.354  -0.245  -0.185   0.018
TURBID                 0.309   0.156   0.166   0.037   0.111
SITE_LNGTH_M          -0.216  -0.273  -0.104  -0.057   0.264
SV_MEAN                0.126  -0.200  -0.232   0.365   0.130
SV_CV                 -0.100  -0.085   0.292   0.126   0.161
DEPTH_MEAN             0.179  -0.162  -0.080  -0.429   0.329
DEPTH_STD              0.116  -0.234  -0.120  -0.483   0.020
DEPTH_CV              -0.001  -0.216   0.042  -0.346  -0.390
WIDTH_DEPTH_RATIO     -0.105  -0.163  -0.205   0.428  -0.357
WET_PER                0.088  -0.392  -0.281   0.013  -0.161
OVRSTRY                0.370  -0.036  -0.011   0.077   0.042
SHRUB                  0.368  -0.078  -0.054   0.088   0.068
HERB                  -0.158   0.307   0.267  -0.035   0.149
RIPRAP                -0.354   0.010   0.042  -0.026   0.086
OVR_W                  0.366  -0.059  -0.035   0.092   0.097
SUB_PRIMARY_MEAN      -0.255  -0.100  -0.207   0.017   0.394
SUB_PRIMARY_STD       -0.109  -0.204   0.307  -0.149  -0.146
SUB_SECONDARY_MEAN    -0.238  -0.136  -0.288   0.024   0.261
SUB_SECONDARY_STD     -0.150  -0.271   0.261  -0.032  -0.257
```

Table 23. Results from ANOSIM procedure to assess differences in faunal similarity between sampled waterbodies.

ANOSIM

Analysis of Similarities

```
Resemblance worksheet
Name: Resem7
Data type: Similarity
Selection: All

Global Test
Sample statistic (Global R): 0.506
Significance level of sample statistic: 0.1% (P = 0.001)
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 0

Pairwise Tests
                                         R  Significance     Possible        Actual Number >=
Groups                           Statistic       Level % Permutations  Permutations  Observed
Martinez Creek, Alazan Creek         0.750         0.100           10            10         1
Martinez Creek, San Pedro Creek      0.228         0.167           84            84        14
Martinez Creek, Apache Creek         0.302         0.092          120           120        11
Martinez Creek, Medio Creek          0.742         0.006          165           165         1
Martinez Creek, Medina River         0.235         0.107           84            84         9
Alazan Creek, San Pedro Creek       -0.135         0.607           28            28        17
Alazan Creek, Apache Creek           0.182         0.194           36            36         7
Alazan Creek, Medio Creek            0.940         0.022           45            45         1
Alazan Creek, Medina River           0.740         0.036           28            28         1
San Pedro Creek, Apache Creek        0.127         0.110         1716           999       109
San Pedro Creek, Medio Creek         0.922         0.002         3003           999         1
San Pedro Creek, Medina River        0.574         0.002          462           462         1
Apache Creek, Medio Creek            0.706         0.001         6435           999         0
Apache Creek, Medina River           0.476         0.003         1716           999         2
Medio Creek, Medina River            0.376         0.004         3003           999         3
```

Table 24. Results from SIMPER procedure to describe percent faunal similarity between sampled waterbodies.

```
SIMPER
Similarity Percentages - species contributions

CPUE species abundance matrix

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Groups Martinez Creek  &  San Pedro Creek
Average dissimilarity = 72.46

                      Group Martinez Creek  Group San Pedro Creek
Species                           Av.Abund               Av.Abund  Av.Diss  Diss/SD  Contrib%  Cum.%
Central stoneroller                   6.29                   1.07    48.08     1.96     66.36  66.36
Western mosquitofish                  1.30                   0.08     9.64     0.92     13.30  79.66
Common carp                           0.00                   0.65     7.01     0.73      9.67  89.33
Red shiner                            0.33                   0.05     2.87     0.80      3.96  93.28



Groups Alazan Creek  &  Medina River
Average dissimilarity = 91.00

                      Group Alazan Creek  Group Medina River
Species                         Av.Abund            Av.Abund  Av.Diss  Diss/SD  Contrib%  Cum.%
Blacktail shiner                    0.00                2.57    23.81     1.15     26.16  26.16
Western mosquitofish                0.00                2.05    16.81     0.85     18.48  44.64
Central stoneroller                 0.84                1.69    15.30     1.55     16.82  61.45
Orangethroat darter                 0.00                0.57     7.98     0.63      8.77  70.22
Red shiner                          0.42                0.00     6.14     0.77      6.75  76.97
Rio Grande cichlid                  0.00                0.36     5.67     0.82      6.24  83.21
Longear sunfish                     0.00                0.36     3.41     0.81      3.75  86.96
Common carp                         0.19                0.00     2.53     0.79      2.78  89.74
Channel catfish                     0.00                0.10     1.69     0.43      1.86  91.60
```

Table 25. Results from SIMPER procedure to describe percent similarity of environmental variables between Westside Creek (Group 1) and reference stations (Group 2).

SIMPER

Similarity Percentages - species contributions
One-Way Analysis

```
Data worksheet
Name: Data5
Data type: Environmental
Sample selection: 1-26,28-33
Variable selection: All

Parameters
Resemblance: D1 Euclidean distance
Cut off for low contributions: 90.00%

Factor Groups
Sample restoration_code

Group 1 – Westside Creek stations
Group 2 – Medina and Medio

Groups 1  &  2
Average squared distance = 51.82

                      Group 1  Group 2
                        Av.      Av.
Variable              Value    Value   Av.Sq.Dist  Sq.Dist/SD  Contrib%  Cum.%
SHRUB                 -0.795    1.140        3.89        2.45      7.51   7.51
OVRSTRY               -0.782    1.120        3.84        2.35      7.42  14.93
OVR_W                 -0.773    1.100        3.81        1.84      7.35  22.28
RIPRAP                 0.710   -1.040        3.46        2.82      6.68  28.96
HERB                   0.548   -0.782        3.09        0.77      5.95  34.92
TURBID                -0.425    0.667        2.62        0.93      5.06  39.97
SV_MEAN               -0.459    0.539        2.59        0.95      5.00  44.97
SITE_LNGTH_M           0.403   -0.470        2.46        0.62      4.74  49.71
SUB_PRIMARY_MEAN       0.343   -0.596        2.41        0.63      4.65  54.37
SUB_SECONDARY_MEAN     0.249   -0.512        2.21        0.84      4.26  58.62
DEPTH_MEAN            -0.256    0.538        2.09        0.80      4.03  62.66
WET_PER               -0.233    0.519        2.07        0.66      4.00  66.66
SUB_PRIMARY_STD        0.194   -0.240        2.05        0.95      3.95  70.61
DEPTH_STD             -0.161    0.410        2.03        0.77      3.92  74.53
WIDTH_DEPTH_RATIO   6.21E-4 -7.69E-2         2.03        0.80      3.92  78.45
SUB_SECONDARY_STD     0.221   -0.284         2.02        0.96      3.90  82.35
DO                    0.258   -0.451         1.88        0.72      3.62  85.97
SV_CV               6.68E-2   -0.235         1.85        0.75      3.58  89.55
DEPTH_CV              0.197  1.21E-4          1.6        0.87      3.08  92.63
```

WESTSIDE CREEKS ECOSYSTEM RESTORATION

Appendix D: Cost Effectiveness-Incremental Cost Analysis

COST EFFECTIVENESS AND INCREMENTAL COST ANALYSIS (CE/ICA) APPENDIX

INTRODUCTION

Comparing benefits and costs for ecosystem restoration provides a challenge to planners and decision makers because benefits and costs are not measured in the same units. Environmental restoration benefits can be measured in habitat units or some other physical unit, while costs are measured in dollars. Therefore benefits and costs cannot be directly compared. Two analyses are conducted to help planners and decision makers identify plans for implementation, though the analyses themselves do not identify a single ideal plan. These two techniques are cost effectiveness and incremental cost analysis. Use of these techniques are described in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resource Implementation Studies* (U.S. Water Resources Council 1983).

Cost effectiveness compares the annual costs and benefits of plans under consideration to identify the least cost plan alternative for each possible level of environmental output, and for any level of investment, the maximum level of output is identified.

Incremental cost analysis of the cost effective plans is conducted to reveal changes in costs as output levels are increased. Results from both analyses are presented graphically to help planners and decision makers select plans. For each of the best buy plans identified through incremental cost analysis, an “is it worth it?” analysis is then conducted for each incremental measure or plan to justify the incremental cost per unit of output to arrive at a recommended plan.

For this study, the environmental output is the avian community unit, which is derived from the product of an Avian Index of Biotic Integrity (AIBI) and a measure’s acreage. The development of the AIBI is discussed in detail in the environmental technical appendix.

MEASURES AND PLANS

Measures were formulated incrementally for each of the four creeks. These measures included riparian meadows, construction of a natural design pilot channel inclusive of instream structures to restore pool-riffle-run sequences, riparian woody vegetation plantings in the riparian meadow, slackwater features, and on Martinez Creek, wetlands. A brief description of each measure follows:

Riparian Meadow (RM): The change from non-native herbaceous vegetation to a restored native riparian meadow would be a hydraulically neutral action, and can be implemented as a standalone alternative.

Restoration of the riparian meadow would partially address the restoration objective for the WSC by providing some increased vertical structure diversity in the riparian habitat, some increased insect (primary producer) biomass production, and some increased allochthonous material input to the aquatic habitat. The increase in allochthonous materials and temperature reduction from limited shading would provide some limited improvement in dissolved oxygen levels for the aquatic environment.

Cost components for establishment of a native riparian meadow include:

- removal of top six inches of existing soil to remove the non-native seed bank,
- ripping to a depth of 12-18 inches to reduce compaction and provide an acceptable strata for deep root growth,
- incorporation of compost material into the top 2-4 inches to promote germination and sustained growth,
- planting a diverse mix of native riparian meadow seeds, and
- provisions for short-term watering to aid in quick establishment of ground cover of the exposed floodway slopes.

Pilot Channel (PC): The pilot channel management measure would support the ecosystem restoration objective by addressing the problems associated with the increased bed slope and loss of aquatic habitat structure and function.

The amount of ground disturbance from the excavation to construct the pilot channel would require re-establishment of a large portion of the slope vegetation. For this reason, the pilot channel management measure was not considered as a stand-alone management measure, but rather implementable only in combination with the riparian meadow management measure.

Specifically, the pilot channel management measure would mimic the ecological functions of the channel forming process through construction of a pilot channel sized to carry the channel forming flow and the use of in-stream structures which flattens the bed slope during channel forming events thereby balancing movement of sediment through the system. The in-stream structures will restore pool-riffle complexes and support appropriate substrate deposition for pool and riffle habitats. Further, the pilot channel management measure, primarily through the pool/riffle habitats, will allow some slackwater micro habitat formation. The riffles will assist with dissolved oxygen levels, and increased pool depths will provide aquatic locations as high temperature refugia. Properly functioning riffles and pools are important primary producer habitats, serving as breeding, brooding, and foraging grounds for a diverse list of benthic organisms, aquatic insects, and fish. Pools support the aquatic functional need for allochthonous material inputs through providing a low velocity location where these materials fall-out of the velocity stream and begin the decaying process to return energy to the system.

Cost components for establishment of the pilot channel include:

- excavation to accommodate the pilot channel and initial pool depths, and construct riffle structures,
- grading to form the pilot channel and transition to existing floodway slopes,
- rock constructed riffle structures,
- armoring, and
- utility relocation.

Riparian Woody Vegetation (RWV) (30, 70): The riparian woody vegetation management measure would support the ecosystem restoration objective by addressing the problems of lack of aquatic shading, reduced allochthonous material inputs, lack of stratification of vertical structure, lack of terrestrial shading, and lack of soft and hard mast diversity.

A well developed, age and species diverse woody riparian habitat provides numerous ecological benefits to the riparian and aquatic components of the riverine system which are requirements for many migratory birds. The habits of different species of birds for things like foraging, resting, and defense can range from upper-canopy, mid-canopy, shrub, to leaf-layer, and that is just based on vertical and horizontal stratification. A well developed and sustaining riparian woodland provides each of these layers and supports the feeding, resting, and defensive requirements for a great number of birds. Woody vegetation provides an important source of allochthonous material to the aquatic environment through leaf drop to small and large woody debris. These allochthonous inputs add energy to the aquatic system required by the organisms lowest on the primary producer scale; these organisms are at the true base of the system and are required in large sustained numbers of individuals to ensure there is adequate energy surplus at each trophic level to feed the next higher level through to the primary consumers.

Cost components for the establishment of the RWV include:

- spot treatment herbicide to remove herbaceous competition in the immediate area around the seedling,
- purchase of seedlings in a diverse mix of native riparian shrubs and trees,
- planting of seedlings, and
- provisions for short term watering to aid in quick establishment.

Consistent with the study constraints, implementation of the RWV would require an increase in hydraulic capacity within the floodway to accommodate the increased hydraulic roughness of RWV. Implementation of the pilot channel management measure would gain some hydraulic capacity through the required excavation to implement that management measure. Therefore, it was determined that implementation of the RWV management measure would be implemented only in combination with the pilot channel management measure.

Slackwater (SW): The slackwater management measure would support the ecosystem restoration objective by an important micro-habitat component of the aquatic ecosystem.

Natural channel forming processes create areas, generally along the bank margins, where the velocity is slower. These are generally small areas, but they pay big benefits to the aquatic system. Slackwater habitats serve as velocity refugia for many aquatic organisms to rest and forage. Due to the slower velocities, allochthonous materials tend to congregate and pack in these areas, and therefore slackwaters are generally locations with high energy for the lower aquatic organisms. The aquatic food chain of primary producers through to primary consumer is supported at a micro level in slackwater habitats. These are the locations provide easy hunting and foraging for primary consumers due to the small area – high population effect of these habitats.

Cost components for the establishment of slackwater include:

- minor excavation,
- minor grading,
- armoring

Implementation of the slackwater management measure would require mobilization of equipment and staging sites for each location. Since the pilot channel is continuous and requires multiple staging sites, significant cost reduction for this management measure would be experienced by combining the slackwater work with the pilot channel work. Furthermore, the slackwater areas would remain difficult to maintain without the installation of the pilot channel addressing sediment transport. Therefore, slackwater would only be implemented in combination with the pilot channel.

Wetland (WL): The wetland management measure would support the ecosystem restoration objective by addressing the loss of aquatic habitat structure and function.

The management measure would restore uniquely productive microhabitats through the accumulation of organic materials.

Cost components for the establishment of wetland include:

- real estate acquisition,
- excavation,
- grading,
- armoring,
- planting a diverse mixture of wetland vegetation, and
- provisions for short term actions to aide in establishment.

Implementation of the wetland management measure would require ensuring a consistent, if intermittent, source of water. The nearest source is Martinez, but modifications to the existing channel would be required. Operation and maintenance of a wetland area would be labor intensive without a balanced sediment transport system. For this reason the team determined the wetland management measure would only be implemented in combination with the pilot channel management measure.

Of these measures, only riparian meadows were considered as a stand-alone measure. Riparian meadows is a prerequisite for the pilot channel, and the pilot channel a pre-requisite for riparian woody vegetation, slackwater, and the wetland. For the woody vegetation measure, two scales were considered: 30 stems per acre in all areas identified for woody vegetation planting and a combination of 70 stems in locations where the impact on water surface elevations were neutral and 30 stems per acre in the remaining areas identified for woody vegetation. Table 1 presents a list of measure combinations (fully formed plans) for each of the four creeks.

Table 1. List of Plans by Creek

Stream	Plans
San Pedro Creek	Riparian Meadow
	Riparian Meadow + Pilot Channel
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (30 stems per acre)
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (70 stems per acre)
	Riparian Meadow + Pilot Channel + Slackwater
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (30 stems per acre) + Slackwater
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (70 stems per acre) + Slackwater
Alazán Creek	Riparian Meadow
	Riparian Meadow + Pilot Channel
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (30 stems per acre)
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (70 stems per acre)
	Riparian Meadow + Pilot Channel + Slackwater
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (30 stems per acre) + Slackwater
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (70 stems per acre) + Slackwater
Martinez Creek	Riparian Meadow
	Riparian Meadow + Pilot Channel
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (30 stems per acre)
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (70 stems per acre)
	Riparian Meadow + Pilot Channel + Slackwater
	Riparian Meadow + Pilot Channel + Wetland
	Riparian Meadow + Pilot Channel + Slackwater + Wetland
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (30 stems per acre) + Slackwater

Stream	Plans
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (70 stems per acre) + Slackwater
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (30 stems per acre) + Wetlands
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (70 stems per acre) + Wetlands
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (30 stems per acre) + Slackwater + Wetlands
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (30 stems per acre) + Slackwater + Wetlands
Apache Creek	Riparian Meadow
	Riparian Meadow + Pilot Channel
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (30 stems per acre)
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (70 stems per acre)
	Riparian Meadow + Pilot Channel + Slackwater
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (30 stems per acre) + Slackwater
	Riparian Meadow + Pilot Channel + Riparian Woody Vegetation (70 stems per acre) + Slackwater

ANNUALIZED AVIAN COMMUNITY UNITS AND COSTS

EXISTING AND FUTURE WITHOUT-PROJECT AVIAN COMMUNITY UNITS

In order to determine benefits of an environmental restoration plan, future with-project environmental outputs are compared to future without-project outputs. The difference between the two represents the benefits from project implementation. For this study, future without-project conditions are assumed to be the same as existing conditions, given the existing habitat quality and that the area is completely built up. The future without-project avian community units are shown in Table 2.

Table 2. Future Without-Project Avian Community Units

		Future Without Project		
Stream	**Plans**	**Avian IBI**	**Acres**	**Avian Community Unit**
San Pedro Creek	Riparian Meadow	0.91368	67.35	61.53655
	Riparian Meadow + Pilot Channel	0.91368	67.35	61.53655
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	0.91368	67.35	61.53655
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	0.91368	67.35	61.53655
	Riparian Meadow + Pilot Channel + Slackwater	0.91368	67.35	61.53655
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	0.91368	67.35	61.53655
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	0.91368	67.35	61.53655
Alazán Creek	Riparian Meadow	0.91949	70.35	64.68619
	Riparian Meadow + Pilot Channel	0.91949	70.35	64.68619
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	0.91949	70.35	64.68619
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	0.91949	70.35	64.68619
	Riparian Meadow + Pilot Channel + Slackwater	0.91949	70.35	64.68619
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	0.91949	70.35	64.68619

Stream	Plans	Future Without Project		
		Avian IBI	Acres	Avian Community Unit
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	0.91949	70.35	64.68619
Martinez Creek	Riparian Meadow	0.92020	50.56	46.52511
	Riparian Meadow + Pilot Channel	0.92020	50.56	46.52511
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	0.92020	50.56	46.52511
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	0.92020	50.56	46.52511
	Riparian Meadow + Pilot Channel + Slackwater	0.92020	50.56	46.52511
	Riparian Meadow + Pilot Channel + Wetland	0.92020	50.56	46.52511
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	0.92020	50.56	46.52511
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	0.92020	50.56	46.52511
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	0.92020	50.56	46.52511
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	0.92020	50.56	46.52511
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	0.92020	50.56	46.52511
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	0.92020	50.56	46.52511
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	0.92020	50.56	46.52511
Apache Creek	Riparian Meadow	0.93985	34.02	31.97356
	Riparian Meadow + Pilot Channel	0.93985	34.02	31.97356
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	0.93985	34.02	31.97356
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	0.93985	34.02	31.97356
	Riparian Meadow + Pilot Channel + Slackwater	0.93985	34.02	31.97356
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	0.93985	34.02	31.97356
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	0.93985	34.02	31.97356

FUTURE WITH-PROJECT

ENVIRONMENTAL OUTPUTS

For comparison of measures, both environmental outputs and costs are converted to annual averages, or annualized. For the avian community units, an Avian IBI was first developed for each measure over a period of 75 years, with indexes estimated for 1 year following construction; 15 years following construction, 25 years following construction, 50 years following construction and 75 years following construction. A period of 75 years was chosen to allow the maturing of the riparian woody vegetation so that full benefits can be captured. The respective AIBIs were then multiplied by acreage to get the Avian Community Units for each measure in each of the reference years. Tables 3 through 7 show the calculation of these Avian Community Units. Using the annualizer module in the IWR Planning Suite software, these environmental outputs were annualized. Table 8 shows the data entered into the annualizer module and the resulting average annual avian community units for each measure. In performing the annualization, linear interpolation was used for the calculation.

Table 3. Calculation of Total Avian Community Units for Year 1

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
San Pedro Creek	Riparian Meadow	1.11	67.35	74.77										74.77
	Riparian Meadow + Pilot Channel	1.16	67.35	78.18										78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.16	50.24	58.32	1.16	17.11	19.86							78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.16	50.24	58.32	1.16	9.14	10.61	1.16	7.97	9.25				78.18
	Riparian Meadow + Pilot Channel + Slackwater	1.21	67.35	81.59										81.59
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.21	50.24	60.9	1.21	17.11	20.73							81.59
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.21	50.24	60.9	1.21	9.14	11.07	1.21	7.97	9.66				81.59
Alazán Creek	Riparian Meadow	1.15	70.35	80.82										80.82
	Riparian Meadow + Pilot Channel	1.20	70.35	84.39										84.39
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	58.02	69.60	1.20	12.33	14.79							84.39
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	58.02	69.60	1.20	7.86	9.42	1.20	4.47	5.36				84.39
	Riparian Meadow + Pilot Channel + Slackwater	1.25	70.35	87.95										87.95
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	1.25	58.02	72.54	1.25	12.33	15.41							87.95
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	58.02	72.54	1.25	7.86	9.83	1.25	4.47	5.59				87.95
Martinez Creek	Riparian Meadow	1.15	50.56	58.08										58.08
	Riparian Meadow + Pilot Channel	1.20	50.56	60.64										60.64
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	41.77	50.10	1.20	8.79	10.54							60.64

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	41.77	50.10	1.20	5.03	6.03	1.20	3.76	4.51				60.64
	Riparian Meadow + Pilot Channel + Slackwater	1.25	50.56	63.20										63.20
	Riparian Meadow + Pilot Channel + Wetland	1.20	50.56	60.64							1.45	5.20	7.54	68.18
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	1.25	50.56	63.20							1.45	5.20	7.54	70.74
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.25	41.77	52.21	1.25	8.79	10.99							63.20
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	41.77	52.21	1.25	5.03	6.29	1.25	3.76	4.70				63.20
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	1.20	41.77	50.10	1.20	8.79	10.54			0.00	1.45	5.20	7.54	68.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	1.20	41.77	50.10	1.20	5.03	6.03	1.20	3.76	4.51	1.45	5.20	7.54	68.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	1.25	8.79	10.99			0.00	1.45	5.20	7.54	70.74
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	1.25	5.03	6.29	1.25	3.76	4.70	1.45	5.20	7.54	70.74
Apache Creek	Riparian Meadow	1.09	34.02	37.20										37.20
	Riparian Meadow + Pilot Channel	1.11	34.02	37.73										37.73
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.11	27.22	30.19	1.11	6.80	7.54							37.73
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.11	27.22	30.19	1.11	2.00	2.22	1.11	4.80	5.32				37.73
	Riparian Meadow + Pilot Channel + Slackwater	1.13	34.02	38.27										38.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.13	27.22	30.62	1.13	6.80	7.65							38.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.13	27.22	30.62	1.13	2.00	2.25	1.13	4.80	5.40				38.27

Table 4. Calculation of Total Avian Community Units for Year 15

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
San Pedro Creek	Riparian Meadow	1.11	67.35	74.77										74.77
	Riparian Meadow + Pilot Channel	1.16	67.35	78.18										78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.16	50.24	58.31	1.65	17.11	28.17							86.49
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.16	50.24	58.31	1.65	9.14	15.04	2.00	7.97	15.95				89.31
	Riparian Meadow + Pilot Channel + Slackwater	1.21	67.35	81.59										81.59
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.21	50.24	60.86	1.70	17.11	29..04							89.90
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.21	50.24	60.86	1.70	9.14	15.51	2.05	7.97	16.35				92.73
Alazán Creek	Riparian Meadow	1.15	70.35	80.82										80.82
	Riparian Meadow + Pilot Channel	1.20	70.35	84.39										84.38
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	58.02	69.60	1.69	12.33	20.78							90.38
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	58.02	69.60	1.69	7.86	13.25	2.04	4.47	9.12				91.96
	Riparian Meadow + Pilot Channel + Slackwater	1.25	70.35	87.95										87.95
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	1.25	58.02	72.54	1.74	12.33	21.40							93.94
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	58.02	72.54	1.74	7.86	13.64	2.04	4.47	9.12				95.30
Martinez Creek	Riparian Meadow	1.15	50.56	58.08										58.08
	Riparian Meadow + Pilot Channel	1.20	50.56	60.64										60.64
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	41.77	50.09	1.69	8.79	14.81							64.91
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	41.77	50.09	1.69	5.03	8.48	2.04	3.76	7.67				66.24
	Riparian Meadow + Pilot Channel + Slackwater	1.25	50.56	63.20										63.20

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
	Riparian Meadow + Pilot Channel + Wetland	1.20	50.56	60.64							1.45	5.20	7.54	68.18
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	1.25	50.56	63.20							1.45	5.20	7.54	70.74
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.25	41.77	52.21	1.74	8.79	15.26							67.47
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	41.77	52.21	1.74	5.03	8.73	2.09	3.76	7.86				68.80
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	1.20	41.77	50.09	1.69	8.79	14.81				1.45	5.20	7.54	72.44
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	1.20	41.77	50.09	1.69	5.03	8.48	2.04	3.76	7.67	1.45	5.20	7.54	73.78
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	1.74	8.79	15.26				1.45	5.20	7.54	75.01
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	1.74	5.03	8.73	2.09	3.76	7.86	1.45	5.20	7.54	76.34
Apache Creek	Riparian Meadow	1.09	34.02	37.20										37.20
	Riparian Meadow + Pilot Channel	1.11	34.02	37.73										37.73
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.11	27.22	30.19	1.59	6.80	10.85							41.04
	Riparian Meadow + Pilot Channel + Woody Vegetation 70 stems per acre)	1.11	27.22	30.19	1.59	2.00	3.19	1.95	4.80	9.36				42.74
	Riparian Meadow + Pilot Channel + Slackwater	1.13	34.02	38.27										38.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.13	27.22	30.63	1.61	6.80	10.95							41.58
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.13	27.22	30.63	1.61	2.00	3.22	1.97	4.80	9.43				43.28

Table 5. Calculation of Total Avian Community Units for Year 25

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
San Pedro Creek	Riparian Meadow	1.11	67.35	74.77										74.77
	Riparian Meadow + Pilot Channel	1.16	67.35	78.18										78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.16	50.24	58.32	2.01	17.11	34.35							92.67
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.16	50.24	58.32	2.01	9.14	18.35	2.48	7.97	19.77				96.44
	Riparian Meadow + Pilot Channel + Slackwater	1.21	67.35	81.59										81.59
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.21	50.24	60.86	2.06	17.11	35.21							96.08
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.21	50.24	60.86	2.06	9.14	18.81	2.53	7.97	20.17				99.85
Alazán Creek	Riparian Meadow	1.15	70.35	80.82										80.82
	Riparian Meadow + Pilot Channel	1.20	70.35	84.39										84.39
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	58.02	69.59	2.05	12.33	25.23							94.83
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	58.02	69.59	2.05	7.86	16.08	2.52	4.47	11.26				96.94
	Riparian Meadow + Pilot Channel + Slackwater	1.25	70.35	87.95										87.95
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	1.25	58.02	72.54	2.10	12.33	25.86							98.39
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	58.02	72.54	2.10	5.86	16.48	2.57	4.47	11.49				100.50
Martinez Creek	Riparian Meadow	1.15	50.56	58.08										58.08
	Riparian Meadow + Pilot Channel	1.20	50.56	60.64										60.64
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	41.77	50.10	2.05	8.79	17.98							68.08
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	41.77	50.10	2.05	5.03	10.29	2.52	3.76	9.47				69.86
	Riparian Meadow + Pilot Channel + Slackwater	1.25	50.56	63.20										63.20

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
	Riparian Meadow + Pilot Channel + Wetland	1.20	50.56	60.64							1.45	5.20	7.54	68.17
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	1.25	50.56	63.20							1.45	5.20	7.54	70.74
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.25	41.77	52.21	2.10	8.79	18..43							70.65
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	41.77	52.21	2.10	5.03	10.55	2.57	3.76	9.66				72.42
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	1.20	41.77	50.09	2.05	8.79	17.99				1.45	5.20	7.54	75.62
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	1.20	41.77	50.09	2.05	5.03	10.29	2.52	3.76	9.47	1.45	5.20	7.54	77.40
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	2.10	8.79	18.43				1.45	5.20	7.54	78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	2.10	5.03	10.55	2.57	3.76	9.66	1.45	5.20	7.54	79.96
Apache Creek	Riparian Meadow	1.09	34.02	37.20										37.20
	Riparian Meadow + Pilot Channel	1.11	34.02	37.73										37.73
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.11	27.22	30.19	1.96	6.80	13.30							43.49
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.11	27.22	30.19	1.96	2.00	3.91	2.43	4.80	11.66				45.76
	Riparian Meadow + Pilot Channel + Slackwater	1.13	34.02	38.27										38.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.13	27.22	30.62	1.97	6.80	13.41							44.03
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.13	27.22	30.62	1.97	2.00	3.94	2.44	4.80	11.73				46.30

Table 6. Calculation of Total Avian Community Units for Year 50

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
San Pedro Creek	Riparian Meadow	1.11	67.35	74.77										74.77
	Riparian Meadow + Pilot Channel	1.16	67.35	78.18										78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.16	50.24	58.32	2.48	17.11	42.44							100.76
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.16	50.24	58.32	2.48	9.14	22.67	3.02	7.97	24.03				105.02
	Riparian Meadow + Pilot Channel + Slackwater	1.21	67.35	81.59										81.59
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.21	50.24	60.86	2.53	17.11	43.31							104.17
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.21	50.24	60.86	2.53	9.14	23.13	3.07	7.97	24.44				108.43
Alazán Creek	Riparian Meadow	1.15	70.35	80.82										80.82
	Riparian Meadow + Pilot Channel	1.20	70.35	84.39										84.39
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	58.02	69.60	2.52	12.33	31.06							100.66
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	58.02	69.60	2.52	7.86	19.80	3.05	4.47	13.65				103.05
	Riparian Meadow + Pilot Channel + Slackwater	1.25	70.35	87.95										87.95
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	1.25	58.02	72.54	2.57	12.33	31.69							104.22
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	58.02	72.54	2.57	7.86	20.20	3.10	4.47	13.88				106.61
Martinez Creek	Riparian Meadow	1.15	50.56	58.08										58.08
	Riparian Meadow + Pilot Channel	1.20	50.56	60.64										60.64
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	41.77	50.10	2.52	8.79	22.14							72.24
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	41.77	50.10	2.52	5.03	12.67	3.05	3.76	11.48				74.25
	Riparian Meadow + Pilot Channel + Slackwater	1.25	50.56	63.20										63.20
	Riparian Meadow + Pilot Channel + Wetland	1.20	50.56	60.64							1.45	5.20	7.54	68.18
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	1.25	50.56	63.20							1.45	5.20	7.54	70.74
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.25	41.77	52.21	2.57	8.79	22.59							74.80
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	41.77	52.21	2.57	5.03	12.93	3.10	3.76	11.67				76.81

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	1.20	41.77	50.10	2.52	8.79	22.14				1.45	5.20	7.54	79.78
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	1.20	41.77	50.10	2.52	5.03	12.67	3.05	3.76	11.48	1.45	5.20	7.54	81.79
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	2.57	8.79	22.59				1.45	5.20	7.54	82.33
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	2.57	5.03	12.93	3.10	3.76	11.67	1.45	5.20	7.54	84.35
Apache Creek	Riparian Meadow	1.09	34.02	37.20										37.20
	Riparian Meadow + Pilot Channel	1.11	34.02	37.73										37.73
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.11	27.22	30.19	2.43	6.82	16.52							46.71
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.11	27.22	30.19	2.43	2.00	4.86	2.96	4.80	14.23				49.28
	Riparian Meadow + Pilot Channel + Slackwater	1.13	34.02	38.27										38.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.13	27.22	30.62	2.44	6.82	16.62							47.24
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.13	27.22	30.62	2.44	2.00	4.89	2.98	4.80	14.30				49.82

Table 7. Calculation of Total Avian Community Units for Year 75

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
San Pedro Creek	Riparian Meadow	1.11	67.35	74.77										74.77
	Riparian Meadow + Pilot Channel	1.16	67.35	78.18										78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.16	50.24	58.32	2.48	17.11	42.44							100.76
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.16	50.24	58.32	2.48	9.14	22.67	3.02	7.97	24.03				105.02
	Riparian Meadow + Pilot Channel + Slackwater	1.21	67.35	81.59										81.59
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.21	50.24	60.86	2.53	17.11	43.31							104.17
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.21	50.24	60.86	2.53	9.14	23.13	3.07	7.97	24.44				108.43
Alazán Creek	Riparian Meadow	1.15	70.35	80.82										80.82
	Riparian Meadow + Pilot Channel	1.20	70.35	84.39										84.39
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	58.02	69.60	2.52	12.33	31.06							100.66
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	58.02	69.60	2.52	7.86	19.80	3.05	4.47	13.65				103.05
	Riparian Meadow + Pilot Channel + Slackwater	1.25	70.35	87.95										87.95
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	1.25	58.02	72.54	2.57	12.33	31.69							104.22
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	58.02	72.54	2.57	7.86	20.20	3.10	4.47	13.88				106.61
Martinez Creek	Riparian Meadow	1.15	50.56	58.08										58.08
	Riparian Meadow + Pilot Channel	1.20	50.56	60.64										60.64
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	41.77	50.09	2.52	8.79	22.14							72.24
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	41.77	50.09	2.52	5.03	12.67	3.05	3.76	11.48				74.25
	Riparian Meadow + Pilot Channel + Slackwater	1.25	50.56	63.20										63.20
	Riparian Meadow + Pilot Channel + Wetland	1.20	50.56	60.64							1.45	5.20	7.54	68.18

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	1.25	50.56	63.20							1.45	5.20	7.54	70.74
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.25	41.77	52.21	2.57	8.79	22.59							74.80
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	41.77	52.21	2.57	5.03	12.93	3.10	3.76	11.67				76.81
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	1.20	41.77	50.09	2.52	8.79	22.14				1.45	5.20	7.54	79.78
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	1.20	41.77	50.09	2.52	5.03	12.67	3.05	3.76	11.48	1.45	5.20	7.54	81.79
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	2.57	8.79	22.59				1.45	5.20	7.54	82.34
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	2.57	5.03	12.93	3.10	3.76	11.67	1.45	5.20	7.54	84.35
Apache Creek	Riparian Meadow	1.09	34.02	37.20										37.20
	Riparian Meadow + Pilot Channel	1.11	34.02	37.73										37.73
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.11	27.22	30.19	2.43	6.80	16.52							46.71
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.11	27.22	30.19	2.43	2.00	4..86	2.96	4.80	14.23				49.28
	Riparian Meadow + Pilot Channel + Slackwater	1.13	34.02	38.27										38.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.13	27.22	30.62	2.44	6.80	16.62							47.25
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.13	27.22	30.62	2.44	2.00	4.89	2.98	4.80	14.30				49.82

Table 8. Average Annual ABI

Stream	Measure	Year						Average Annual Avian Community Units
		0	1	15	25	50	75	
San Pedro Creek	Riparian Meadow	61.54	74.77	74.77	74.77	74.77	74.77	74.27
	Riparian Meadow + Pilot Channel	61.54	78.18	78.18	78.18	78.18	78.18	77.66
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	61.54	78.18	86.49	92.67	100.76	100.76	93.66
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	61.54	78.18	89.32	96.44	105.02	105.02	97.12
	Riparian Meadow + Pilot Channel + Slackwater	61.54	81.59	81.59	81.59	81.59	81.59	81.05
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	61.54	81.59	89.90	96.08	104.17	104.17	97.05
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	61.54	81.59	92.73	99.85	108.43	108.43	100.51
Alazán Creek	Riparian Meadow	64.69	80.82	80.82	80.82	80.82	80.82	80.28
	Riparian Meadow + Pilot Channel	64.69	84.39	84.39	84.39	84.39	84.39	83.83
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	64.69	84.39	90.38	94.83	100.66	100.66	95.35
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	64.69	84.39	91.96	96.94	103.05	103.05	97.30
	Riparian Meadow + Pilot Channel + Slackwater	64.69	87.95	87.95	87.95	87.95	87.95	87.36
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	64.69	87.95	93.94	98.39	104.22	104.22	98.89
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	64.69	87.95	95.30	100.50	106.61	106.61	100.80
Martinez Creek	Riparian Meadow	46.53	58.08	58.08	58.08	58.08	58.08	57.69
	Riparian Meadow + Pilot Channel	46.53	60.64	60.64	60.64	60.64	60.64	60.24
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	46.53	60.64	64.91	68.08	72.24	72.24	68.46
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	46.53	60.64	66.24	69.86	74.25	74.25	70.09
	Riparian Meadow + Pilot Channel + Slackwater	46.53	63.20	63.20	63.20	63.20	63.20	62.78
	Riparian Meadow + Pilot Channel + Wetland	46.53	68.18	68.18	68.18	68.18	68.18	67.73
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	46.53	70.74	70.74	70.74	70.74	70.74	70.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	46.53	63.20	67.47	70.65	74.80	74.80	71.00
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	46.53	63.20	68.80	72.42	76.81	76.81	72.63
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	46.53	68.18	72.45	75.62	79.78	79.78	75.94
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	46.53	68.18	73.78	77.40	81.79	81.79	77.58
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	46.53	70.74	75.01	78.18	82.34	82.34	78.49
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	46.53	70.74	76.34	79.96	84.35	84.35	80.12
Apache Creek	Riparian Meadow	31.97	37.20	37.20	37.20	37.20	37.20	36.92
	Riparian Meadow + Pilot Channel	31.97	37.73	37.73	37.73	37.73	37.73	37.48
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	31.97	37.73	41.04	43.49	46.71	46.71	43.84
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	31.97	37.73	42.74	45.76	49.28	49.28	45.93
	Riparian Meadow + Pilot Channel + Slackwater	31.97	38.27	38.27	38.27	38.27	38.27	38.02
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	31.97	38.27	41.58	44.03	47.25	47.25	44.38
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	31.97	38.27	43.28	46.30	49.82	49.82	46.46

Environmental restoration benefits are calculated by subtracting the future without-project avian community units from the with-project average annual avian community units. The resulting benefits are then used, along with annual costs, to identify cost effective plans and perform incremental cost analysis. The calculation of benefits (outputs) are shown in Table 9.

COSTS

Annual costs were calculated using the annualizer in IWR Planning Suite. A period of analysis of 75 years was used, along with a federal discount rate of 3.75% (per EGM13-01 dated 27 OCT 2012), and a construction time of 18 months. Prices are expressed in October 2012 dollars. Since all plans are expected to have similar annual operation and maintenance costs and monitoring costs, the values would not affect plan formulation or selection, and were not included in the analysis. First costs were developed the cost engineering section, including contingencies. Details of the development of costs can be found in the Cost Engineering Appendix. Table 10 provides first costs, interest during construction, and average annual costs for the measure combinations. First costs ranged from $2.3 million ($93,000 annual cost) for riparian meadow only in Apache Creek to $17.9 million ($736,000 annual cost) for riparian meadow, pilot channel, slackwater, wetlands, and 70/30 trees per acre in Martinez Creek.

Table 9. Calculation of Benefits (Output)

		Future Without Project			Future With Project		
Stream	**Plan**	**Avian IBI**	**Acres**	**Avian Community Unit**	**Acres**	**Average Annual Avian Community Unit**	**Benefits Average Annual Avian Community Units (Output)**
San Pedro Creek	Riparian Meadow	0.913683	67.35	61.53655	67.35	74.27136	12.73481
	Riparian Meadow + Pilot Channel	0.913683	67.35	61.53655	67.35	77.65872	16.12217
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	0.913683	67.35	61.53655	67.35	93.65845	32.1219
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	0.913683	67.35	61.53655	67.35	97.12074	35.58419
	Riparian Meadow + Pilot Channel + Slackwater	0.913683	67.35	61.53655	67.35	81.04609	19.50954
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	0.913683	67.35	61.53655	67.35	97.04702	35.51047
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	0.913683	67.35	61.53655	67.35	100.5093	38.97276
Alazán Creek	Riparian Meadow	0.919491	70.35	64.68619	70.35	80.28135	15.59516
	Riparian Meadow + Pilot Channel	0.919491	70.35	64.68619	70.35	83.82717	19.14098
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	0.919491	70.35	64.68619	70.35	95.35475	30.66856
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	0.919491	70.35	64.68619	70.35	97.29697	32.61078
	Riparian Meadow + Pilot Channel + Slackwater	0.919491	70.35	64.68619	70.35	87.36366	22.67746
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	0.919491	70.35	64.68619	70.35	98.89363	34.20744
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	0.919491	70.35	64.68619	70.35	100.799	36.11277
Martinez Creek	Riparian Meadow	0.920196	50.56	46.52511	50.56	57.69275	11.16764
	Riparian Meadow + Pilot Channel	0.920196	50.56	46.52511	50.56	60.23575	13.71064
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	0.920196	50.56	46.52511	50.56	68.45646	21.93135
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	0.920196	50.56	46.52511	50.56	70.08925	23.56414
	Riparian Meadow + Pilot Channel + Slackwater	0.920196	50.56	46.52511	50.56	62.77875	16.25364
	Riparian Meadow + Pilot Channel + Wetland	0.920196	50.56	46.52511	55.76	67.72526	21.20015
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	0.920196	50.56	46.52511	55.76	70.26826	23.74315
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	0.920196	50.56	46.52511	50.56	70.99986	24.47475
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	0.920196	50.56	46.52511	50.56	72.63278	26.10767
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	0.920196	50.56	46.52511	55.76	75.9433	29.41819
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	0.920196	50.56	46.52511	55.76	77.57538	31.05027
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	0.920196	50.56	46.52511	55.76	78.48657	31.96146
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	0.920196	50.56	46.52511	55.76	80.12042	33.59531
Apache Creek	Riparian Meadow	0.939846	34.02	31.97356	34.02	36.92178	4.948216
	Riparian Meadow + Pilot Channel	0.939846	34.02	31.97356	34.02	37.47876	5.505194
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	0.939846	34.02	31.97356	34.02	43.84279	11.86922
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	0.939846	34.02	31.97356	34.02	45.92924	13.95568
	Riparian Meadow + Pilot Channel + Slackwater	0.939846	34.02	31.97356	34.02	38.01507	6.041507
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	0.939846	34.02	31.97356	34.02	44.37816	12.4046
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	0.939846	34.02	31.97356	34.02	46.46449	14.49093

Table 10. First Costs and Annual Costs (October 2012 dollars, 75 year period of analysis, 3.75% discount rate, 18 month construction period)

Stream	Plan	First Cost	Interest During Construction	Investment Cost	Annual Interest	Annual Principle	Total Annual Costs
San Pedro Creek	Riparian Meadow	$5,602,146	$148,734	$5,750,880	$215,658	$14,555	$230,213
	Riparian Meadow + Pilot Channel	13,510,677	358,702	13,869,379	520,102	35,103	555,205
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	13,557,982	359,958	13,917,940	521,923	35,226	557,149
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	13,588,627	360,772	13,949,399	523,102	35,306	558,408
	Riparian Meadow + Pilot Channel + Slackwater	13,952,155	370,423	14,322,578	537,097	36,250	573,347
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	13,999,460	371,679	14,371,139	538,918	36,373	575,291
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	14,030,105	372,493	14,402,598	540,097	36,453	576,550
Alazán Creek	Riparian Meadow	5,840,873	155,073	5,995,946	224,848	15,176	240,024
	Riparian Meadow + Pilot Channel	14,968,729	397,413	15,366,142	576,230	38,892	615,122
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	15,002,253	398,303	15,400,556	577,521	38,979	616,500
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	15,017,421	398,706	15,416,127	578,105	39,018	617,123
	Riparian Meadow + Pilot Channel + Slackwater	15,407,899	409,073	15,816,972	593,136	40,033	633,169
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	15,441,423	409,963	15,851,386	594,427	40,120	634,547
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	15,456,591	410,366	15,866,957	595,011	40,159	635,170
Martinez Creek	Riparian Meadow	4,210,779	111,794	4,322,573	162,096	10,940	173,037
	Riparian Meadow + Pilot Channel	16,199,039	430,077	16,629,116	623,592	42,088	665,680
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	16,228,382	430,856	16,659,238	624,721	42,165	666,886
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	16,246,542	431,338	16,677,880	625,421	42,212	667,632
	Riparian Meadow + Pilot Channel + Slackwater	16,310,494	433,036	16,743,530	627,882	42,378	670,260

	Riparian Meadow + Pilot Channel + Wetland	17,743,650	471,086	18,214,736	683,053	46,101	729,154
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	17,855,105	474,045	18,329,150	687,343	46,391	733,734
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	16,339,837	433,815	16,773,652	629,012	42,454	671,466
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	16,357,997	434,297	16,792,294	629,711	42,501	672,212
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	17,772,993	471,865	18,244,858	684,182	46,178	730,360
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	17,791,153	472,347	18,263,500	684,881	46,225	731,106
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	17,884,448	474,824	18,359,272	688,473	46,467	734,940
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	17,902,608	475,306	18,377,914	689,172	46,515	735,686
Apache Creek	Riparian Meadow	2,262,528	60,069	2,322,597	87,097	5,878	92,976
	Riparian Meadow + Pilot Channel	5,122,882	136,010	5,258,892	197,208	13,310	210,519
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	5,152,302	136,791	5,289,093	198,341	13,387	211,728
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	5,171,069	137,290	5,308,359	199,063	13,435	212,499
	Riparian Meadow + Pilot Channel + Slackwater	5,262,602	139,720	5,402,322	202,587	13,673	216,260
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	5,292,022	140,501	5,432,523	203,720	13,750	217,469
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	5,310,789	140,999	5,451,788	204,442	13,798	218,241

COST EFFECTIVENESS AND INCREMENTAL COST ANALYSIS

To conduct the cost CE/ICA analysis, environmental restoration benefits (increase in with-project average annual avian community units) and annual costs (expressed in thousands of dollars) were entered into IWR Planning Suite. This data is presented in Table 11. Using the 34 measures, the plan generator in the software was used to create all possible combinations of the measures. This resulted in 7,168 plans.

Table 11. Inputs for IWR Planning Suite CEICA Analysis

Stream	Measure	Average Annual Avian Community Benefit (Output)	Average Annual Costs ($1,000)
San Pedro Creek	Riparian Meadow	12.73481	$230.213
	Riparian Meadow + Pilot Channel	16.12217	555.205
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	32.12190	557.149
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	35.58419	558.408
	Riparian Meadow + Pilot Channel + Slackwater	19.50954	573.347
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	35.51047	575.291
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	38.97276	576.550
Alazán Creek	Riparian Meadow	15.59516	240.024
	Riparian Meadow + Pilot Channel	19.14098	615.122
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	30.66856	616.500
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	32.61078	617.123
	Riparian Meadow + Pilot Channel + Slackwater	22.67746	633.169
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	34.20744	634.547
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	36.11277	635.170
Martinez Creek	Riparian Meadow	11.16764	173.037
	Riparian Meadow + Pilot Channel	13.71064	665.680
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	21.93135	666.886
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	23.56414	667.632
	Riparian Meadow + Pilot Channel + Slackwater	16.25364	670.260
	Riparian Meadow + Pilot Channel + Wetland	21.20015	729.154
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	23.74315	733.734
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	24.47475	671.466
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	26.10767	672.212
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	29.41819	730.360
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	31.05027	731.106
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	31.96146	734.940

Stream	Measure	Average Annual Avian Community Benefit (Output)	Average Annual Costs ($1,000)
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	33.59531	735.686
Apache Creek	Riparian Meadow	4.94822	92.976
	Riparian Meadow + Pilot Channel	5.50519	210.519
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	11.86922	211.728
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	13.95568	212.499
	Riparian Meadow + Pilot Channel + Slackwater	6.04151	216.260
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	12.40460	217.469
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	14.49093	218.241

COST EFFECTIVENESS

Using the generated plans, their costs and benefits, a cost effective analysis was performed using the IWR Planning Suite Software. Of the 7,168 plans, 96 cost effective alternatives (including no action) were identified. From the cost effective alternatives, 7 (including the no action plan) were identified as "Best Buy" plans. The results of the analysis is shown graphically in Figure 1.

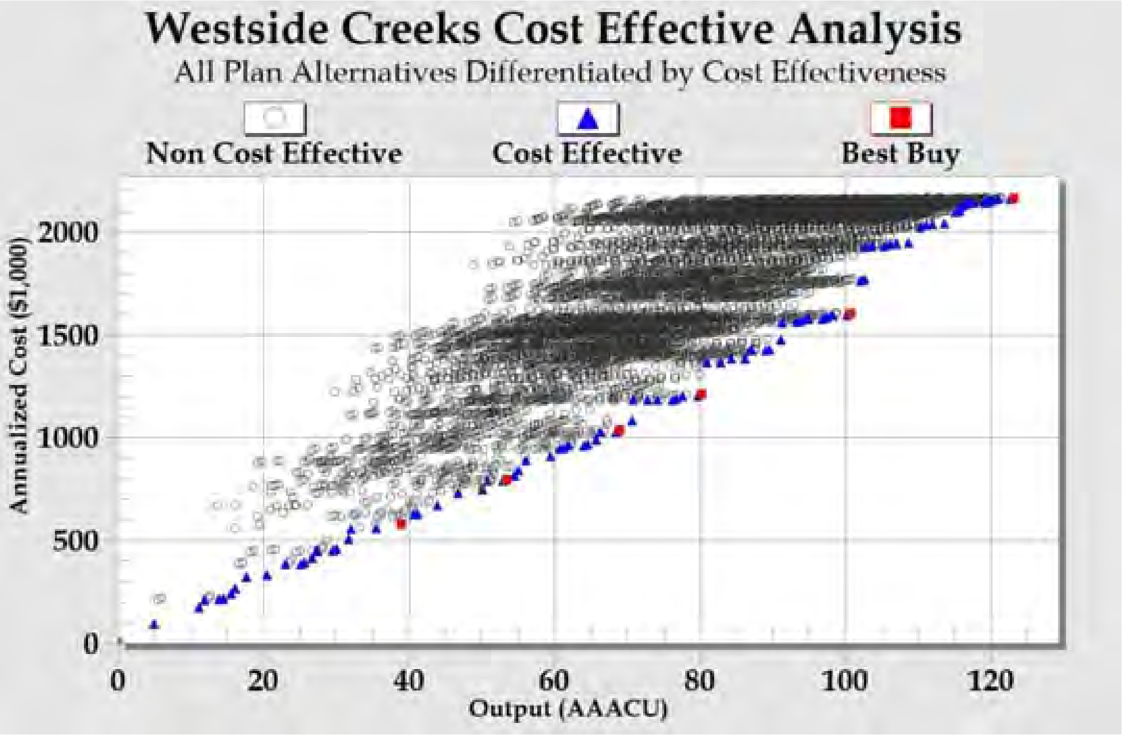


Figure 1. Cost Effective Results

INCREMENTAL COST ANALYSIS

Through incremental cost analysis, six action plans were identified as best buy plans. Those plans are:

- Alternative 2: Riparian meadow, pilot channel, riparian woody vegetation, and slackwater in San Pedro Creek.
- Alternative 3: Alternative 2 plus riparian meadow, pilot channel, riparian woody vegetation, and slackwater in Apache Creek.
- Alternative 4: Alternative 3 plus riparian meadow in Alazán Creek.
- Alternative 5: Alternative 4 plus riparian meadow in Martinez Creek
- Alternative 6: Alternative 5 plus pilot channel, riparian woody vegetation, and slackwater in Alazán Creek
- Alternative 7: Alternative 6 plus pilot channel, riparian woody vegetation, slackwater, and wetlands in Martinez Creek

Figure 2 presents the six "action" plans resulting from the incremental cost analysis showing the incremental average annual cost per incremental output and the environmental output (measured in AAACUs) for each alternative.

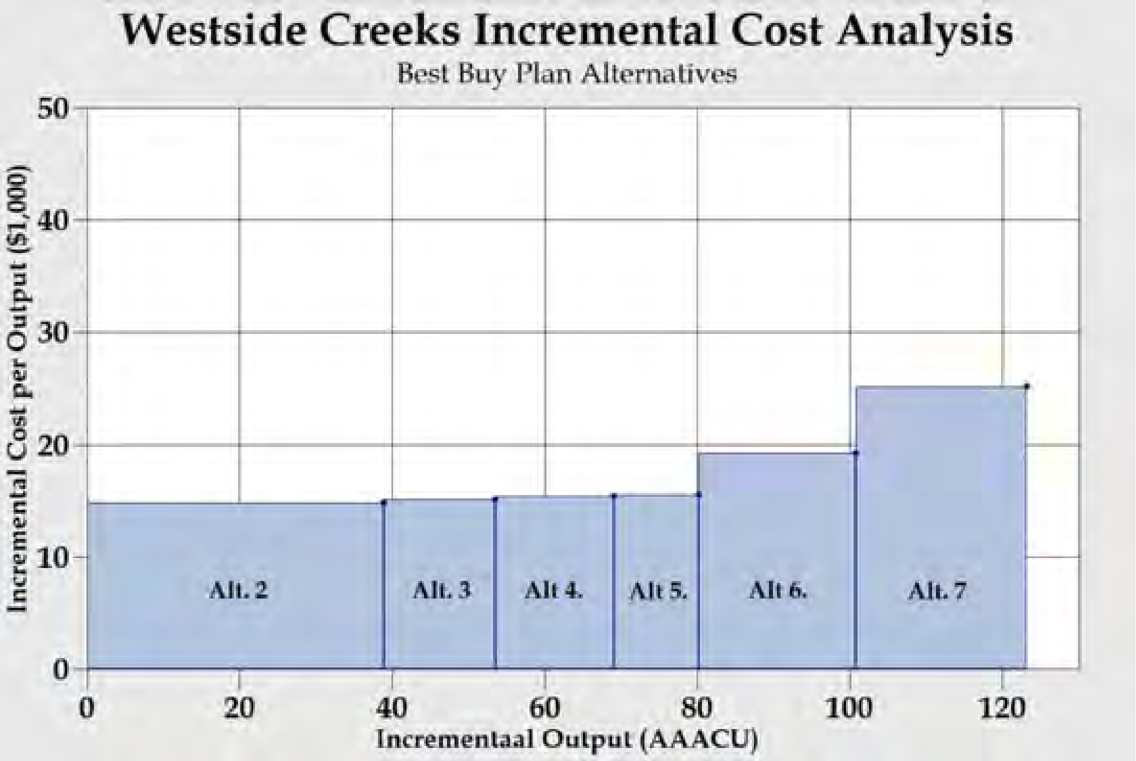


Figure 2. Incremental Cost and Output Results

Table 12 presents the incremental cost and outputs generated by the IWR Planning Suite

Table 12. Incremental Cost of Best Buy Plan Combinations

Alt.	Increment Added	Output (Avian Community Unit)	Annual Cost ($1,000)	Average Annual Cost ($1,000 / ACU)	Incremental Cost ($1,000)	Incremental Output (Avian Community Unit)	Incremental Cost Per Incremental Output
1	No Action Plan on All Creeks	0	0				
2	San Pedro – Pilot Channel, Slackwater, 70/30 Woody Stems/Acre	38.97	$576.55	$14.7937	$576.5500	38.9728	$14.7937
3	Alternate 2 + Apache - Pilot Channel, Slackwater, 70/30 Woody Stems/Acre	53.46	794.79	14.8660	218.2410	14.4909	15.0605
4	Alternate 3 + Alazán Creek Riparian Meadow	69.06	1,034.82	14.9845	240.0240	15.5952	15.3909
5	Alternatve 4 +Martinez Creek Riparian Meadow	80.23	1,207.85	15.0555	173.0370	11.1676	15.4945
6	Alternate 5 + Alazán Creek Pilot Channel, Slackwater, 70/30 Woody Stems/Acre	100.74	1,603.00	15.9116	395.1460	20.5176	19.2589
7	Alternate 6 + Martinez Creek Pilot Channel, Slackwater, Wetlands, 70/30 Woody Stems/Acre	123.17	2,165.65	17.5823	562.6490	22.4277	25.0873

Alternative 2 has increases the AAACUs by 39 units over the no action plan with an incremental cost per incremental output of $15,000. The alternative's first cost is $14 million, with an average annual cost of $577 thousand.

Alternative 3 creates a total AAACU of 53 units, an increase of 14 over alternative 2. However, the incremental cost per incremental output remains at $15,000, indicating no increases in costs for the last AAACU added over alternative 2. The first cost of alternative 3 is $19 million, an increase of $5 million from alternative 2. The average annual cost for the alternative 3 is $795 thousand, an increase of 218 thousand from alternative 2.

Alternative 4 creates a total AAACU of 69 units over the no action plan, an increase of 16 AAACUs over alternative 3. The incremental cost per incremental output remains at $15,000, indicating no increase in cost for the last AAACU added. The first cost of the alternative is $25 million, an increase of $6 million over alternative 3. The average annual cost is $1 million, an increase of $240 thousand over alternative 3.

Alternative 5 creates a total of 80 AAAACUs above the no action plan, which is an increase of 11 AACUs over alternative 4. The incremental cost per incremental output remains at $15,000, indicating no increase in cost for the last unit of habitat added. The first cost is $29 million, an increase of $4 million over alternative 4. The average annual cost is $1.2 million, an increase of $200 thousand over alternative 4.

Alternative 6 creates a total of 101 AAACUs above the no action plan, and an increase of 21 AAACUs above alternative 5. With alternative 6, there is an increase in the incremental cost per incremental output to $19 thousand, indicating the cost of the last added unit of habitat is greater than prior alternatives. The alternative's first cost is $39 million, a $10 million increase over alternative 5. The average annual cost is $1.6 million, an increase of $400 thousand over alternative 5.

Alternative 7 creates a total of 123 AAACUs above the no action plan, and an increase of 22 AAACUs over alternative 6. The incremental cost per incremental output is $25 thousand, an increase of $6 thousand over alternative 6, showing the last added ACCCU has an increasing cost. The first cost is $53 million, an increase of $14 million over alternative 6. The average annual cost is$2.2 million, an increase of $600 thousand over alternative 6.

With the best buy plans identified and their incremental costs per incremental output calculated, each plan must be evaluated through an “Is It Worth It” analysis to make the case that each successive alternative is worth its incremental cost when compared to its incremental and total AAACU. Since the costs and AAACUs are measured in different units, this analysis is more qualitative than empirical. The “Is It Worth It” analysis for this study is presented in the plan formulation section of the main report.

WESTSIDE CREEKS ENVIRONMENTAL RESTORATION

Appendix E: Civil Engineering

CIVIL ENGINEERING APPENDIX

METHODOLOGY

The Westside Creeks Ecosystem Restoration Feasibility Study is located along the west side of San Antonio, TX. The study encompasses defined limits within the following creeks: Apache, Alazan, Martinez, and San Pedro. The defined study area limits for these creeks are as follows: San Pedro Creek extends from its confluence with the San Antonio River to the Camp Street bridge crossing (near hydraulic station 126+76), Apache Creek extends from its confluence with San Pedro Creek to Southwest 19th Street bridge crossing (near hydraulic station 143+44), Alazan Creek extends from its confluence with Apache Creek to the Josephine Tobin Drive South bridge crossing (near hydraulic station 175+71), and Martinez Creek extends from its confluence with Alazan Creek to the Hildebrand Avenue bridge crossing (near hydraulic station 147+26).

In order to complete this study, the San Antonio River Authority (SARA) provided data for existing site features, structures, roads, utilities, topography, etc. via GIS files. However, the existing GIS utility data was limited to only domestic water, sanitary sewer, and storm sewer. For all other utilities, SARA has coordinated with local utility companies to obtain locations of existing gas, electrical, and communication lines. Through SARA's coordination efforts, utility companies with utilities in our study area became known and are as follows: San Antonio Water System (SAWS) (domestic water and sanitary sewer), CPS Energy (natural gas and electric), Grande Communications (communication), and Williams Communications (communication). Drawings in PDF format were provided by the aforementioned utility companies illustrating utility crossings within our study area.

For all four creeks, excavation will be required to produce pilot channels and lower channel bottoms for implementation of the ecosystem restoration alternatives. Pilot channels are being proposed for the defined study limits as stated above except for within Apache Creek. The pilot channel limits proposed for Apache Creek extend from its confluence with San Pedro Creek to a point approximately half between the South Brazos Street and South Trinty Street crossings (near hydraulic station 42+70). In order to implement proposed ecosystem restoration measures within the creeks, locations exist requiring lowering of the flood channel bottom, in addition to executing the pilot channel, to ensure there is no increase in water surface elevation. The Hydraulics & Hydrology Section for the U.S. Army Corps of Engineers – Fort Worth District is producing the excavation quantities for the proposed channel sections using the HEC-RAS software program. Additional excavation quantities were calculated to account for stripping and utility relocations.

Clearing, grubbing, stripping, and ripping will take place along the full length of all four creeks within the defined study limits, from the right descending top bank to the left descending top bank with exception to Apache Creek upstream of hydraulic station 42+70. In this reach, clearing, grubbing, stripping, and ripping will only take place where no impervious areas exist within the flood channel. The alternative plans propose stripping 6-inches of natural ground and replacing with organic topsoil. Ripping of natural ground will take place to a depth of 12-inches below the stripped soil finish grade. Ripping will not take place in sensitive areas that would negatively impact existing utilities or other structures designated to remain. Additional topsoil is included within the estimated quantities to account for blending operations within the ripped soil layer. In order to treat invasive plants and unwanted growth during and after clearing, grubbing, stripping, and ripping operations, herbicides will be used. The same acreage determined for clearing and grubbing has also been used to quantify herbicide treatments. Quantities provided to cost estimating account for two herbicide treatments per creek.

The GIS data and aerials show a few patches of existing concrete within the flood channels of Alazan and Martinez Creeks. The concrete lining within these two creeks will be demolished, excluding storm drain outfalls. Concrete channel lining for storm drain outfalls, in all creeks, not affected by excavation will remain in place. No demolition of existing concrete or channel lining will be implemented for the study alternatives upstream of hydraulic station 42+70 within Apache Creek. GIS data did not show San Pedro to have existing concrete except at the confluence with the San Antonio River. This concrete is to remain. In addition, no demolition quantities will be provided for removal of existing retaining walls within the four creeks. The PDT decided for the purposes of this study, all existing retaining walls will remain. As-builts of Apache Creek show the concrete lining to be 8-inches in thickness, reinforced with #5 bars @ 12-inches O.C. E.W. All concrete within the study limits designated to be demolished were assumed to have the same thickness and reinforcement as the concrete lining for Apache. In order to account for shear stresses at proposed concrete removal locations, Turf Reinforcement Mats (TRM's) will be used and were quantified for the study alternatives. A TRM was chosen that accounts for shear stresses up to 12 pounds per square foot. Storm water pollution prevention quantities, to include stabilized construction accesses, were determined for all four creeks and were incorporated into the cost estimate accordingly.

For all identified existing utilities, determinations were made concerning the need for relocations in order to implement specific ecosystem restoration alternatives. Utility relocations were quantified for the entire lengths of channel within the study area for Martinez, San Pedro, and Alazan Creeks. For Apache Creek, utility relocation quantities were only quantified for the reach where excavation will take place to construct the proposed pilot channel, which is from its confluence with San Pedro Creek to hydraulic station 42+70. Sanitary sewer relocations were determined by analyzing the impact of the proposed channel section on the existing sanitary sewer pipe using the provided GIS data. Using the cross sections, provided by H&H, a digital terrain model (DTM) was created. Then using the manhole invert elevations, provided in the GIS data, profiles of the sanitary sewer pipes were created. In locations where the proposed channel section exposes the existing sanitary sewer pipe or decreases the ground cover to an unacceptable level, relocation and/or modification quantities were determined and provided to cost estimating. There are some cases where existing sanitary sewer pipe affected by the proposed channel excavation will only require concrete encasement versus relocation. Existing domestic water and natural gas pipe elevations are not known. Therefore, where excavation depths exceed 1-foot below the existing channel bottom, relocation of these utility lines were quantified and submitted to cost estimating. For all four creeks, storm sewer utilities consisted of pipes entering the channel predominately on the flood channel banks. There are numerous storm drain outfalls in all four creeks. No alteration of existing storm pipe is required to implement the proposed channel sections. However, modifications of existing concrete channel lining for storm sewer outfalls will be required in order to implement the proposed channel sections. Quantities were provided to cost estimating to demolish existing concrete lining impacted by the proposed excavation and to add Turf Reinforcement Mats (TRMs) from the end of the remaining concrete lining down to the channel bottom of the proposed pilot channel. All existing CPS Energy and Grande Communication electric and communication utility lines were found to be aerial; therefore, no relocations were necessary. The communication lines owned by WilTel run along the top bank of Apache; therefore, no relocations are necessary. There is one known underground communication line (owned by Williams Communication) crossing beneath San Pedro Creek upstream of Interstate 35, immediately upstream of and within the Union Pacific Railroad Right-of-Way. The information provided is not sufficient to determine whether this line will require relocation. This uncertainty is captured in the abbreviated risk analysis.

STRUCTURAL

The measures proposed in the Westside Creeks Ecosystem Restoration Feasibility Study include excavation to produce pilot channels and lower channel bottoms for implementation of the ecosystem restoration. It has been determined that these measures do not affect the supports for existing pedestrian and vehicle bridges. Additionally, with no raise in water surface elevation there is no change in the hydraulic loading on bridge superstructures. Therefore at this point there is no structural engineering scope of work. The structural section follows development of the study and in the event new pedestrian bridges or modifications to existing bridges are incorporated in the proposed ecosystem restoration measures the scope will be defined and quantified for the cost estimate as necessary.

WESTSIDE CREEKS ECOSYSTEM RESTORATION

Appendix F: Geotechnical Assessment

GEOTECHNICAL ASSESSMENT

GENERAL

The Westside Creeks (WSC) study focuses on Alazán, Apache, Martinez and San Pedro Creeks totaling approximately 14 miles of creek channel. WSC is part of the San Antonio Channel Improvement Project (SACIP) originally designed and constructed in the 1950's and 1960's.

- Alazán Creek from Woodlawn Lake to its confluence with Apache and San Pedro Creek. Significant area would be the Martinez Creek confluence.
- Apache Creek from Lake Elmendorf Lake to its confluence with San Pedro Creek. Significant areas include a sharp bend just upstream of S Zarzamora Street, and another significant bend and old channel remnant around S Brazos Street.
- Martinez Creek from W Hildebrand Avenue to its confluence with Alazán Creek. Significant areas would include the reaches along Interstate 10, series of bends between Fredericksburg Road and N. Sabinas Street, and close proximity to I-10 around Culebra Road.
- San Pedro Creek from the outlet of the San Pedro Tunnel to its confluence with the San Antonio River. Significant areas include U-lined channel through part of the downtown, underpasses and close alignment to I-35, and underpass to I-10.

GENERAL GEOLOGY AND PHYSIOGRAPHY

PHYSIOGRAPHY

Bexar County is located within the Interior Coastal Plain, Edwards Plateau and Black Prairie. The topography of the county is nearly level or undulating in the southern two-thirds of the county, where the area rises from 500-ft elevation NGVD to 1000-ft elevation from the southeast to the northwest. This region of the county is underlain by beds of old alluvium, chalk and marl dipping to the southeast at a greater rate than in the Edwards Plateau. In the northern third of the county covering the Edwards Plateau, the topography is strongly sloping to steep, rising from 1000-ft to 1900-ft in elevation and is underlain by limestone beds which dip very slightly toward the southeast.

The Balcones fault zone is a dominant geologic feature of Bexar County. It is characterized by numerous parallel and en echelon faults, usually downthrown to the southeast. To some extent, faulting has controlled soil formation and stream courses. The Balcones Escarpment forms a sharp boundary between the Interior Coastal Plains and Black Prairie. The project area lies approximately 5 to 10 miles south of the Edwards Aquifer recharge zone in south-central Texas, and completely within the Edwards Aquifer artesian zone. The San Pedro Springs are less than a mile from Martinez Creek, along the fault that transverses the confluence of Alazán and Martinez Creek. The springs may act as a direct link to the Edwards Aquifer.

SITE CONDITIONS

Overburden materials within the Westside Creeks project area contain moderately deep to deep clayey and calcareous soils over chalk and marl and in old alluvium. The soils within the study area range from well drained to practically impervious. Depth to seasonal high water table varies across the site from very deep to shallow and would need to be investigated prior to construction considerations.

Northeast-trending faults of the Balcones fault zone cross the project area. These faults are en echelon to the Balcones fault zone, high angle, normal, and downthrown to the southeast. Geomorphic expression of this fault may consist of expressions of clay-shale beds between hard, erosion- resistant limestone. This fault zone is highly complicated and contains numerous small and irregularly shaped fault blocks. Construction considerations in this area should take into account the potential limitations to structures and excavation due to faulting.

PRIMARY FORMATIONS

Geologic primary formations underlying the Westside Creeks study area consist of faulted stratigraphic units downthrown to the south and east. Geologic formations outcropping in the project study area are Cretaceous and Paleocene in age. In order of deposition (oldest to youngest), the Cretaceous age formations include the Austin Chalk (KA), Anacacho Limestone (KAN), Taylor Marl (KTA), and Navarro Group (KN). The Wills Point (TWP) formation of the Midway Group is Paleocene in age and outcrops at the southernmost extent of the project area.

The northern reaches of Martinez and Alazán Creek overlie the Taylor Marl, characterized by gray to brown marl and calcareous clay. This unit has a maximum thickness of 535 ft, and has very low porosity and permeability. This unit is not known to be water-bearing, but likely does transmit water through fractures especially in the Edwards Aquifer recharge zones. This unit does not tend to develop cave formations. The Taylor Marl forms a sharp contact with the Anacacho Limestone at a northeast to southwest trending fault plane.

The remaining extents of Martinez and Alazán Creek before the confluence overlie the Anacacho Limestone formation, which is characterized by brittle light yellow, yellow and light gray marly chalk. This unit thickens downdip and to the east to a maximum thickness of 355 ft and is not water-bearing, but may transmit water through fractures. The Anacacho Limestone may contain weathered bentonite beds and is fossiliferous. Within the project area, this unit forms a sharp contact with the Austin Chalk formation at a northeast to southwest trending fault plane. To the south, the Anacacho Limestone forms a sharp contact with a second outcropping fault block of the Taylor Marl formation at an east-northeast to west-southwest trending fault plane.

The Austin Chalk formation does not directly underlie any of the creeks within the scope of the project. The Austin Chalk is characterized by grayish white to white limestone and argillaceous chalky limestone, and contains local bentonite seams. This unit is nearly uniformly thick down dip with a 210-ft maximum thickness. The Austin chalk is fossiliferous and weathers to yellow. This unit is generally confining but is known to transmit water through fractures, and yields small to large supplies of water of good to poor quality. This unit has a low potential to develop cave formations. Like the Anacacho Limestone, the Austin Chalk within the project area forms a sharp contact with an outcropping fault block of the Taylor Marl at an east-northeast to west-southwest trending fault plane.

San Pedro Creek to the confluence with the San Antonio River overlies the Navarro Group, characterized by gray to brown clay and marl. This unit thickens downdip and toward the west to a maximum thickness of 535 ft. This unit may contain near-surface layers of well-indurated limestone. This unit is not known to be water-bearing, but water may transmit through fractures in the formation. The Navarro Group forms a sharp contact with the Wills Point formation at a northeast to southwest trending fault plane.

The Wills Point formation of the Midway Group outcrops to the south of the confluence of San Pedro Creek and the San Antonio River. This unit is characterized by greenish-gray to yellow-brown arenaceous clay containing numerous arenaceous and calcareous concretions. The Wills Point formation is moderately water-bearing and has a maximum thickness of 490-ft.

OVERBURDEN MATERIALS

Within the Westside Creeks project area, overburden materials are comprised of the Austin-Tarrant association, Lewisville-Houston Black terrace association and Venus-Frio-Trinity association. These overburden units can be divided by location, from the northern extent of the project area to the southern extent. Please refer to Figure 1: Overburden Soils for WSC Study Area for detailed soil locations.

Along Martinez Creek, overburden materials are anticipated to consist of Austin silty clay (AuC) (typically forming on 3 to 5 percent slopes) along the western embankment and Houston Black clay (HsB) along the eastern embankment.

Austin silty clay is a pale to dark, gray-brown silty clay with good to fair drainage. This soil forms from chalk, chalky marl and contains many small shale fragments. Austin silty clay is very hard when dry and crumbly when moist, has moderate runoff, high permeability and a moderate to severe hazard for water erosion. The pH of this soil typically ranges from 7.9 to 8.4 and the plasticity index ranges from 20 to 31 Construction considerations in this area should take into account the potentially severe impacts of the high shrink-swell potential, low soil strength when moist and potential corrosion to uncoated steel of these overburden soils.

The Houston Black clay is a deep, gray to black clay with poor to practically impervious drainage. This soil forms from old alluvium containing calcareous clay. The Houston Black clay is very firm when moist and cracks when desiccated, has slow runoff when dry to rapid runoff when saturated, very slow permeability and a moderate to severe hazard for water erosion, particularly on slopes without vegetation. In gravel lenses, the permeability is very high. The pH of this soil typically ranges from 7.5 to 8.4 and the plasticity index ranges from 56 to 77+. Construction considerations in this area should take into account the potentially severe impacts of the high shrink-swell potential, discontinuous gravel layers, potential corrosion to uncoated steel, and low shear strength when saturated.

Near the confluence with Alazán Creek, overburden materials along Martinez Creek are anticipated to consist of Houston Black clay along the western embankment and both Houston Black Clay and Lewisville silty clay along the eastern embankment.

Lewisville silty clay is a moderately deep, dark brown to grayish brown calcareous silty clay to clay with moderate to good drainage. This unit forms from old alluvium consisting of silty clay to gravelly loam with varying amounts of lime. Lewisville silty clay is very firm when dry and crumbly when moist, has slow to medium runoff, medium to high permeability and a moderate to severe hazard for water erosion, particularly on slopes without vegetation. The pH of this soil typically ranges from 7.9 to 8.4 and the plasticity index ranges from 20 to 44. Construction considerations in this area should take into account the potentially severe impacts of the high shrink-swell potential, discontinuous gravel layers, potential corrosion to uncoated steel, and low shear strength when saturated.

Along Alazán Creek upstream of the confluence with Martinez Creek, overburden materials are comprised of Houston Black clay along the eastern embankment and Houston Black gravelly clay along the western embankment.

Houston Black gravelly clay is deep, calcareous, black gravelly clay and has poor to impervious drainage. This soil forms from old alluvium containing calcareous clay. Generic properties and considerations are the same as for the Houston Black clay detailed above in the Martinez Creek discussion.

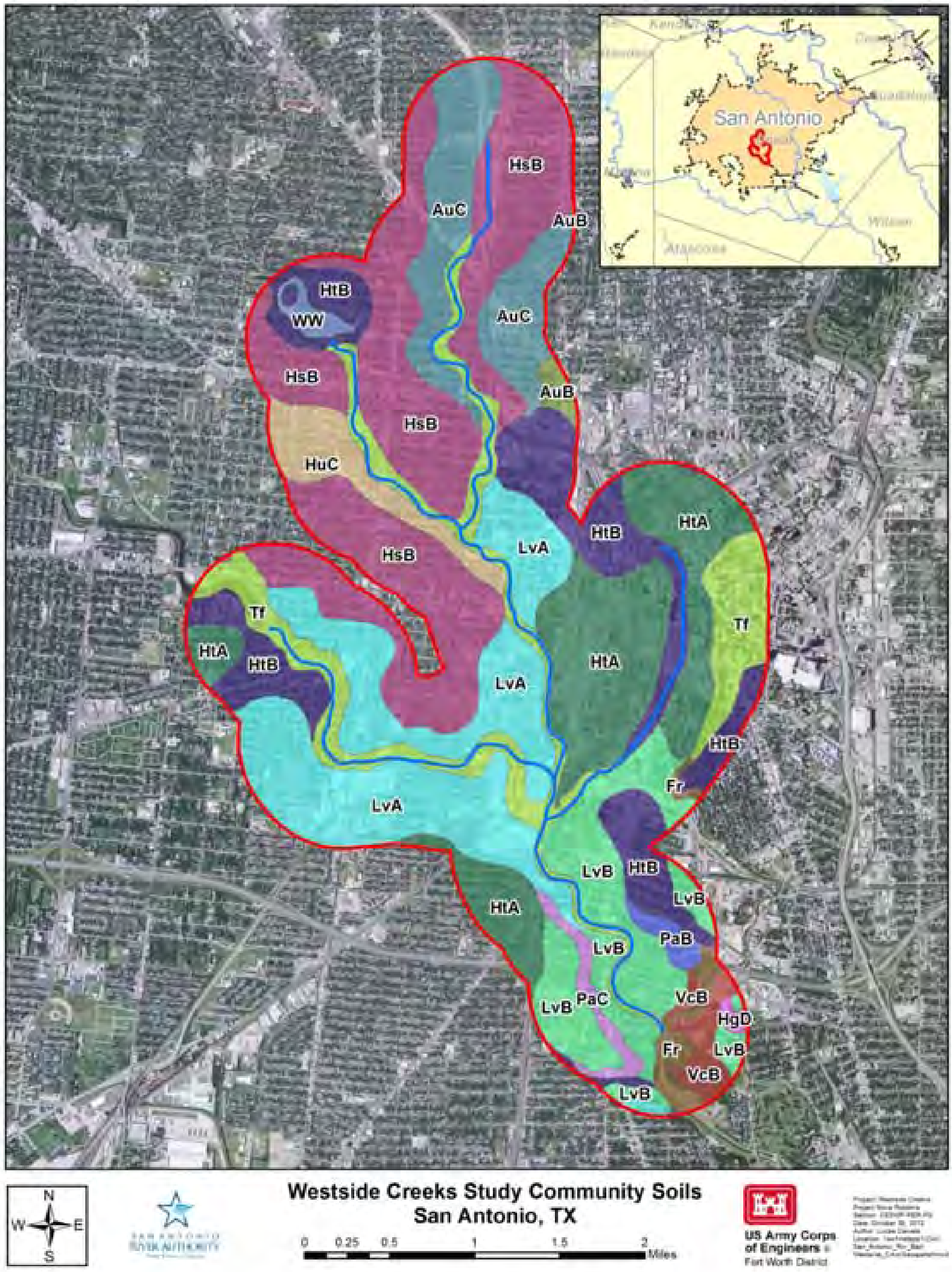


Figure 1: Overburden Soils for WSC Study Area

Along Alazán Creek downstream of the confluence with Martinez Creek, overburden materials are comprised of Lewisville silty clay and Houston Black clay on the eastern embankment and Lewisville silty clay on the western embankment. There are small sections of Houston Black clay and gravelly clay that extend into this extent from before the confluence.

Along the upstream third of Apache Creek, overburden materials consist of Houston Black clay along the both embankments. Along the remaining extent of Apache Creek, overburden materials are comprised of Lewisville silty clay.

Along San Pedro Creek before the confluence with Alazán Creek, overburden materials are mostly comprised of Houston Black clay. South of the confluence, overburden materials consist of Lewisville silty clay.

The stream channels and floodplains within the project area are generally composed of Trinity and Frio soils. This soil series is comprised of deep, brownish gray clay, silty clay and gravelly clay. This material forms from alluvium washed from clayey, upland soils and is subject to deposition and scouring. Channels that form in this material are generally poorly defined and of small capacity.

AVAILABLE GEOTECHNICAL DATA

For WSC Study, it was determined that a significant amount of available project and local geotechnical data was available.

ORIGINAL SACIP DATA

A potential source for existing geotechnical data is from the original SACIP plans and construction. Borings for the study area have been located by geo-referencing the available as-built information. The investigation, testing, and evaluations within the study area were performed prior to 1956. However, after review of the data within the study area, the average applicability of the data is fairly low due to predominantly shallow borings and the differences in state of the practice for investigation and design. The San Pedro and San Antonio tunnel projects are the exception. Significant drilling and testing was conducted during design and construction.

MISSION REACH RESTORATION

The most recent and ample source for geotechnical information would be the Mission Reach project. The 8-miles of project along the San Antonio River had multiple rounds of geotechnical investigation, laboratory testing, back analyses of a large slope slide, and rigorous slope stability evaluations. In addition to technical data, there were some geotechnical lessons learned, as discussed below, that have been adapted into the WSC Study.

SLOPE STABILITY

Stability of the channel slopes became a major issue for MRR. Through feasibility into PED, the lack of stability issues on the project was used as justification that the existing slope configuration was stable; and was a major factor in the assumptions used to shape the project design. These assumptions were challenged late in the project design, and resulted in expensive remediation measures.

An initial assumption for WSC was that the overbank slopes of the channels are over-steepened. This in conjunction with restricted right of way meant that our channel modifications had to avoid impact to the channel over-bank slopes.

As the project was in an urban area, the width of right of way was often kept to a minimum, meaning that increased capacity most often came from increased channel depth. Consequently, as flows accumulate moving downstream, especially after confluences, the height of the channel banks generally tends to increase. This trend is apparent in the existing WSC study area, where the heights of the channel banks are consistently higher at the south end versus the north end of the study area. The channel banks of Martinez Creek are generally around 15 to 25 feet in height with the general trend of increasing height moving downstream. The channel banks of Alazán Creek are generally the same although increasing to heights of 30 to 35 feet at downstream of the Martinez confluence. The channel banks of Apache Creek have a little more variance as the channel width tends to vary more than the other creeks. The channel banks where the pilot channel alternative is being considered are generally 15 to 35 feet in height. The channel banks of San Pedro Creek are generally 20 to 35 feet in height, and have a very large cross section at the downstream edge of the study area.

A metric used to screen relative slope stability from the remediation design in MRR Phase 1 has been adapted for an initial screening of slope stability of existing and modified slopes for WSC Study. The crux of the metric is that rather than a static target slope, the stable configuration of a slope is based upon its height. Deepening and widening the pilot channel alters the overall channel slope configuration, and its impacts need to be evaluated. Utilizing this metric is applicable as the slope materials and underlying primary formations for the upper portion of MRR are the similar to those encountered in the WSC Study Area; especially in the southern portion of the study area.

FAULTING

Investigations were conducted to better locate a fault in MRR Phase 1. The impact to design was relatively minor, and the construction impact was to fill a few void spaces that were encountered. The WSC Study has many more faults crossing it than MRR. The WSC Study Area is within the Edward’s Aquifer Artesian zone, so while the study area generally does not have outcrops of the Edwards Aquifer unit at the ground surface, the aquifer unit underlies the surface formations. The primary formations of the study area are generally confining, but can transmit water through fractures. The San Pedro Spring system lies approximately 1 mile east of Martinez Creek, which may provide a link from the surface to the aquifer unit. Historically, there is no forthcoming documentation regarding faults impacting private construction or the original SACIP phases in the WSC study area. There were issues encountered in the tunneling operations for underground diversions of the San Antonio River and San Pedro Creek.

WESTSIDE CREEK DRAINAGE – DESKTOP STUDY

Following discussions on available data, SARA requested a geotechnical desktop study to an engineering firm they had under contract. On 23 February 2012, Raba Kistner Consultants, Inc. provided the *Westside Creek Drainage – Desktop Study* attached as Attachment 1 to this appendix. The report provided additional historic data that the consulting firm has available in areas pertinent to the study. Of particular notice were notes of bentonite seams at sites along Alazán and Apache creeks, with coinciding liquid limits up to 121 and 150. Although this would not impact the limited excavation for these reaches.

MILITARY BASE DATA

The study area is also located near multiple US Military bases. Data has not yet been accumulated and tabulated for use on this project, but additional laboratory data for the overburden and primary materials could be available based upon similar materials in the surrounding bases.

STABILITY SCREENING

The biggest challenge to this study from a geotechnical standpoint was assessing slope stability concerns and impacts from alternatives. The study area includes 28 miles of slopes, varying overburden materials, varying primary formations, hard armoring and slope reinforcement, and limited available geotechnical data. The solution implemented was to use the developed existing and proposed alternative hydraulic cross sections to come up with slope height and effective slope, and evaluate them against the metric used in MRR near the San Pedro confluence. The point data for 459 hydraulic cross-sections were sorted and run through a series of calculations that computed the critical average slope angle and height for both channel slopes for both existing and proposed alternatives. See Figure 2: Graphical output of slope screening for San Pedro Creek for a graphical output conveying the stability evaluations for San Pedro Creek.

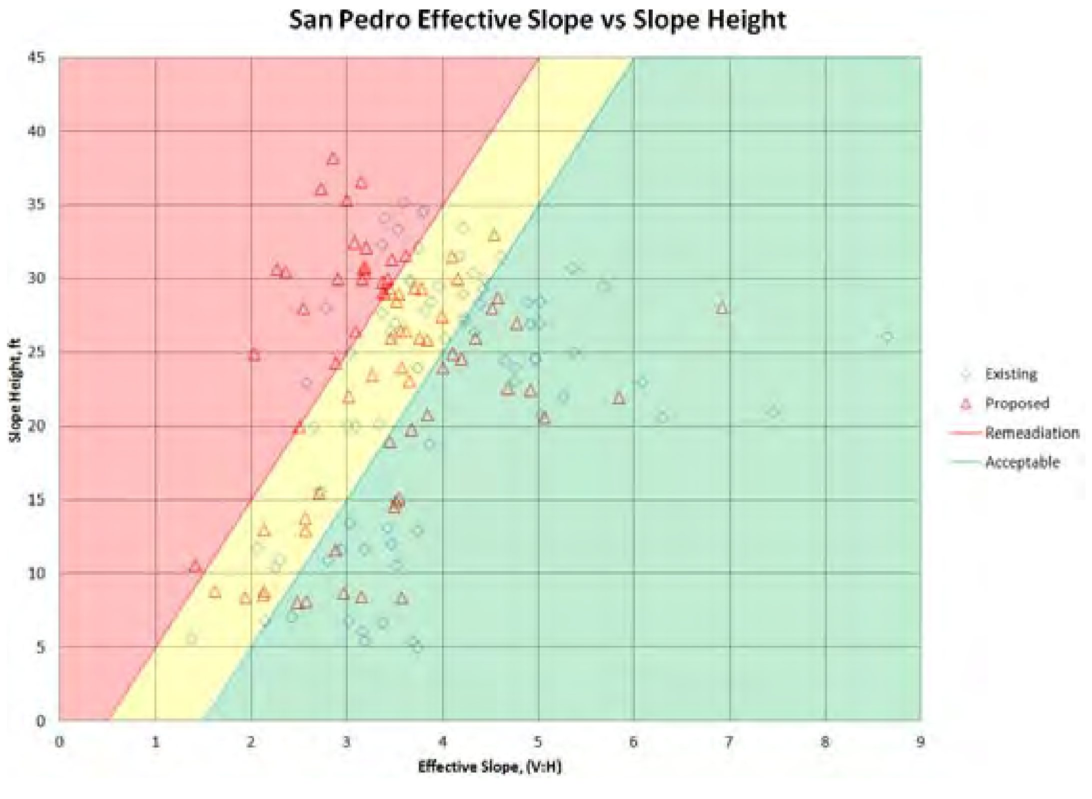


Figure 2: Graphical output of slope screening for San Pedro Creek

This output represents the qualitative chance of slope instability, and should err on the conservative side. There are also many locations with hard armoring or the cross sections were not tangential to the slope that needed the output to be altered or removed. Consequences also needed to be assessed for areas of concern so that the resulting information is risk-based per the pilot paradigm. Figures 2 to 5 depict the qualitative chance of slope instability.

Figure 3: Graphical output of slope screening for Alazán Creek

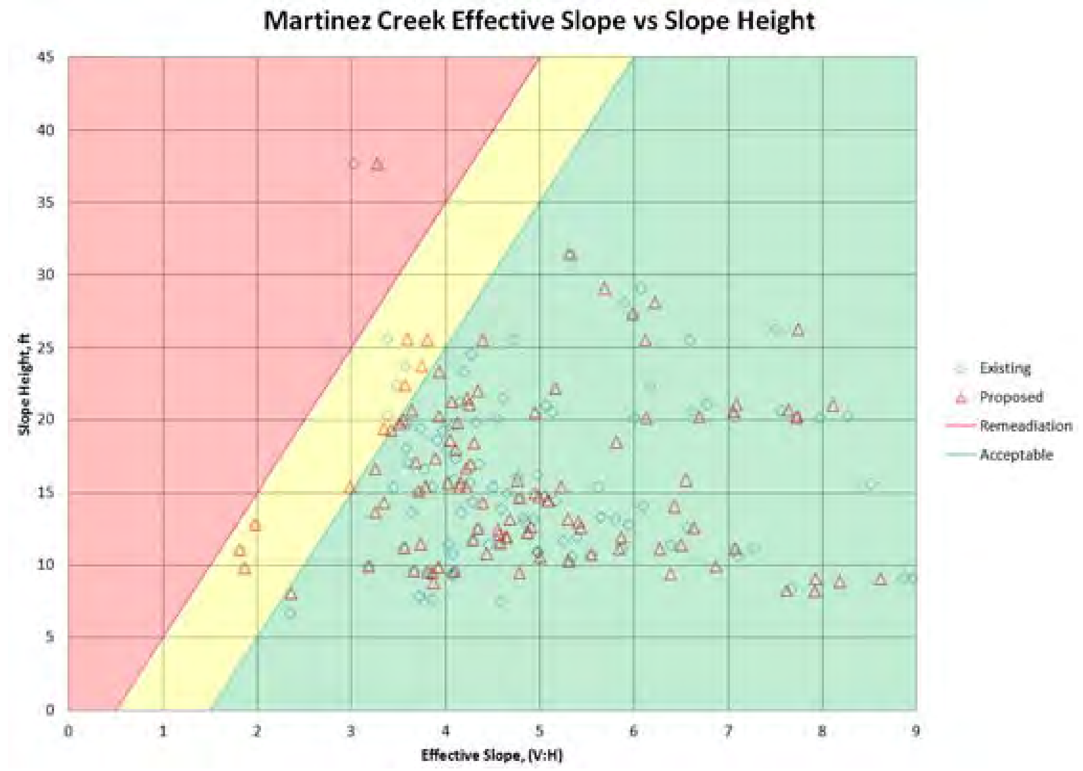


Figure 4: Graphical output of slope screening for Martinez Creek

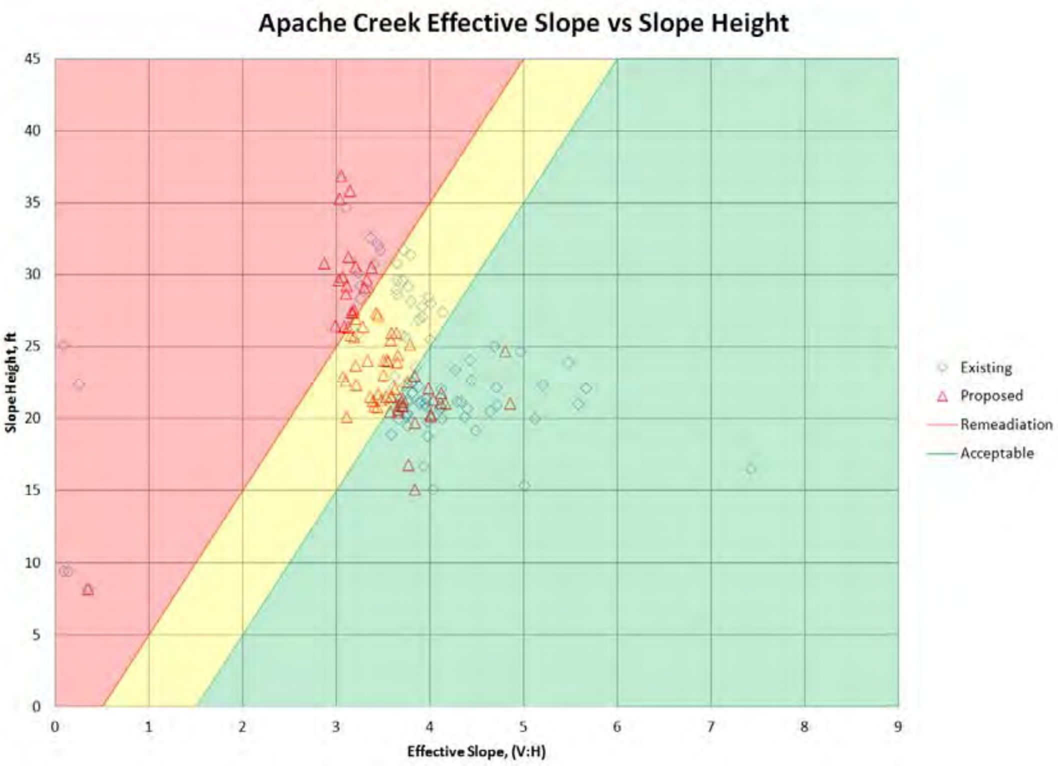


Figure 5: Graphical output of slope screening for Apache Creek

DISCUSSION AND RECOMMENDATIONS

Most of the key design considerations from a geotechnical standpoint for the existing and proposed project features were identified at the kickoff meeting, and have shaped the development of project alternatives. The major items have been tracked on the Geotechnical Risk Register, and minor items would have been covered in team discussion and correspondence.

REGIONAL FAULTING

At least 21 faults have been identified that cross the study area and existing creek channels. Fractured or brecciated zones at the faults could affect the overall stability of the channel slopes. The faults have apparently had little impact on the existing channel configuration based upon the good general performance of the channel slopes and lack of observed surficial features indicative of faulting. Although, a history of good performance does not mean that the faults could not be a problem. This was a primary consideration in an initial constraint that the feasibility study would not modify the overbank slopes to reduce the risk of triggering slope instability. One of these faults also crossed the northern section of the Mission Reach project.

Implementing the pilot paradigm for this project, the data acquisition costs for fault investigation would not be justified compared to the limited amount of risk reduction that could be obtained for the study at this time. The faults pre-date the original Westside Creek project and private construction activities in the region; with very minor impacts to construction at the surface level. Additional investigation of the faults would be pertinent and appropriate during the design phase where the faulting may coincide with critical structures, extensive excavation, or channel instability.

GLOBAL STABILITY

Concern and considerations for global stability were lessons learned on the Mission Reach project that definitely need to be applied to the WSC project. The desire to limit ROW acquisition and achieve flood damage reduction for the area coupled with the then state of the practice resulted in very steep slopes with respect to the current state of the geotechnical practice. This was also a primary consideration behind the initial constraint that the feasibility study would not modify the overbank slopes to reduce the risk of triggering slope instability.

The slope stability screening method discussed above was used to evaluate the existing and proposed alternatives with modification of the pilot channel. This preliminary screening was used to evaluate the potential design and construction costs where global instability may be a concern and which stations or reaches of the creeks may be at the highest risk. These results should be used to help shape the subsurface investigation and prioritize stability evaluation in design.

Some proposed and existing features could affect global stability. Permanent excavations or erosion within the creek channel could affect passive wedges for stability. The potential impact from the currently proposed alternatives would be very low, but should be evaluated when they coincide with areas identified as high risk for slope instability. Mass wasting is another potential concern in a natural channel system. However; the in stream structures are designed to balance sediment transport which should deter mass wasting of native soils. Some alternatives include the demolition of concrete structures which serve as scour protection. As discussed in the Civil Engineering Appendix, Turf Reinforcing Mats (TRM) will be used to account for shear stresses where concrete is removed. In general, this should be sufficient to prevent scour in areas that will not be inundated continuously, and suitability of TRMs should be evaluated in design. Existing concrete features that provide support to slopes or structures were not considered for demolition.

ATTACHMENT 1: WESTSIDE CREEKS DRAINAGE – DESKTOP STUDY BY RABA KISTNER

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TBPE Firm F-3257

Project No. ASA12-017-00
February 23, 2012

Russell A. Persyn, P.E., PhD, CFM
San Antonio River Authority
100 East Guenther
San Antonio, Texas 78204

RE: Westside Creek Drainage – Desktop Study
San Antonio River Authority
Bexar County, Texas

Dear Dr. Persyn:

Raba Kistner Consultants Inc. (RKCI) has completed the authorized desktop study for the Westside Creek Drainage area located in Bexar County, Texas. The purpose of this study was to provide subsurface information from geotechnical engineering reports previously prepared by **RKCI** at locations selected by the San Antonio River Authority (SARA).

Background

RKCI has performed over 10,000 geotechnical engineering studies in the Bexar County area and has developed a library of previous geotechnical engineering studies. The locations of a majority of these studies have been cross-referenced onto maps to show the original study location.

At the request of SARA, RKCI provided a map of the Westside Creek Drainage area indicating the location of previous geotechnical engineering studies. As a result of a review of these maps and our discussions, thirteen studies were selected. A map showing the approximate location of the previous projects is presented on Figure 1. Additionally, due to the variable geologic conditions across Bexar County, the project sites have been shown on a USGS map which reflects the surface geology across the area, which is presented on Figure 2. The boring location map, boring logs, and other collected data for the individual projects are separated by tabs labeled 1 through 13.

Surface Geology

As referenced above, as a result of our proximity to the Balcones fault and the alluvial nature of Bexar County, surface geologic formations vary highly across the region. Consequently, when comparing previous geotechnical engineering studies, it is important to cross reference surface geology to verify if the previous borings are drilled in the same geologic formation. In order to assist SARA in this regard, the surface geologic formations for each of the site is presented below.

Boring Location	Project Number	Surface Geology
1	ASA87-074-00	Fluviatile Terrace Deposits
2	ASA08-174-00	Fluviatile Terrace Deposits
3	ASA69-086-00	Fluviatile Terrace Deposits
4	ASA97-014-00	Fluviatile Terrace Deposits
5	ASA84-004-00	Fluviatile Terrace Deposits
6	ASA85-065-00	Fluviatile Terrace Deposits
7	ASA09-051-00	Fluviatile Terrace Deposits
8	ASA88-052-00	Fluviatile Terrace Deposits
9	ASA71-113-00	Navarro Group and Marlbrook Marls
10	ASA78-059-00	Navarro Group and Marlbrook Marls
11	ASA80-057-00	Navarro Group and Marlbrook Marls
12	ASA92-007-00	Navarro Group and Marlbrook Marls
13	ASA95-005-00	Pecan Gap Chalk

Geology

The geology listed above is the surface geology at the specific sites and does not indicate any depth at which this geology may transition to another geologic formation. Presented below are general descriptions of the surface geologic formations, as well as the Uvalde Gravel which may underlie the Fluviatile Terrace Deposits in some of the more southern and eastern projects. The boring logs should be consulted for more specific stratigraphic information.

All of the geologic formations were identified by reviewing the San Antonio Sheet in the Geologic Atlas of Texas.

Fluviatile Terrace Deposits Fluviatile terrace deposits are stream bed deposits typically consisting of clays, sands, silts, and gravels. Such deposits can contain point bars, cutbanks, oxbows, and abandoned channel segments associated with variations in stream bed activity. As a result, soil profiles in terrace deposit areas may vary greatly over relatively short distances. Key geotechnical engineering concerns for development supported on this formation are the expansive nature of the clays, the consistency or relative density of the deposits, and the absence/presence as well as thickness of potentially water-bearing gravels. Due to the alluvial nature of these deposits, significant variations can occur over short distances.

Navarro Group and Marlbrook Marls Navarro Group and Marlbrook Marls typically consist of clays and marly clays and can contain hard layers of marl, sandstone, and siltstone. The clays of this formation are typically highly expansive, montmorillonitic clays. These clays typically grade to harder, intermediate materials such as marl or chalk at depths typically ranging from 15 to 50 ft below existing grades. Key geotechnical engineering considerations for development supported on this formation is the expansive nature of the clays, and the depth to the harder, more competent material. Although near surface permanent ground water is not typically encountered in this formation, transient groundwater is commonly encountered at the clay/marl or clay/chalk interface, particularly following periods of heavy precipitation.

Pecan Gap Chalk The Pecan Gap Chalk weathers to form moderately deep soil and typically consists of clays, marly clays, and marl grading to chalk at depth. Thin seams of bentonite and/or bentonitic clays are also often encountered in this formation. Because such seams are typically thin and random, they are often difficult to locate and identify with standard geotechnical sampling methods and sampling intervals. Similar to the Navarro Group, key geotechnical engineering considerations for development supported on this formation is the expansive nature of the clays, and the depth to the harder, more competent material. Although near surface permanent ground water is not typically encountered in this formation, transient groundwater is commonly encountered at the clay/chalk interface, particularly following periods of heavy precipitation.

Uvalde Gravel Uvalde Gravel can consist of clays, silts, and gravels including cobbles, chert, boulders, and caliche-cemented gravel. The Uvalde Gravels can be highly variable and can therefore result in highly variable conditions over relatively short distances. Key geotechnical engineering concerns for development supported on the Uvalde Gravels are the expansive nature of the clays, the consistency and/or relative density of the deposits, the absence/presence as well as thickness of potentially water-bearing gravels, and the absence/presence of cobbles, boulders and/or cemented materials.

Limitations

The subsurface information presented in this report is specific to the site identified. Horizontal translations of subsurface profiles may not reflect actual subsurface conditions beneath adjacent sites, particularly for those sites located along creeks and streams. This information should be utilized for preliminary planning purposes only, and should not be utilized for final design.

We appreciate the opportunity to be of continued service to you on this project. If you have any questions or need additional assistance, please call.

Very truly yours,
RABA KISTNER CONSULTANTS, INC.

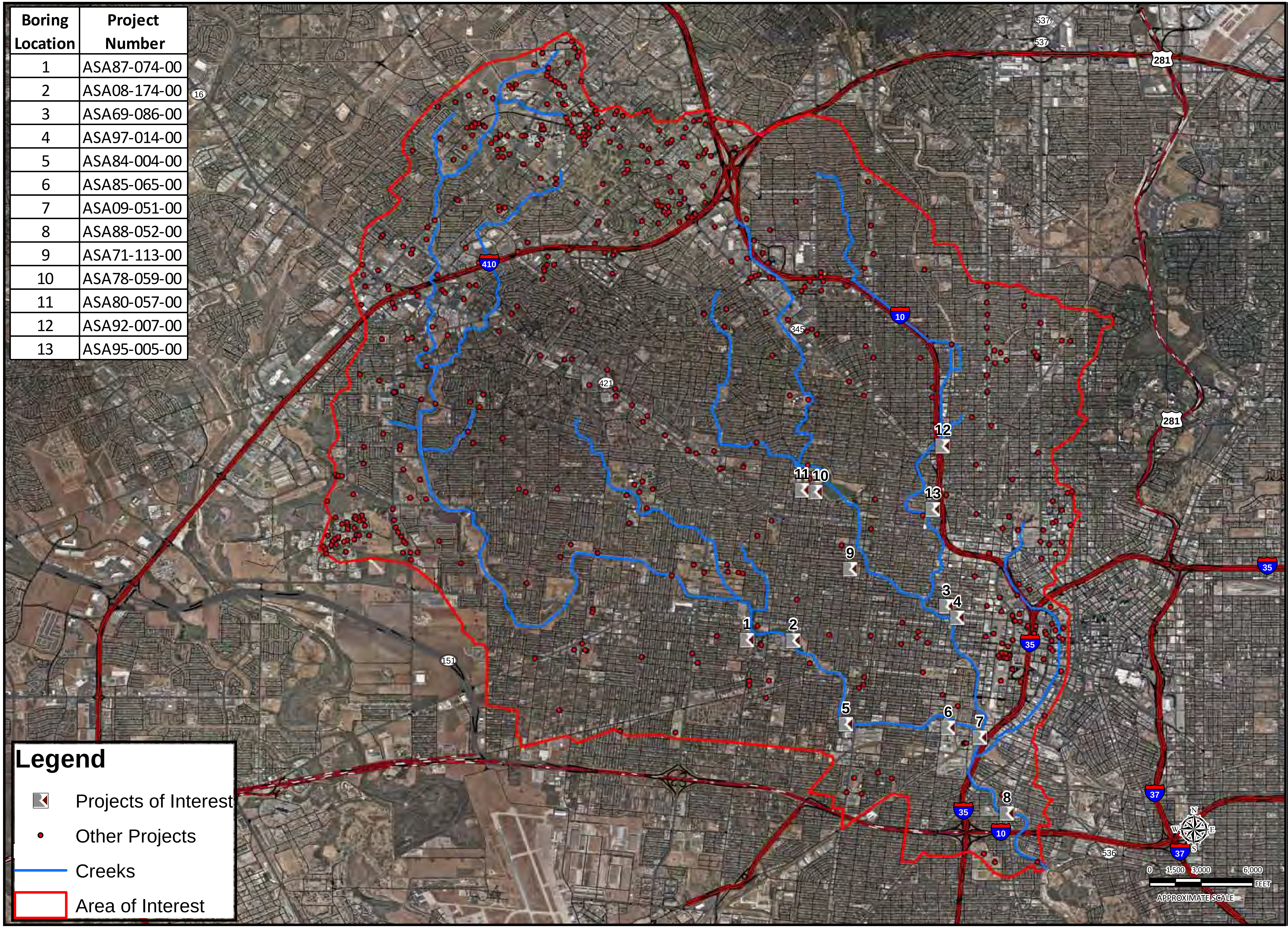
Matthew J. Robbins, E.I.T.	Chris L. Schultz, P.E., PMP
Graduate Engineer	Senior Vice President

MJR/CLS/mem

Attachments

Copies Submitted: Above (3)

Boring Location	Project Number
1	ASA87-074-00
2	ASA08-174-00
3	ASA69-086-00
4	ASA97-014-00
5	ASA84-004-00
6	ASA85-065-00
7	ASA09-051-00
8	ASA88-052-00
9	ASA71-113-00
10	ASA78-059-00
11	ASA80-057-00
12	ASA92-007-00
13	ASA95-005-00



Legend

- Projects of Interest
- ● Other Projects
- Creeks
- Area of Interest

NOTE: This Drawing is Provided for Illustration Only, May Not be to Scale and is Not Suitable for Design or Construction Purposes

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TBPE Firm Number 3257

SOURCE:

Westside Creek Drainage - Desktop Study
San Antonio River Authority
San Antonio, Texas

REVISIONS:

No.	DATE	DESCRIPTION

PROJECT No.:
ASA12-017-00

ISSUE DATE:	2/21/2012
DRAWN BY:	MJR
CHECKED BY:	MJR
REVIEWED BY:	CLS

FIGURE

1

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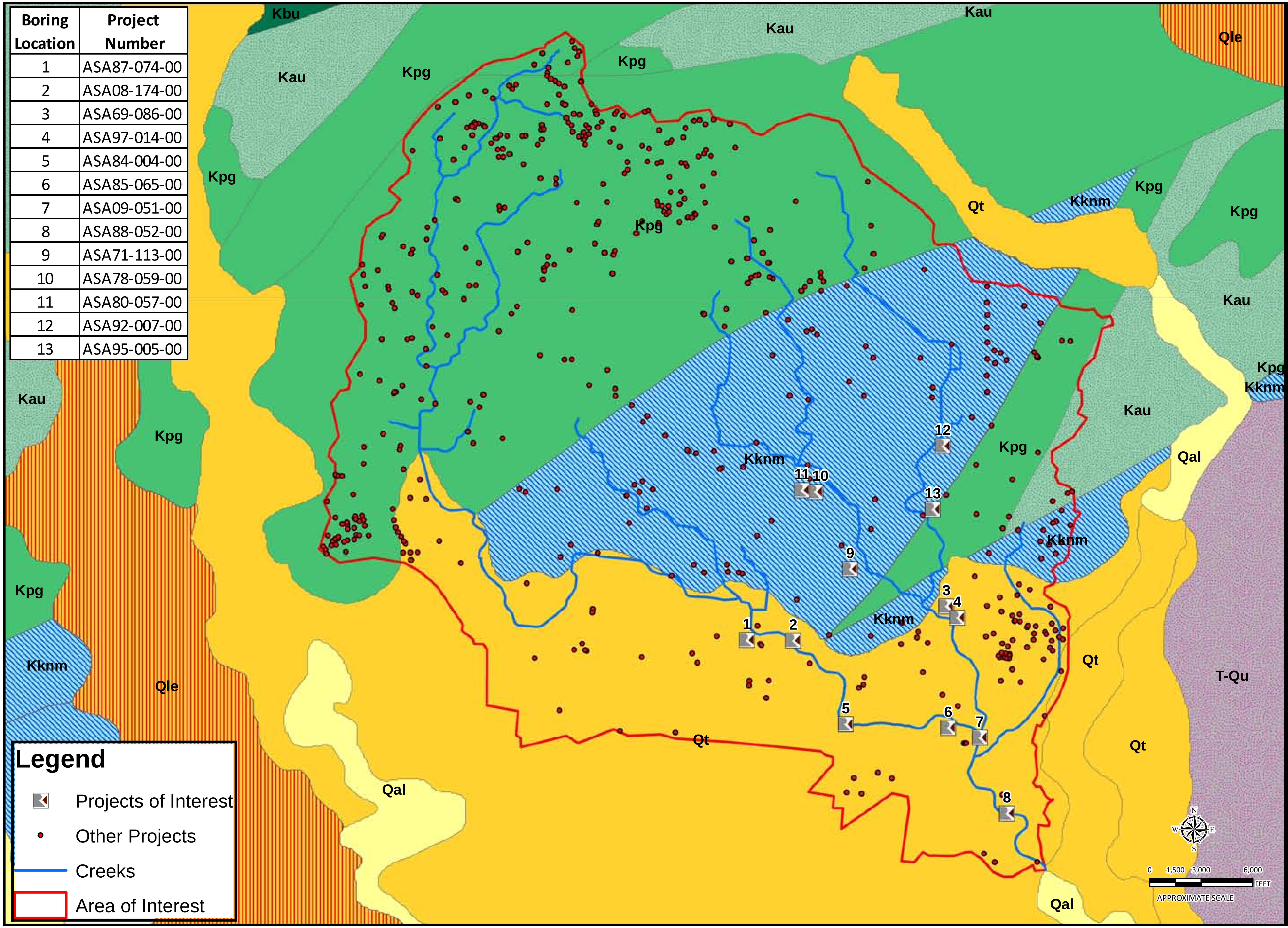
Boring Location	Project Number
1	ASA87-074-00
2	ASA08-174-00
3	ASA69-086-00
4	ASA97-014-00
5	ASA84-004-00
6	ASA85-065-00
7	ASA09-051-00
8	ASA88-052-00
9	ASA71-113-00
10	ASA78-059-00
11	ASA80-057-00
12	ASA92-007-00
13	ASA95-005-00



Legend

◩	Projects of Interest
●	Other Projects
—	Creeks
☐	Area of Interest

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PROJECT No.:
ASA12-017-00

ISSUE DATE:	2/21/2012
DRAWN BY:	MJR
CHECKED BY:	MJR
REVIEWED BY:	CLS

FIGURE

2

NOTE: This Drawing is Provided for Illustration Only, May Not be to Scale and is Not Suitable for Design or Construction Purposes

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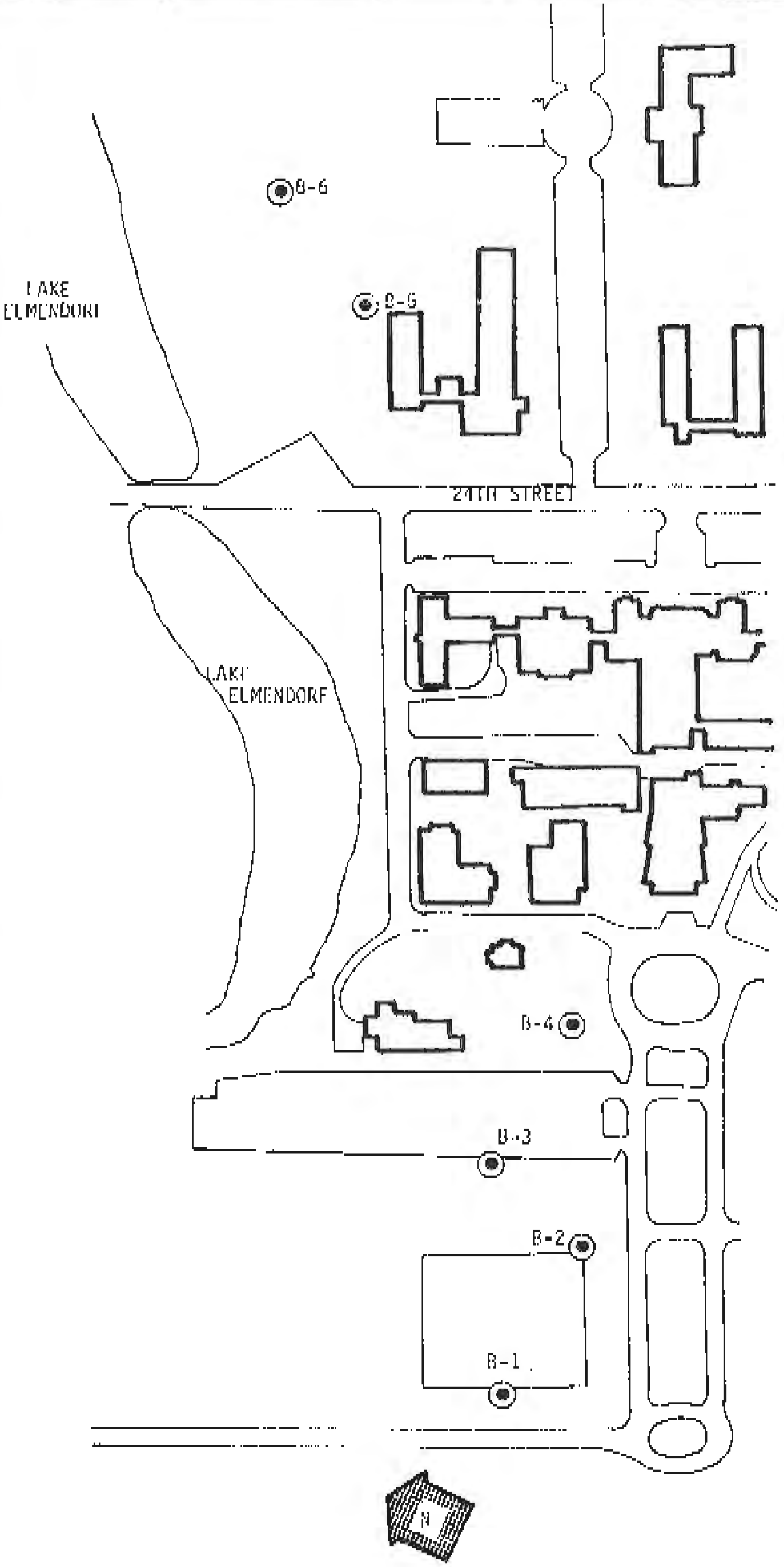
REPORT 1



PLAN OF BORINGS
SCALE: 1" = 250'

Rabe-Kistner Consultants inc

PROJ. NO. SA0287-0074
PLATE 1

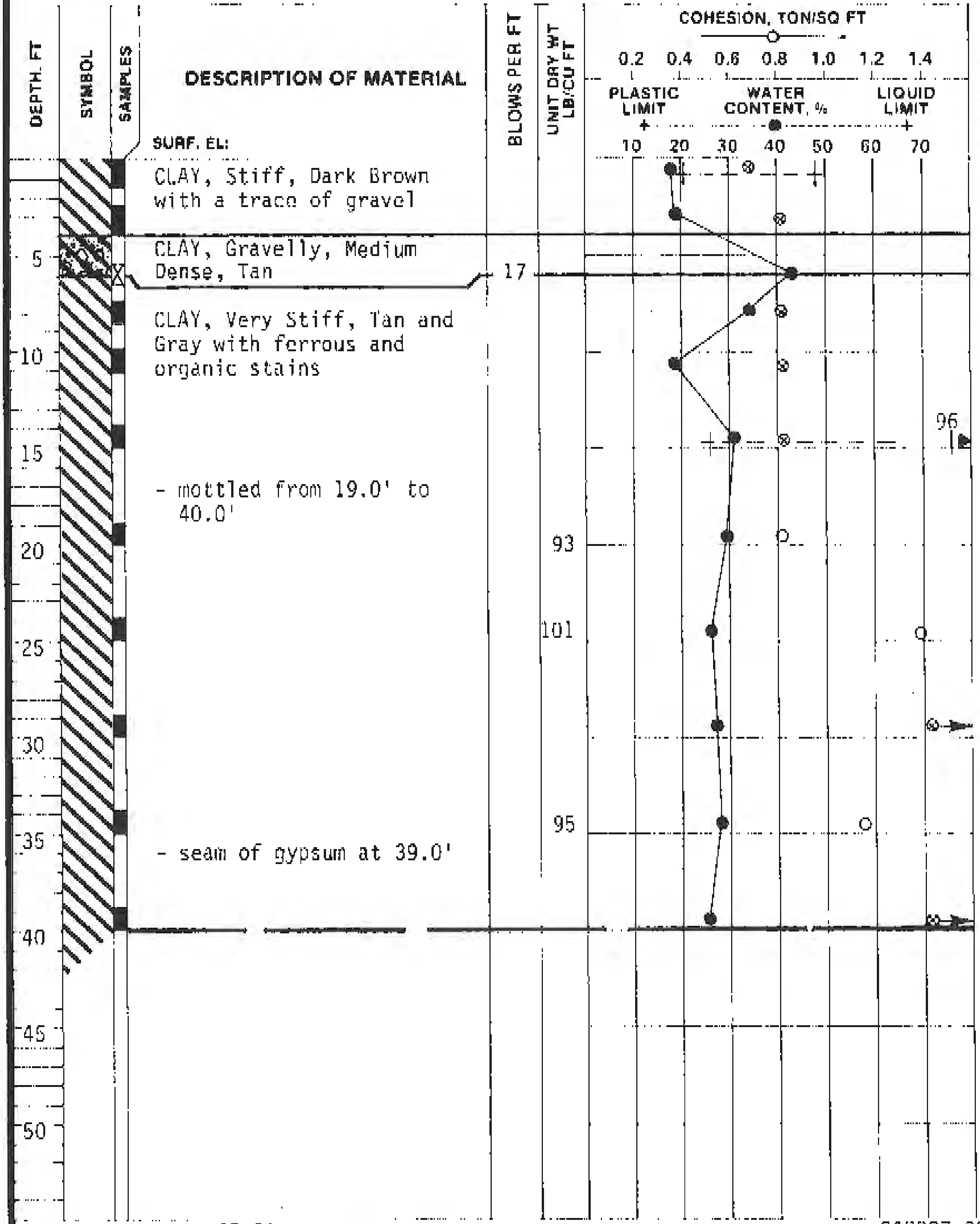
LOG OF BORING NO. B-1

UNIVERSITY ACTIVITIES AND WELLNESS CENTER
SAN ANTONIO, TEXAS

Raba-Kistner
Consultants, Inc.

TYPE: 2" Split Spoon
3" Shelby Tube

LOCATION: See Plate 1



CLAY, Stiff, Dark Brown with a trace of gravel

CLAY, Gravelly, Medium Dense, Tan

CLAY, Very Stiff, Tan and Gray with ferrous and organic stains

- mottled from 19.0' to 40.0'

- seam of gypsum at 39.0'

NOTE: These logs should not be user   parately from the project report.

COMPLETION DEPTH: 40.0'
DATE: 7-8-87

DEPTH TO WATER IN BORING: 4.9'

DATE: 7-10-87

PROJ. NO. SA0287-0074
PLATE 2

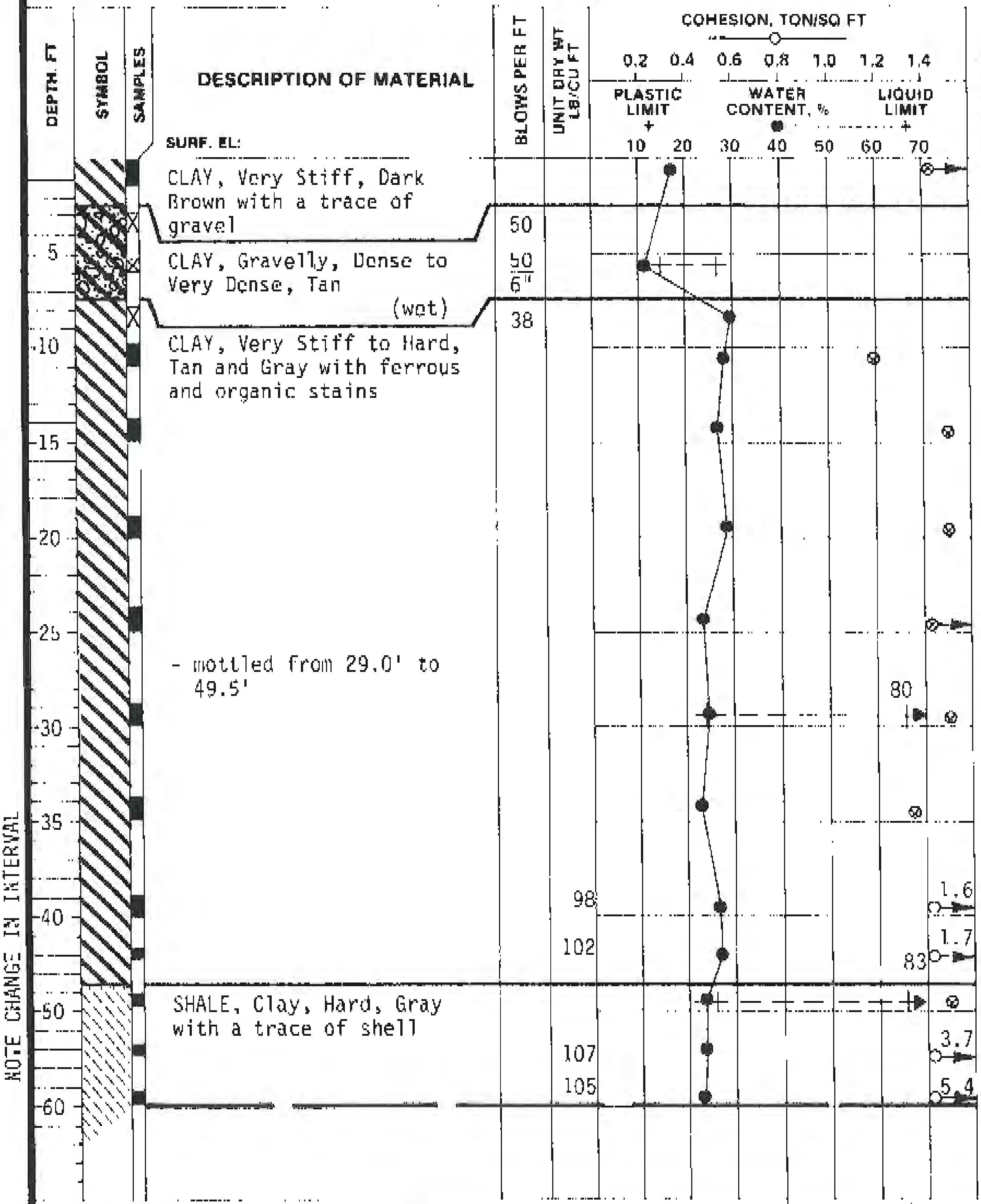
LOG OF BORING NO. B-2

UNIVERSITY ACTIVITIES AND WELLNESS CENTER
SAN ANTONIO, TEXAS

Raba-Kistner Consultants, Inc

TYPE: 2" Split Spoon
3" Shelby Tube

LOCATION: See Plate 1



CLAY, Very Stiff, Dark Brown with a trace of gravel

CLAY, Gravelly, Dense to Very Dense, Tan (wet)

CLAY, Very Stiff to Hard, Tan and Gray with ferrous and organic stains

- mottled from 29.0' to 49.5'

SHALE, Clay, Hard, Gray with a trace of shell

COMPLETION DEPTH: 60.0'
DATE: 7-8-87

DEPTH TO WATER IN BORING: 4.4'

DATE: 7-10-87

PROJ. NO. SA0287-0074
PLATE 3

NOTE: These logs should not be used separately from the project report.

LOG OF BORING NO. B-3

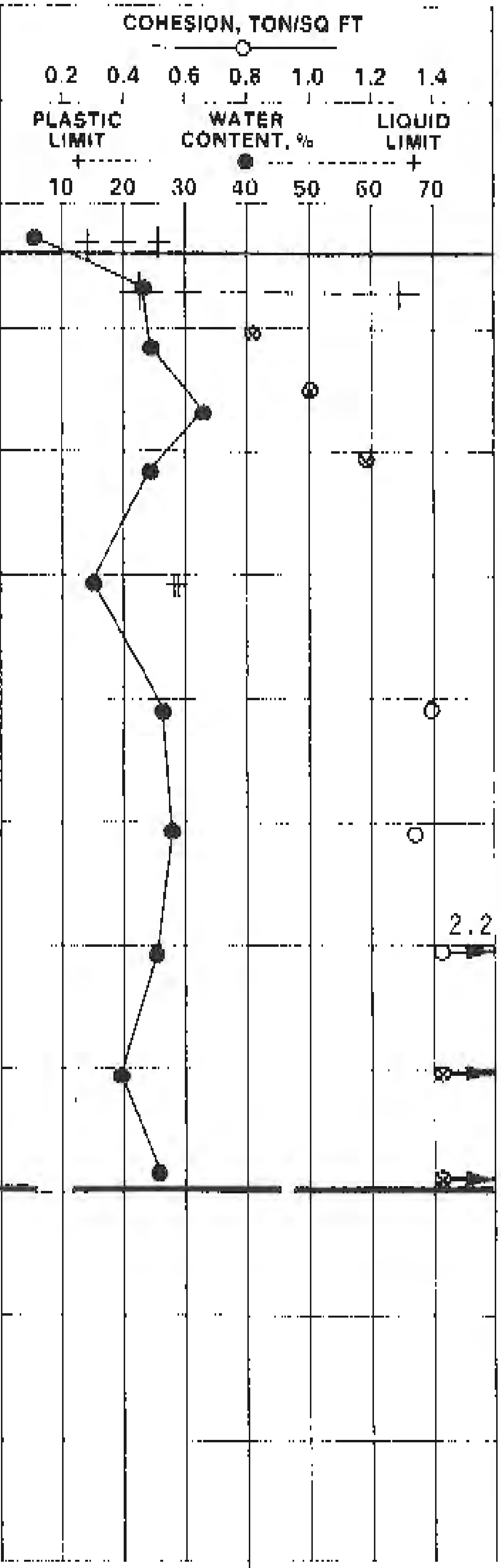
UNIVERSITY ACTIVITIES AND WELLNESS CENTER
SAN ANTONIO, TEXAS

Raba-Kistner
Consultants, Inc.

TYPE: 2" Split Spoon
3" Shelby Tube

LOCATION: See Plate 1

DEPTH, FT	DESCRIPTION OF MATERIAL	UNIT DRY WT LB/CU FT
	SURF. EL:	
0	PAVEMENT: ASPHALT - 1-1/2" BASE 22-1/2" (Tan Gravelly Clay)	
5	CLAY, Stiff to Hard, Tan and Gray with ferrous stains and a trace of caliche to 7.0'	
15	- seam of Reddish-Brown Silt Stone from 15.0' to 16.5'	
20		98
25	- mottled from 25.0' to 32.0'	99
30		101
35	- seams of Ferrous Oxide from 35.0' to 40.0'	



BLOWS PER FT

ELEVATION, FT

COMPLETION DEPTH 40.0'
DATE: 7-8-87

DEPTH TO WATER IN BORING 7.0'
DATE 7-10-87

PROJ. NO. SA0287-0074
PLATE 4

NOTE: These logs should not be usec parately from the project report.

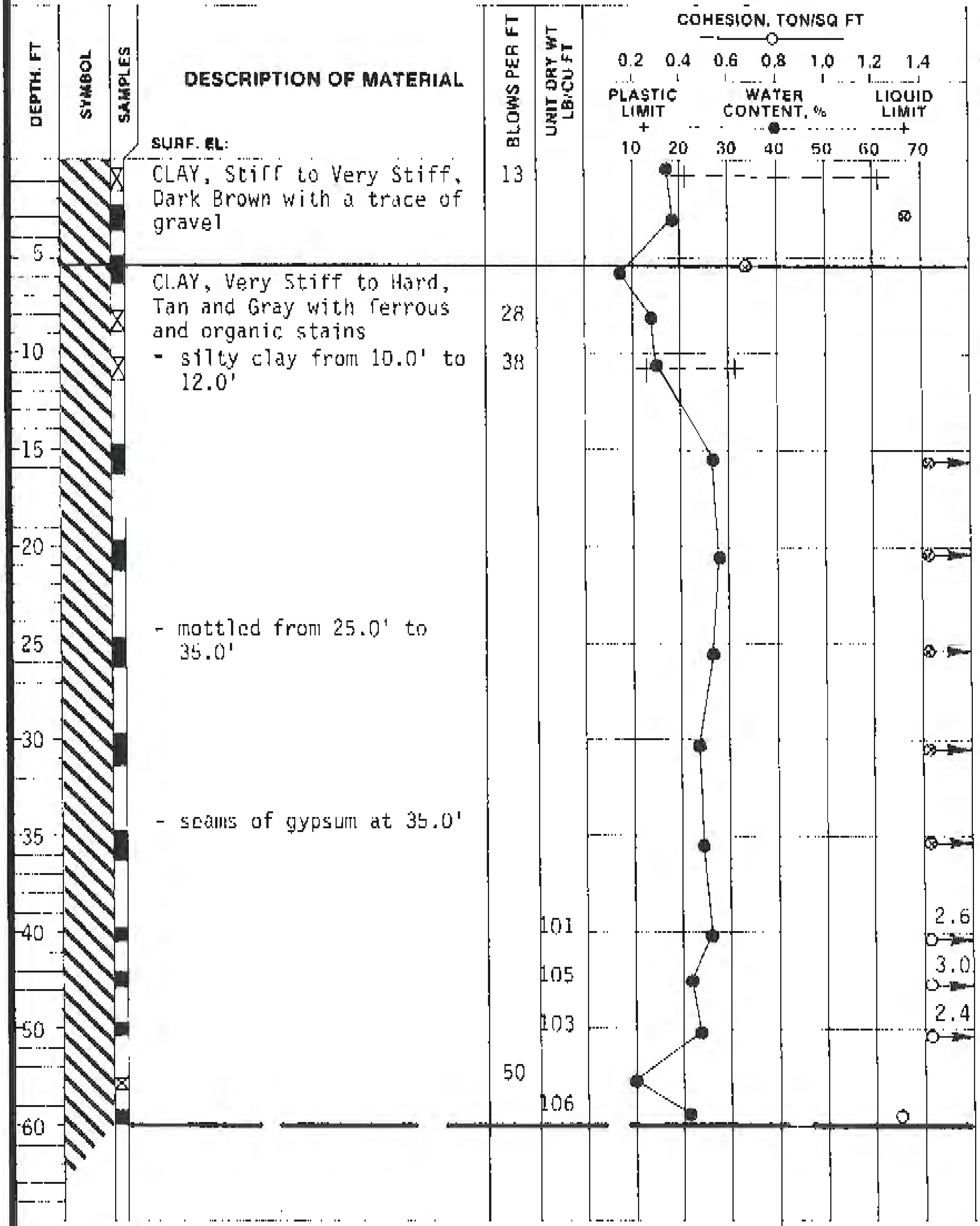
LOG OF BORING NO. B-4

UNIVERSITY ACTIVITIES AND WELLNESS CENTER
SAN ANTONIO, TEXAS

Raba-Kistner Consultants, Inc.

TYPE: 2" Split Spoon
3" Shelby Tube

LOCATION: See Plate 1



CLAY, Stiff to Very Stiff, Dark Brown with a trace of gravel

CLAY, Very Stiff to Hard, Tan and Gray with ferrous and organic stains

- silty clay from 10.0' to 12.0'
- mottled from 25.0' to 35.0'
- seams of gypsum at 35.0'

BLOWS PER FT	13
BLOWS PER FT	28
BLOWS PER FT	38
BLOWS PER FT	50
UNIT DRY WT LB/CU FT	101
UNIT DRY WT LB/CU FT	105
UNIT DRY WT LB/CU FT	103
UNIT DRY WT LB/CU FT	106

NOTE CHANGE IN INTERVAL

NOTE: These logs should not be used separately from the project report.

COMPLETION DEPTH: 60.0'
DATE: 7-8-87

DEPTH TO WATER IN BORING: 7.0'

DATE 7-10-87

PROJ. NO. SA0287-0074
PLATE 5

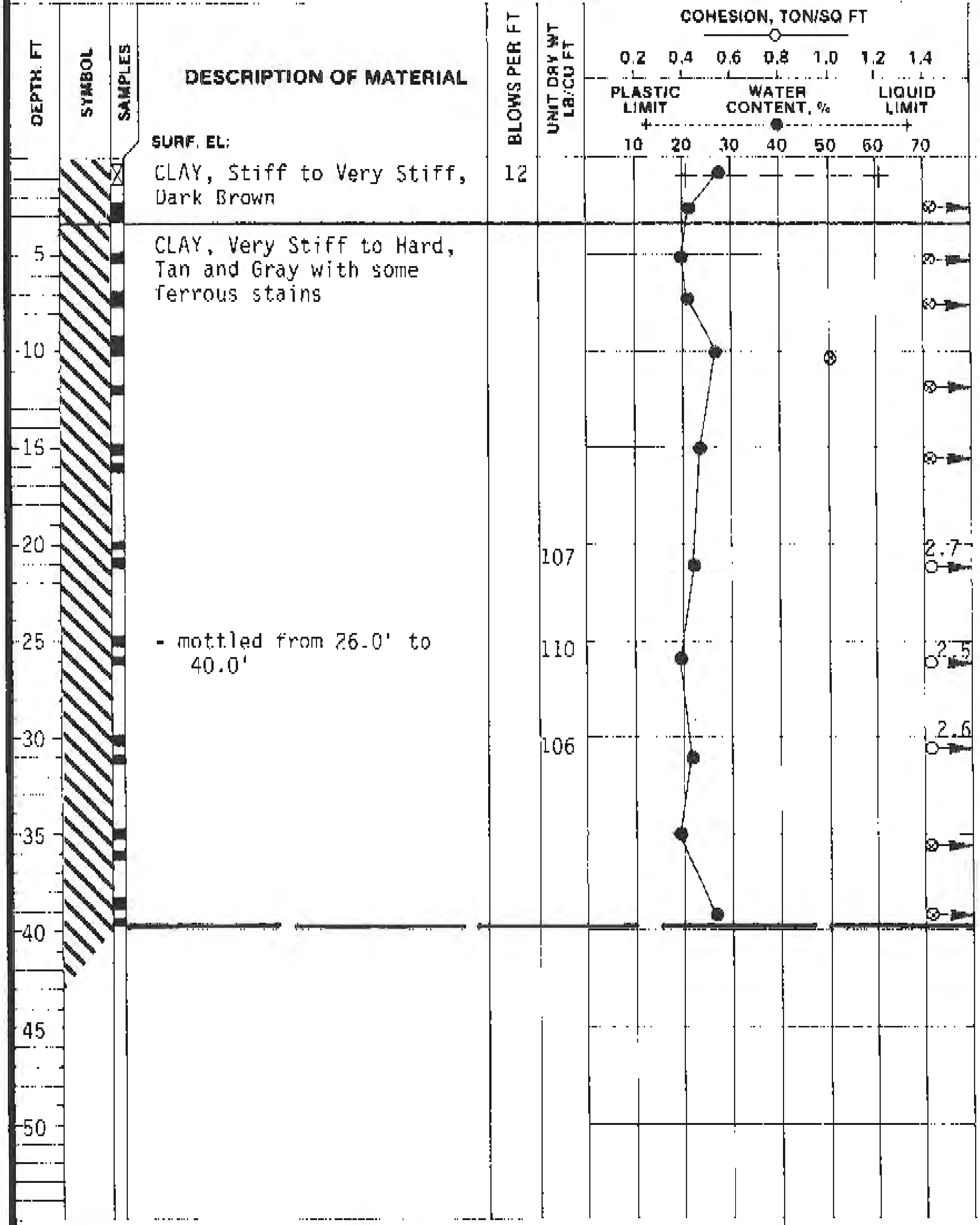
LOG OF BORING NO. B-5

UNIVERSITY ACTIVITIES AND WELLNESS CENTER
SAN ANTONIO, TEXAS

Raba-Kistner
Consultants, Inc.

TYPE: 2" Split Spoon
3" Shelby Tube

LOCATION: See Plate 1



CLAY, Stiff to Very Stiff, Dark Brown

CLAY, Very Stiff to Hard, Tan and Gray with some ferrous stains

- mottled from 26.0' to 40.0'

COMPLETION DEPTH: 40.0'
DATE: 7-6-87

DEPTH TO WATER
IN BORING: 9.0'

DATE 7-7-87

PROJ. NO. SA0287-0074
PLATE 6

NOTE: These logs should not be usec parately from the project report.

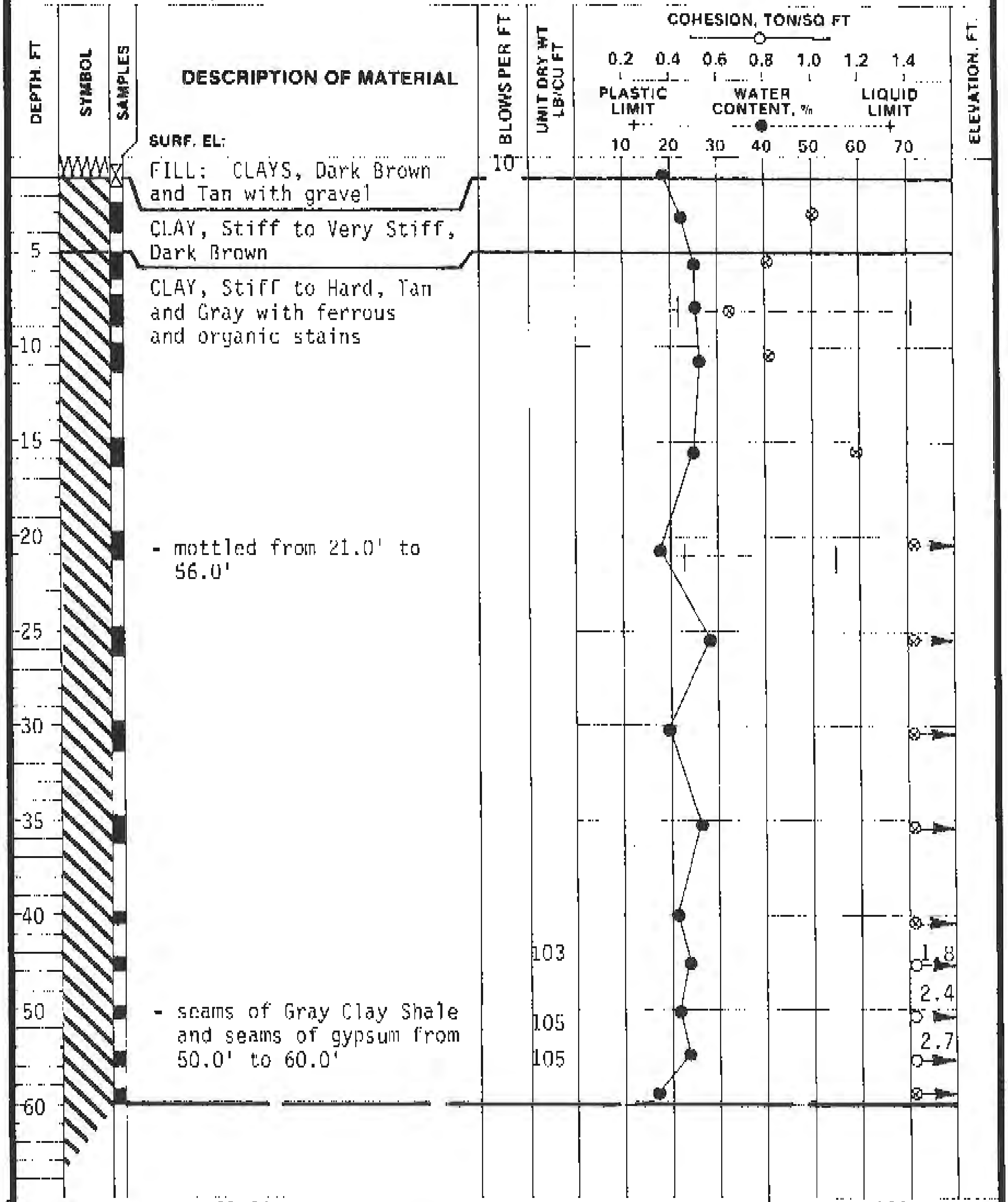
LOG OF BORING NO. B-6

UNIVERSITY ACTIVITIES AND WELLNESS CENTER
SAN ANTONIO, TEXAS

Raba-Kistner
Consultants, Inc.

TYPE: 2" Split Spoon
3" Shelby Tube

LOCATION: See Plate 1



FILL: CLAYS, Dark Brown and Tan with gravel

CLAY, Stiff to Very Stiff, Dark Brown

CLAY, Stiff to Hard, Tan and Gray with ferrous and organic stains

- mottled from 21.0' to 56.0'

- seams of Gray Clay Shale and seams of gypsum from 50.0' to 60.0'

COMPLETION DEPTH: 60.0'
DATE: 7-7-87

DEPTH TO WATER IN BORING: 8.0'

DATE: 7-10-87

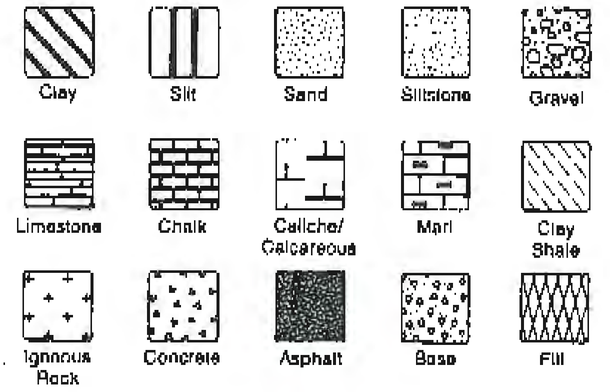
PROJ. NO. SA0287-0074
PLATE 7

NOTE: These logs should not be used separately from the project report.

SYMBOLS AND TERMS USED ON BORING LOGS

SOIL OR ROCK TYPES

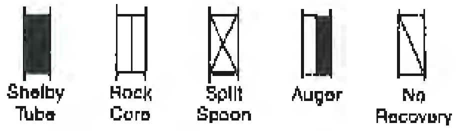
(shown in symbols column)



(Predominate Soil Types Shown Heavy)

SAMPLER TYPES

(shown in sample column)



STRENGTH TEST RESULTS

⊕ - Estimated Strength
◇ - Torvane
○ - Unconfined Compression

TRIAXIAL COMPRESSION

△ - Unconsolidated-undrained
▢ - Consolidated-undrained

c - Cohesion (Total)
Φ - Angle of Internal Friction (Total)

c' - Cohesion (Effective)
Φ' - Angle of Internal Friction (Effective)

NOTE:

Values symbolized on boring logs represent shear strengths unless otherwise noted.

TERMS DESCRIBING CONSISTENCY, CONDITION OR TEXTURE

Terms used in this report to describe soils with regard to their consistency or condition are in general accordance with the discussion presented in Article 45 of SOIL MECHANICS IN ENGINEERING PRACTICE, Terzaghi and Peck, John Wiley & Sons, Inc. 1967, using the most reliable information available from the field and laboratory investigations. Terms used for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in Technical Memorandum No. 3-357, Waterways Experiment Station, March 1953.

TERMS CHARACTERIZING SOIL STRUCTURE

Slickensided	- having inclined planes of weakness that are slick and glossy in appearance.
Fissured	- containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.
Laminated	- composed of thin layers of varying color and texture.
Interbedded	- composed of alternate layers of different soil types.
Calcareous	- containing appreciable quantities of calcium carbonate.
Well graded	- having wide range in grain sizes and substantial amounts of all intermediate particle sizes.
Poorly graded	- predominantly of one grain size, or having a range of sizes with some intermediate size missing.

TERMS DESCRIBING CONSISTENCY OR CONDITION

RELATIVE DENSITY

Penetration Resistance, blows per foot	Relative Density
0-4	Very Loose
4-10	Loose
10-30	Medium Dense
30-50	Dense
> 50	Very Dense

COHESIVE STRENGTH

Penetration Resistance, blows per foot	Consistency	Cohesion, TSF
0-2	Very Soft	0-0.125
2-4	Soft	0.125-0.25
4-8	Firm	0.25-0.5
8-15	Stiff	0.5-1.0
15-30	Very Stiff	1.0-2.0
> 30	Hard	> 2.0

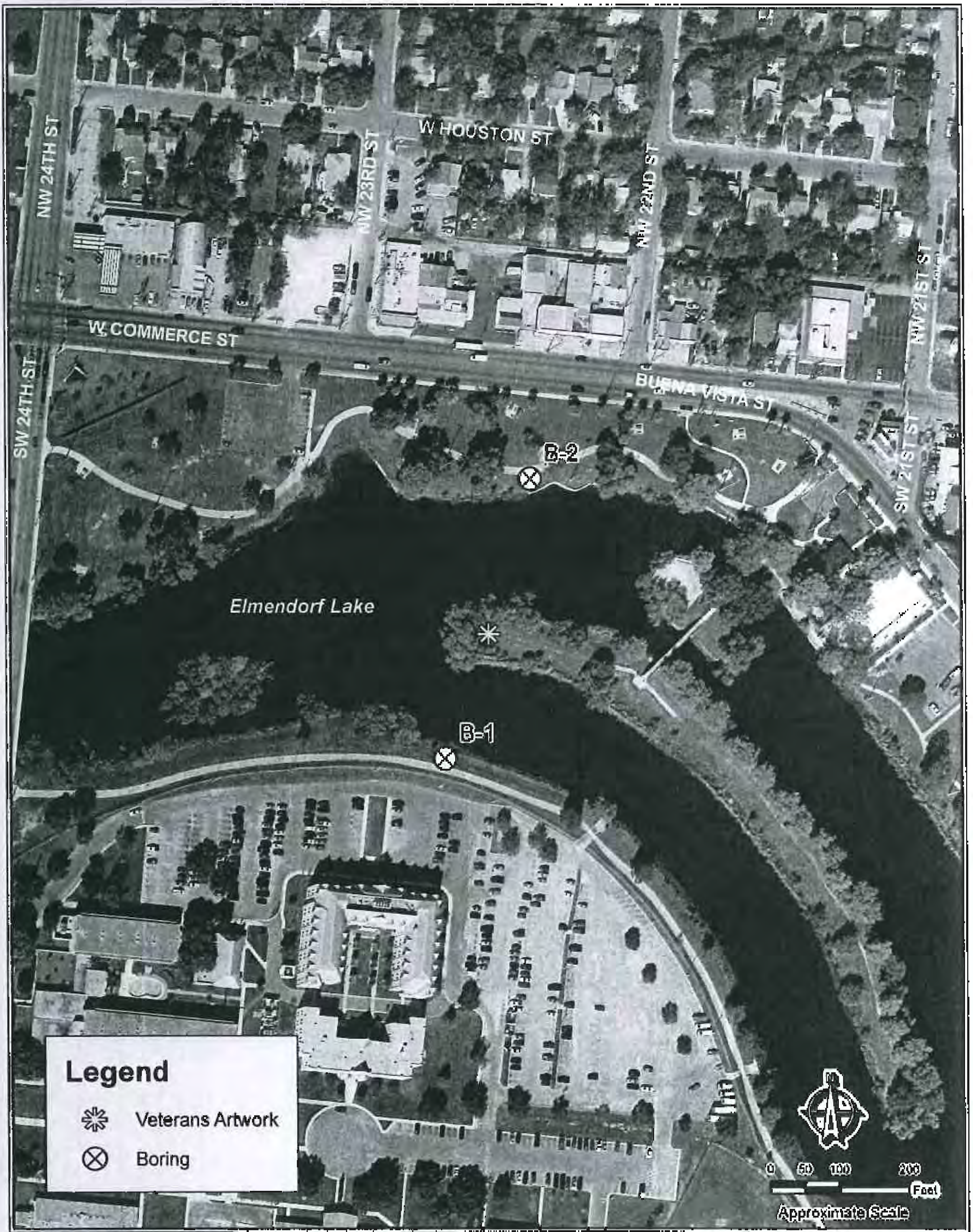
PLASTICITY

Plasticity Index	Degree of Plasticity
0-5	None
5-10	Low
10-20	Moderate
20-40	Plastic
> 40	Highly Plastic

NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above because of planes of weakness or cracks in the soil. The consistency ratings of such soils are based on penetrometer readings.

REPORT 2

RABAKISTNER



Raba Kistner

Engineering • Testing • Environmental
Facilities • Infrastructure

BORING LOCATION MAP

ELMENDORF LAKE PARK VETERANS ARTWORK
SAN ANTONIO, TEXAS

Project No.
ASA08-174-00

FIGURE 1

SOURCE: 2007 Aerial Photograph Provided by The City of San Antonio (COSA)
NOTE: This Drawing is Provided for Illustration Only, May Not be to Scale and is Not Suitable for Design or Construction Purposes

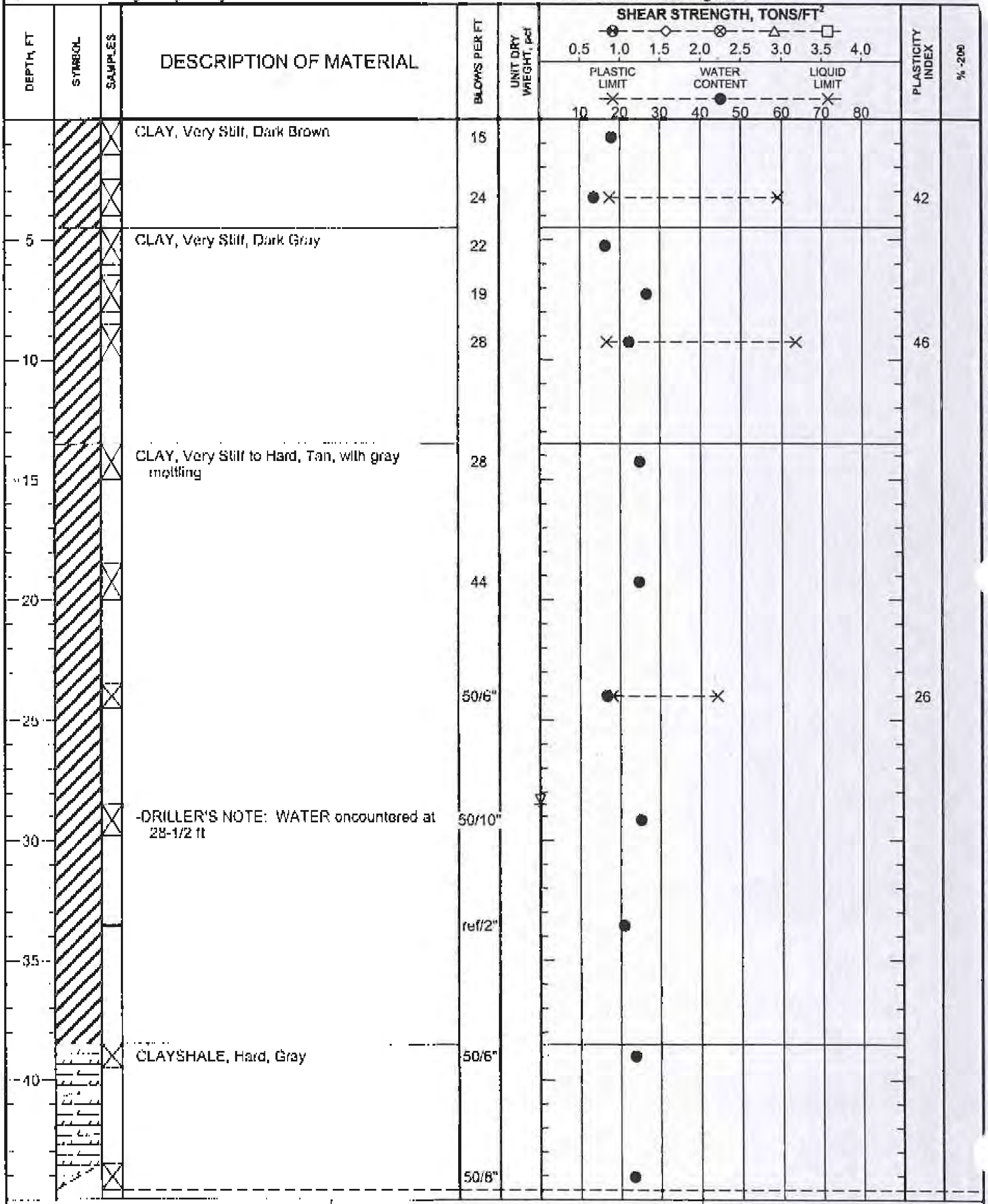
LOG OF BORING NO. B-1

Elmendorf Lake Park Veteran's Artwork
San Antonio, Texas

Raba Kistner

DRILLING METHOD: Straight Flight Auger

LOCATION: See Figure 1



DESCRIPTION OF MATERIAL	BLOWS PER FT	PLASTICITY INDEX
CLAY, Very Stiff, Dark Brown	15	
	24	42
CLAY, Very Stiff, Dark Gray	22	
	19	
	28	46
CLAY, Very Stiff to Hard, Tan, with gray mottling	28	
	44	
	50/6"	26
-DRILLER'S NOTE: WATER encountered at 28-1/2 ft	50/10"	
	ref/2"	
CLAYSHALE, Hard, Gray	50/6"	
	50/6"	

NOTE: THESE LOGS SHOULD NOT BE U SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED: 44.6 ft
DATE DRILLED: 1/15/2009

DEPTH TO WATER: 28.5 ft
DATE MEASURED: 1/15/2009

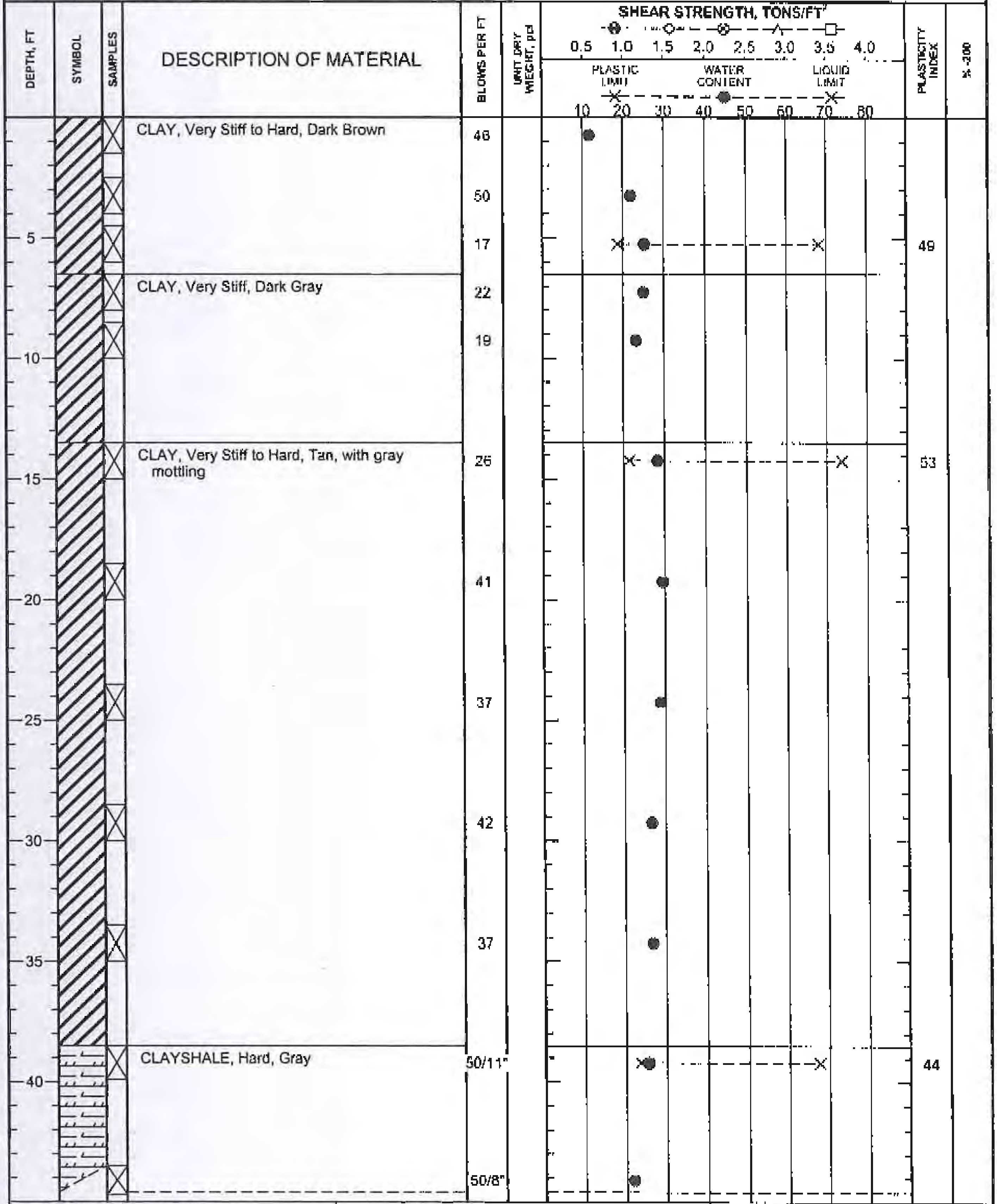
PROJ. No.: ASA08-174-00
FIGURE: 2

LOG OF BORING NO. B-2

Elmendorf Lake Park Veteran's Artwork
San Antonio, Texas

DRILLING METHOD: Straight Flight Auger

LOCATION: See Figure 1



DESCRIPTION OF MATERIAL	BLOWS PER FT	PLASTICITY INDEX
CLAY, Very Stiff to Hard, Dark Brown	46	
	50	
	17	49
CLAY, Very Stiff, Dark Gray	22	
	19	
CLAY, Very Stiff to Hard, Tan, with gray mottling	26	53
	41	
	37	
	42	
	37	
CLAYSHALE, Hard, Gray	50/11"	44
	50/8"	

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED: 44.7 ft
DATE DRILLED: 1/15/2009

DEPTH TO WATER: Dry
DATE MEASURED: 1/15/2009

PROJ. No.: ASA08-174-00
FIGURE: 3

KEY TO TERMS AND SYMBOLS

MATERIAL TYPES

SOIL TERMS

- CALCAREOUS
- CALICHE
- CLAY
- CLAYEY
- GRAVEL
- GRAVELLY
- PEAT
- SAND
- SANDY
- SILT
- SILTY
- FILL

ROCK TERMS

- CHALK
- CLAYSTONE
- CLAY-SHALE
- CONGLOMERATE
- DOLOMITE
- IGNEOUS
- LIMESTONE
- MARL
- METAMORPHIC
- SANDSTONE
- SHALE
- SILTSTONE

OTHER

- ASPHALT
- BASE
- CONCRETE/CEMENT
- BRICKS / PAVERS
- WASTE
- NO INFORMATION

WELL CONSTRUCTION AND PLUGGING MATERIALS

- BLANK PIPE
- SCREEN
- BENTONITE
- CEMENT GROUT
- BENTONITE & CUTTINGS
- CONCRETE/CEMENT
- CUTTINGS
- GRAVEL
- SAND
- VOLCLAY

SAMPLE TYPES

- AIR ROTARY
- GRAB SAMPLE
- CORE
- GEOPROBE SAMPLER
- MUD ROTARY
- NO RECOVERY
- NX CORE
- TEXAS CONE PENETROMETER
- SHELBY TUBE
- SPLIT BARREL
- SPLIT SPOON

STRENGTH TEST TYPES

- ● POCKET PENETROMETER
- ◇ TORVANE
- ⊗ UNCONFINED COMPRESSION
- △ TRIAXIAL COMPRESSION UNCONSOLIDATED-UNDRAINED
- ☐ TRIAXIAL COMPRESSION CONSOLIDATED-UNDRAINED

NOTE: VALUES SYMBOLIZED ON BORING LOGS REPRESENT SHEAR STRENGTHS UNLESS OTHERWISE NOTED

KEY TO TERMS AND SYMBOLS (CONT'D)

TERMINOLOGY

Terms used in this report to describe soils with regard to their consistency or conditions are in general accordance with the discussion presented in Article 45 of SOILS MECHANICS IN ENGINEERING PRACTICE, Terzaghi and Peck, John Wiley & Sons, Inc., 1967, using the most reliable information available from the field and laboratory investigations. Terms used for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in American Society for Testing and Materials D2487-06 and D2488-00, Volume 04.08, Soil and Rock; Dimension Stone; Geosynthetics; 2005.

The depths shown on the boring logs are not exact, and have been estimated to the nearest half-foot. Depth measurements may be presented in a manner that implies greater precision in depth measurement, i.e 6.71 meters. The reader should understand and interpret this information only within the stated half-foot tolerance on depth measurements.

RELATIVE DENSITY

Penetration Resistance Blows per ft	Relative Density
0 - 4	Very Loose
4 - 10	Loose
10 - 30	Medium Dense
30 - 50	Dense
> 50	Very Dense

COHESIVE STRENGTH

Resistance Blows per ft	Consistency	Cohesion TSF
0 - 2	Very Soft	0 - 0.125
2 - 4	Soft	0.125 - 0.25
4 - 8	Firm	0.25 - 0.5
8 - 15	Stiff	0.5 - 1.0
15 - 30	Very Stiff	1.0 - 2.0
> 30	Hard	> 2.0

PLASTICITY

Plasticity Index	Degree of Plasticity
0 - 5	None
5 - 10	Low
10 - 20	Moderate
20 - 40	Plastic
> 40	Highly Plastic

ABBREVIATIONS

B = Benzene
T = Toluene
E = Ethylbenzene
X = Total Xylenes
BTEX = Total BTEX
TPH = Total Petroleum Hydrocarbons
ND = Not Detected
NA = Not Analyzed
NR = Not Recorded/No Recovery
OVA = Organic Vapor Analyzer
ppm = Parts Per Million

Qam, Qas, Qal = Quaternary Alluvium
Qat = Low Terrace Deposits
Qbc = Beaumont Formation
Qt = Fluviatile Terrace Deposits
Qao = Seymour Formation
Qle = Leona Formation
Q-Tu = Uvalde Gravel
Ewi = Wilcox Formation
Emi = Midway Group
Mc = Catahoula Formation
El = Laredo Formation
Kknm = Navarro Group and Marlbrook Marl
Kpg = Pecan Gap Chalk
Kau = Austin Chalk

Kef = Eagle Ford Shale
Kbu = Buda Limestone
Kdr = Del Rio Clay
Kft = Fort Terrett Member
Kgt = Georgetown Formation
Kep = Person Formation
Kek = Kainer Formation
Kes = Escondido Formation
Kew = Walnut Formation
Kgr = Glen Rose Formation
Kgru = Upper Glen Rose Formation
Kgrl = Lower Glen Rose Formation
Kh = Hensell Sand

PROJECT NO. ASA08-174-00

KEY TO TERMS AND SYMBOLS (CONT'D)

TERMINOLOGY

SOIL STRUCTURE

Slickensided	Having planes of weakness that appear slick and glossy.
Fissured	Containing shrinkage or relief cracks, often filled with fine sand or silt; usually more or less vertical.
Pocket	Inclusion of material of different texture that is smaller than the diameter of the sample.
Parting	Inclusion less than 1/8 inch thick extending through the sample.
Seam	Inclusion 1/8 inch to 3 inches thick extending through the sample.
Layer	Inclusion greater than 3 inches thick extending through the sample.
Laminated	Soil sample composed of alternating partings or seams of different soil type.
Interlayered	Soil sample composed of alternating layers of different soil type.
Intermixed	Soil sample composed of pockets of different soil type and layered or laminated structure is not evident.
Calcareous	Having appreciable quantities of carbonate.
Carbonate	Having more than 50% carbonate content.

SAMPLING METHODS

RELATIVELY UNDISTURBED SAMPLING

Cohesive soil samples are to be collected using three-inch thin-walled tubes in general accordance with the Standard Practice for Thin-Walled Tube Sampling of Soils (ASTM D1587) and granular soil samples are to be collected using two-inch split-barrel samplers in general accordance with the Standard Method for Penetration Test and Split-Barrel Sampling of Soils (ASTM D1586). Cohesive soil samples may be extruded on-site when appropriate handling and storage techniques maintain sample integrity and moisture content.

STANDARD PENETRATION TEST (SPT)

A 2-in.-OD, 1-3/8-ID split spoon sampler is driven 1.5 ft into undisturbed soil with a 140-pound hammer free falling 30 in. After the sampler is seated 6 in. into undisturbed soil, the number of blows required to drive the sampler the last 12 in. is the Standard Penetration Resistance or "N" value, which is recorded as blows per foot as described below.

SPLIT-BARRELL SAMPLER DRIVING RECORD

Blows Per Foot	Description
25	25 blows drove sampler 12 inches, after initial 6 inches of seating.
50/7"	50 blows drove sampler 7 inches, after initial 6 inches of seating.
Ref/3"	50 blows drove sampler 3 inches during initial 6-inch seating interval.

NOTE: To avoid damage to sampling tools, driving is limited to 50 blows during or after seating interval.

RESULTS OF SOIL SAMPLE ANALYSES

PROJECT NAME: Elmendorf Lake Park Veteran's Artwork
San Antonio, Texas

FILE NAME: ASA08-174-00.GPJ

3/4/2009

Boring No.	Sample Depth (ft)	Blows per ft	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS	Dry Unit Weight (pcf)	% -200 Sieve	Shear Strength (tsf)	Strength Test
B-1	0.0 to 1.5	15	18								
	2.5 to 4.0	24	13	59	17	42					
	4.5 to 6.0	22	16								
	6.5 to 8.0	19	27								
	8.5 to 10.0	28	22	63	17	46					
	13.5 to 15.0	28	25								
	18.5 to 20.0	44	25								
	23.5 to 24.5	50/6"	17	44	18	26					
	28.5 to 29.8	50/10"	25								
	33.5 to 33.6	ref/2"	21								
	38.5 to 39.5	50/6"	24								
	43.5 to 44.6	50/8"	23								
B-2	0.0 to 1.5	46	12								
	2.5 to 4.0	50	22								
	4.5 to 6.0	17	25	68	19	49					
	6.5 to 8.0	22	25								
	8.5 to 10.0	19	23								
	13.5 to 15.0	26	28	74	21	53					
	18.5 to 20.0	41	29								
	23.5 to 25.0	37	29								
	28.5 to 30.0	42	26								
	33.5 to 35.0	37	27								
	38.5 to 39.9	50/11"	25	67	23	44					
	43.5 to 44.7	50/8"	22								

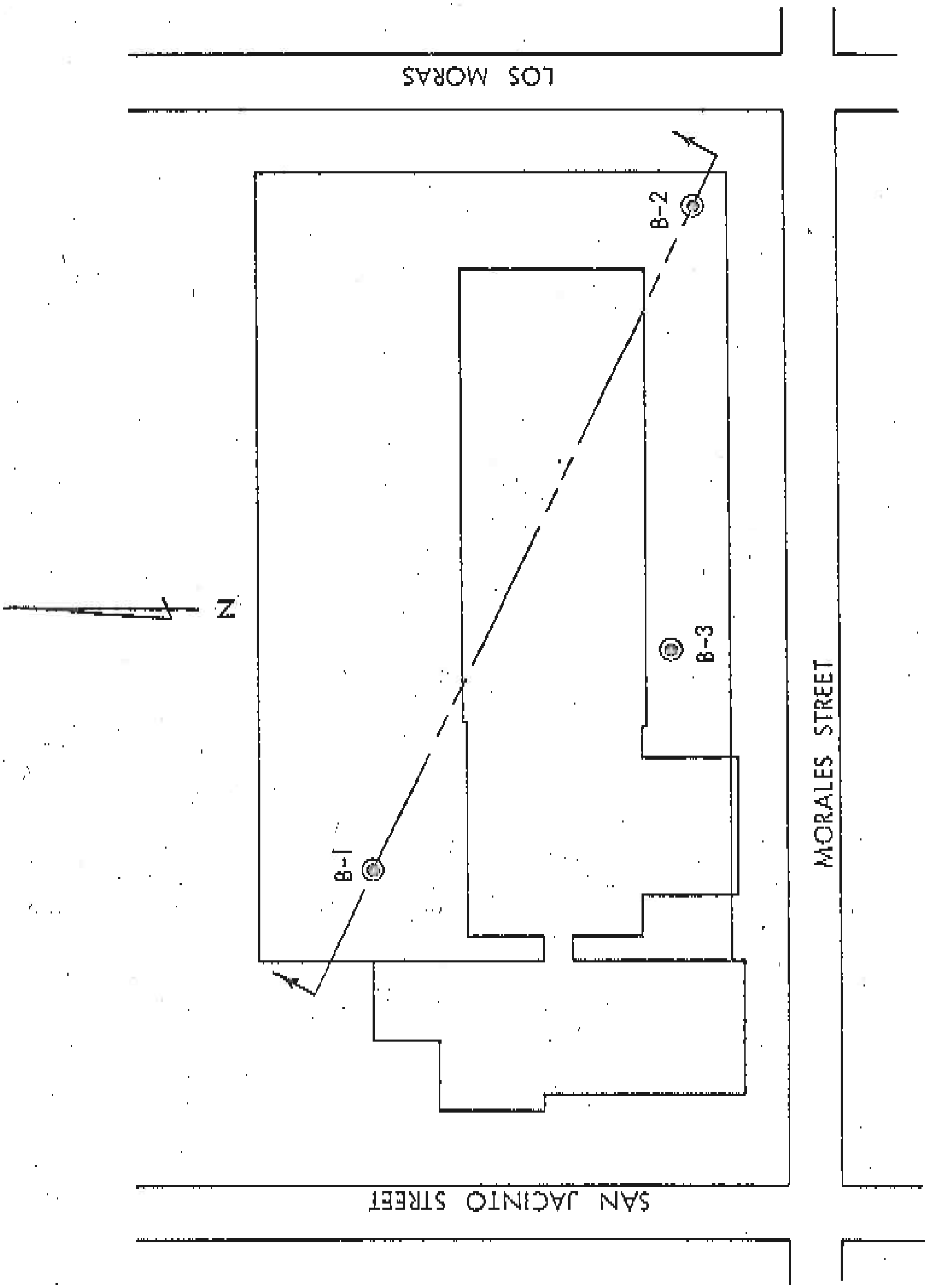
PP = Pocket Penetrometer TV = Torvane UC = Unconfined Compression FV = Field Vane UU = Unconsolidated Undrained Triaxial

CU = Consolidated Undrained Triaxial

PROJECT NO. ASA08-174-00

FIGURE 5

REPORT 3



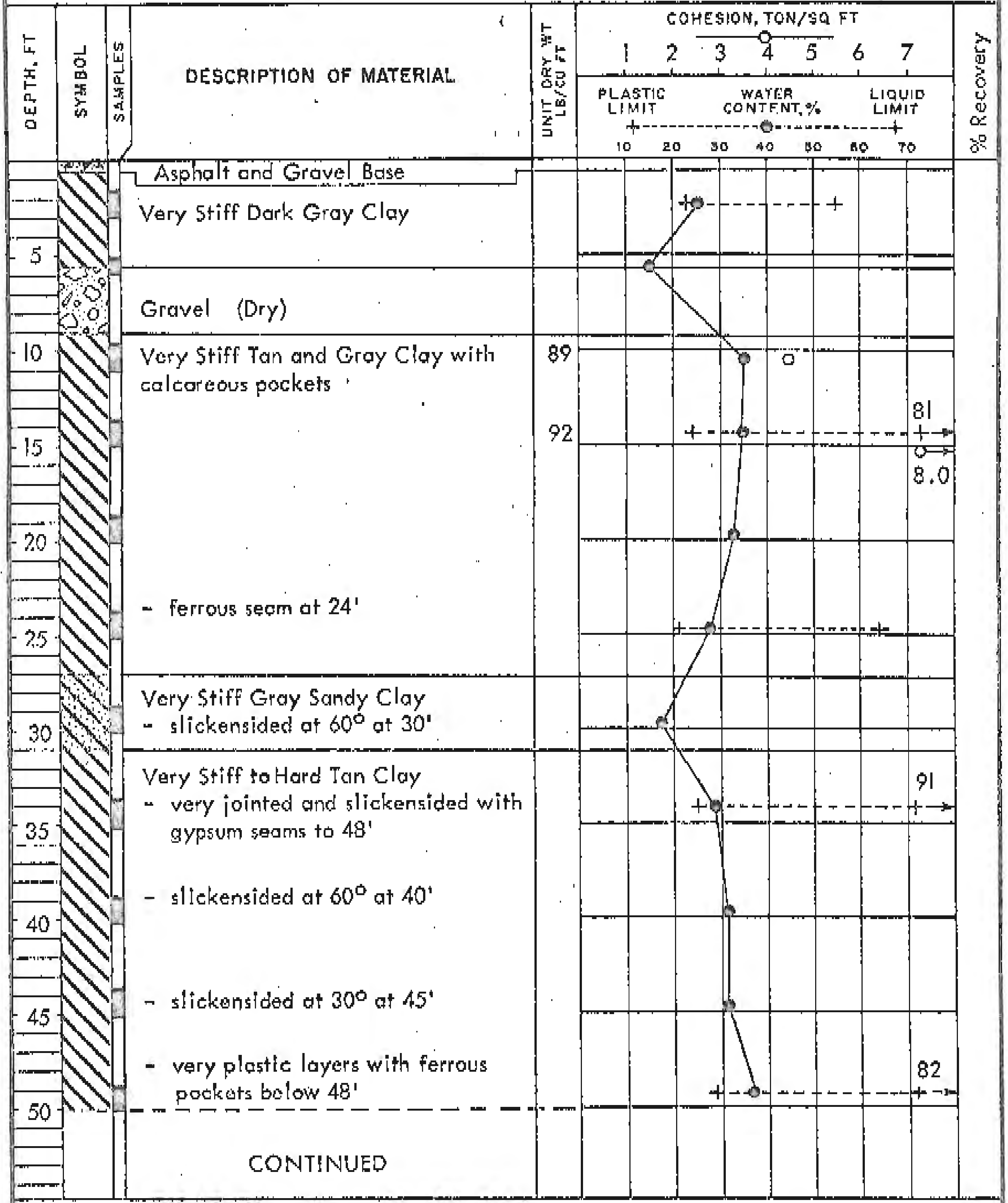
LAYOUT OF BORINGS

Scale: 1" = 50'

LOG OF BORING NO. 1

ANTHONY MARGILL ELEMENTARY SCHOOL
SAN ANTONIO, TEXAS

TYPE: 3" Shelby tube & NX Core Barrel   LOCATION: See Plate I



Asphalt and Gravel Base

Very Stiff Dark Gray Clay

Gravel (Dry)

Very Stiff Tan and Gray Clay with calcareous pockets

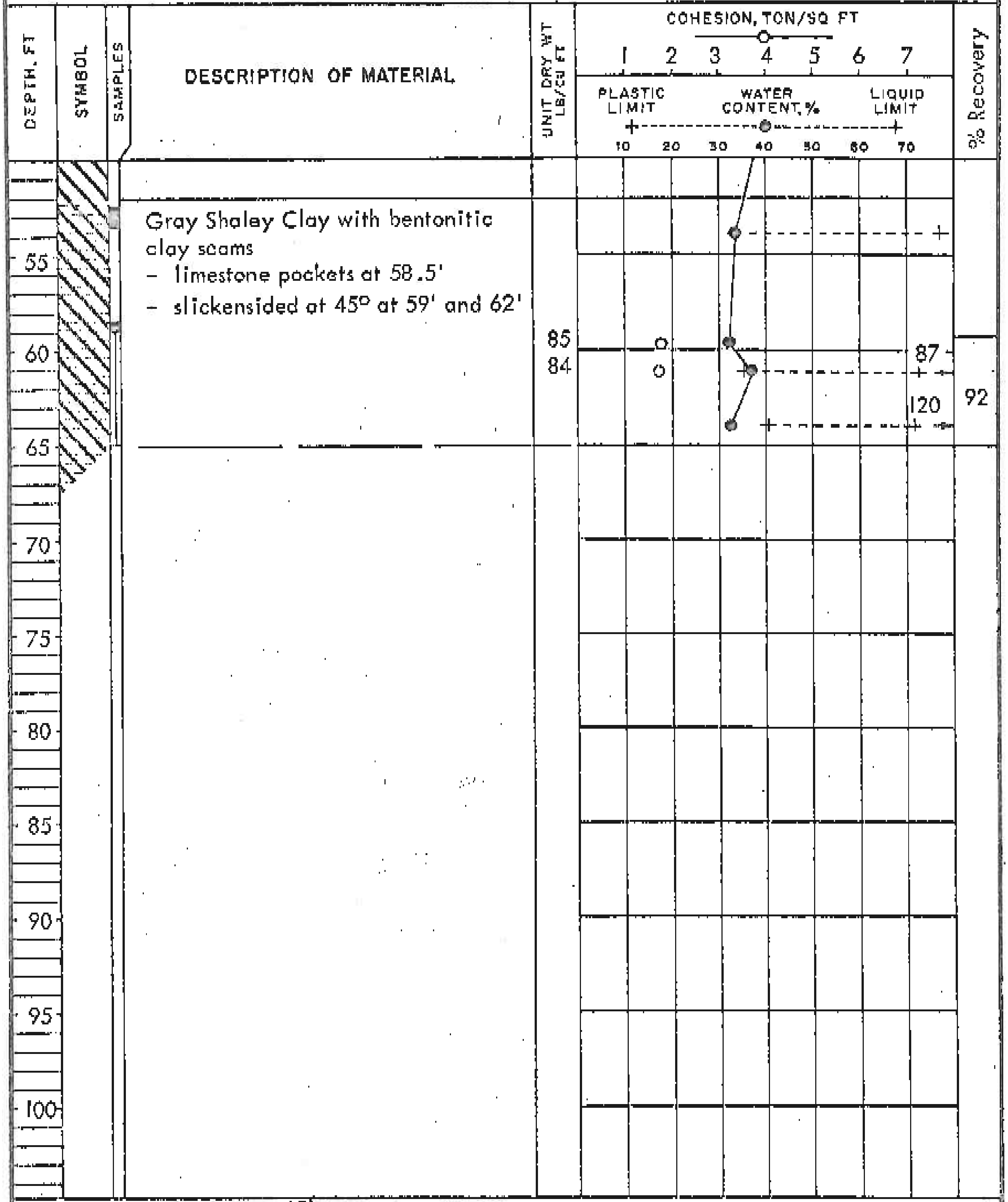
- ferrous seam at 24'

Very Stiff Gray Sandy Clay
- slickensided at 60° at 30'

Very Stiff to Hard Tan Clay
- very jointed and slickensided with gypsum seams to 48'
- slickensided at 60° at 40'
- slickensided at 30° at 45'
- very plastic layers with ferrous pockets below 48'

CONTINUED

LOG OF BORING NO. 1 (continued)



Gray Shaley Clay with bentonitic clay seams

- limestone pockets at 58.5'
- slickensided at 45° at 59' and 62'

COMPLETION DEPTH: 65'
DATE: August 29, 1969

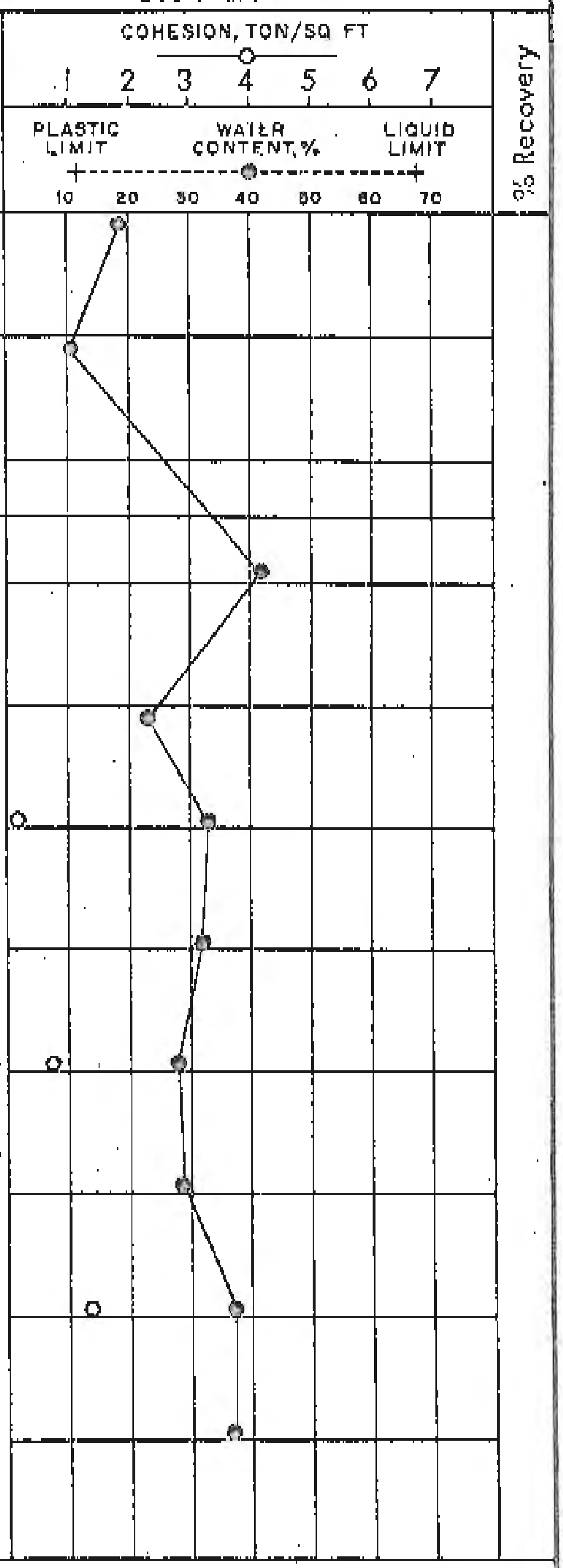
LOG OF BORING NO. 2

ANTHONY MARGILL ELEMENTARY SCHOOL
SAN ANTONIO, TEXAS

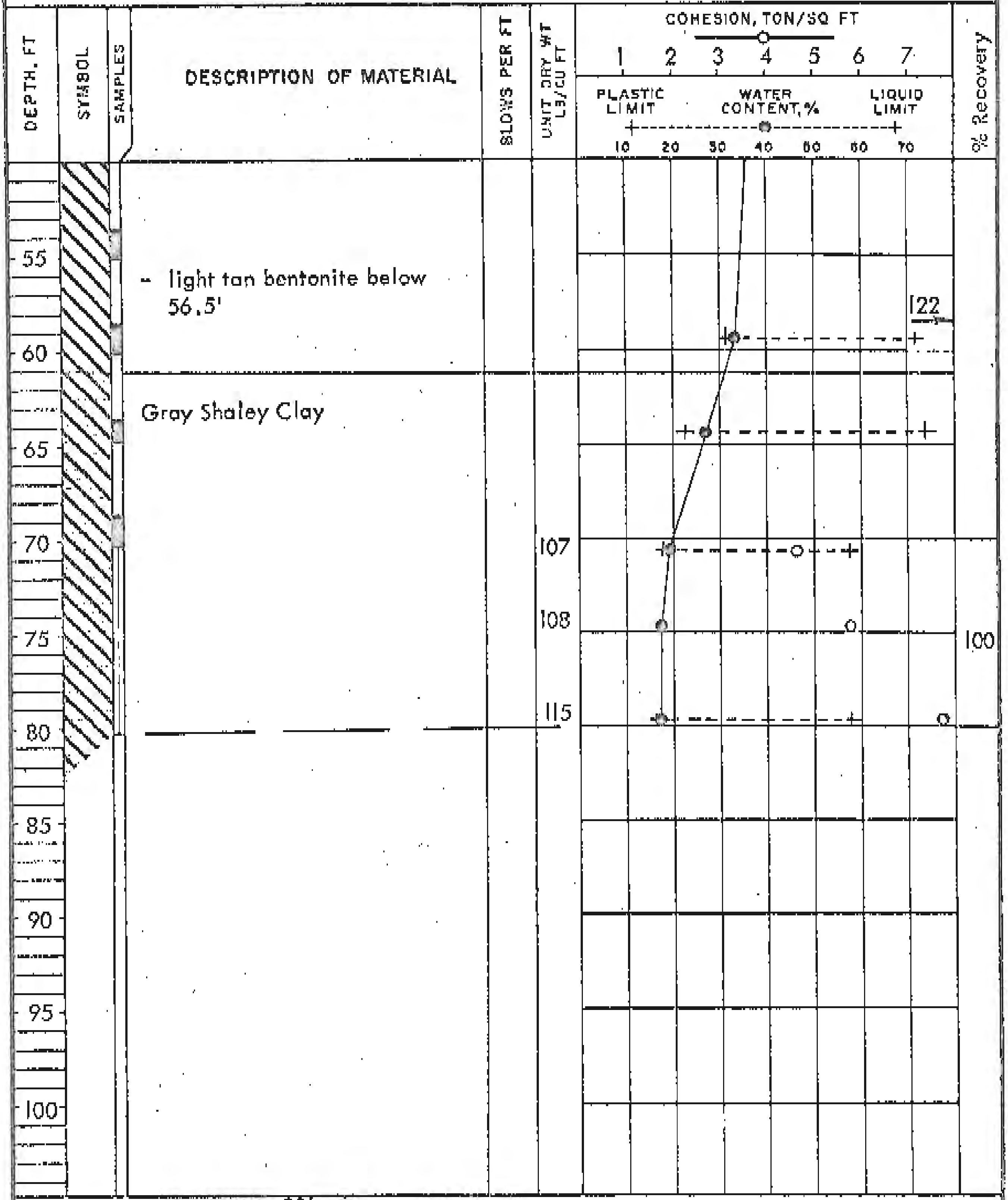
TYPE: 3" Shelby tube, 2" Split-spoon & NX Core Barrel

LOCATION: See Plate 1

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT
	Very Stiff Dark Gray Clay with gravel		
5	Clayey Gravel (Dry)	38	
10			
	Very Stiff Tan and Gray Clay, very jointed and slickensided		
15			
20			
25			89
30			
35	- gypsum filled seams and pockets below 35' - slickensided at 45° at 35'		94
40			
45			84
	- very plastic below 48'		
50			
	CONTINUED		



LOG OF BORING NO. 2 (continued)



- light tan bentonite below 56.5'

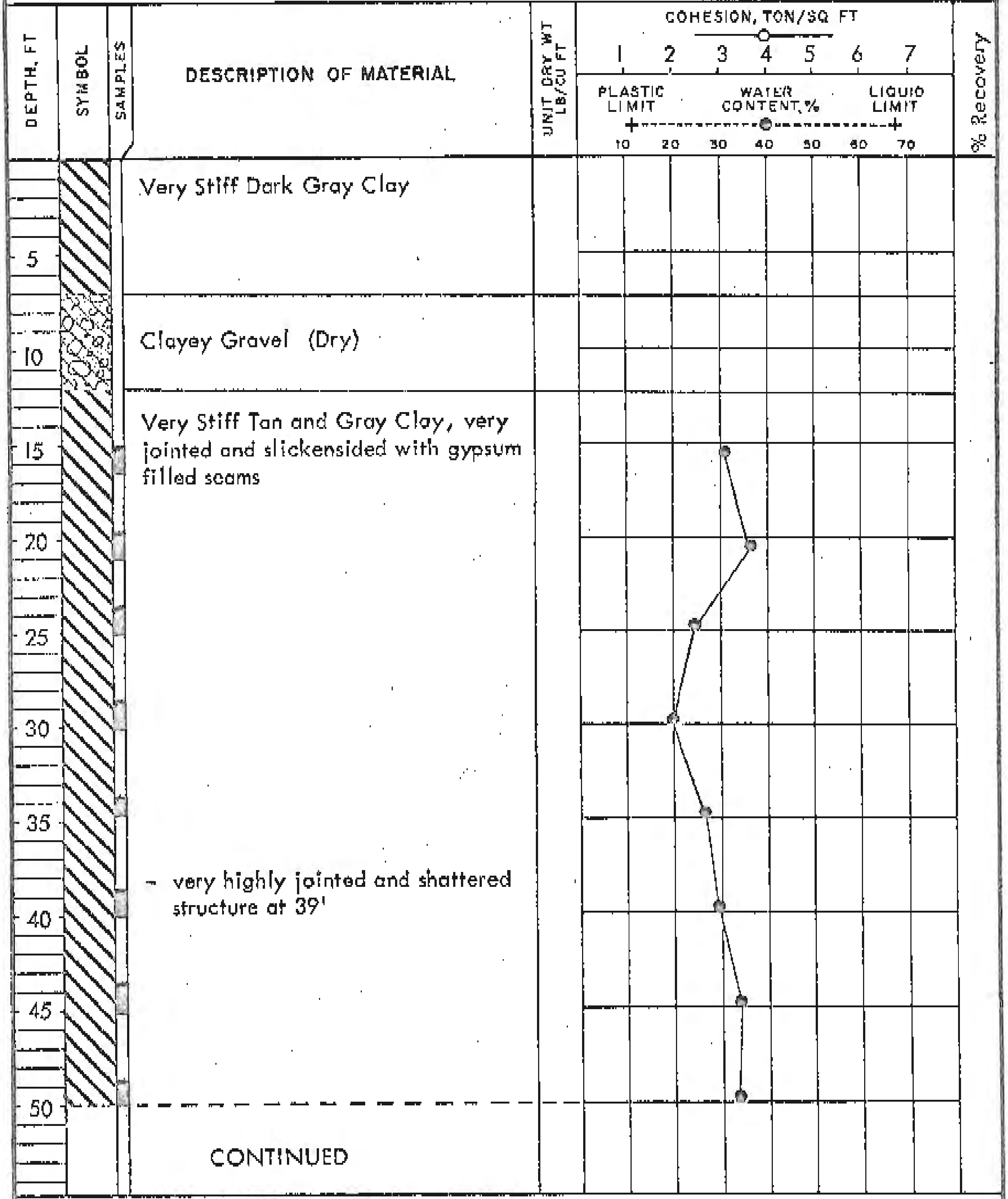
Gray Shaley Clay

COMPLETION DEPTH: 80'
DATE: September 3, 1969

LOG OF BORING NO. 3

ANTHONY MARGILL ELEMENTARY SCHOOL
SAN ANTONIO, TEXAS

TYPE: 3" Shelby tube & NX Core Barrel LOCATION: See Plate 1



Very Stiff Dark Gray Clay

Clayey Gravel (Dry)

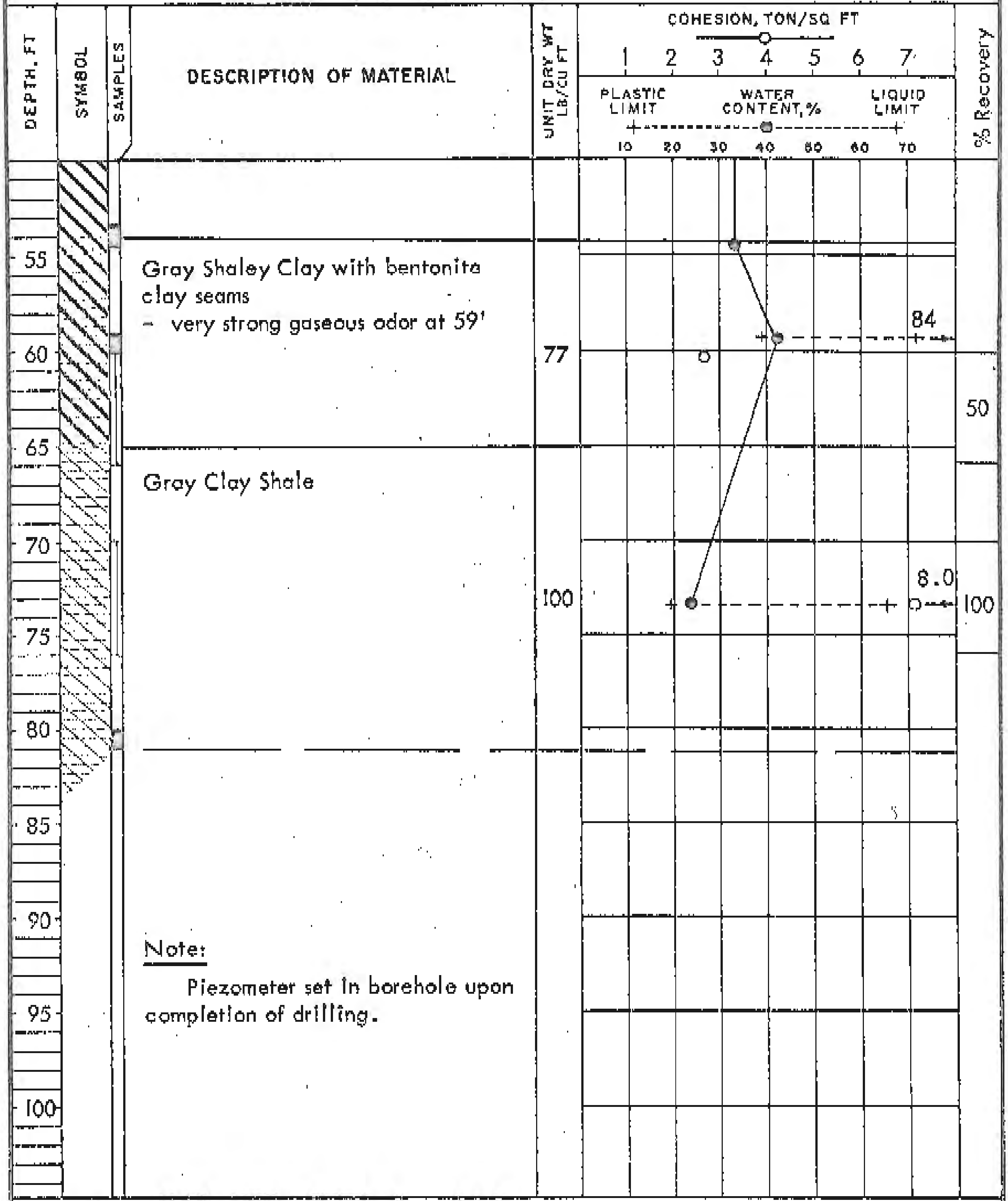
Very Stiff Tan and Gray Clay, very jointed and slickensided with gypsum filled seams

- very highly jointed and shattered structure at 39'

CONTINUED

RABA AND TOLSON CONSULTING ENGINEERS, INC.

LOG OF BORING NO. 3 (continued)



Gray Shaley Clay with bentonite clay seams
- very strong gaseous odor at 59'

Gray Clay Shale

Note:

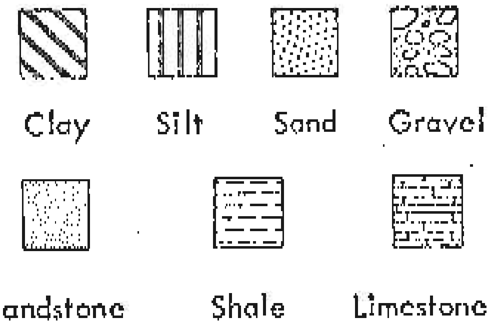
Piezometer set in borehole upon completion of drilling.

COMPLETION DEPTH: 81'
DATE: September 12, 1969

SYMBOLS AND TERMS USED ON BORING LOGS

SOIL OR ROCK TYPES

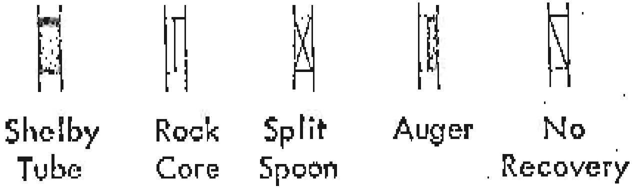
(shown in symbols column)



Predominate Soil Types Shown Heavy

SAMPLER TYPES

(shown in sample column)



STRENGTH TEST RESULTS

⊗ - Estimated Strength
○ - Unconfined Compression

TRIAXIAL COMPRESSION

(Single-Stage Tests)

△ - Unconsolidated-undrained
□ - Consolidated-undrained

(Multiple-Stage Tests)

c - Apparent Cohesion
ϕ - Apparent Angle of Internal Friction

NOTE:
Values symbolized on boring logs represent shear strengths unless otherwise noted.

TERMS DESCRIBING CONSISTENCY, CONDITION OR TEXTURE

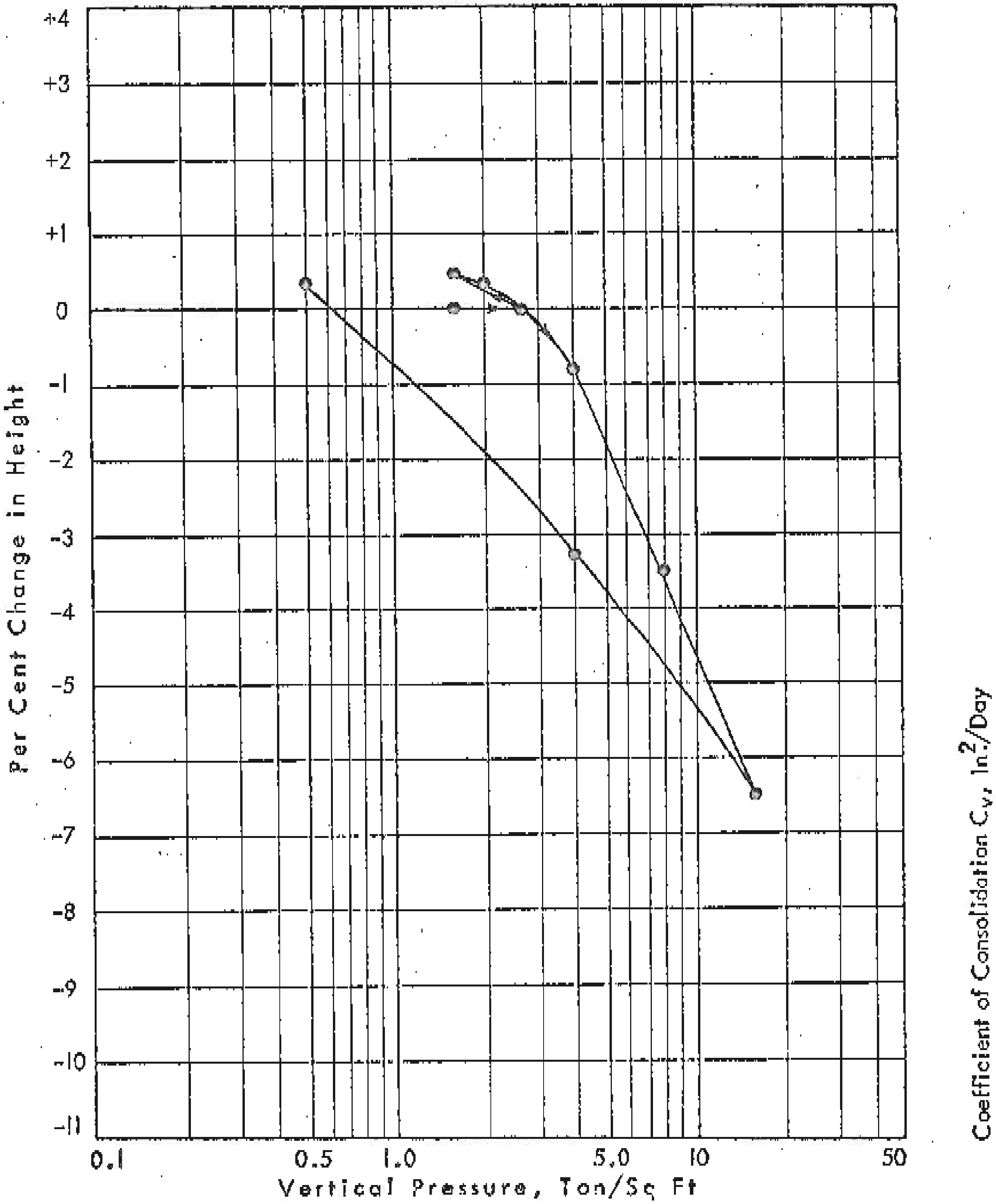
Terms used in this report to describe soils with regard to their consistency or condition are in general accordance with the discussion presented in Article 45 of SOIL MECHANICS IN ENGINEERING PRACTICE, Terzaghi and Peck, John Wiley & Sons, Inc., August, 1960, using the most reliable information available from the field and laboratory investigations. Terms used for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in Technical Memorandum No. 3-357, Waterways Experiment Station, March 1953.

TERMS CHARACTERIZING SOIL STRUCTURE

Slickensided -	having inclined planes of weakness that are slick and glossy in appearance.
Fissured -	containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.
Laminated -	composed of thin layers of varying color and texture.
Interbedded -	composed of alternate layers of different soil types.
Calcareous -	containing appreciable quantities of calcium carbonate.
Well graded -	having wide range in grain sizes and substantial amounts of all intermediate particle sizes.
Poorly graded -	predominantly of one grain size, or having a range of sizes with some intermediate size missing.

Boring: B-1 Depth: 24.5'
Material: Very Stiff Tan and Gray Clay

Unit Dry Weight: 89 lb/cu ft
Water Content: 30 %
Liquid Limit: 65
Plastic Limit: 21

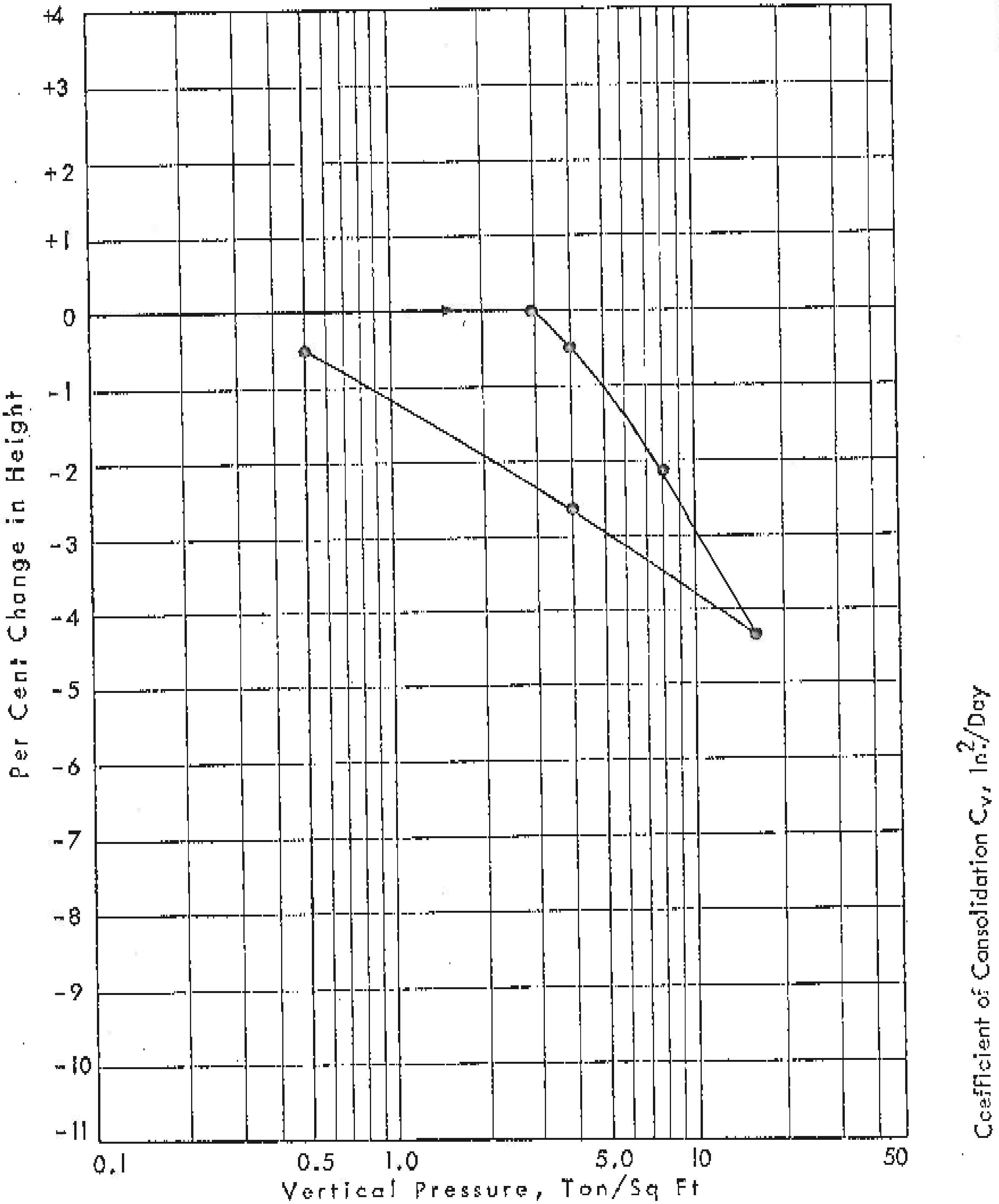


SWELL AND
CONSOLIDATION TEST RESULTS

RABA AND TOLSON CONSULTING ENGINEERS, INC.

Boring: B-1 Depth: 50'
Material: Very Stiff Tan Clay

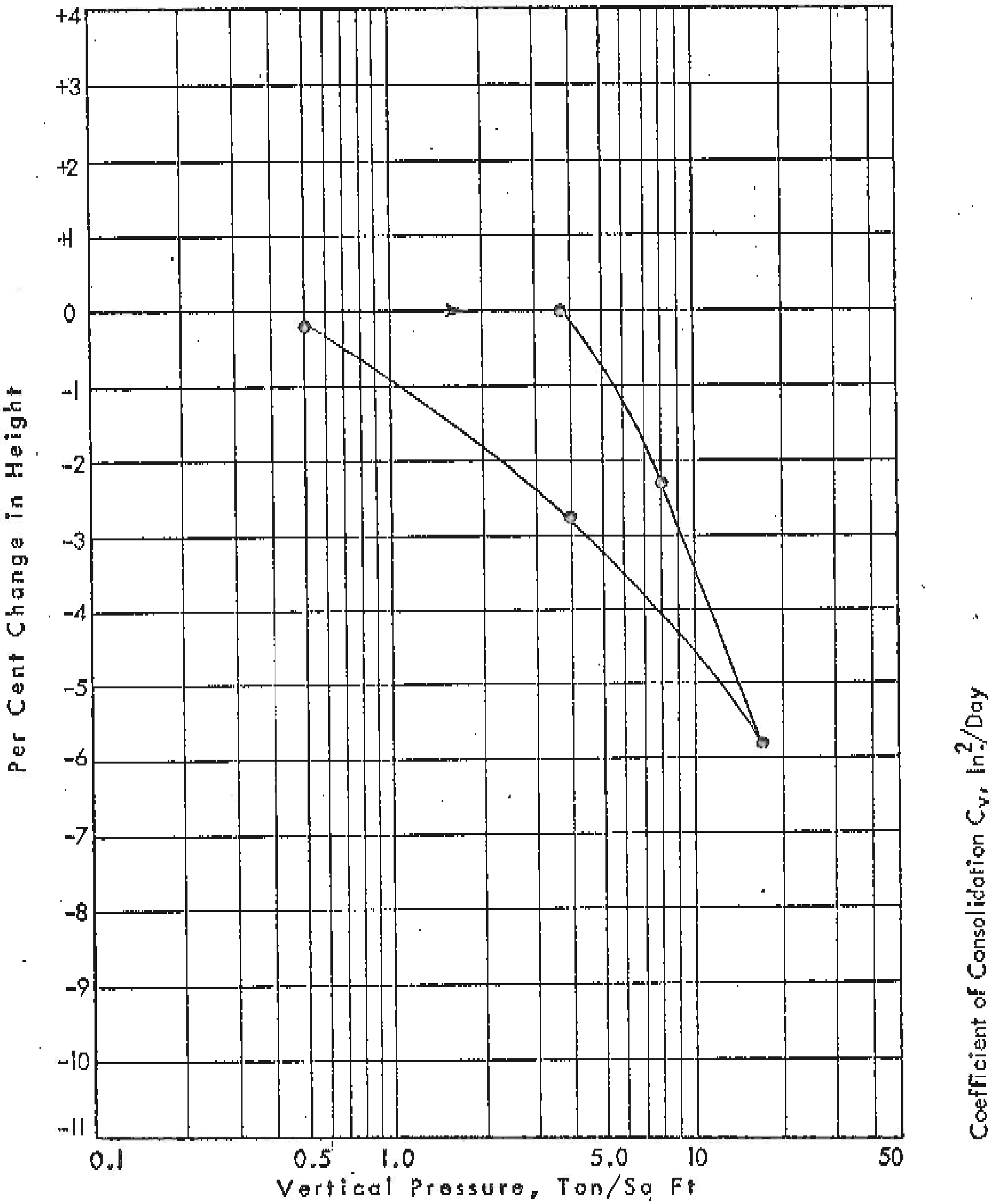
Unit Dry Weight: 86 lb/cu ft
Water Content: 36 %
Liquid Limit: 82
Plastic Limit: 29



SWELL AND CONSOLIDATION TEST RESULTS

Boring: B-2 Depth: 59'
Material: Very Stiff Light Tan Bentonitic Clay

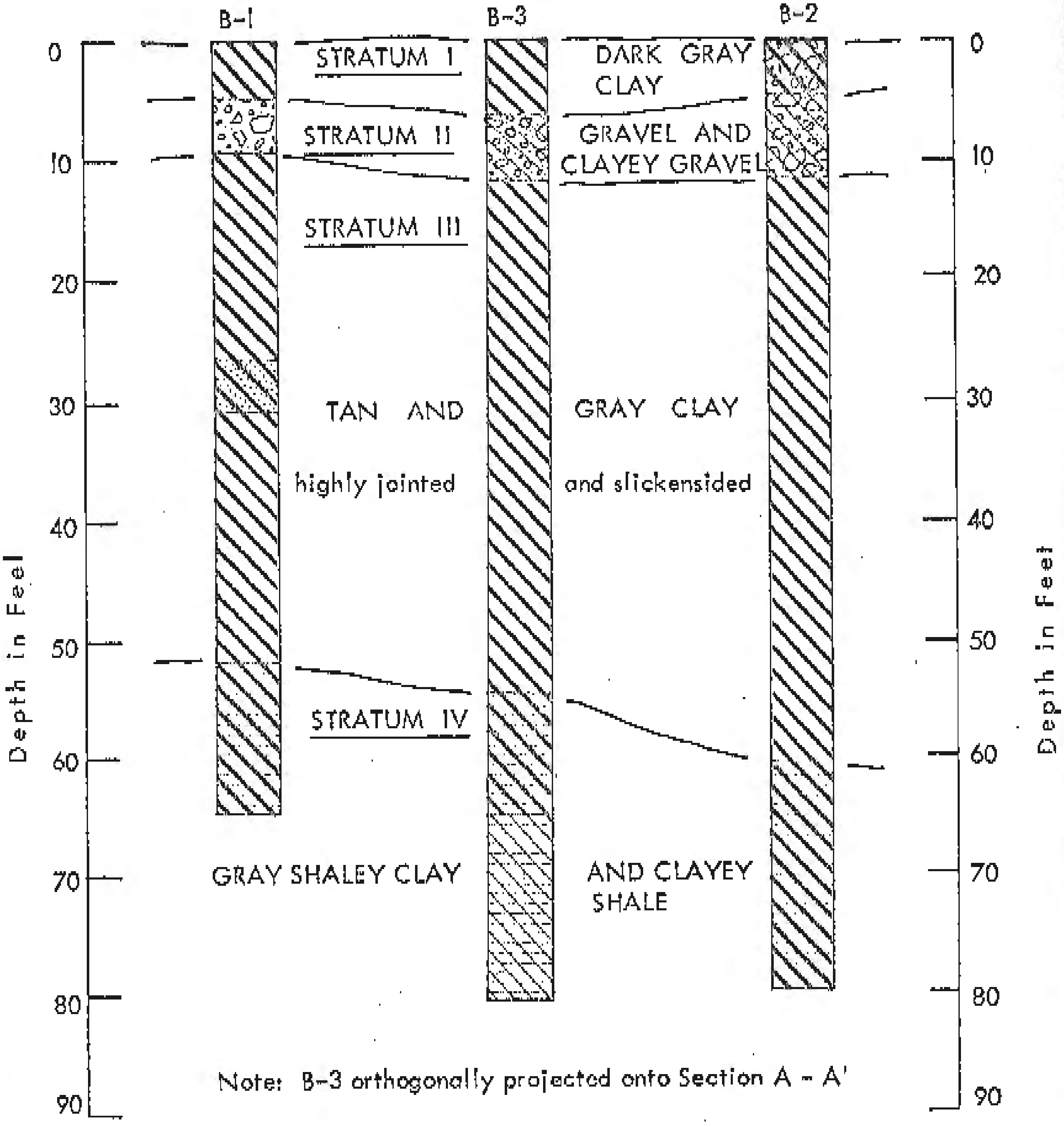
Unit Dry Weight: 73 lb/cu ft
Water Content: 47 %
Liquid Limit: 122
Plastic Limit: 31



SWELL AND CONSOLIDATION TEST RESULTS

RABA AND TOLSON CONSULTING ENGINEERS, INC.

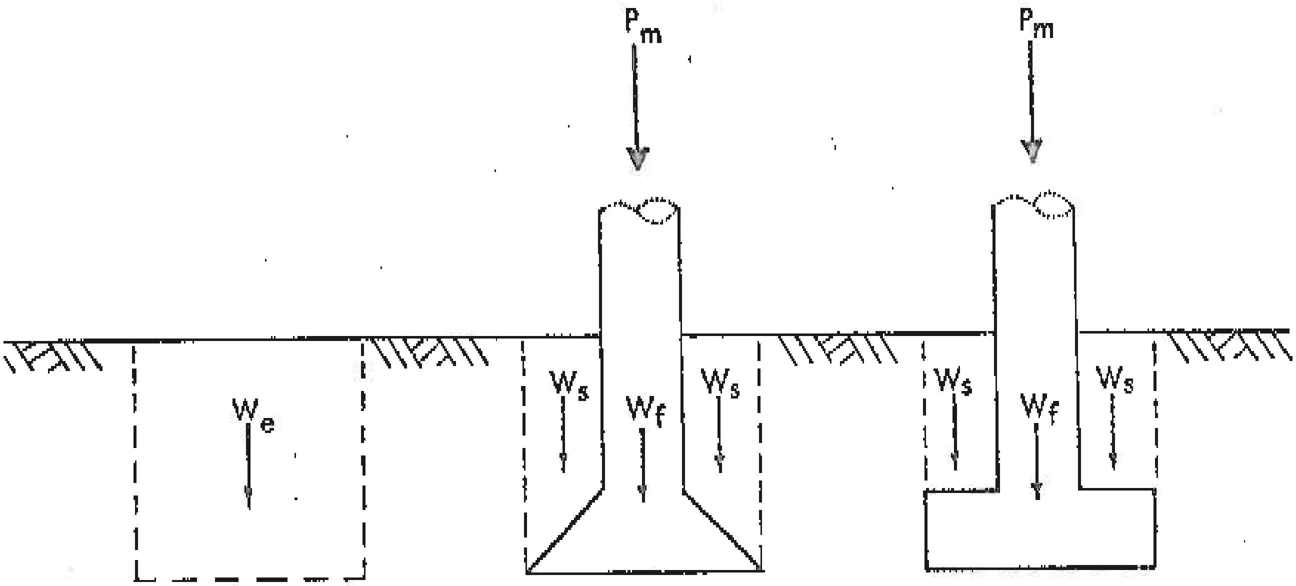
SECTION A - A'



Note: B-3 orthogonally projected onto Section A - A'

GENERALIZED SOIL PROFILE

COMPUTATION OF BEARING PRESSURES



Gross Bearing Pressure, p, for any column load is the total effective pressure acting on the base of the foundation.

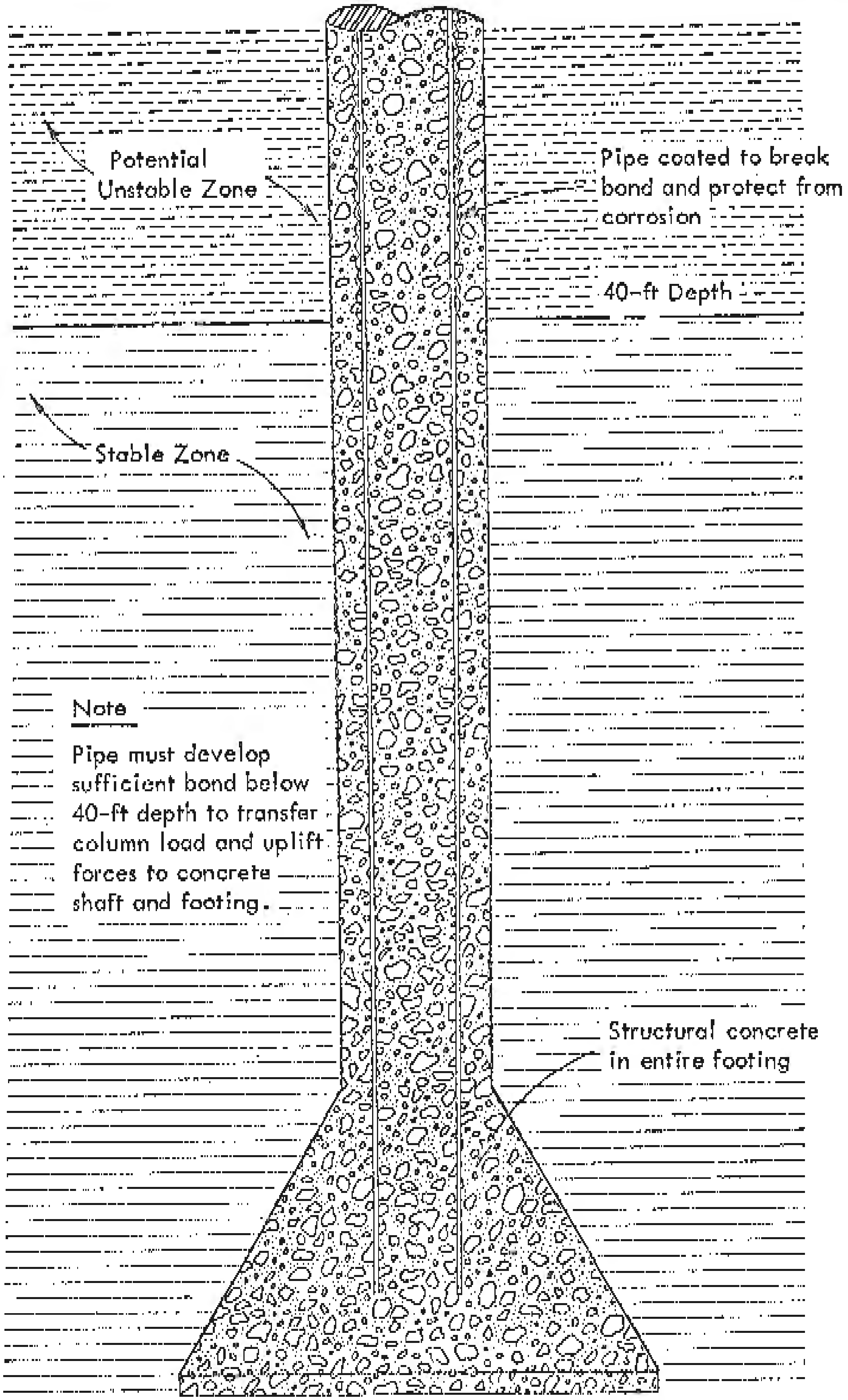
$$p = \frac{1}{A}(P_m + W_s + W_f)$$

Net Bearing Pressure, p', for any column load is the difference between the gross bearing pressure acting on the base of the foundation and the soil pressure existing at that elevation prior to excavation.

$$p' = \frac{1}{A}(P_m + W_s + W_f - W_e)$$

Where: A = Area of base of foundation
P_m = Maximum design column load
W_s = Weight of soil located above the foundation *
W_f = Weight of foundation
W_e = Weight of soil located above base of foundation prior to excavation *

* Position of water table must be considered in determining unit weights. Effective, or buoyant unit weights should be used below the highest expected water table.

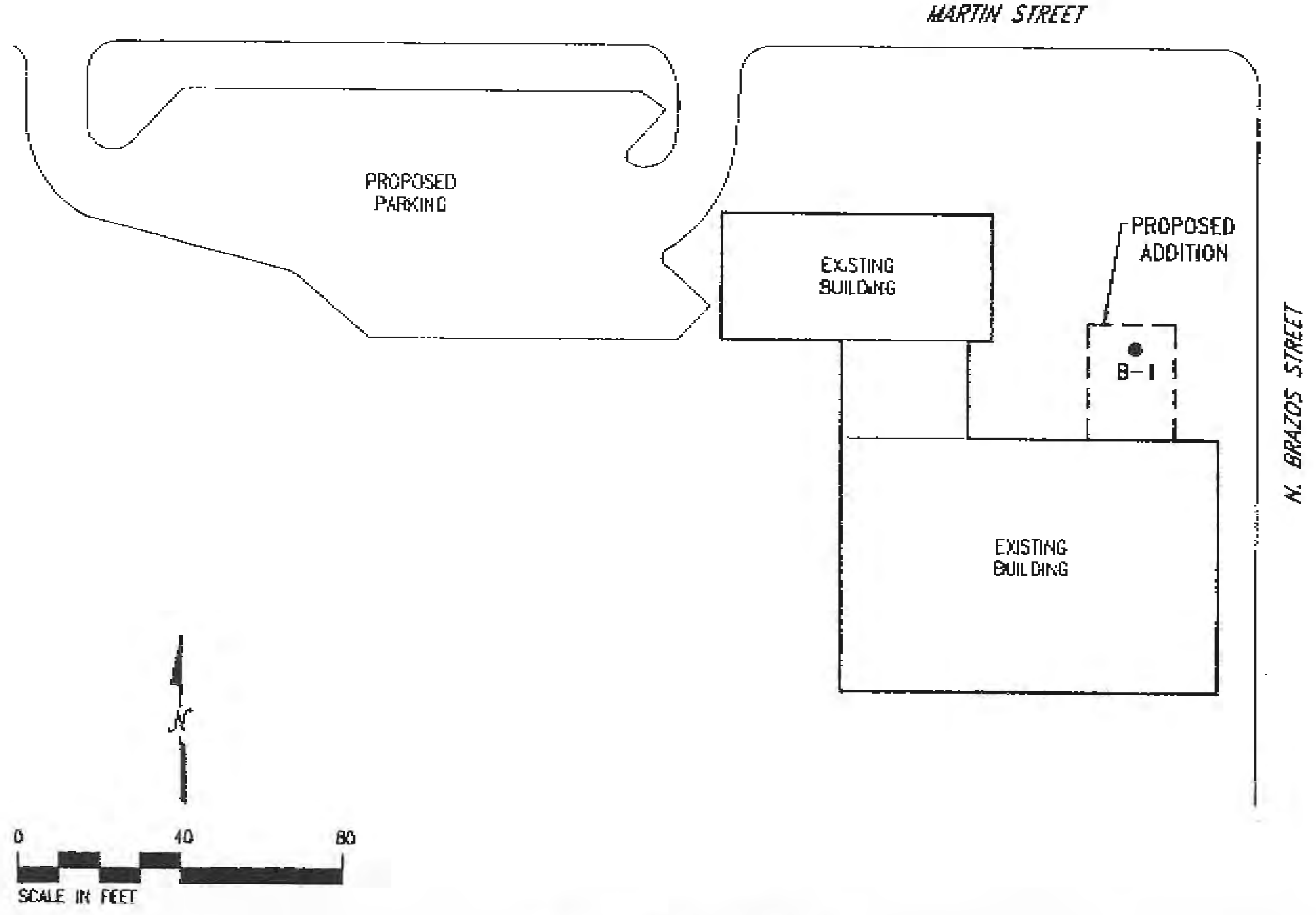


PIER DESIGN CRITERIA

RABA AND TOLSON CONSULTING ENGINEERS, INC.

PLATE 14

REPORT 4



BORING LOCATION MAP
TOBIN RECREATION CENTER
SAN ANTONIO, TEXAS

Raba-Kistner Consultants, Inc.

PROJECT No. ASA97-014-00

LOG OF BORING NO. B-1

Tobin Community Center
San Antonio, Texas

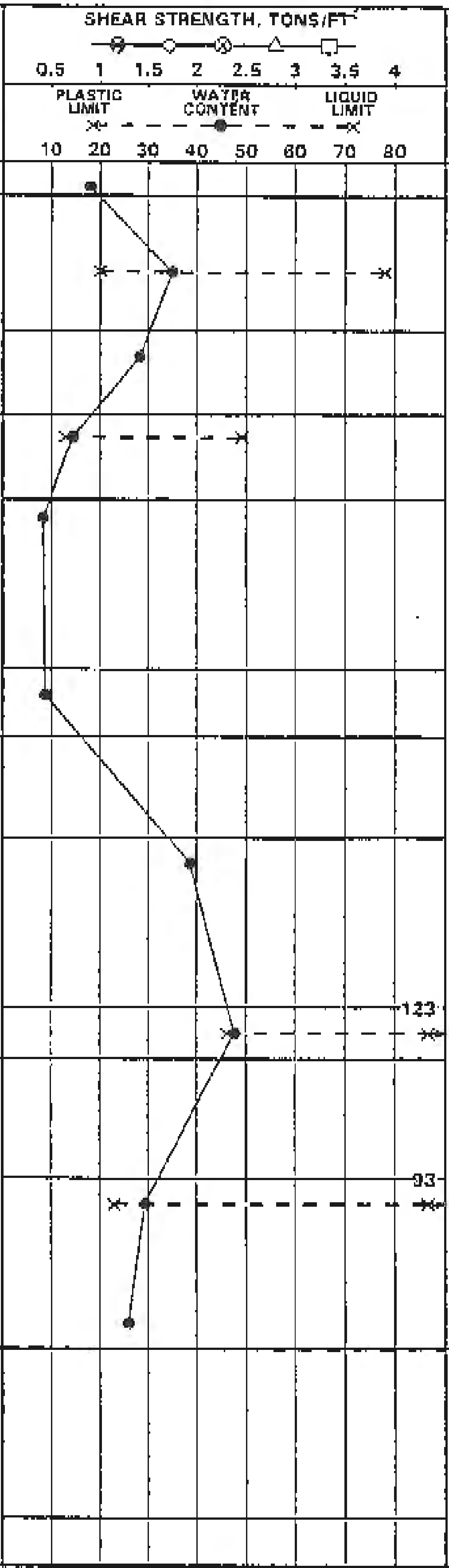
Raba-Kistner

DRILLING METHOD: Straight Flight Auger

LOCATION: See Plate 1

SURFACE ELEVATION:

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	% -200
0	FILL: CLAY, Dark Brown and Tannish-Gray, with gravel	9		
	CLAY, Stiff, Dark Brown, with a trace of very small gravel	8		
5		11		
	GRAVEL, Very Dense, Brown, Chert - clayey, with caliche pockets to 8.5 ft	50/10		
10		50/7"		15
15		50/12		
	CLAY, Bentonitic, Hard, Light Yellowish-Tan, with ferric stains, blocky, soapy			
20		32		
25	- pure bentonite at 25 ft	33		
	CLAY, Hard to Very Stiff, Tan and Gray, with occasional gypsum veins			
30		35		
		29		
35				
40				

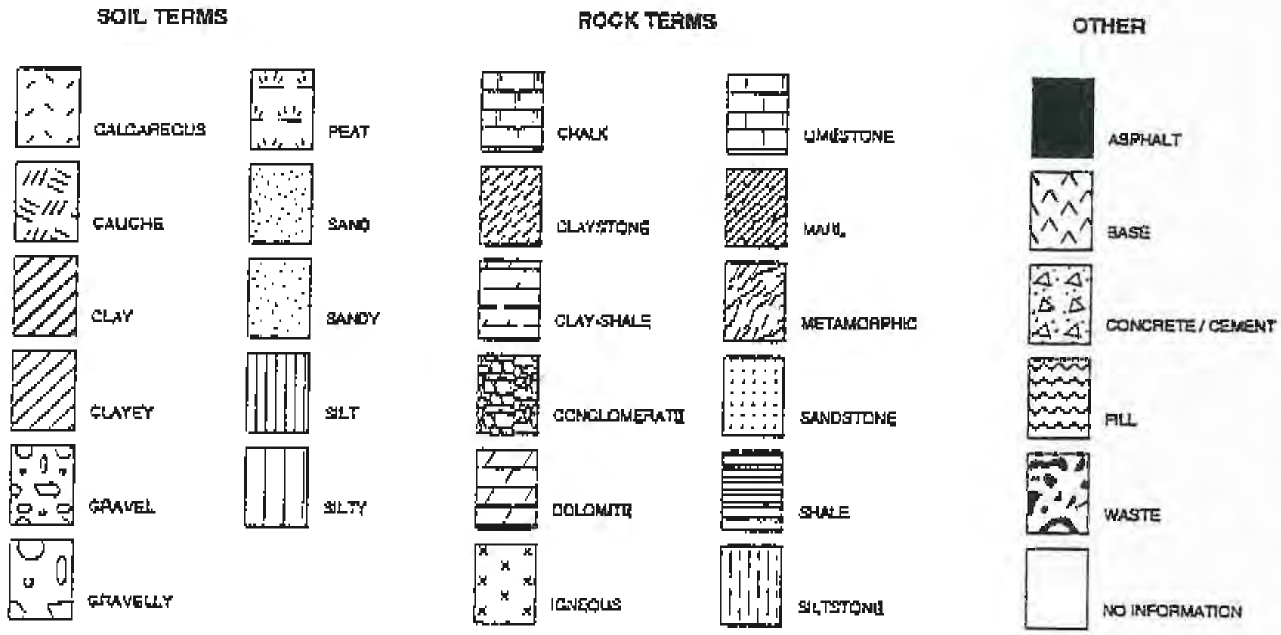


NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT.

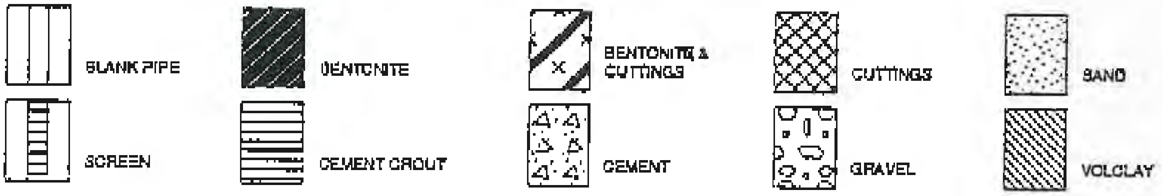
DEPTH DRILLED: 35'
DATE DRILLED: 02/20/97
DEPTH TO WATER: Dry
DATE MEASURED: 02/20/97
PROJ. NO. ASA97-014-00
PLATE 2

KEY TO TERMS AND SYMBOLS

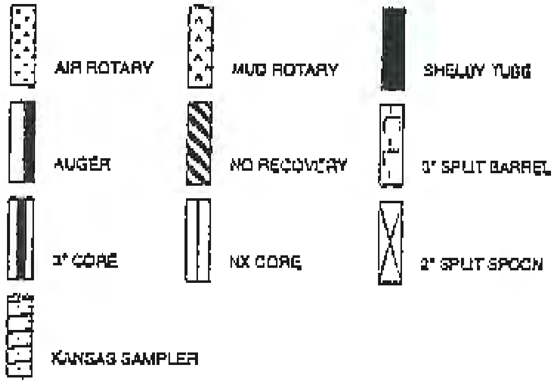
MATERIAL TYPES



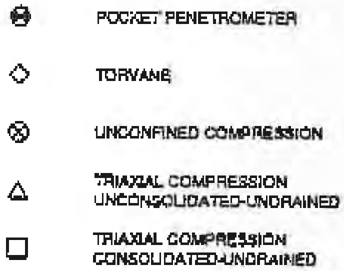
WELL CONSTRUCTION AND PLUGGING MATERIALS



SAMPLE TYPES



STRENGTH TEST RESULTS



NOTE: VALUES SYMBOLIZED ON BORING LOGS REPRESENT SHEAR STRENGTHS UNLESS OTHERWISE NOTED

KEY TO TERMS & SYMBOLS (CONT'D)

TERMINOLOGY

Terms used in this report to describe soil with regard to their consistency or conditions are in general accordance with the discussion presented in Article 45 of SOILS MECHANICS IN ENGINEERING PRACTICE, Terzaghi and Peck, John Wiley & Sons, Inc., 1967, using the most reliable information available from the field and laboratory investigations. Terms used for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in American Society for Testing and Materials D487-85 and D2488-84, Volume 04.08, Soil and Rock; Dimension Stone; Geosynthetics; 1990.

RELATIVE DENSITY

Penetration Resistance Blows per ft	Relative Density
0-4	Very Loose
4-10	Loose
10-30	Medium Dense
30-50	Dense
>50	Very Dense

COHESIVE STRENGTH

Resistance Blows per ft	Consistency	Cohesion TSF
0-2	Very Soft	0-0.125
2-4	Soft	0.125-0.25
4-8	Firm	0.25-0.5
8-15	Stiff	0.5-1.0
15-30	Very Stiff	1.0-2.0
>30	Hard	>2.0

PLASTICITY

Plasticity Index	Degree of Plasticity
0-5	None
5-10	Low
10-20	Moderate
20-40	Plastic
>40	Highly Plastic

ABBREVIATIONS

B = Benzene
T = Toluene
E = Ethylbenzene
X = Total Xylenes
BTEX = Total BTEX
TPH = Total Petroleum Hydrocarbons
ND = Not Detected
NA = Not Analyzed
OVA = Organic Vapor Analyzer
ppm = Parts Per Million

Qam, Qas, Qal = Quaternary Alluvium
Qat = Low Terrace Deposits
Qbc = Beaumont Formation
Qt = Fluviatile Terrace
Qao = Seymour Formation
Qle = Leona Formation
Q-Tu = Uvalde Gravel
Ewi = Wilcox Formation
Emi = Midway Group
Kknm = Navarro Group and Marlbrook Marl
Kpg = Pecan Gap Chalk
Kau = Austin Chalk

Kef = Eagle Ford Shale
Kbu = Buda Limestone
Kdr = Del Rio Clay
Kft = Fort Terrett Member
Kgt = Georgetown Formation
Kep = Person Formation
Kek = Kainer Formation
Kes = Escondido Formation
Kw = Walnut Formation
Kgr = Glen Rose Formation
Kgru = Upper Glen Rose Formation
Kgrl = Lower Glen Rose Formation
Kh = Hensell Sand

RESULTS OF SOIL SAMPLE ANALYSES

PROJECT NAME: Tobin Community Center
San Antonio, Texas

FILE NAME: 9701400

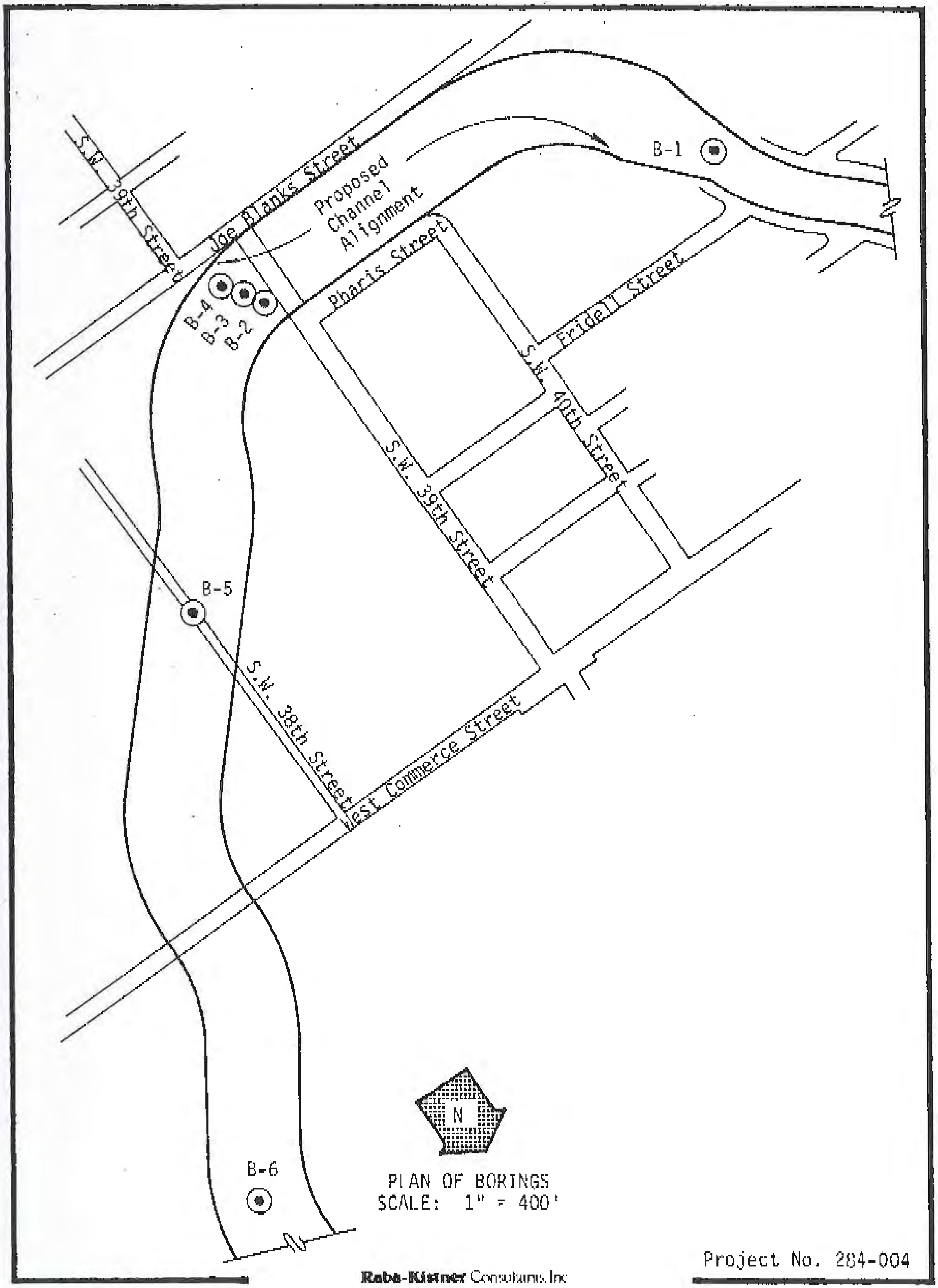
3/14/1997

Boring No.	Sample Depth (ft)	Blows per ft	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS	%-200 Sieve	Shear Strength (tsf)	Strength Test
B-1										
	0.00 to 1.50	9	17.9							
	2.50 to 4.00	8	34.8	78	20	58	CH			
	5.00 to 6.50	11	28.3							
	7.50 to 8.83	50/10	14.4	49	13	36	GC			
	10.00 to 11.08	50/7"	8.3					15		
	15.00 to 16.50	50/12	8.7							
	20.00 to 21.50	32	38.6							
	25.00 to 26.50	33	47.4	123	46	77	CH			
	30.00 to 31.50	35	29.3	93	23	70	CH			
	33.50 to 35.00	29	25.9							

PP=Pocket Penetrometer UC=Unconfined Compression

PROJECT No. ASA97-014-00

REPORT 5



PLAN OF BORINGS
SCALE: 1" = 400'

Raba-Kistner Consultants Inc

Project No. 284-004

PLATE 1

LOG OF BORING NO. B-1

CHANNEL AND BRIDGE IMPROVEMENTS, PROJECT 58E
SAN ANTONIO, TEXAS

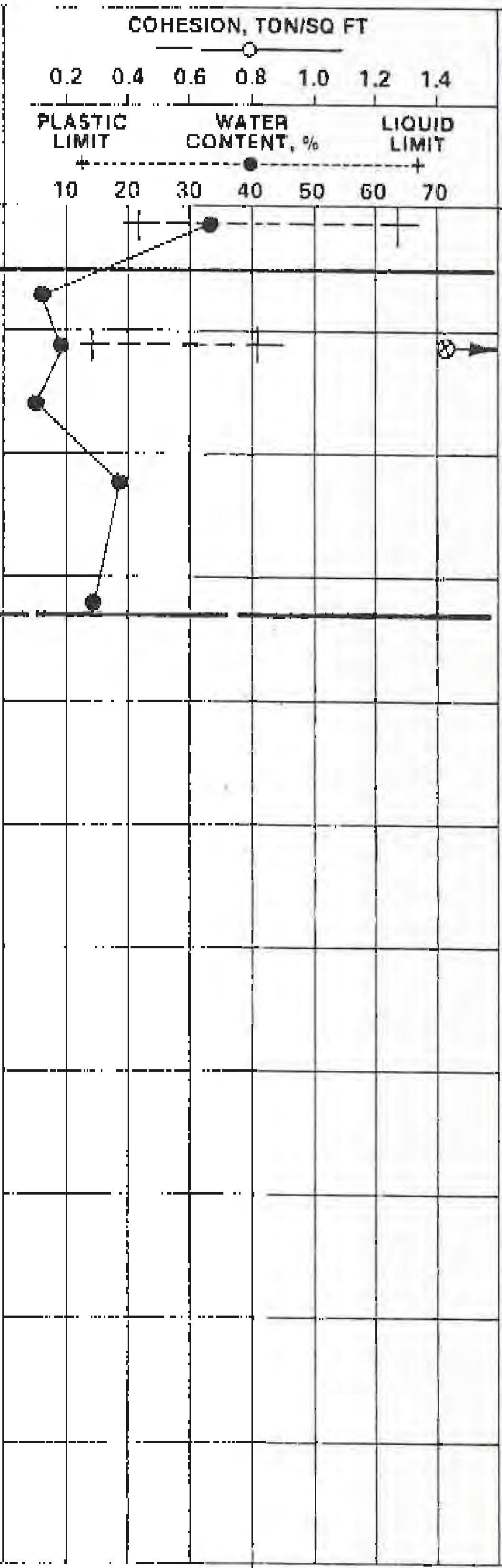
Raba-Kistner
Consultants, Inc.

TYPE: 2" Split Spoon
3" Shelby Tube

LOCATION: See Plate 1

SURF. EL:

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT
	Firm Brown Clay with roots and calcareous nodules	8	
	Very Stiff to Hard Tan Clay with caliche, gravel and some ferrous stains	31	
5			120
		50/4"	
10	- encountered water at 10'		
		30	
15		33	
20			
25			
30			
35			
40			
45			
50			



ELEVATION, FT.

NOTE: These logs should not be used separately from the project report.

COMPLETION DEPTH: 16.5'
DATE: 1-20-84

DEPTH TO WATER IN BORING: 10'
DATE: 1-20-84

PROJ. NO. 284-004
PLATE 2

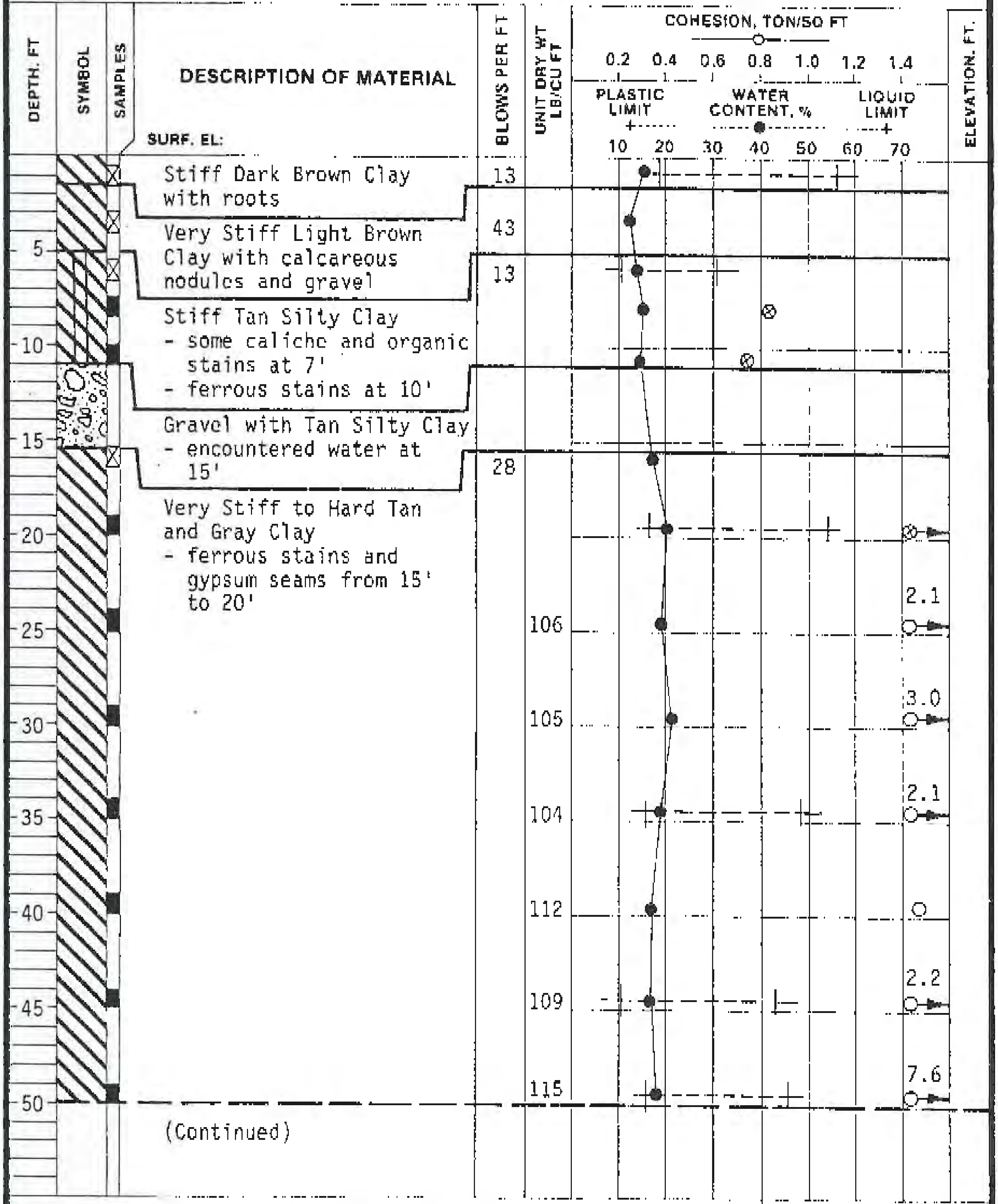
LOG OF BORING NO. B-2

CHANNEL AND BRIDGE IMPROVEMENTS, PROJECT 58E
SAN ANTONIO, TEXAS

Raba-Kistner Consultants, Inc.

TYPE: 2" Split Spoon
3" Shelby Tube
Core Barrel

LOCATION: See Plate 1



Stiff Dark Brown Clay with roots

Very Stiff Light Brown Clay with calcareous nodules and gravel

Stiff Tan Silty Clay
- some caliche and organic stains at 7'
- ferrous stains at 10'

Gravel with Tan Silty Clay
- encountered water at 15'

Very Stiff to Hard Tan and Gray Clay
- ferrous stains and gypsum seams from 15' to 20'

(Continued)

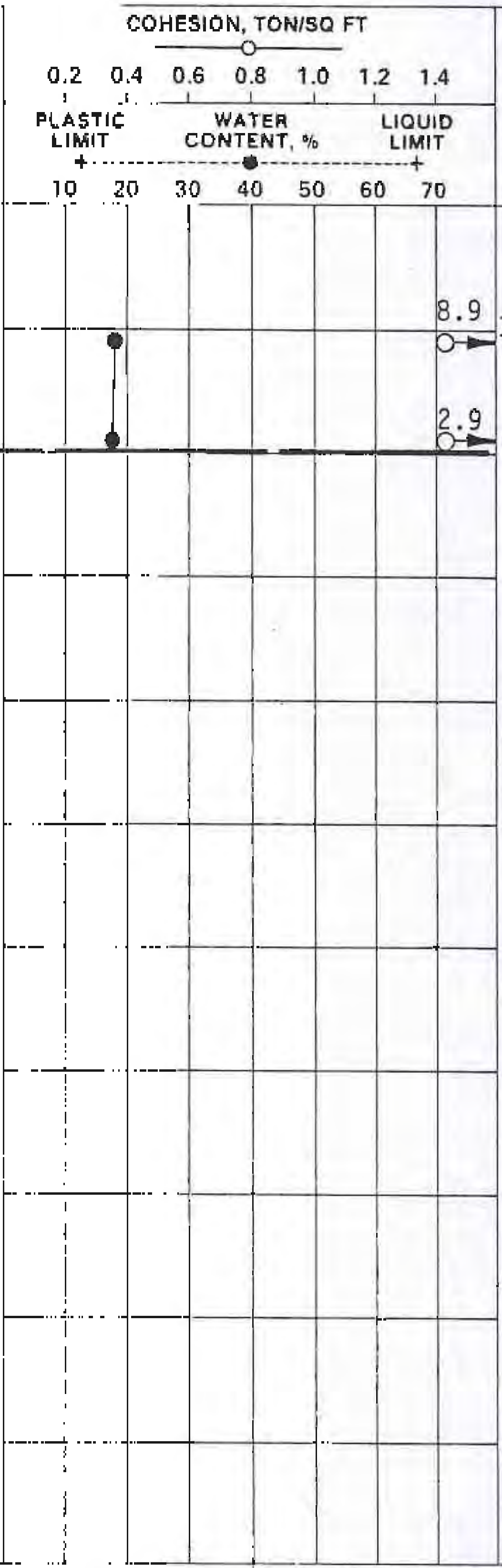
PROJ. NO. 784-004
PLATE 3

NOTE: These logs should not be used separately from the project report.

LOG OF BORING NO. B-2 (Continued)

Raba-Kistner
Consultants, Inc.

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	% Recovery
			SURF. EL:			
			Hard Blue Clay Shale			
55			- lost circulation at 56'		115	100
60					118	
65						
70						
75						
80						
85						
90						
95						
100						



COMPLETION DEPTH. 60'
DATE. 1-19-84

DEPTH TO WATER IN BORING. 8.2'

DATE 1-19-84

PROJ. NO. 284-004
PLATE 4

NOTE: These logs should not be used separately from the project report.

LOG OF BORING NO. B-3

CHANNEL AND BRIDGE IMPROVEMENTS, PROJECT 58E
SAN ANTONIO, TEXAS

Raba-Kistner
Consultants, Inc.

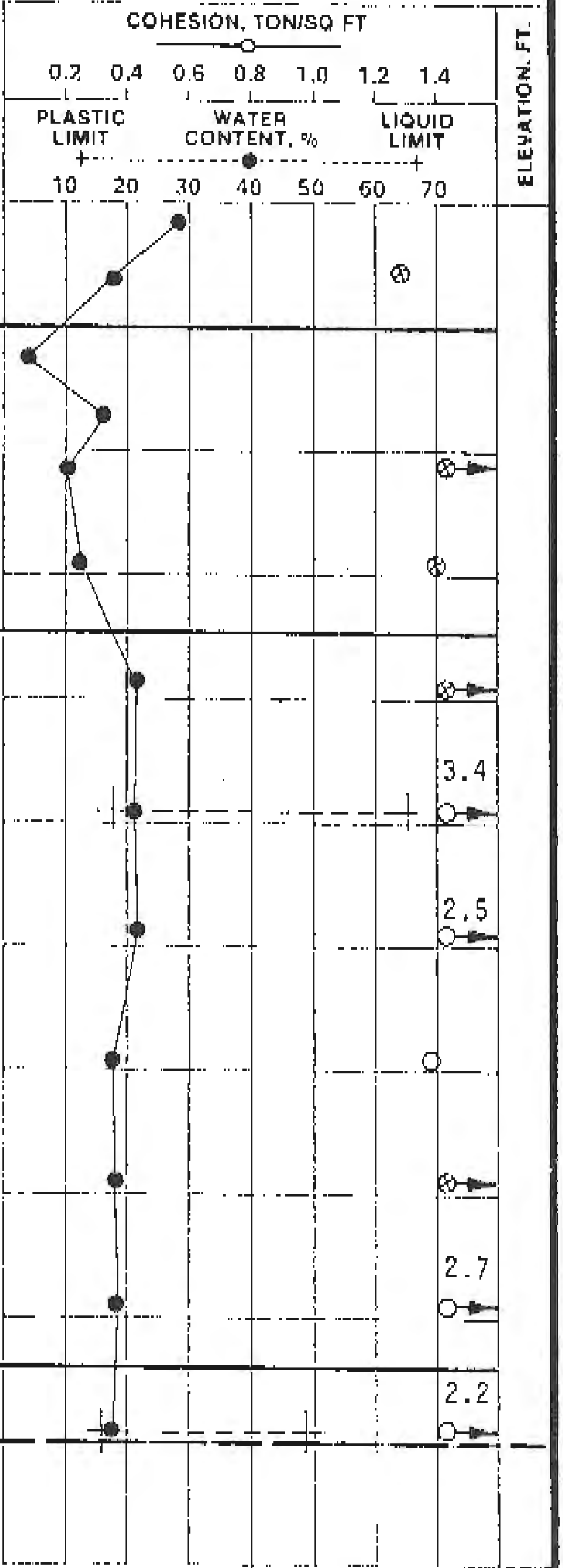
TYPE: Core Barrel
3" Shelby Tube
2" Split Spoon

LOCATION: See Plate 1

SURF. EL:

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT.	UNIT DRY WT LB/CU FT
	Firm to Very Stiff Dark Brown Clay with roots - calcareous nodules and gravel at 2.5'	6	
5	Very Stiff to Hard Tan Silty Clay with calcareous nodules, ferrous stains and organic stains - gravel from 5' to 10'	50/6" 37	
15	- silty sand at 15'		
20	Very Stiff to Hard Tan and Gray Clay with ferrous stains		
25			108
30			103
35			113
40			104
45	Very Stiff to Hard Gray Clay - some tan clay and gypsum at 49'		111
50			106

(Continued)

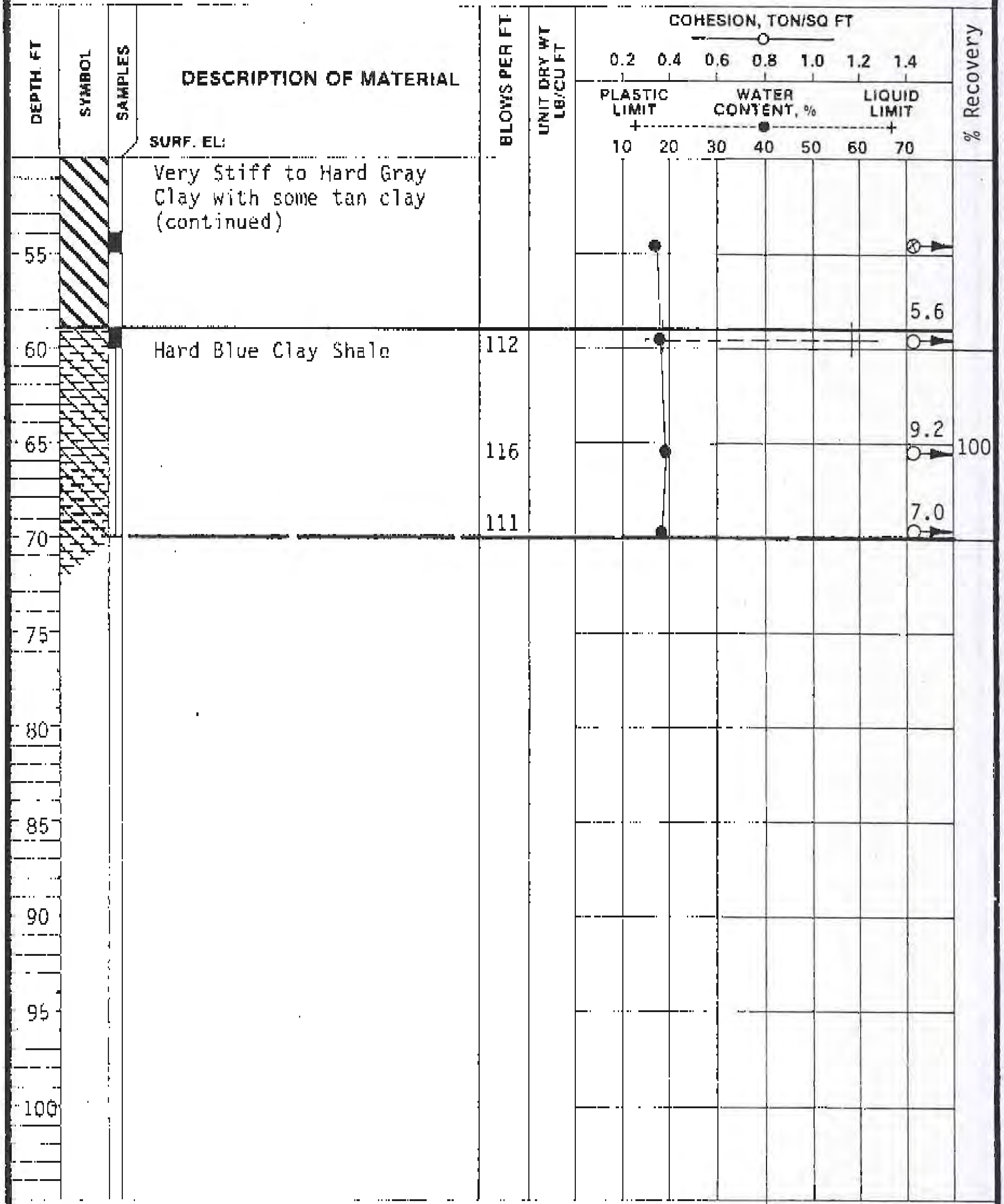


NOTE: These logs should not be used separately from the project report.

PROJ. NO. 284-004
PLATE 5

LOG OF BORING NO. B-3 (Continued)

Raba-Kistner
Consultants, Inc.



Very Stiff to Hard Gray Clay with some tan clay (continued)

Hard Blue Clay Shale

COMPLETION DEPTH: 70'
DATE: 1-20-84

DEPTH TO WATER IN BORING: 15'

DATE 1-20-84

PROJ. NO. 284-004
PLATE 6

NOTE: These logs should not be used separately from the project report.

LOG OF BORING NO. B-4

CHANNEL AND BRIDGE IMPROVEMENTS, PROJECT 58E
SAN ANTONIO, TEXAS

Raba-Kistner
Consultants, Inc.

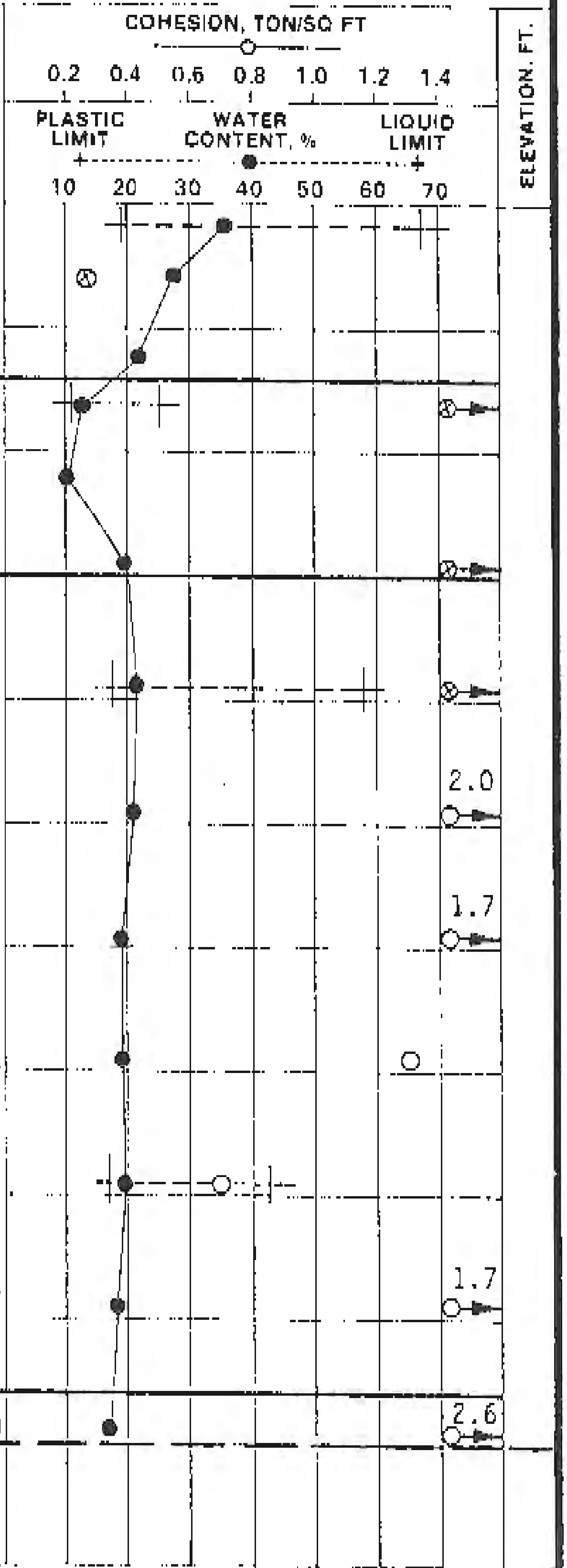
TYPE: Core Barrel
2" Split Spoon
3" Shelby Tube

LOCATION: See Plate 1

SURF. EL:

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT
	Firm to Very Stiff Dark Brown Clay with calcareous nodules	5	
5		22	
	Very Stiff to Hard Tan Silty Clay with ferrous stains and organic deposits - gravel from 9' to 12.5'		
10		50/6"	
15	Very Stiff to Hard Tan and Gray Clay with ferrous stains and organic stains		
20			
25			103
30			108
35			108
40			105
45			107
	Hard Blue Clay Shale		
50			110

(Continued)



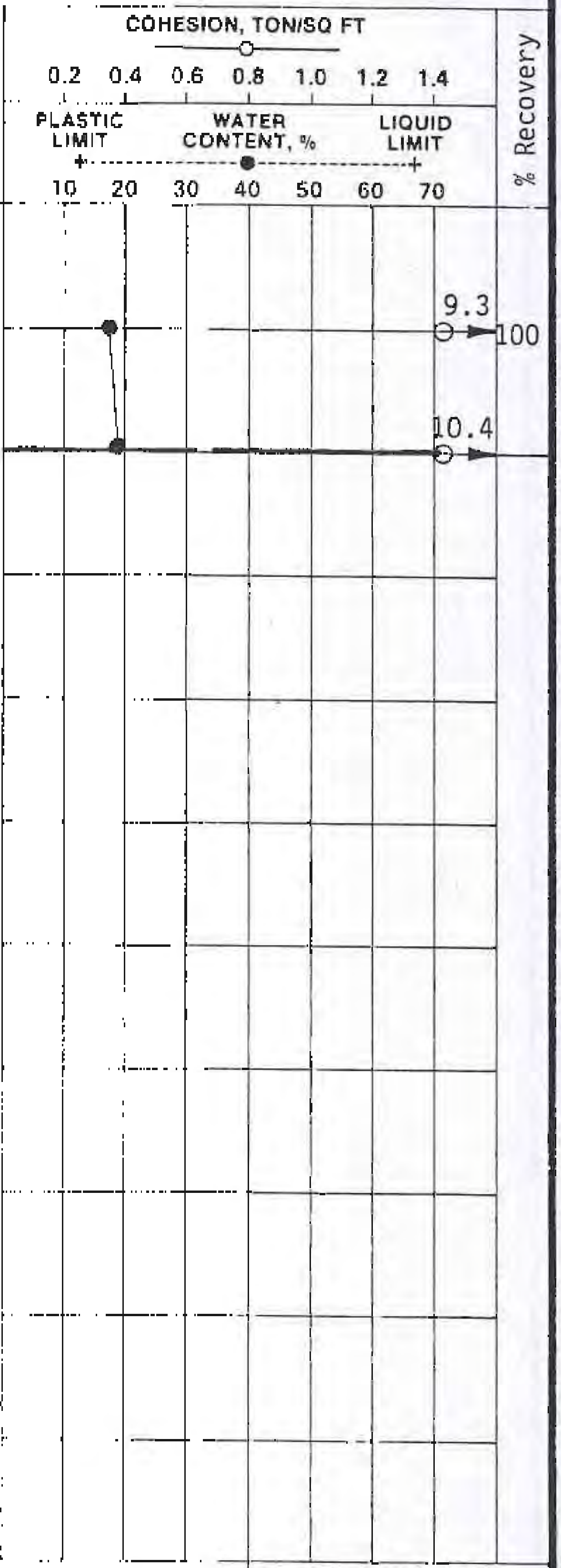
NOTE: These logs should not be used separately from the project report.

PROJ. NO. 284-004
PLATE 7

LOG OF BORING NO. B-4 (Continued)

Raba-Kistner
Consultants, Inc.

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT
			SURF. EL:		
	▨		Hard Blue Clay Shale (continued)		
55	▨				118
60	▨				114
65					
70					
75					
80					
85					
90					
95					
100					



COMPLETION DEPTH: 60'
DATE: 1-20-84

DEPTH TO WATER IN BORING 15'
DATE: 1-20-84

PROJ. NO. 284-004
PLATE 8

NOTE: These logs should not be used separately from the project report.

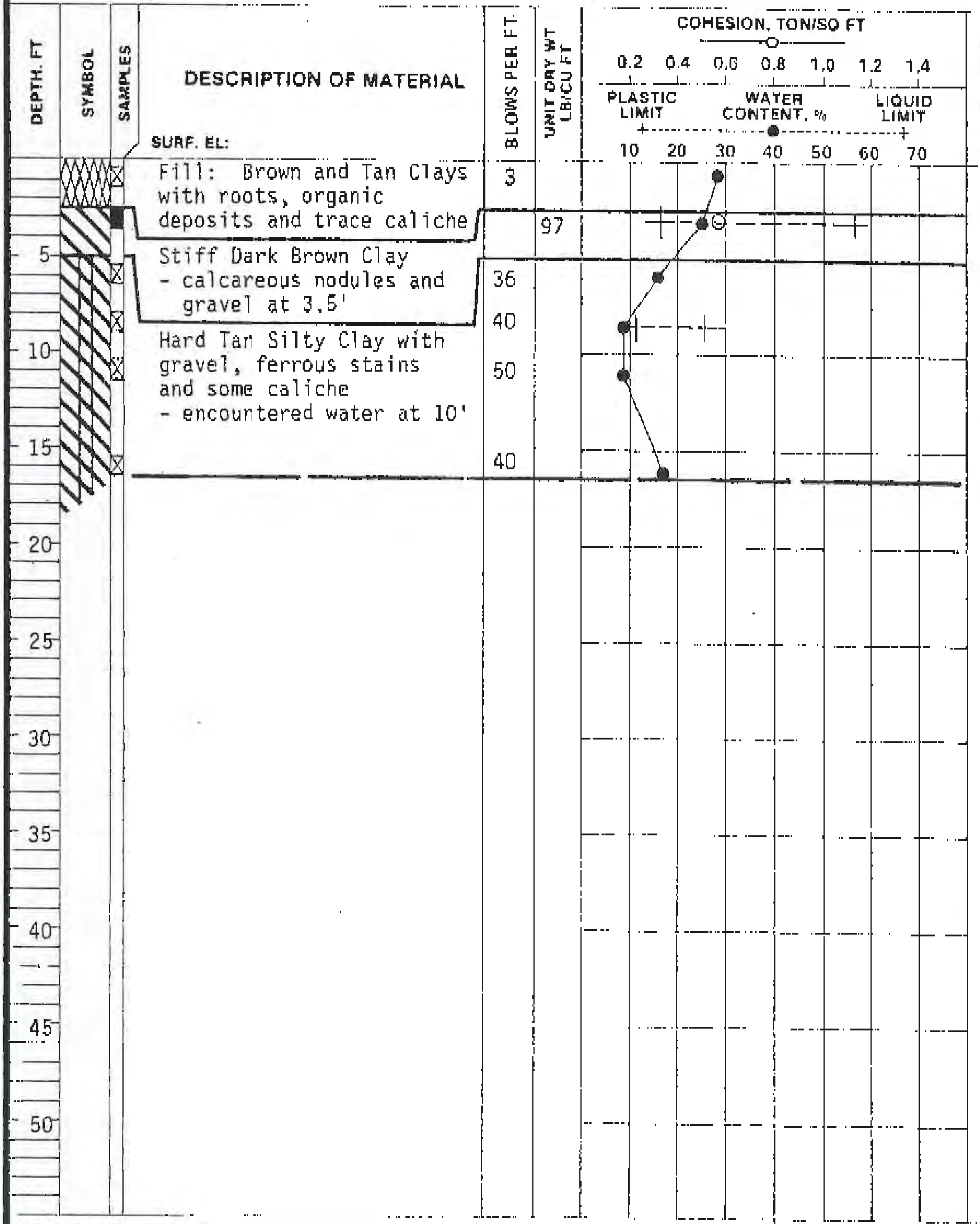
LOG OF BORING NO. B-5

CHANNEL AND BRIDGE IMPROVEMENTS, PROJECT 58E
SAN ANTONIO, TEXAS

Raba-Kistner
Consultants, Inc.

TYPE: 2" Split Spoon
3" Shelby Tube

LOCATION: See Plate 1



DESCRIPTION OF MATERIAL	BLOWS PER FT.	UNIT DRY WT LB/CU FT
Fill: Brown and Tan Clays with roots, organic deposits and trace caliche	3	97
Stiff Dark Brown Clay - calcareous nodules and gravel at 3.5'	36	
Hard Tan Silty Clay with gravel, ferrous stains and some caliche - encountered water at 10'	40 50 40	

COMPLETION DEPTH: 16.5'
DATE: 1-20-84

DEPTH TO WATER IN BORING: None Observed
DATE: 1-20-84

PROJ. NO. 284-004
PLATE 9

NOTE: These logs should not be used separately from the project report.

LOG OF BORING NO. B-6

CHANNEL AND BRIDGE IMPROVEMENTS, PROJECT 58E
SAN ANTONIO, TEXAS

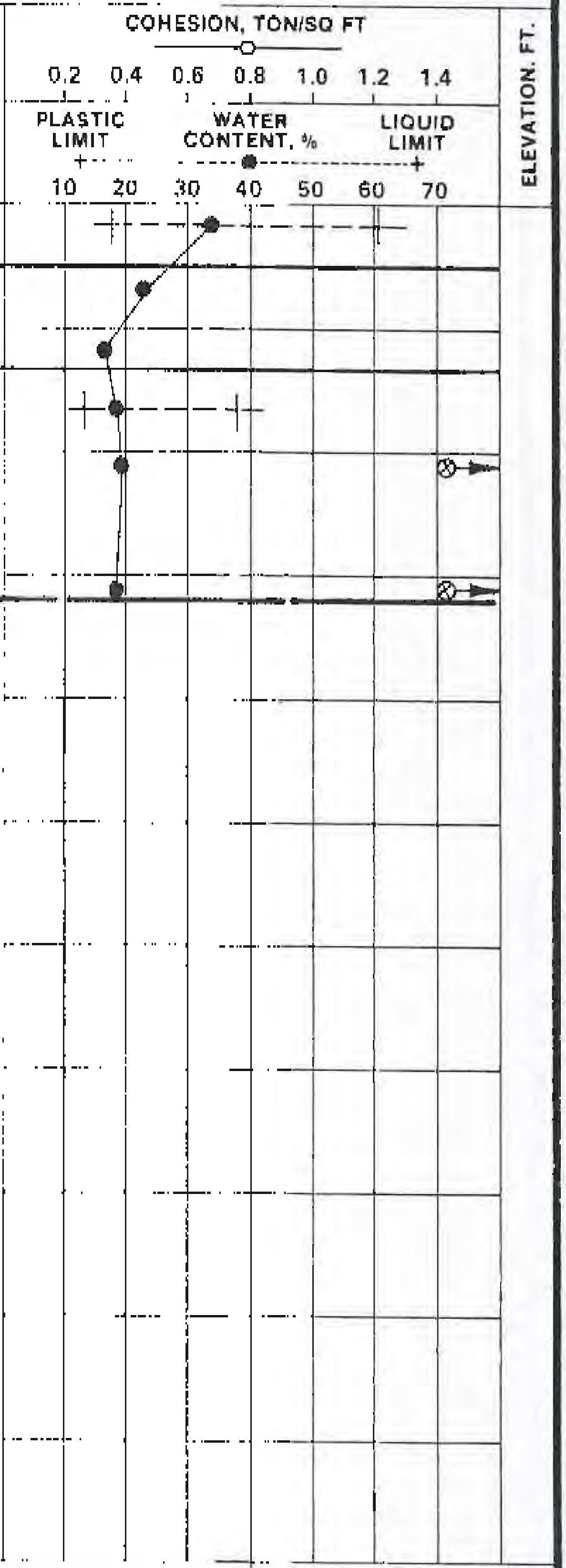
Raba-Kistner
Consultants, Inc.

TYPE: 2" Split Spoon
3" Shelby Tube

LOCATION: See Plate 1

SURF. EL:

DESCRIPTION OF MATERIAL	BLOWS PER FT.	UNIT DRY WT LB/CU FT
Soft Dark Brown Clay with calcareous nodules and organic deposits	4 19	
Very Stiff Tan Silty Clay with calcareous nodules and gravel - encountered water at 2.5'	14 18	
Very Stiff Tan and Gray Clay with ferrous stains and trace caliche		



DEPTH, FT: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50

COMPLETION DEPTH: 16'
DATE 1-20-84

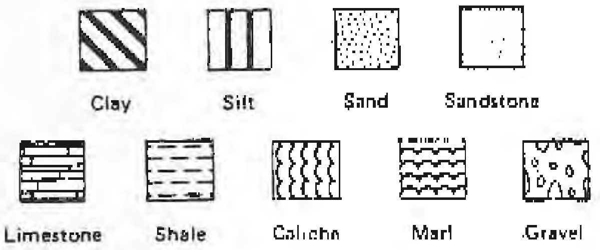
DEPTH TO WATER IN BORING: None Observed DATE 1-20-84

PROJ. NO. 284-004
PLATE 10

NOTE: These logs should not be used separately from the project report.

SYMBOLS AND TERMS USED ON BORING LOGS

SOIL OR ROCK TYPES
(shown in symbols column)



(Predominate Soil Types Shown Heavy)

SAMPLER TYPES
(shown in sample column)

STRENGTH TEST RESULTS

⊕ - Estimated Strength
◇ - Torvane
○ - Unconfined Compression

TRIAXIAL COMPRESSION

△ - Unconsolidated-undrained
□ - Consolidated-undrained

C - Cohesion (Total)
Φ - Angle of Internal Friction (Total)

C' - Cohesion (Effective)
Φ' - Angle of Internal Friction (Effective)

NOTE:

Values symbolized on boring logs represent shear strengths unless otherwise noted.

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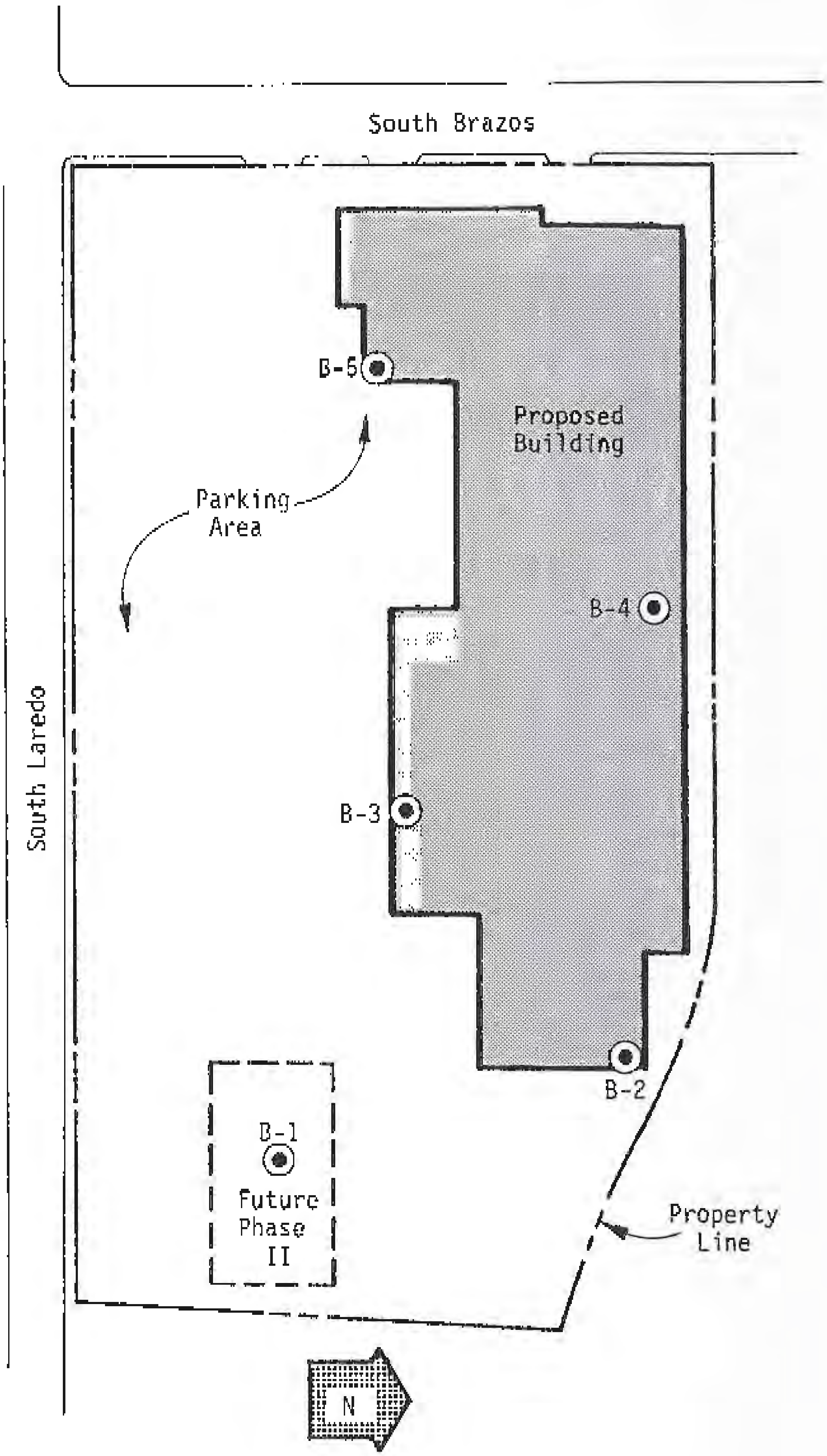
Calcareous	- containing appreciable quantities of calcium carbonate.
Well graded	- having wide range in grain sizes and substantial amounts of all intermediate particle sizes.
Poorly graded	- predominantly of one grain size, or having a range of sizes with some intermediate size missing.

TERMS DESCRIBING CONSISTENCY OR CONDITION

RELATIVE DENSITY		COHESIVE STRENGTH			PLASTICITY	
Penetration Resistance, blows per foot	Relative Density	Penetration Resistance, blows per foot	Consistency	Cohesion, TSF	Plasticity Index	Degree of Plasticity
0-4	Very Loose	0-2	Very Soft	0-0.125	0-5	None
4-10	Loose	2-4	Soft	0.125-0.25	5-10	Low
10-30	Medium Dense	4-8	Firm	0.25-0.5	10-20	Moderate
30-50	Dense	8-15	Stiff	0.5-1.0	20-40	Plastic
> 50	Very Dense	15-30	Very Stiff	1.0-2.0	> 40	Highly Plastic
		> 30	Hard	> 2.0		

NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above because of planes of weakness or cracks in the soil. The consistency ratings of such soils are based on penetrometer readings.

REPORT 6



PLAN OF BORINGS
SCALE: 1" = 115'

Raba-Kistner Consultants, Inc

Project No. 285-065

PLATE 1

LOG OF BORING NO. B-1
CONSOLIDATED PRODUCE WAREHOUSE
SAN ANTONIO, TEXAS

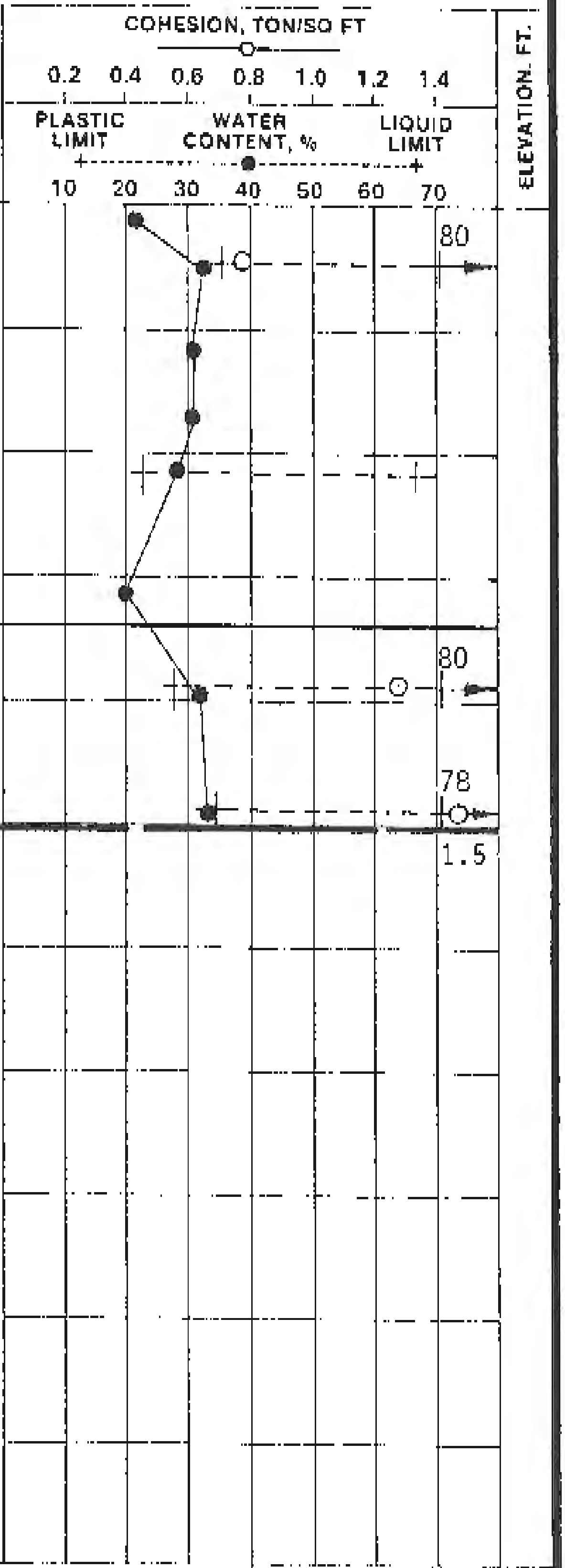
Raba-Kistner
Consultants, Inc.

TYPE: 2" Split Spoon
3" Shelby Tube

LOCATION: See Plate 1

SURF. EL:

DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT
FILL: Brown Clay, Tan and Gray Clay and Gravel with fetid odor	12	
		84
	40	
	12	
- groundwater seepage at 11' - wire at 11.5'	29	
	12	
CLAY, Very Stiff, Tan and Gray with bentonitic clay seams and layers		87
		82



COMPLETION DEPTH: 25'
DATE: 3-22-85

DEPTH TO WATER IN BORING: 11.5'
DATE: 3-22-85

PROJ. NO. 285-065
PLATE 2

NOTE: These logs should not be used separately from the project report.

LOG OF BORING NO. B-2
CONSOLIDATED PRODUCE WAREHOUSE
SAN ANTONIO, TEXAS

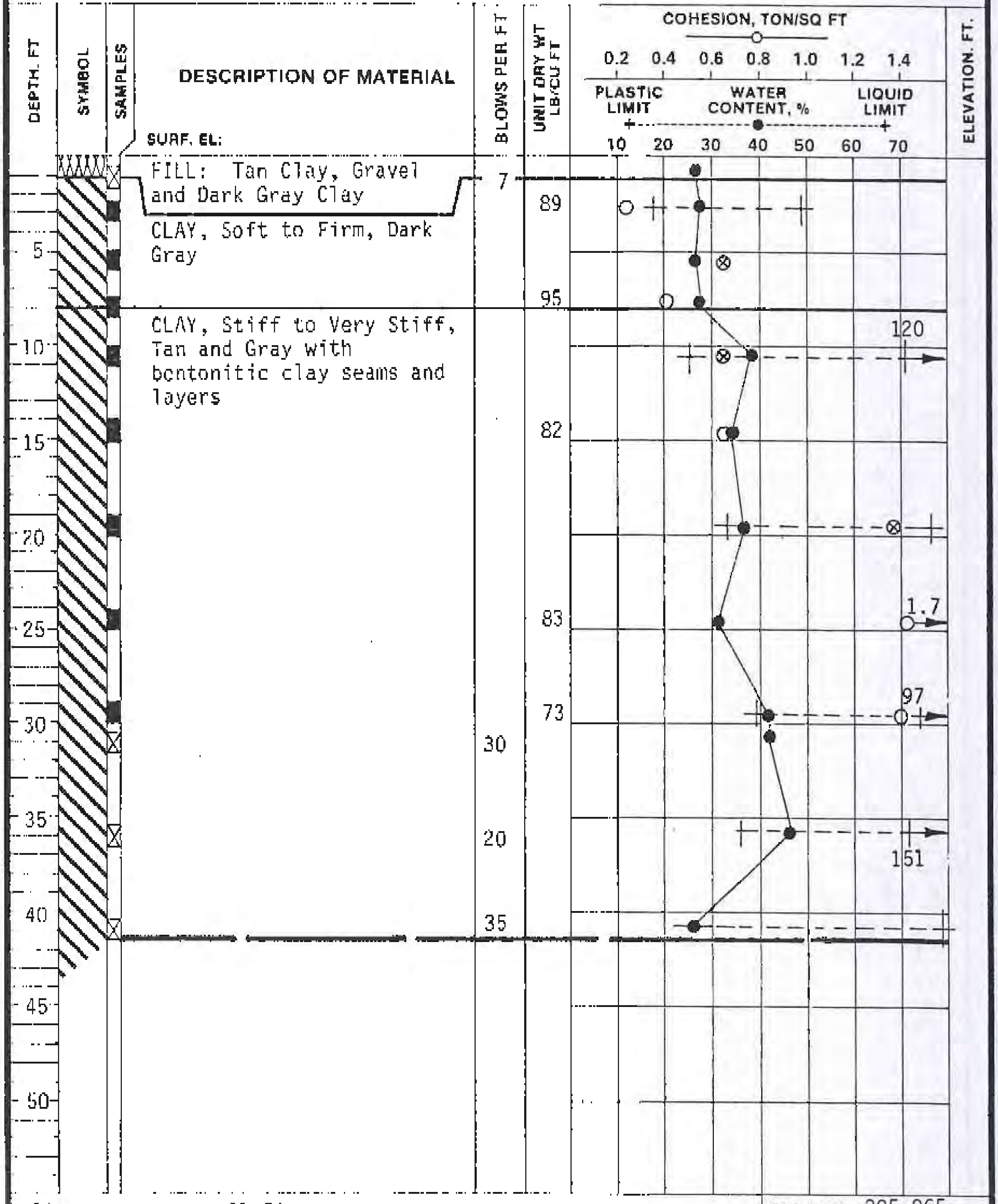
Raba-Kistner
Consultants, Inc.

TYPE: 2" Split Spoon
3" Shelby Tube

LOCATION: See Plate 1

SURF. EL:

DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT
FILL: Tan Clay, Gravel and Dark Gray Clay	7	
CLAY, Soft to Firm, Dark Gray		89
		95
CLAY, Stiff to Very Stiff, Tan and Gray with bentonitic clay seams and layers		
		82
		83
		73
	30	
	20	
	35	



COMPLETION DEPTH: 41.5'
DATE: 3-22-85

DEPTH TO WATER IN BORING: None Observed
DATE: 3-22-85

PROJ. NO. 285-065
PLATE 3

NOTE: These logs should not be used parately from the project report.

LOG OF BORING NO. B-3
CONSOLIDATED PRODUCE WAREHOUSE
SAN ANTONIO, TEXAS

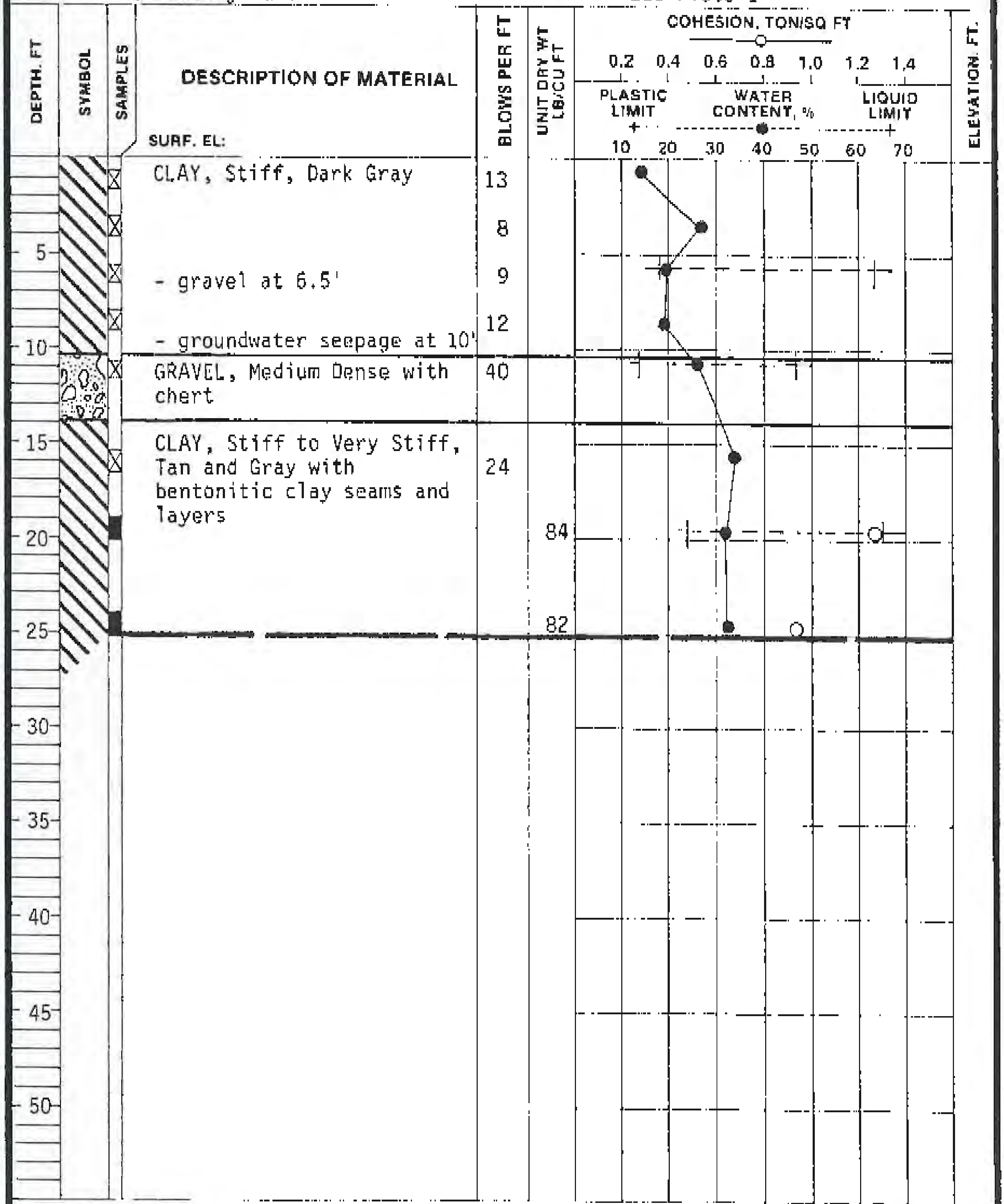
Raba-Kistner
Consultants, Inc.

TYPE: 2" Split Spoon
3" Shelby Tube

LOCATION: See Plate 1

SURF. EL:

DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT
CLAY, Stiff, Dark Gray	13	
	8	
- gravel at 6.5'	9	
	12	
- groundwater seepage at 10'		
GRAVEL, Medium Dense with chert	40	
CLAY, Stiff to Very Stiff, Tan and Gray with bentonitic clay seams and layers	24	
		84
		82



NOTE: These logs should not be used separately from the project report.

COMPLETION DEPTH: 25'
DATE: 3-22-85

DEPTH TO WATER IN BORING: 10'
DATE: 3-22-85

PROJ. NO. 285-065
PLATE 4

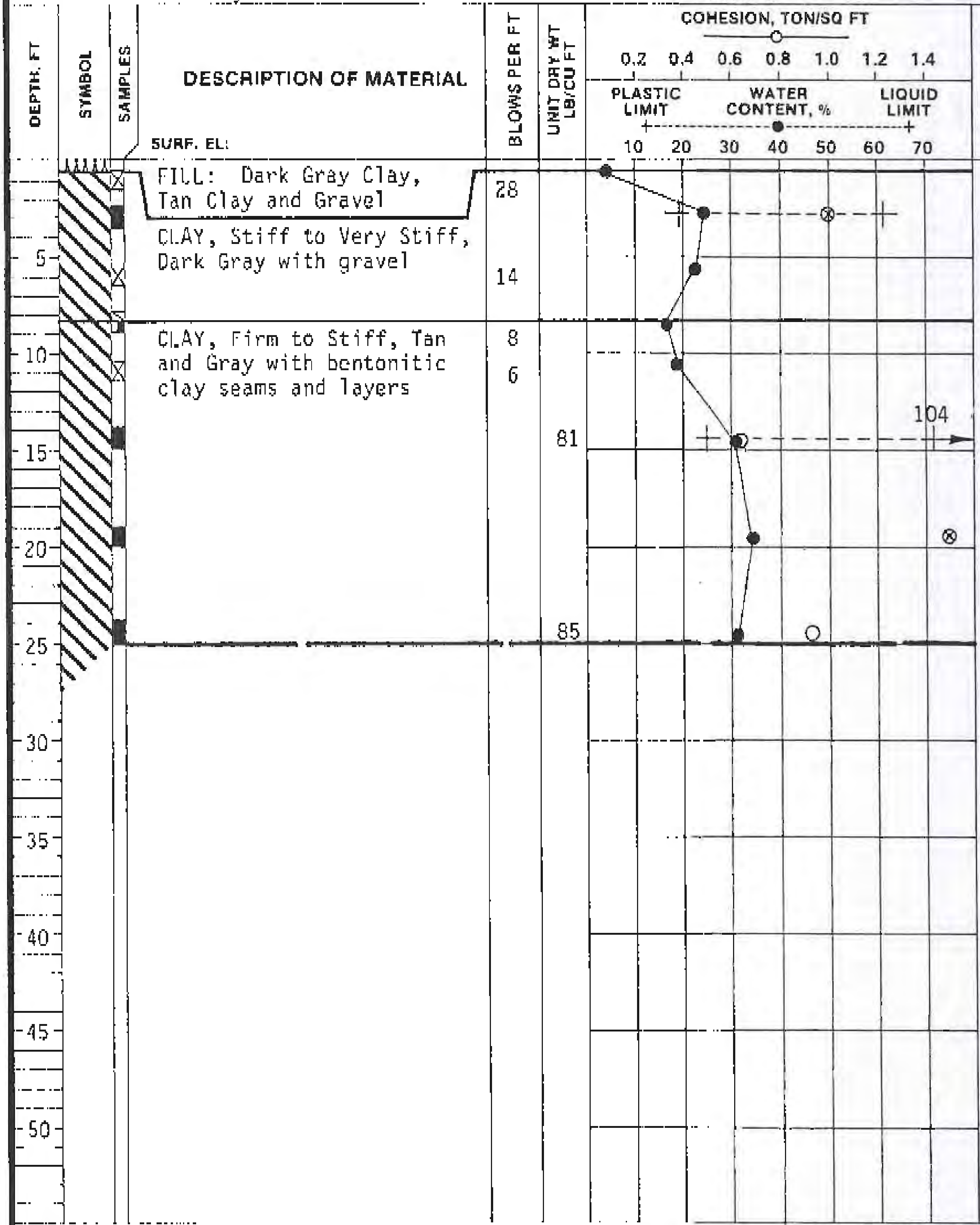
LOG OF BORING NO. B-4

CONSOLIDATED PRODUCE WAREHOUSE
SAN ANTONIO, TEXAS

Raba-Kistner
Consultants, Inc.

TYPE: Auger
2" Split Spoon
3" Shelby Tube

LOCATION: See Plate 1



FILL: Dark Gray Clay, Tan Clay and Gravel — 28

CLAY, Stiff to Very Stiff, Dark Gray with gravel — 14

CLAY, Firm to Stiff, Tan and Gray with bentonitic clay seams and layers — 8, 6

81

85

COMPLETION DEPTH. 25'
DATE. 3-21-85

DEPTH TO WATER IN BORING: None Observed DATE: 3-21-85

PROJ. NO. 285-065
PLATE 5

NOTE: These logs should not be used separately from the project report.

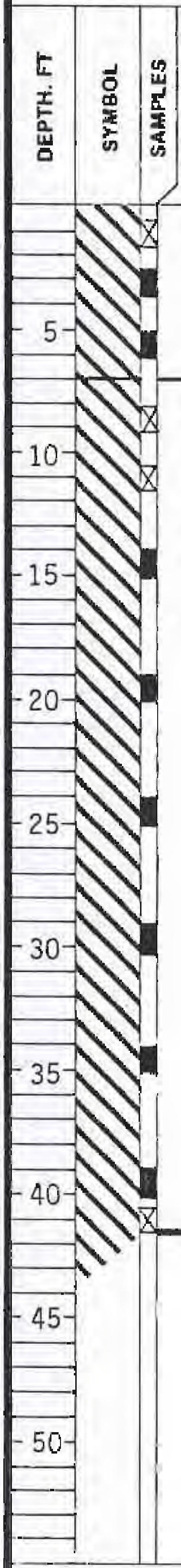
LOG OF BORING NO. B-5
CONSOLIDATED PRODUCE WAREHOUSE
SAN ANTONIO, TEXAS

Raba-Kistner
Consultants, Inc.

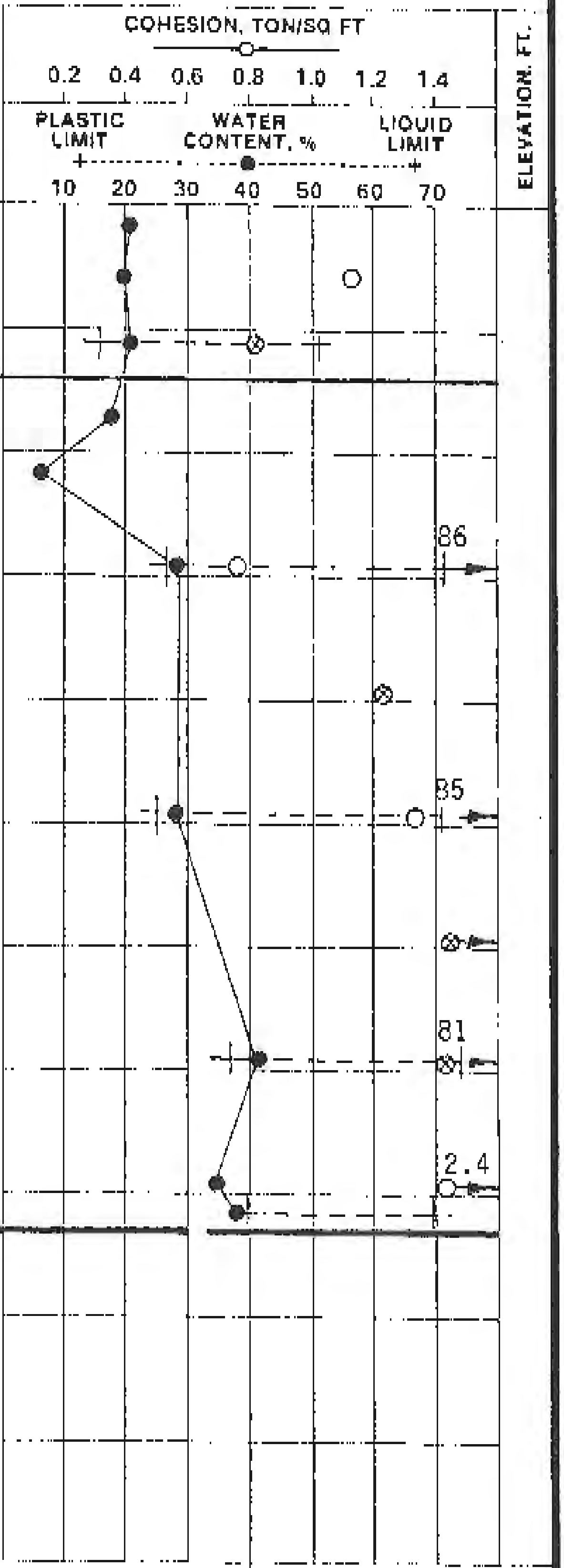
TYPE: 2" Split Spoon
3" Shelby Tube

LOCATION: See Plate I

SURF. EL:



DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT
CLAY, Stiff to Very Stiff, Dark Gray		105
CLAY, Stiff to Very Stiff, Tan and Gray with bentonitic clay seams and layers - gravel from 7' to 7.5' - groundwater seepage at 7.5' - gravel and chert from 9.5' to 13.5'	11 48 37	90 90 78



COMPLETION DEPTH: 41.5'
DATE: 3-21-85

DEPTH TO WATER IN BORING: 7.5'
DATE: 3-21-85

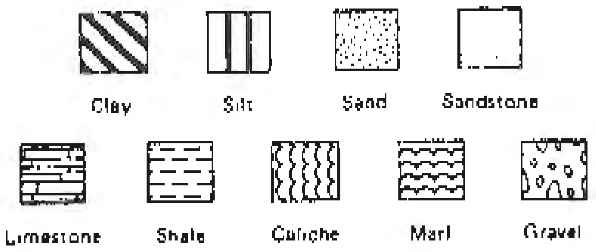
PROJ. NO. 285-065
PLATE 6

NOTE: These logs should not be used separately from the project report.

SYMBOLS AND TERMS USED ON BORING LOGS

SOIL OR ROCK TYPES

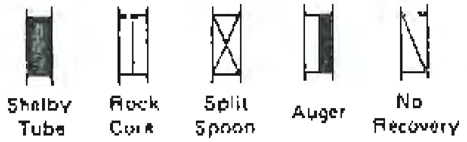
(shown in symbols column)



(Predominate Soil Types Shown Heavy)

SAMPLER TYPES

(shown in sample column)



STRENGTH TEST RESULTS

⊗ - Estimated Strength
◇ - Torvane
○ - Unconfined Compression

TRIAXIAL COMPRESSION

△ - Unconsolidated-undrained
□ - Consolidated-undrained

c - Cohesion (Total)
Φ - Angle of Internal Friction (Total)

c' - Cohesion (Effective)
Φ' - Angle of Internal Friction (Effective)

NOTE:

Values symbolized on boring logs represent shear strengths unless otherwise noted.

TERMS DESCRIBING CONSISTENCY, CONDITION OR TEXTURE

Terms used in this report to describe soils with regard to their consistency or condition are in general accordance with the discussion presented in Article 45 of SOIL MECHANICS IN ENGINEERING PRACTICE, Terzaghi and Peck, John Wiley & Sons, Inc. 1967, using the most reliable information available from the field and laboratory investigations. Terms used for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in Technical Memorandum No. 3-357, Waterways Experiment Station, March 1953.

TERMS CHARACTERIZING SOIL STRUCTURE

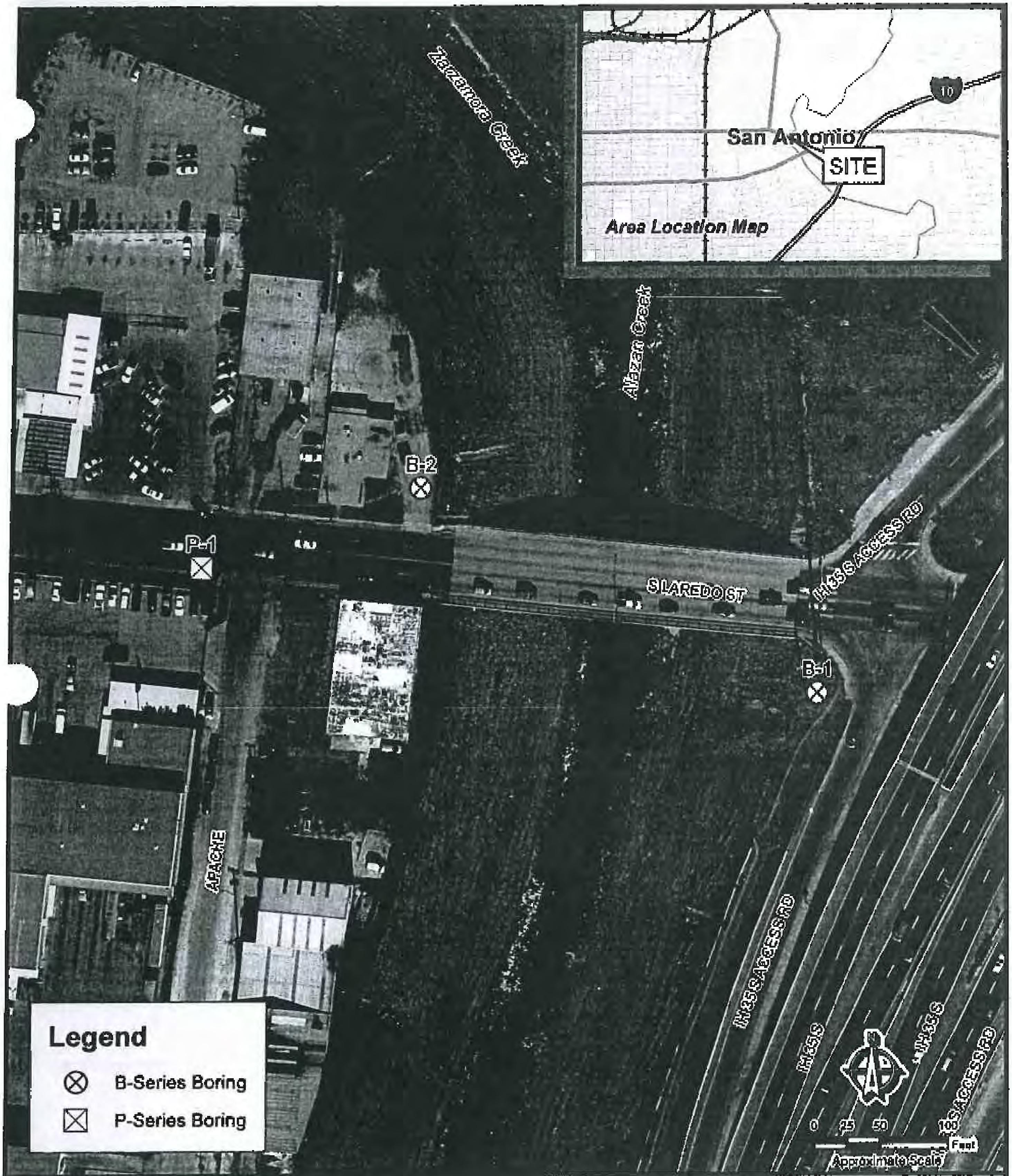
Slickensided	- having inclined planes of weakness that are slick and glossy in appearance.
Fissured	- containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.
Laminated	- composed of thin layers of varying color and texture.
Interbedded	- composed of alternate layers of different soil types.
Calcareous	- containing appreciable quantities of calcium carbonate.
Well graded	- having wide range in grain sizes and substantial amounts of all intermediate particle sizes.
Poorly graded	- predominantly of one grain size, or having a range of sizes with some intermediate size missing.

TERMS DESCRIBING CONSISTENCY OR CONDITION

RELATIVE DENSITY		COHESIVE STRENGTH			PLASTICITY	
Penetration Resistance, blows per foot	Relative Density	Penetration Resistance, blows per foot	Consistency	Cohesion, TSF	Plasticity Index	Degree of Plasticity
0-4	Very Loose	0-2	Very Soft	0-0.125	0-5	None
4-10	Loose	2-4	Soft	0.125-0.25	5-10	Low
10-30	Medium Dense	4-8	Firm	0.25-0.5	10-20	Moderate
30-50	Dense	8-15	Stiff	0.5-1.0	20-40	Plastic
> 50	Very Dense	15-30	Very Stiff	1.0-2.0	> 40	Highly Plastic
		> 30	Hard	> 2.0		

NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above because of planes of weakness or cracks in the soil. The consistency ratings of such soils are based on penetrometer readings.

REPORT 7



Raba Kistner

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Facilities • Infrastructure

12821 West Golden Lane
San Antonio, Texas 78249
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(210)699-6426 FAX
www.rkci.com

SOURCE: 2008 Aerial Photograph Provided by The City of San Antonio (COSA)

BORING LOCATION MAP

ALAZAN CREEK BRIDGE (CIMS)
SAN ANTONIO, TEXAS

REVISIONS:

No.	DATE	DESCRIPTION

PROJECT No.:
ASA09-051-00

ISSUE DATE:	8/5/09
DRAWN BY:	CCL
CHECKED BY:	TIP
REVIEWED BY:	BMK

FIGURE 1

NOTE: This Drawing is Provided for Illustration Only, May Not be to Scale and is Not Suitable for Design or Construction Purposes

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DRILLING LOG

WinCore
Version 3.0

County Bexar
Highway South Laredo Street
CSJ

Hole B-1
Structure Alazan Creek Bridge
Station 15+12.92
Offset 76.95

District San Antonio
Date 08/4/09
Grnd. Elev. 627.58 ft
GW Elev. N/A

Elev. (ft)	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test Lateral Press. (psi)	Triaxial Test Deviator Stress (psi)	Properties MC	Properties LL	Properties PI	Properties Wet Den. (pcf)	Additional Remarks
			FILL MATERIAL, Stiff to Hard, Dark Brown with gravel			7				
5		50 (4.5) 50 (1)								-sandy below 6 ft
						12	34	17		-lime detected
10		9 (6) 14 (6)								
						28				
613.6			CLAY, Blocky, Stiff to Hard, Tan and Gray, with small gravel traces (CH)							
15		10 (6) 15 (6)								
						30	79	57		
20		16 (6) 18 (6)								
						24				
25		23 (6) 25 (6)								
						24				
30		35 (6) 36 (6)								
						24				-with gypsum crystal deposits from 32 to 37 ft
35		39 (6) 42 (6)								
589.6			CLAYSHALE, Very Hard, Dark Gray			23	52	36		
40		50 (1.5) 50 (1)								
						19				
45		50 (1) 50 (1)								-with tan mottling above 45 ft
						21				
50		50 (1) 50 (0.5)								

Remarks:

The ground water elevation was not determined during the course of this boring.

Driller: Eagle Drilling Logger: Fred Mynar

Organization: Raba-Kistner Consultants, Inc.

FIGURE: 2a

DRILLING LOG

WinCore
Version 3.0

County	Bexar	Hole	B-1	District	San Antonio
Highway	South Laredo Street	Structure	Alazan Creek Bridge	Date	08/4/09
CSJ		Station	15+12.92	Grnd. Elev.	627.58 ft
		Offset	76.95	GW Elev.	N/A

Elev. (ft)	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test		Properties				Additional Remarks
				Lateral Press. (psi)	Deviator Stress (psi)	MC	LL	PI	Wet Den. (pcf)	
			CLAYSHALE, Very Hard, Dark Gray							
						21				
55		50 (0.5) 50 (0)								
						17				
60		50 (1) 50 (0.5)								
						23				WATER at 62 ft
65		50 (1) 50 (0.5)								
						19				
70		50 (0.5) 50 (0.5)								
						18				
75		50 (1) 50 (0.5)								
						16				
547.6 80		50 (1.5) 50 (0.5)								
85										
90										
95										
100										

Remarks:

The ground water elevation was not determined during the course of this boring.

Driller: Eagle Drilling **Logger:** Fred Mynar

Organization: Raba-Kistner Consultants, Inc.

FIGURE: 2b

DRILLING LOG

WinCore
Version 3.0

County	Bexar	Hole	B-2	District	San Antonio
Highway	South Laredo Street	Structure	Alazan Creek Bridge	Date	07/1/09
CSJ		Station	11+95.52	Grnd. Elev.	630.17 ft
		Offset	-55.43	GW Elev.	N/A

Elev. (ft)	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test Lateral Press. (psi)	Triaxial Test Deviator Stress (psi)	Properties MC	Properties LL	Properties PI	Properties Wet Den. (pcf)	Additional Remarks
			CLAY, Soft to Stiff, Tan to Light Tan (possible fill material) (CH)							ASPHALT (2 in.) BASE MATERIAL (6 in.)
						11	42	29		
5		13 (6) 21 (6)								
						11				
10		21 (6) 18 (6)								
						38	85	57		-with traces of gravel above 14 ft and calcareous deposits below 14 ft
15		8 (6) 8 (6)								
611.2			CLAY, Blocky, Stiff to Hard, Tan and Gray, with ferrous staining (CH)			41				
20		11 (6) 11 (6)								
						33				
25		15 (6) 18 (6)								
						29				
30		21 (6) 32 (6)								
						27				
35		28 (6) 30 (6)								
						27				
40		50 (6) 50 (6)								
						26				
585.2 45		50 (0.5) 50 (0.5)	CLAYSHALE, Very Hard, Dark Gray							
						30				
50		50 (1) 50 (2.5)								

Remarks:

The ground water elevation was not determined during the course of this boring.

Driller: Alpha & Omega Drilling **Logger: Steve Morris**

Organization: Raba-Kistner Consultants, Inc.

FIGURE: 3a

DRILLING LOG

WinCore
Version 3.0

County	Bexar	Hole	B-2	District	San Antonio
Highway	South Laredo Street	Structure	Alazan Creek Bridge	Date	07/1/09
CSJ		Station	11+95.52	Grnd. Elev.	630.17 ft
		Offset	-55.43	GW Elev.	N/A

Elev. (ft)	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test Lateral Press. (psi)	 Deviator Stress (psi)	Properties MC	 LL	 PI	 Wet Den. (pcf)	Additional Remarks
			CLAYSHALE, Very Hard, Dark Gray							
						27				
55		50 (0.7) 50 (0.2)								
						27				
60		50 (1.2) 50 (1)								
						30				
65		50 (0.5) 50 (0)								
						15				
70		50 (0.5) 50 (0.5)								
						24				
75		50 (0.7) 50 (0.5)								
						17				
550.2 80		50 (0.2) 50 (0.5)								
85										
90										
95										
100										

Remarks:

he ground water elevation was not determined during the course of this boring.

Driller: Alpha & Omega Drilling Logger: Steve Morris

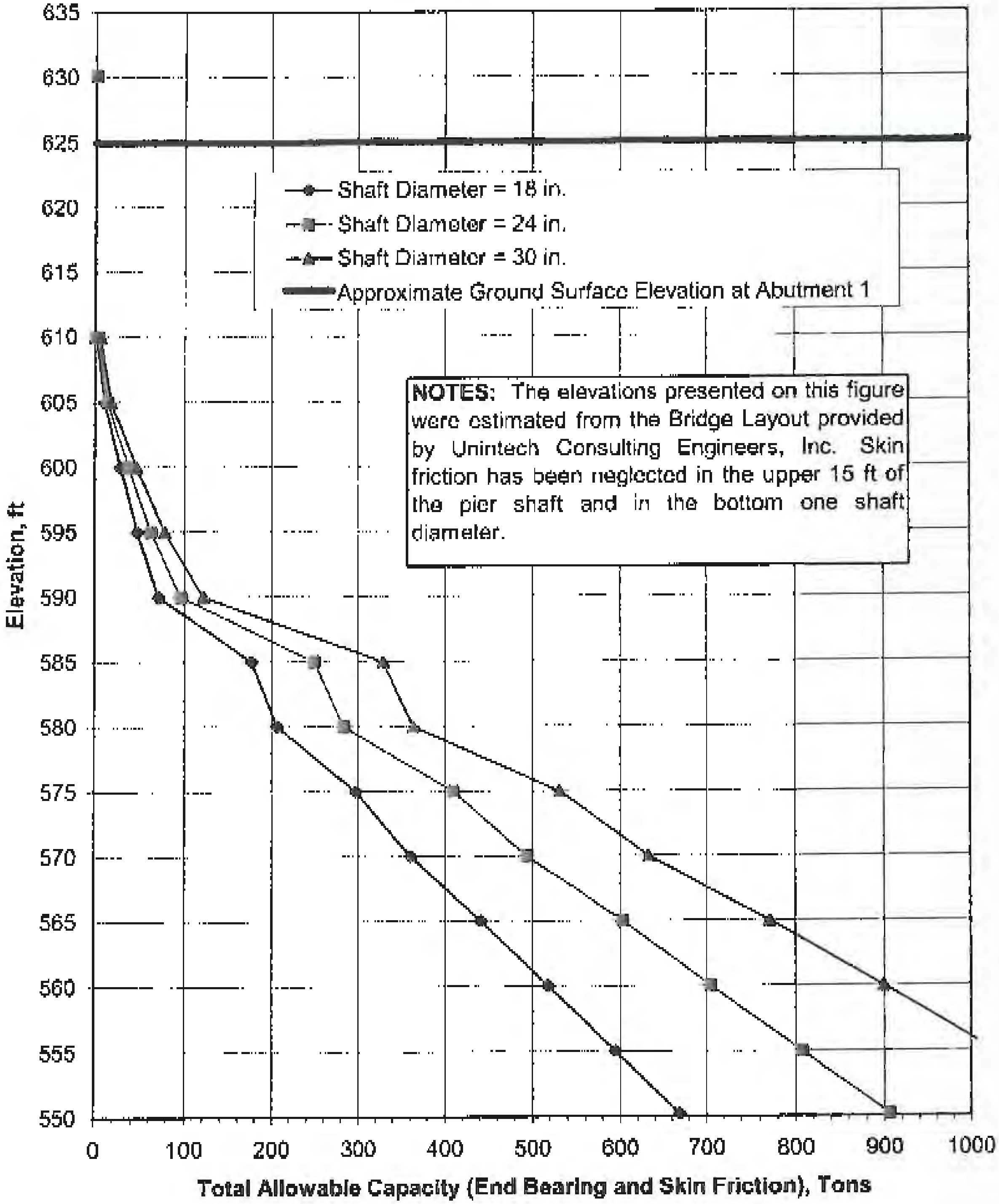
Organization: Raba-Kistner Consultants, Inc.

FIGURE: 3b

DRILLED PIER AXIAL CAPACITY CURVE

Straight Shaft Piers

Alazan Creek Bridge (CIMS)
San Antonio, Texas
(Boring B-2, Abutment 1)

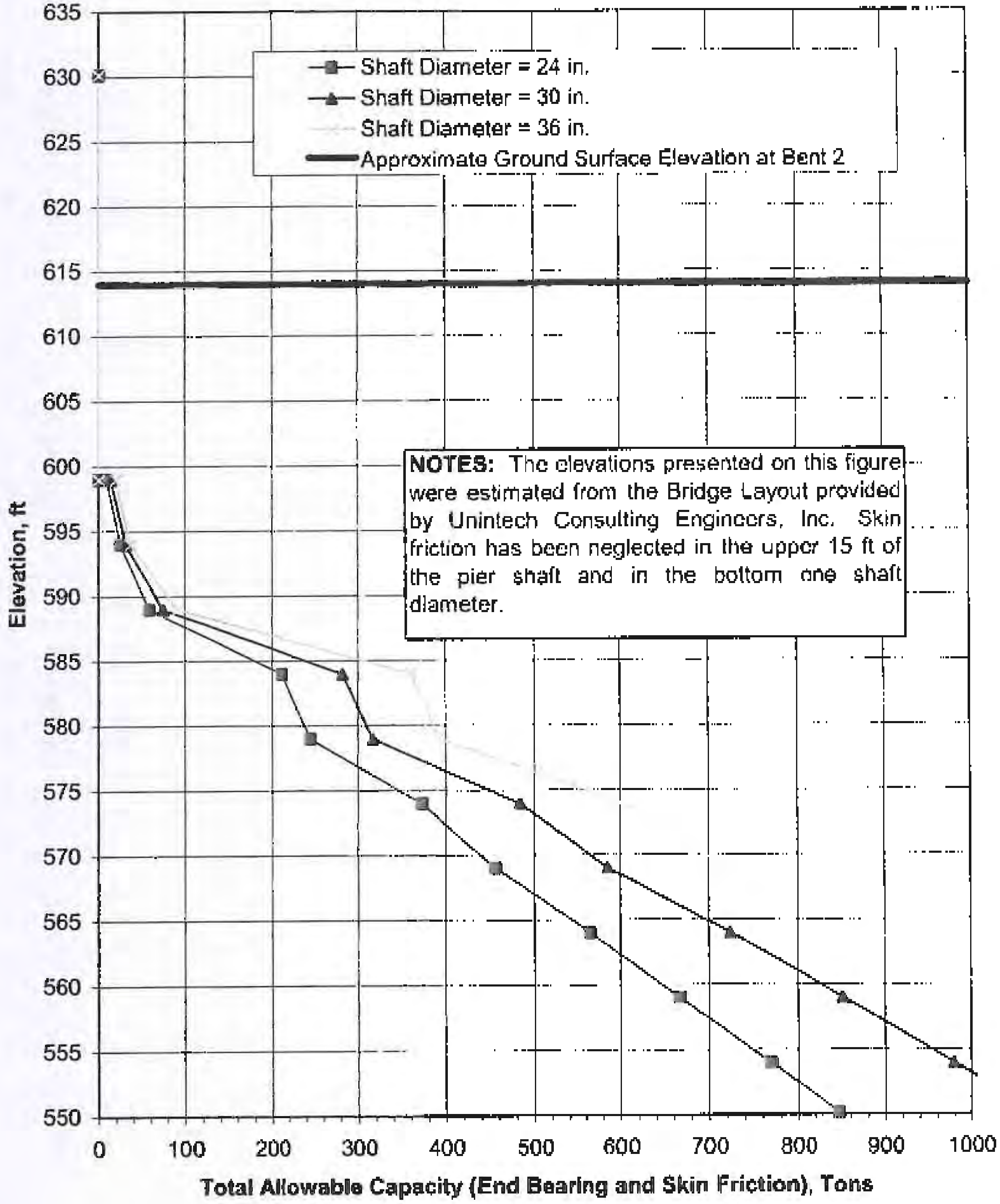


NOTES: The elevations presented on this figure were estimated from the Bridge Layout provided by Unintech Consulting Engineers, Inc. Skin friction has been neglected in the upper 15 ft of the pier shaft and in the bottom one shaft diameter.

DRILLED PIER AXIAL CAPACITY CURVE

Straight Shaft Piers

Alazan Creek Bridge (CIMS)
San Antonio, Texas
(Boring B-2, Bent 2)

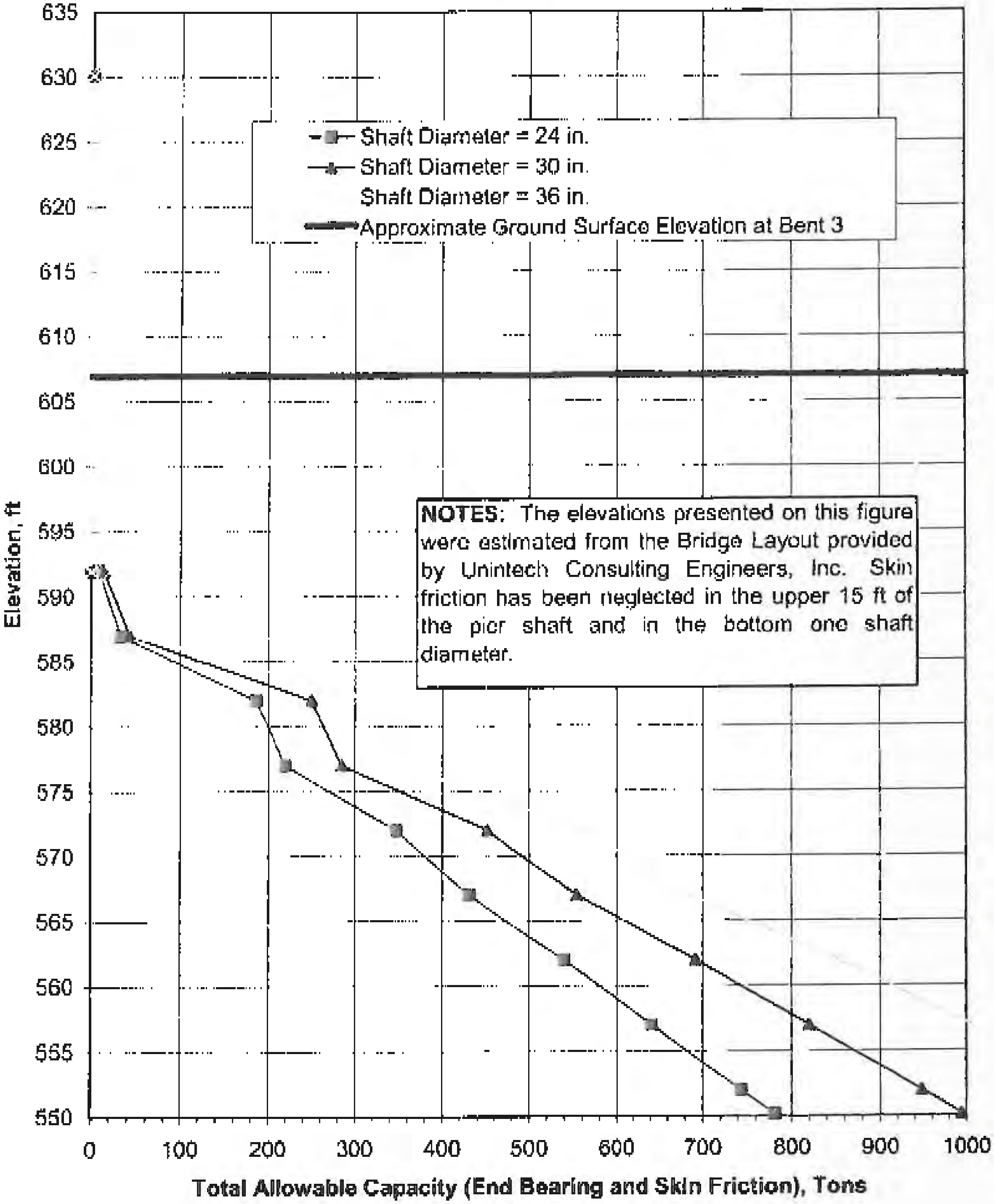


NOTES: The elevations presented on this figure were estimated from the Bridge Layout provided by Unintech Consulting Engineers, Inc. Skin friction has been neglected in the upper 15 ft of the pier shaft and in the bottom one shaft diameter.

DRILLED PIER AXIAL CAPACITY CURVE

Straight Shaft Piers

Alazan Creek Bridge (CIMS)
San Antonio, Texas
(Boring B-2, Bent 3)

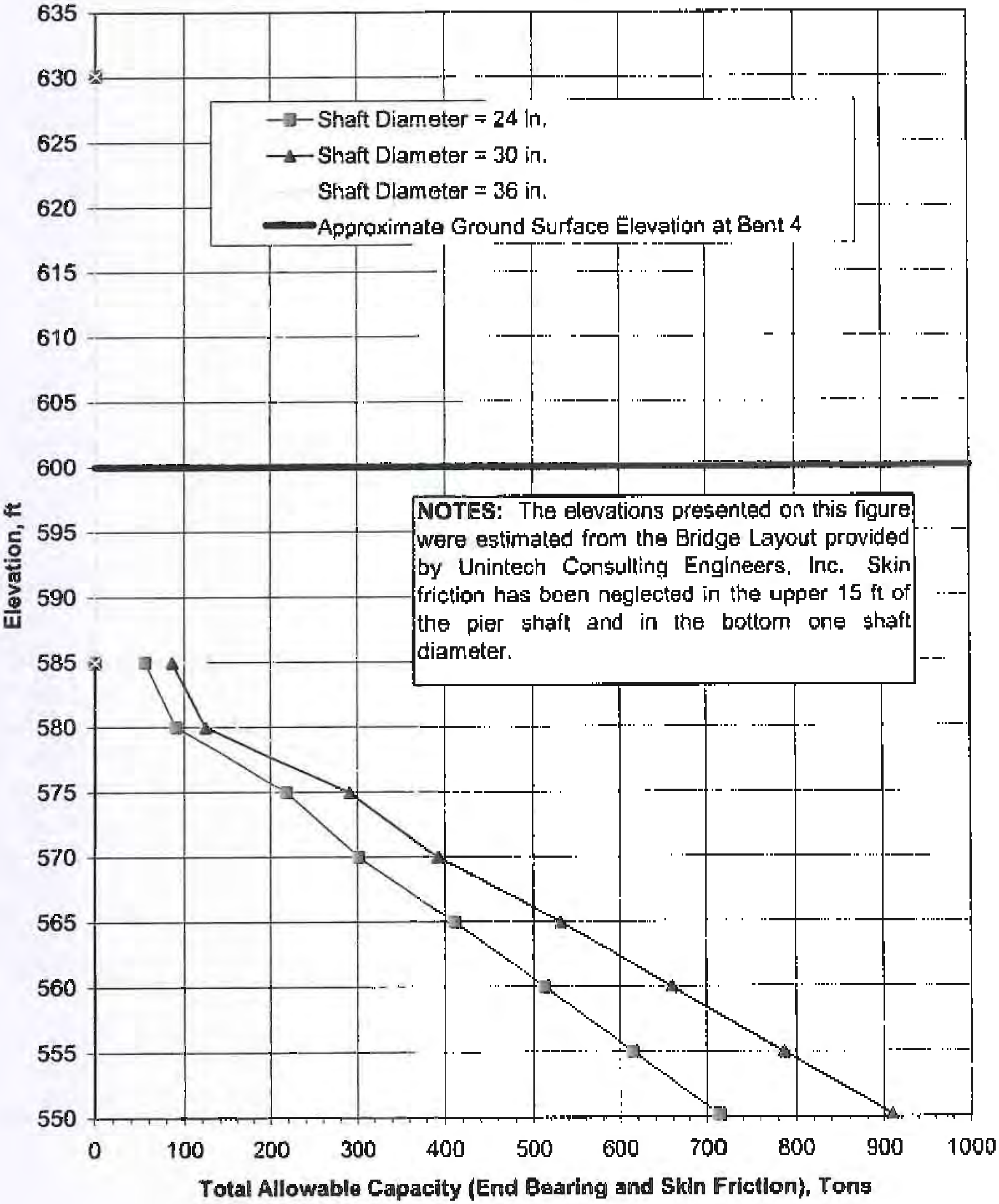


NOTES: The elevations presented on this figure were estimated from the Bridge Layout provided by Unintech Consulting Engineers, Inc. Skin friction has been neglected in the upper 15 ft of the pier shaft and in the bottom one shaft diameter.

DRILLED PIER AXIAL CAPACITY CURVE

Straight Shaft Piers

Alazan Creek Bridge (CIMS)
San Antonio, Texas
(Boring B-2, Bent 4)



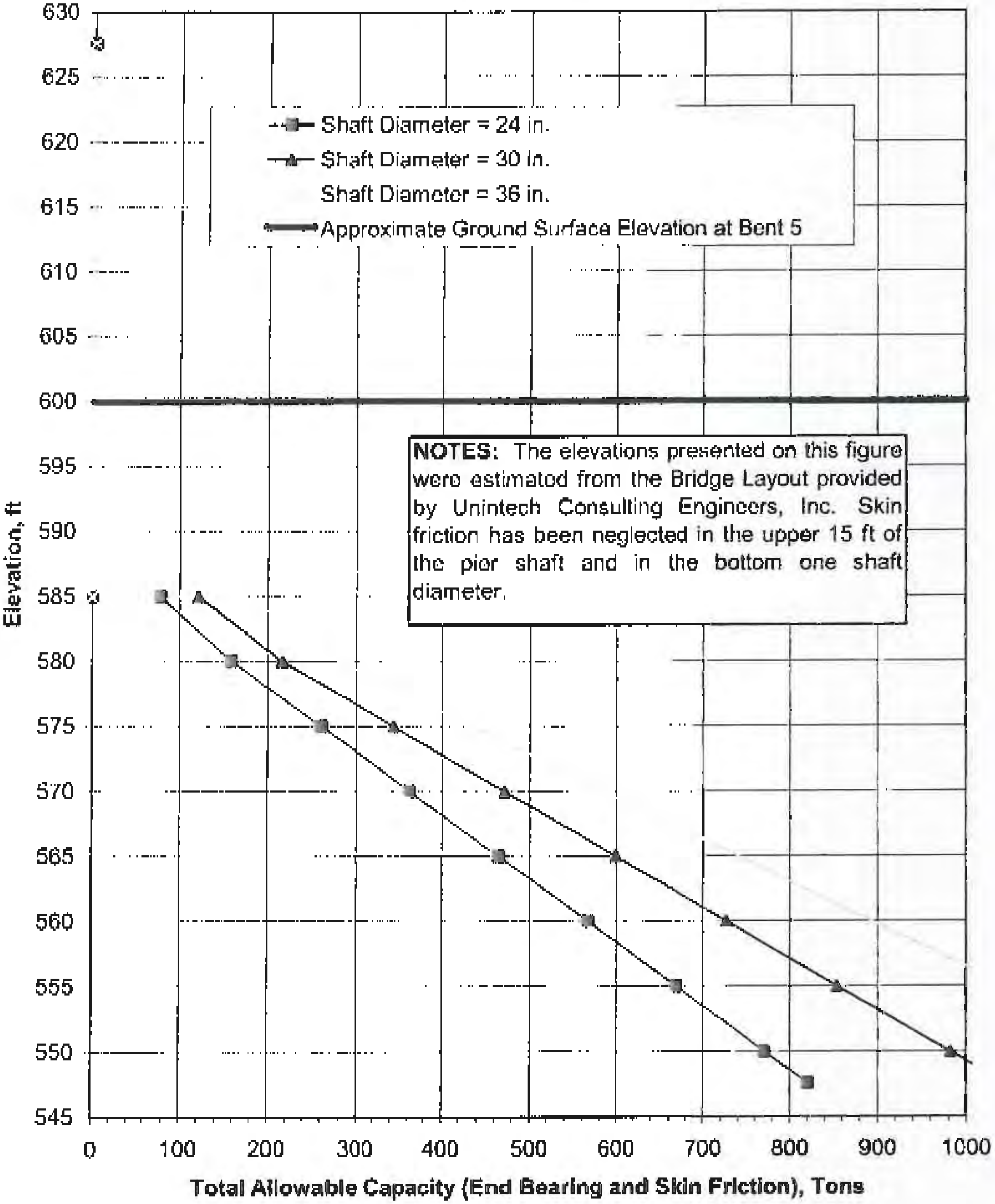
NOTES: The elevations presented on this figure were estimated from the Bridge Layout provided by Unintech Consulting Engineers, Inc. Skin friction has been neglected in the upper 15 ft of the pier shaft and in the bottom one shaft diameter.

Figure 7d

DRILLED PIER AXIAL CAPACITY CURVE

Straight Shaft Piers

Alazan Creek Bridge (CIMS)
San Antonio, Texas
(Boring B-1, Bent 5)

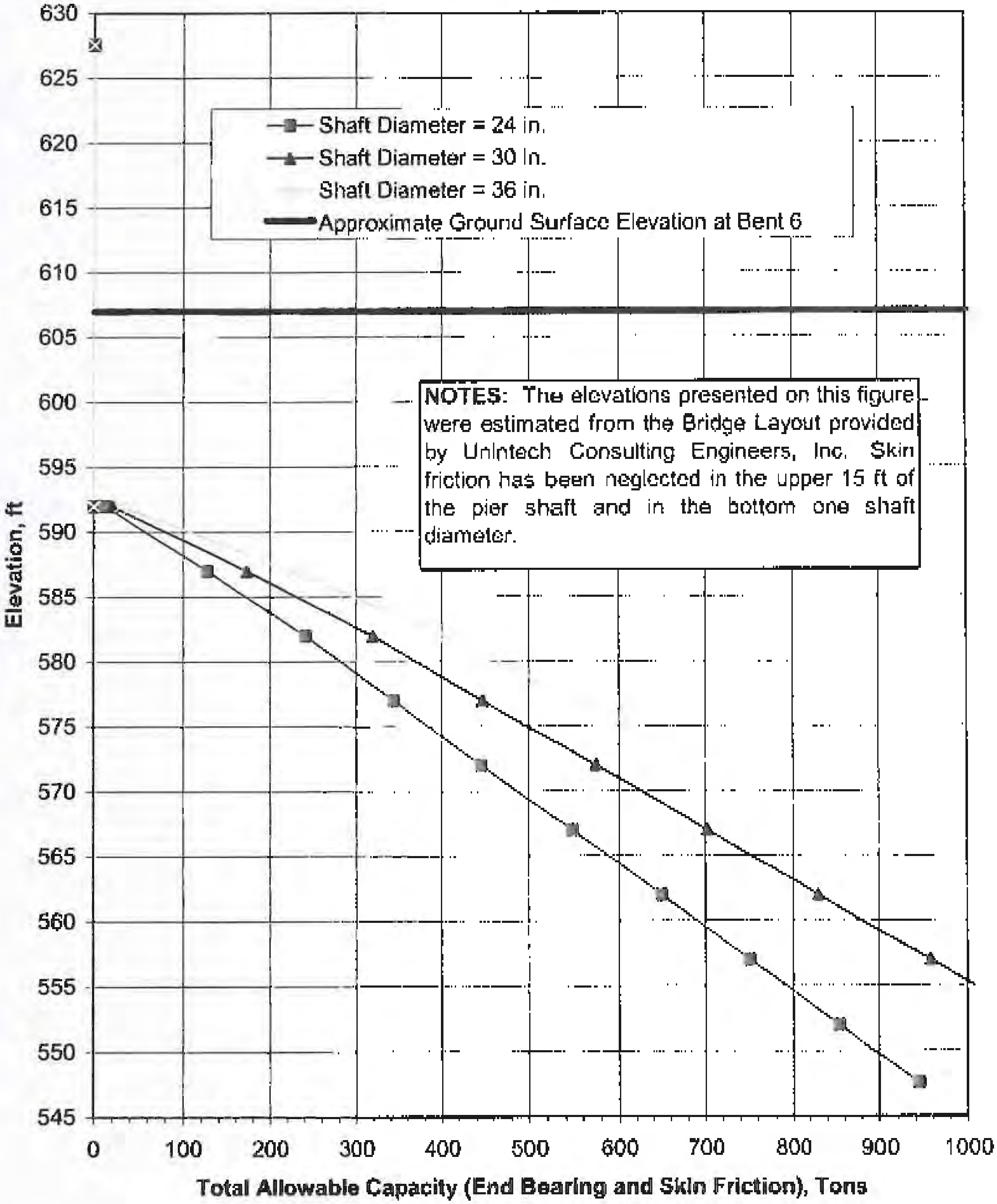


NOTES: The elevations presented on this figure were estimated from the Bridge Layout provided by Unintech Consulting Engineers, Inc. Skin friction has been neglected in the upper 15 ft of the pier shaft and in the bottom one shaft diameter.

DRILLED PIER AXIAL CAPACITY CURVE

Straight Shaft Piers

Alazan Creek Bridge (CIMS)
San Antonio, Texas
(Boring B-1, Bent 6)

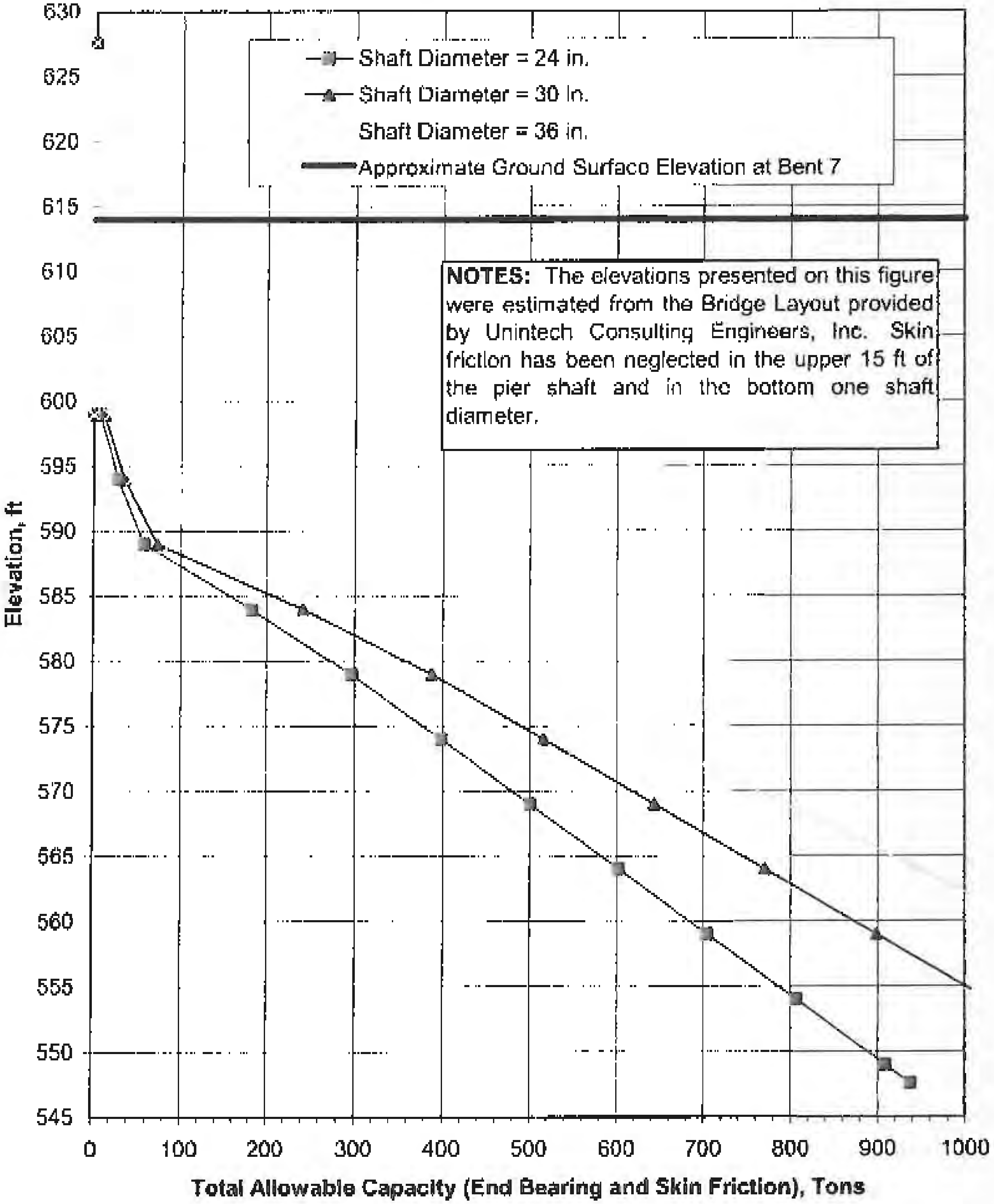


NOTES: The elevations presented on this figure were estimated from the Bridge Layout provided by Unintech Consulting Engineers, Inc. Skin friction has been neglected in the upper 15 ft of the pier shaft and in the bottom one shaft diameter.

DRILLED PIER AXIAL CAPACITY CURVE

Straight Shaft Piers

Alazan Creek Bridge (CIMS)
San Antonio, Texas
(Boring B-1, Bent 7)

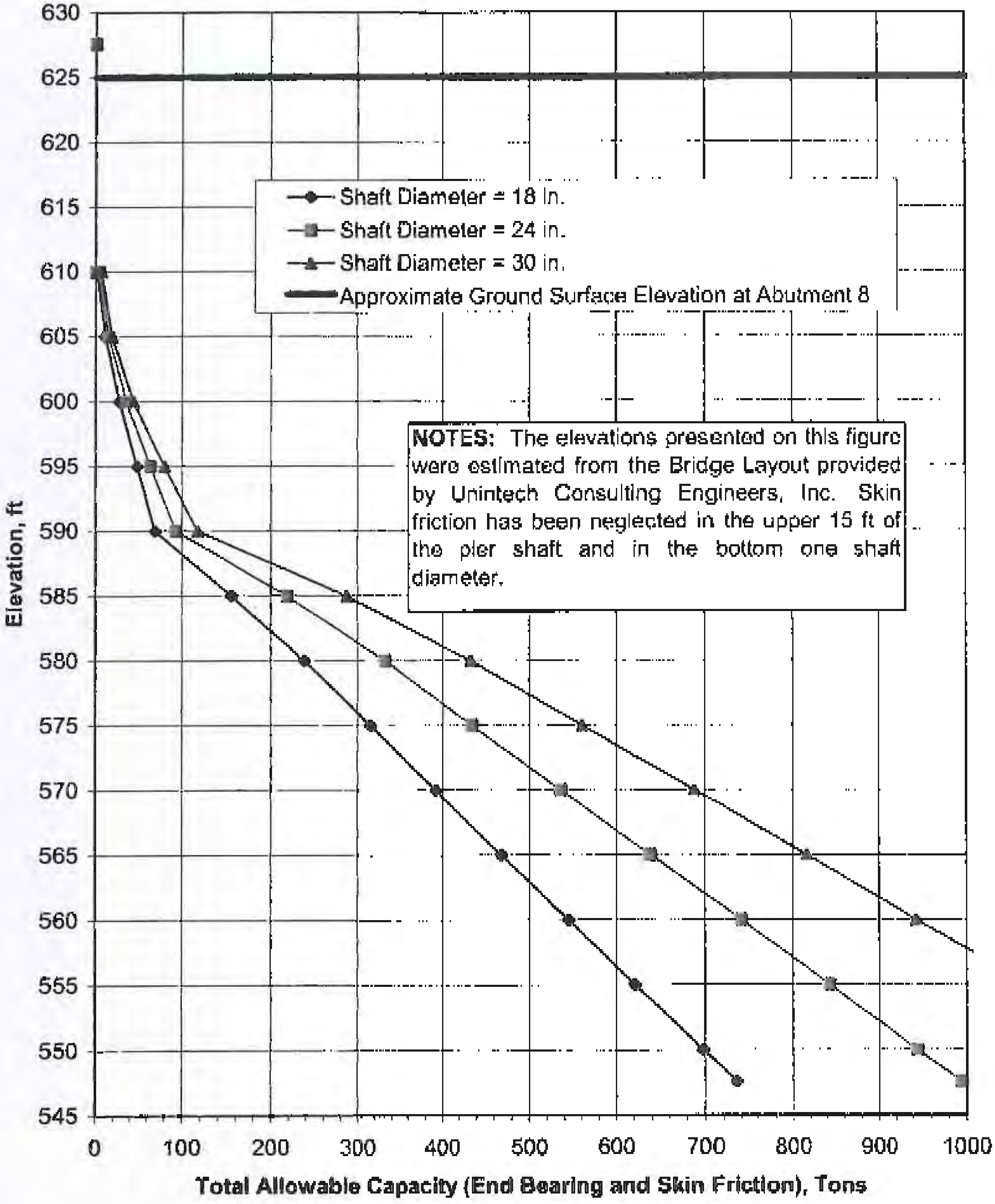


NOTES: The elevations presented on this figure were estimated from the Bridge Layout provided by Unintech Consulting Engineers, Inc. Skin friction has been neglected in the upper 15 ft of the pier shaft and in the bottom one shaft diameter.

DRILLED PIER AXIAL CAPACITY CURVE

Straight Shaft Piers

Alazan Creek Bridge (CIMS)
San Antonio, Texas
(Boring B-1, Abutment 8)



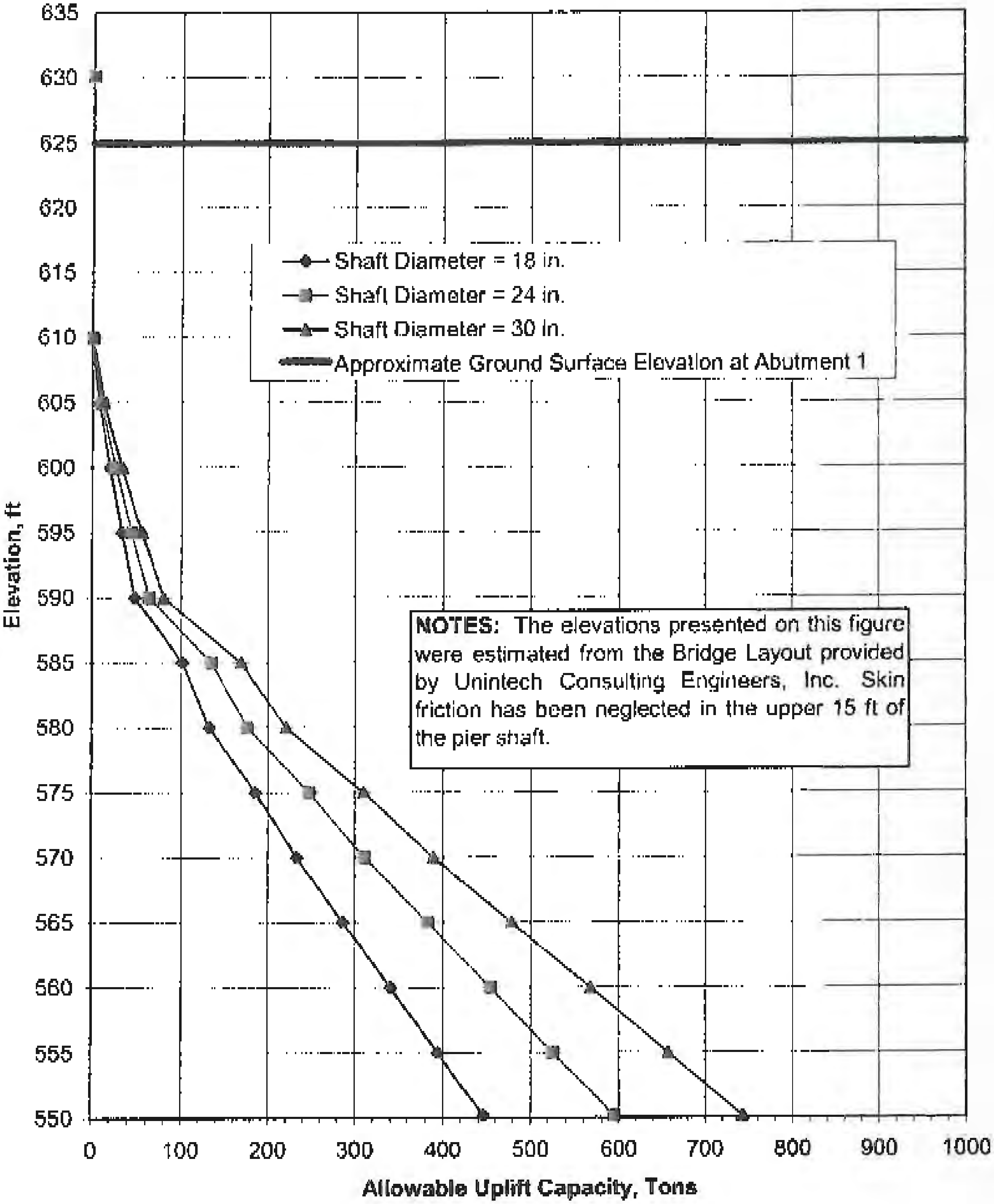
NOTES: The elevations presented on this figure were estimated from the Bridge Layout provided by Unintech Consulting Engineers, Inc. Skin friction has been neglected in the upper 15 ft of the pier shaft and in the bottom one shaft diameter.

Figure 7h

DRILLED PIER UPLIFT CAPACITY CURVE

Straight Shaft Piers

Alazan Creek Bridge (CIMS)
San Antonio, Texas
(Boring B-2, Abutment 1)

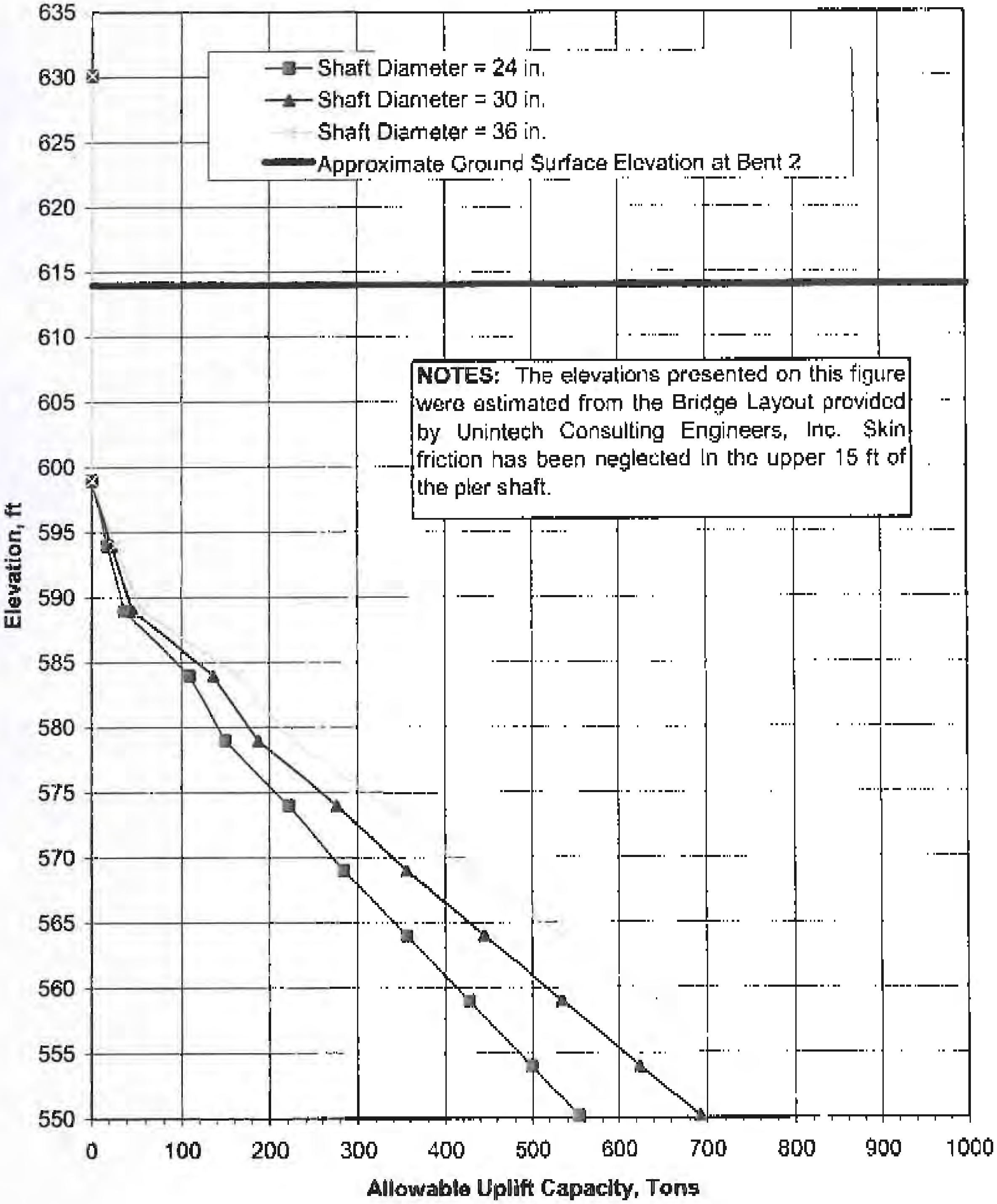


NOTES: The elevations presented on this figure were estimated from the Bridge Layout provided by Unintech Consulting Engineers, Inc. Skin friction has been neglected in the upper 15 ft of the pier shaft.

DRILLED PIER UPLIFT CAPACITY CURVE

Straight Shaft Piers

Alazan Creek Bridge (CIMS)
San Antonio, Texas
(Boring B-2, Bent 2)

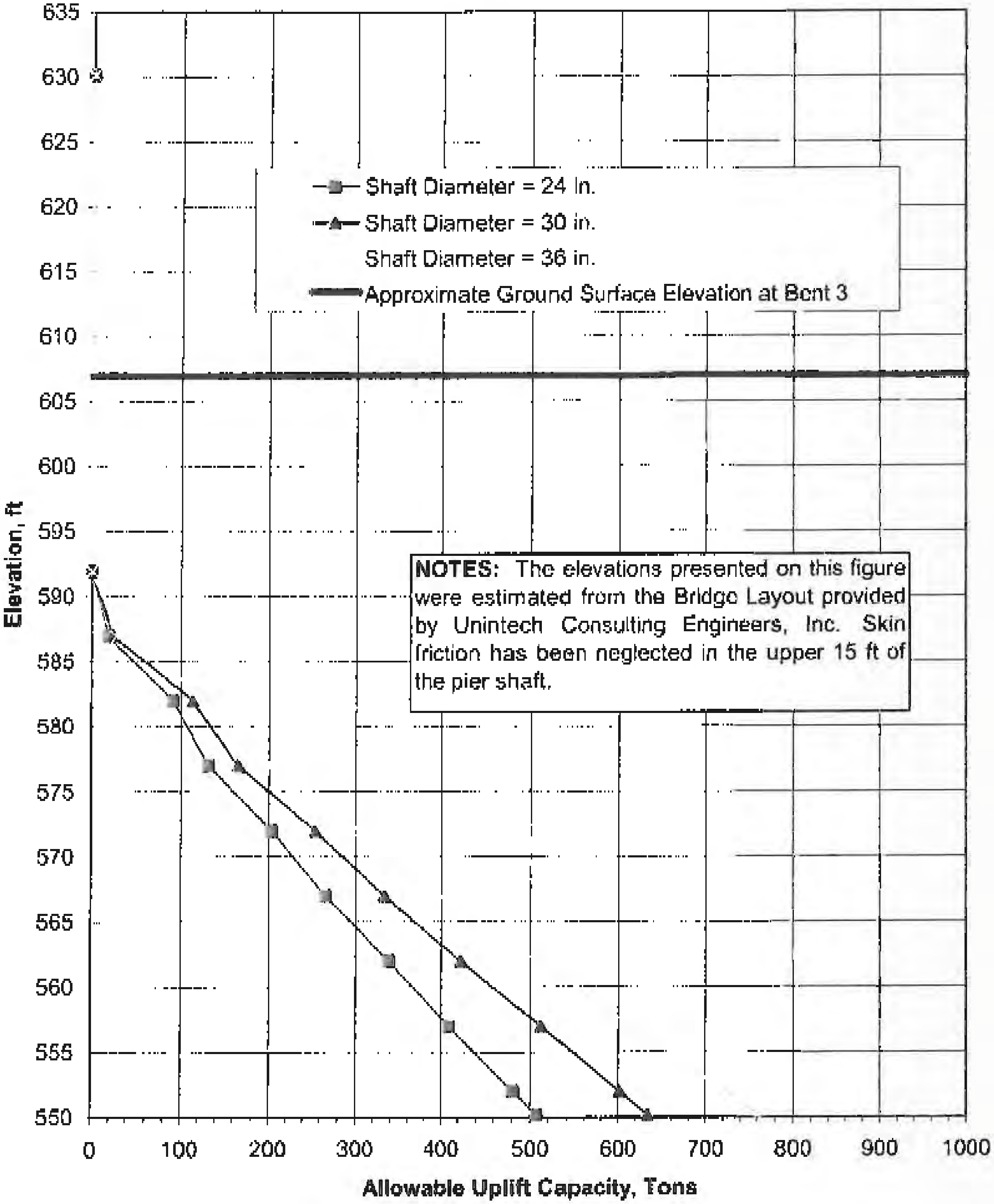


NOTES: The elevations presented on this figure were estimated from the Bridge Layout provided by Unintech Consulting Engineers, Inc. Skin friction has been neglected in the upper 15 ft of the pier shaft.

DRILLED PIER UPLIFT CAPACITY CURVE

Straight Shaft Piers

Alazan Creek Bridge (CIMS)
San Antonio, Texas
(Boring B-2, Bent 3)



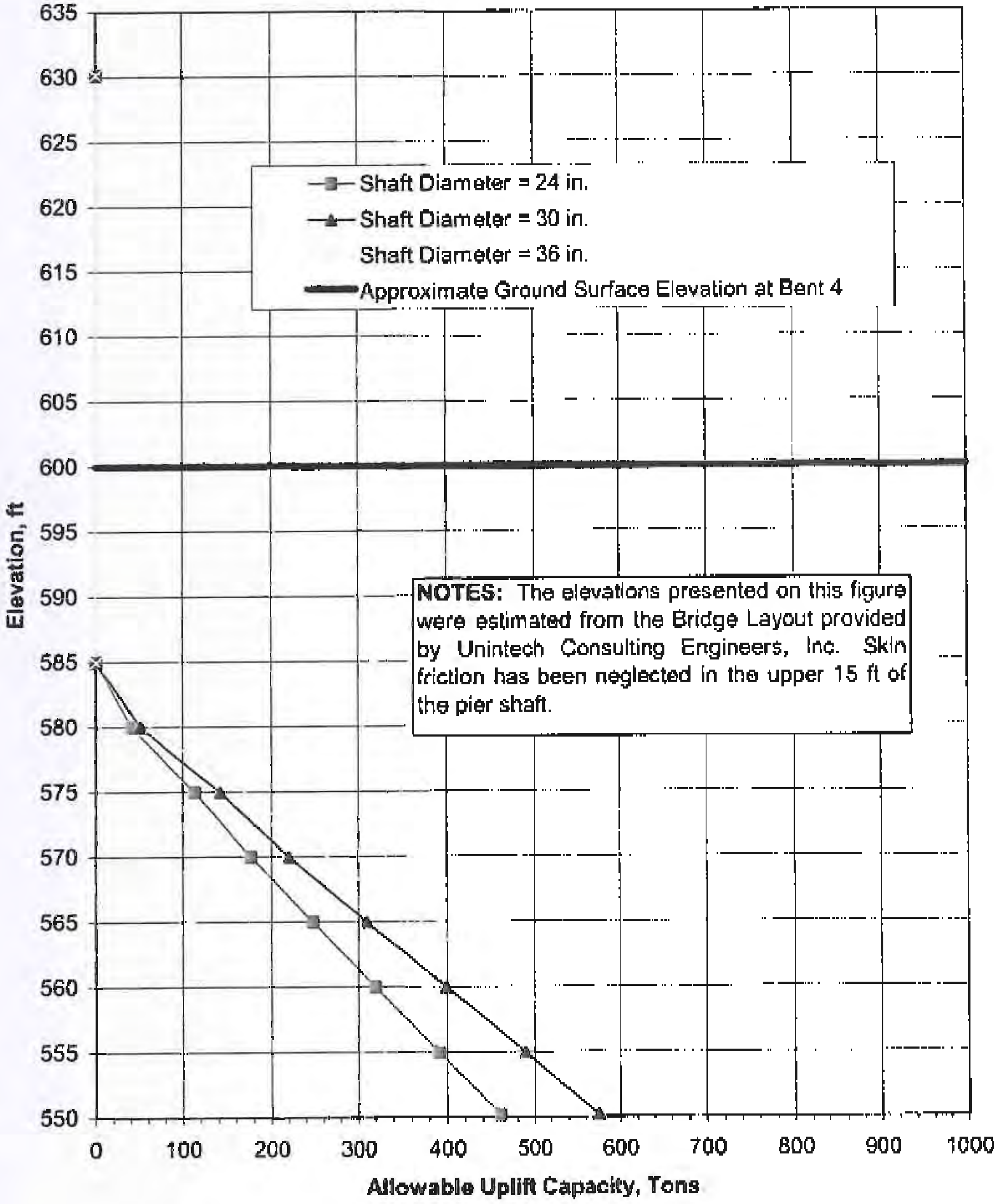
NOTES: The elevations presented on this figure were estimated from the Bridge Layout provided by Unintech Consulting Engineers, Inc. Skin friction has been neglected in the upper 15 ft of the pier shaft.

Figure 8c

DRILLED PIER UPLIFT CAPACITY CURVE

Straight Shaft Piers

Alazan Creek Bridge (CIMS)
San Antonio, Texas
(Boring B-2, Bent 4)

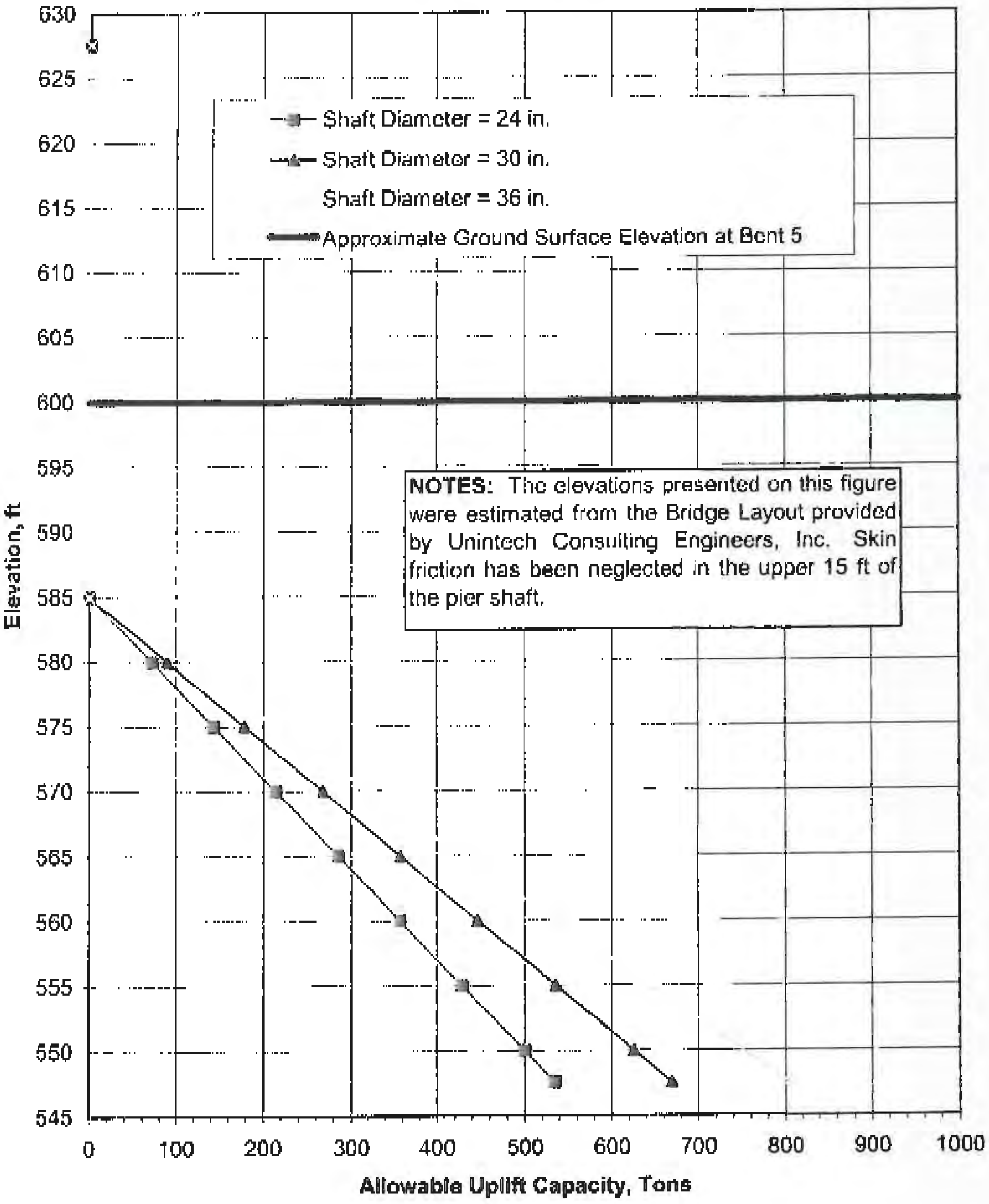


NOTES: The elevations presented on this figure were estimated from the Bridge Layout provided by Unintech Consulting Engineers, Inc. Skin friction has been neglected in the upper 15 ft of the pier shaft.

DRILLED PIER UPLIFT CAPACITY CURVE

Straight Shaft Piers

Alazan Creek Bridge (CIMS)
San Antonio, Texas
(Boring B-1, Bent 5)

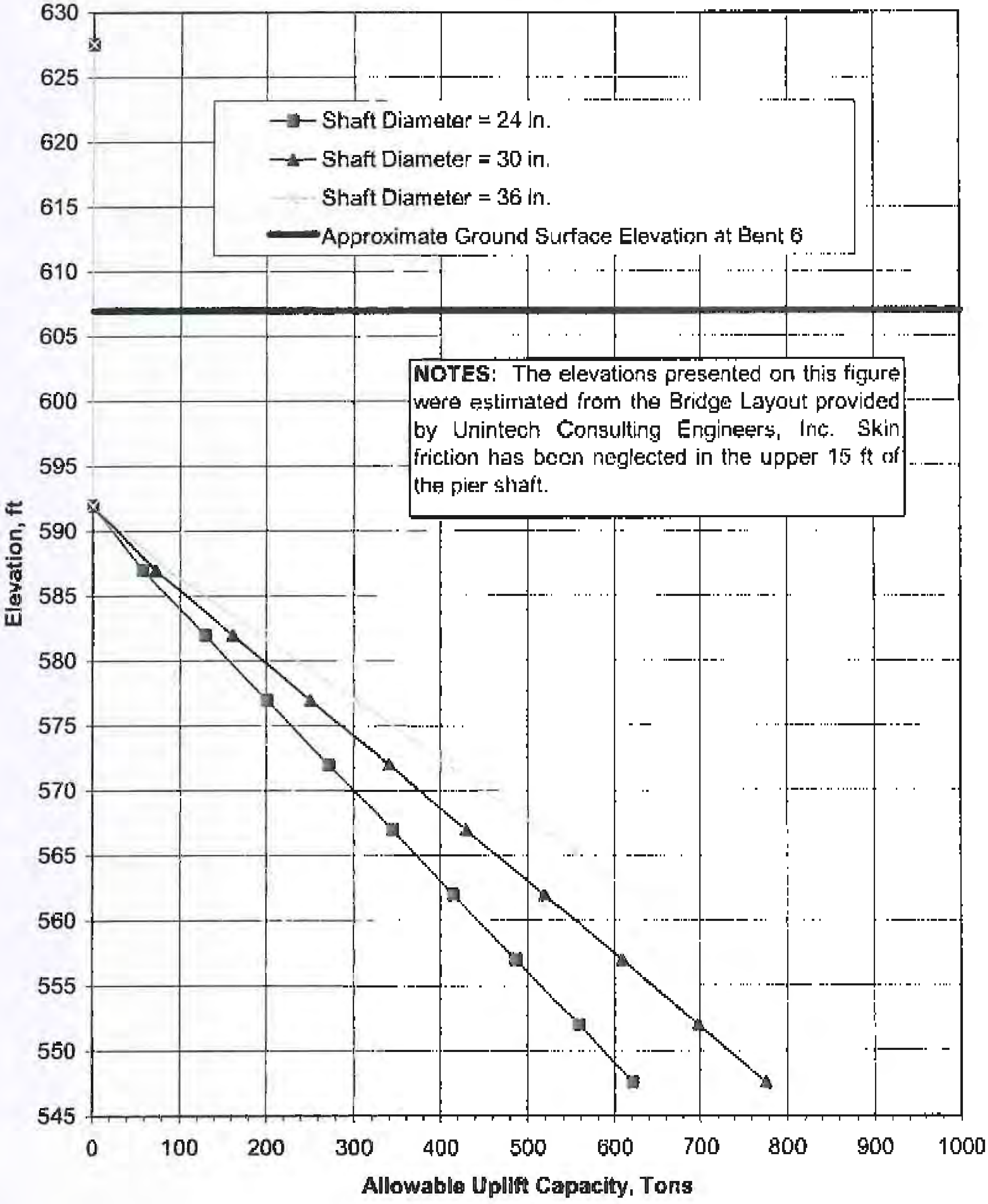


NOTES: The elevations presented on this figure were estimated from the Bridge Layout provided by Unintech Consulting Engineers, Inc. Skin friction has been neglected in the upper 15 ft of the pier shaft.

DRILLED PIER UPLIFT CAPACITY CURVE

Straight Shaft Piers

Alazan Creek Bridge (CIMS)
San Antonio, Texas
(Boring B-1, Bent 6)

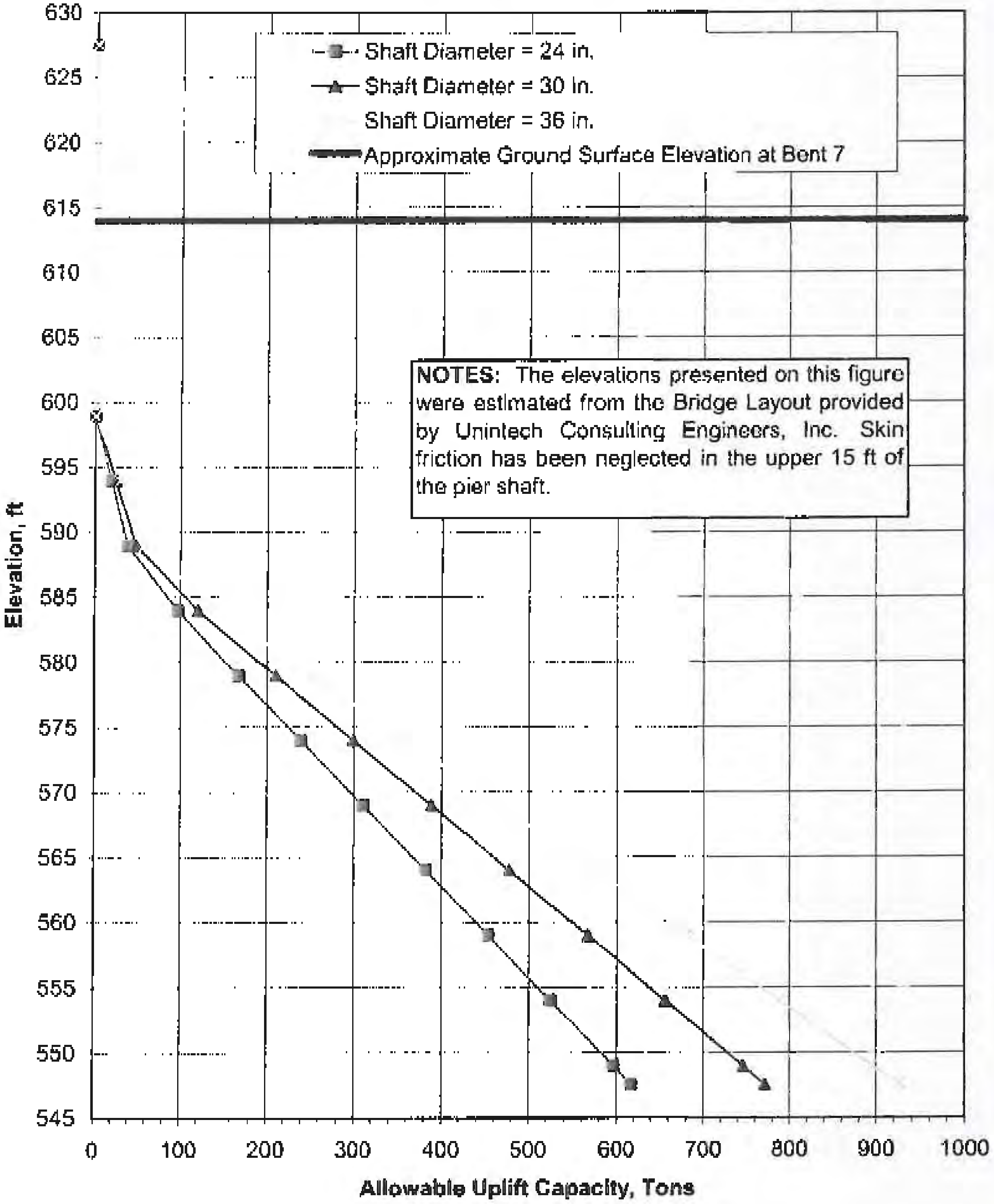


NOTES: The elevations presented on this figure were estimated from the Bridge Layout provided by Unintech Consulting Engineers, Inc. Skin friction has been neglected in the upper 15 ft of the pier shaft.

DRILLED PIER UPLIFT CAPACITY CURVE

Straight Shaft Piers

Alazan Creek Bridge (CIMS)
San Antonio, Texas
(Boring B-1, Bent 7)

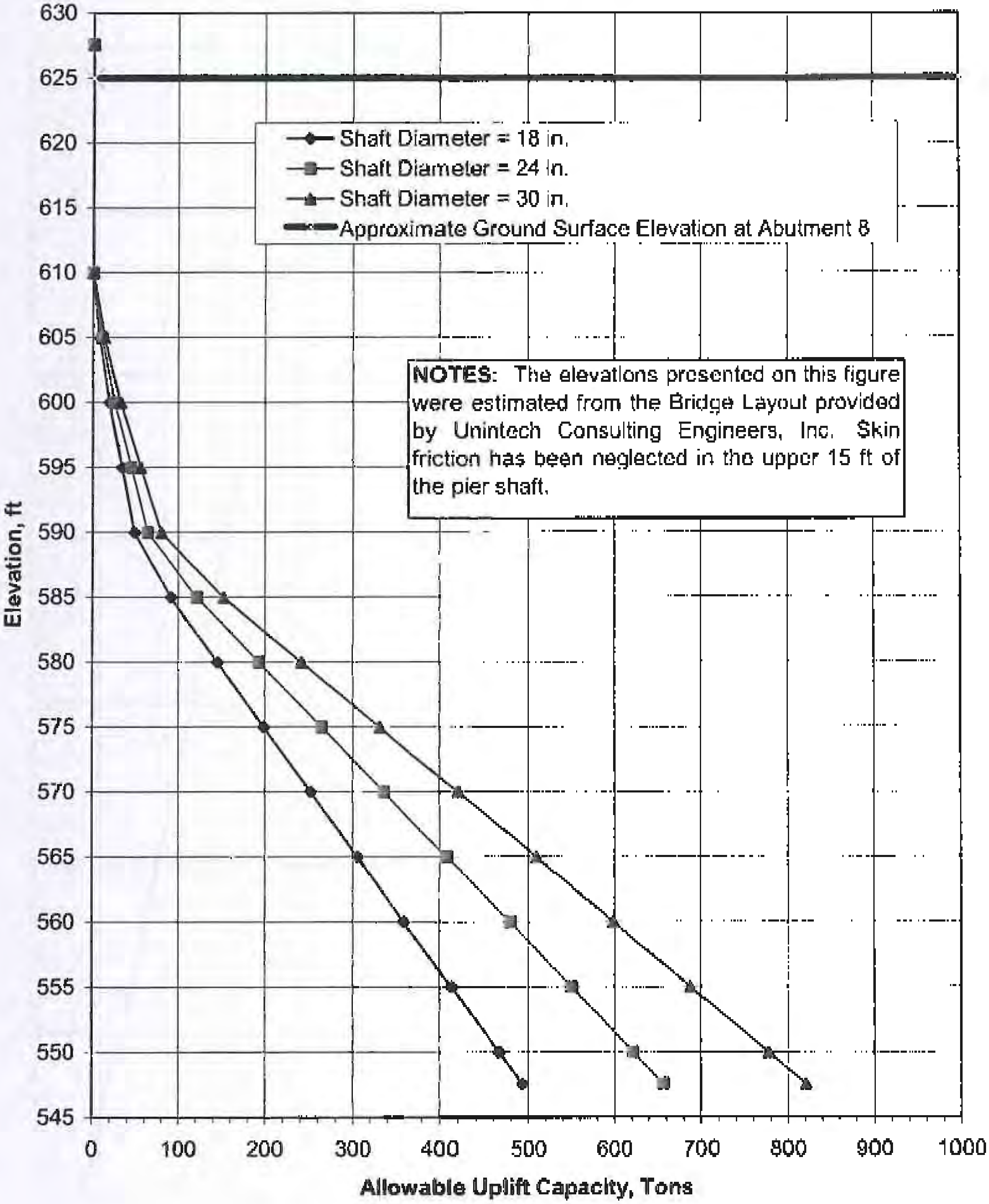


NOTES: The elevations presented on this figure were estimated from the Bridge Layout provided by Unintech Consulting Engineers, Inc. Skin friction has been neglected in the upper 15 ft of the pier shaft.

DRILLED PIER UPLIFT CAPACITY CURVE

Straight Shaft Piers

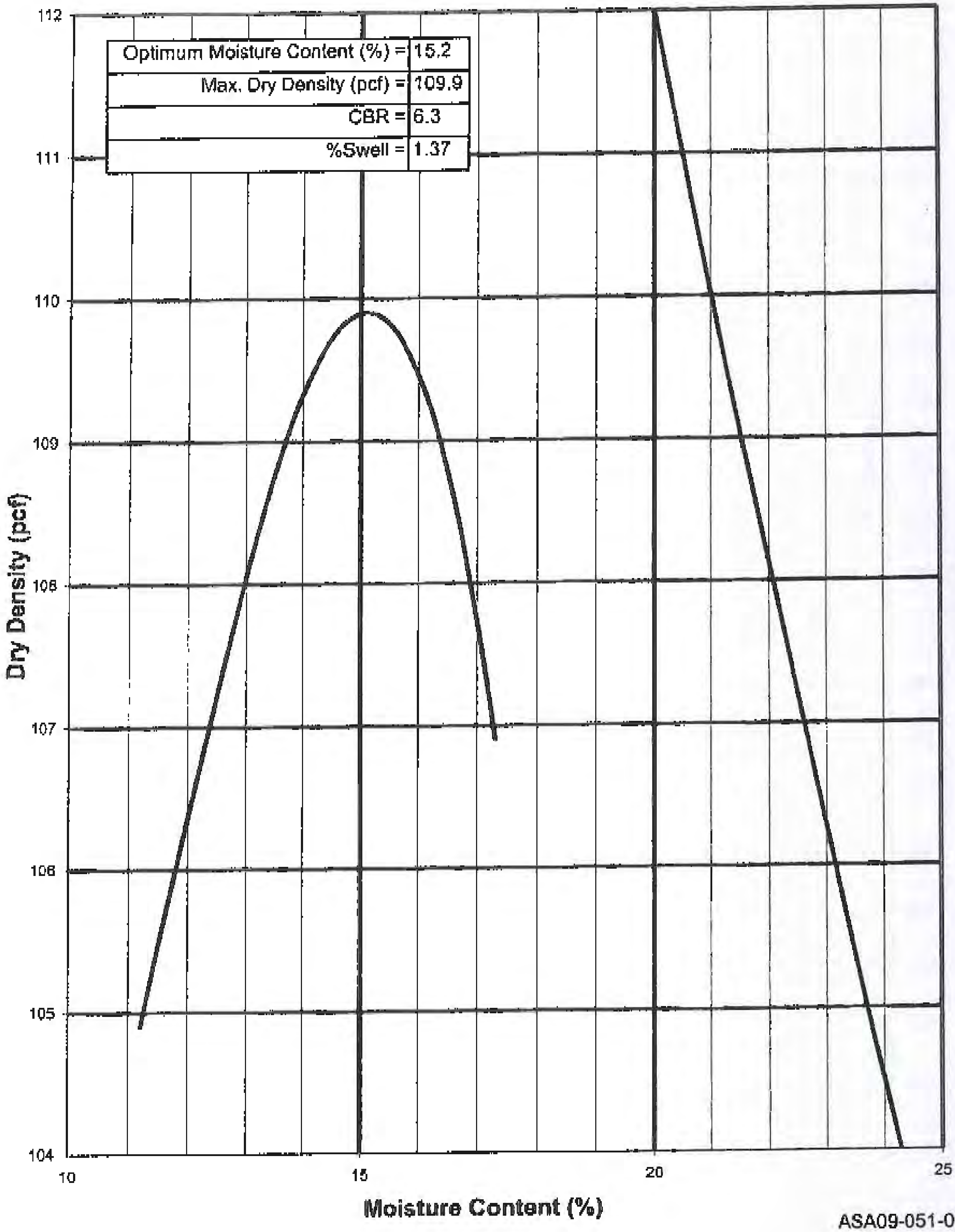
Alazan Creek Bridge (CIMS)
San Antonio, Texas
(Boring B-1, Abutment 8)



NOTES: The elevations presented on this figure were estimated from the Bridge Layout provided by Unintech Consulting Engineers, Inc. Skin friction has been neglected in the upper 15 ft of the pier shaft.

MOISTURE DENSITY RELATIONSHIP

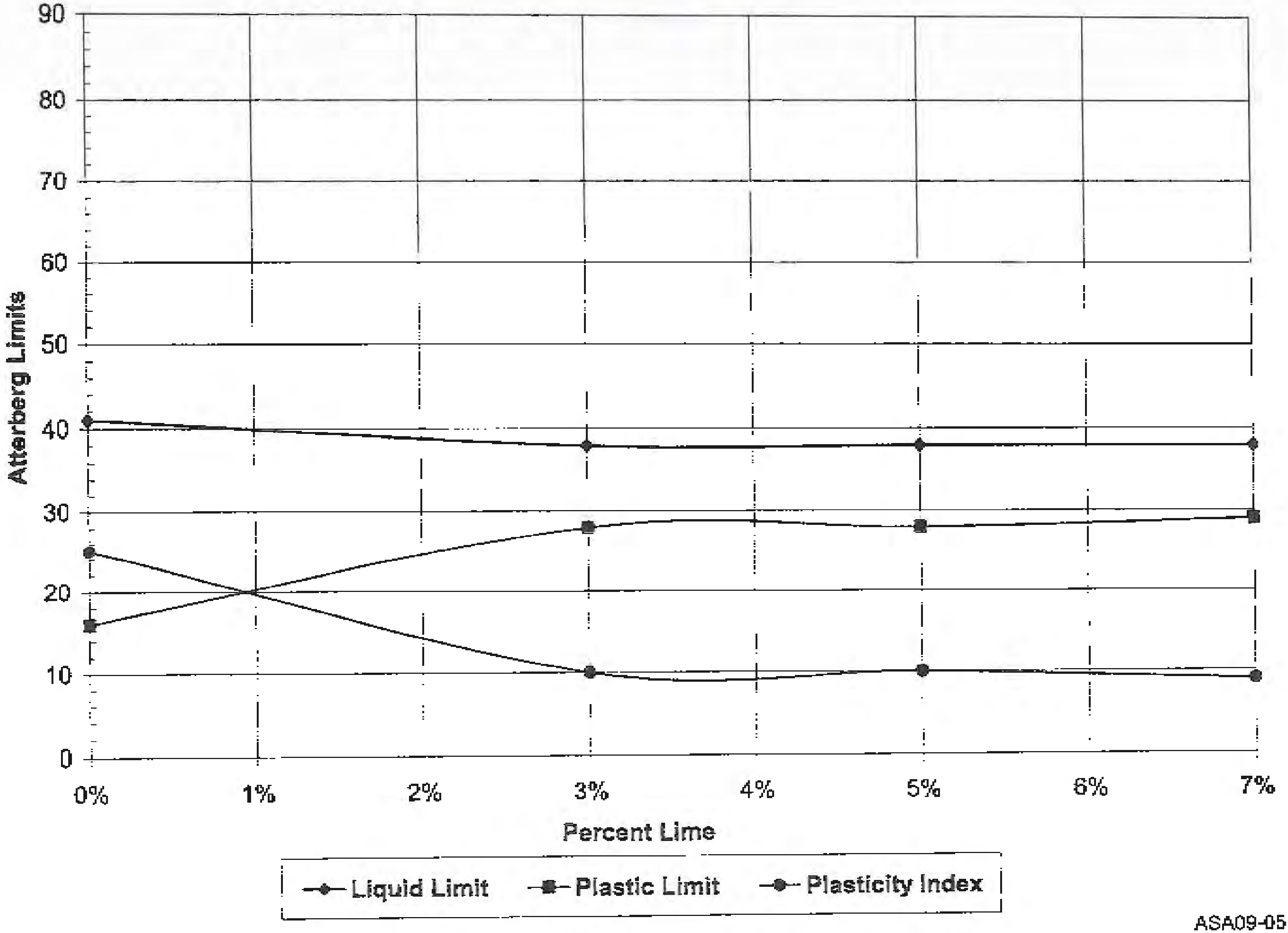
Alzan Creek Bridge (CIMS)



ASA09-051-00
Figure 9

LIME SERIES CURVE

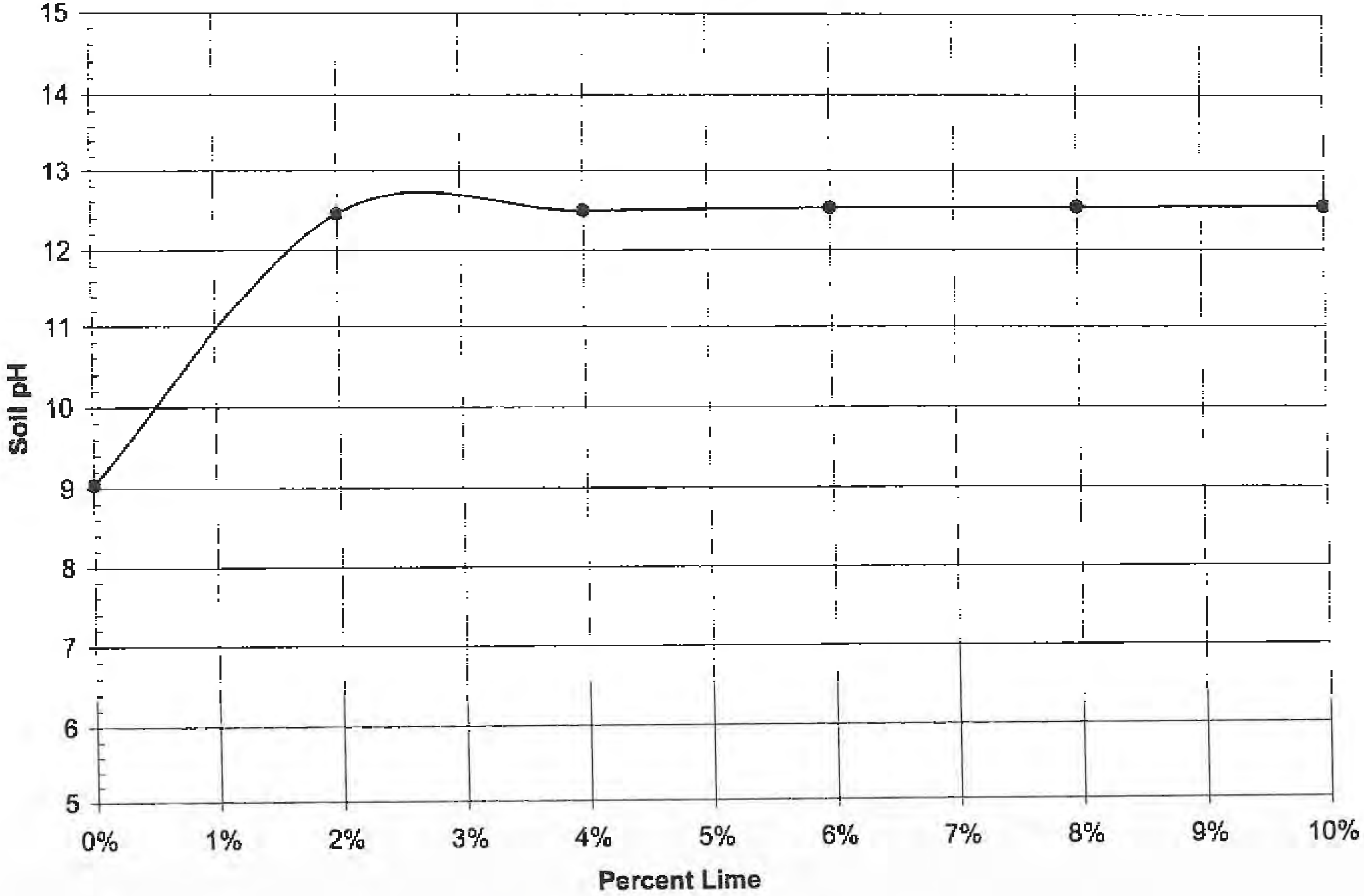
Alzan Creek Bridge (CIMS)



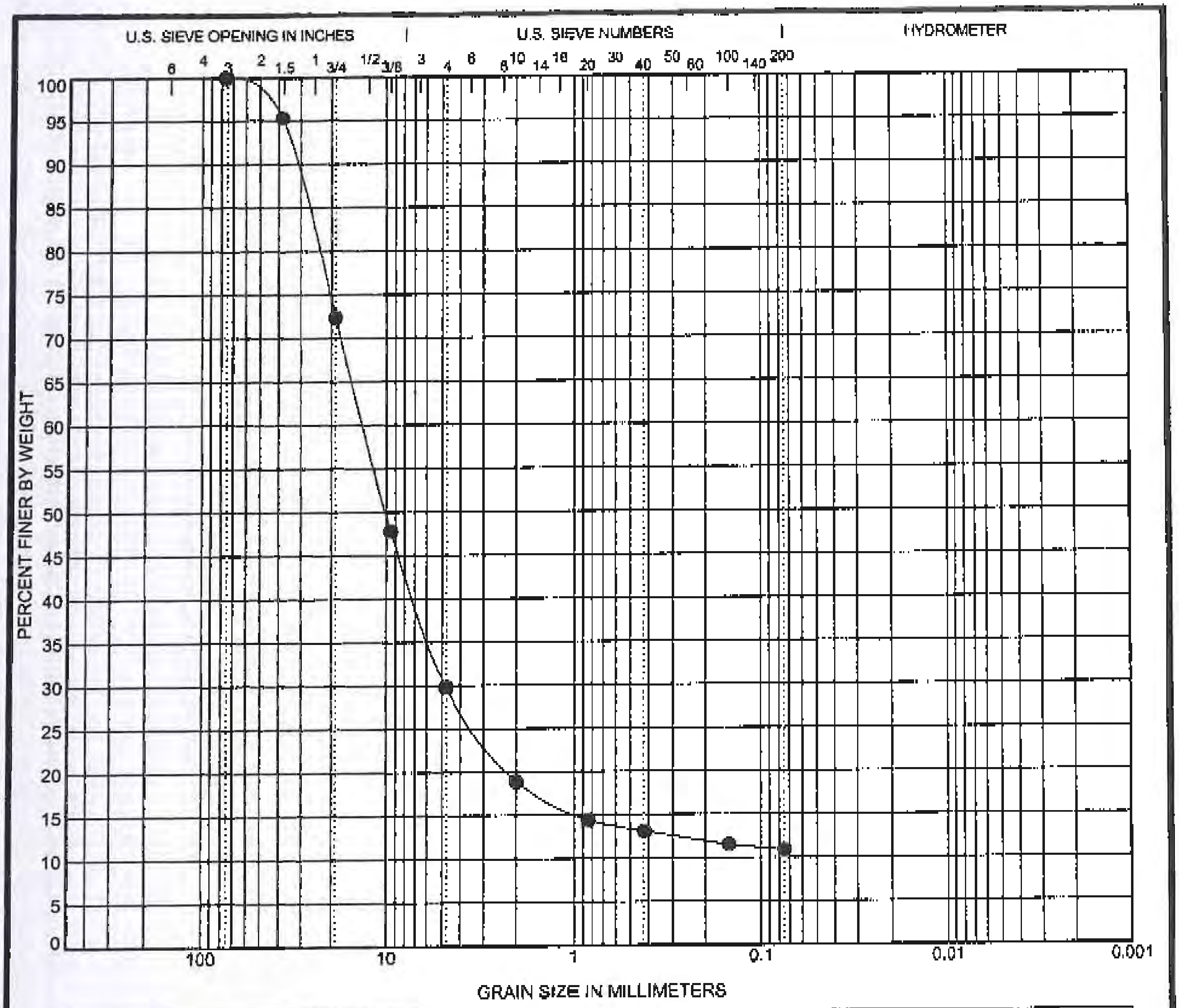
ASA09-051-00
Figure 10

pH SERIES CURVE

Alzan Creek Bridge (CIMS)



ASA09-051-00
Figure 11



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	LL	PL	PI	Cc	Cu
● **Bulk** 0.0					64.09	500.46

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **Bulk** 0.0	76.2	13.404	4.797		70.1	18.9	10.9	

RK GRAIN SIZE AS409-051-00.GPJ RKCI.GDT 8/20/09

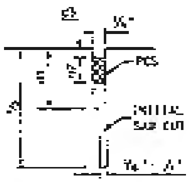
Raba Kistner

12821 W. Golden Lane
San Antonio, Texas 78249
(210) 699-9090
(210) 699-6426 fax
www.rkci.com

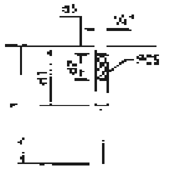
GRAIN SIZE DISTRIBUTION

Alazan Creek Bridge (CIMS)
San Antonio, Texas

FIGURE 12

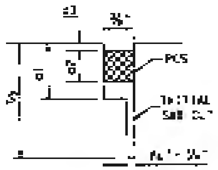


SAWED
LONGITUDINAL JOINT

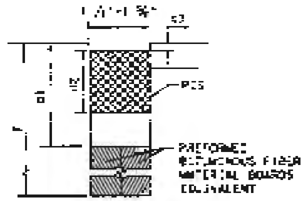


LONGITUDINAL
CONSTRUCTION JOINT

LONGITUDINAL JOINT SEALS



SAWED
CONTRACTION JOINT



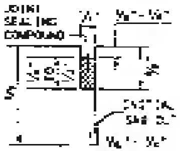
FORMED
FORMED EXPANSION JOINT

TRANSVERSE JOINT SEALS

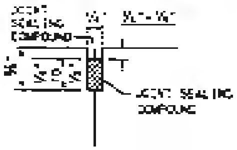
METHOD A: PREFORMED COMPRESSION SEALS (PCS)
(CLASS 6 PREFORMED JOINT SEALANT)

GENERAL NOTES FOR METHOD "A"

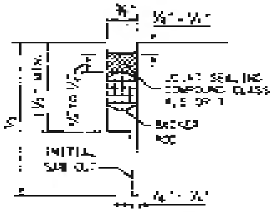
1. UNLESS OTHERWISE SHOWN IN THE PLANS, EITHER METHOD "A" OR METHOD "B" MAY BE USED.
2. THE LOCATION OF JOINTS SHALL BE AS SHOWN ELSEWHERE IN THE PLANS.
3. DIMENSIONS d1, d2, AND d3 SHALL BE IN ACCORDANCE WITH THE PREFORMED COMPRESSION SEAL MANUFACTURERS RECOMMENDATION.
4. THE JOINT RESERVOIR FOR SEALANT SHALL BE SAWED UNLESS OTHERWISE SHOWN ON THE PLANS FOR THE LONGITUDINAL AND TRANSVERSE CONSTRUCTION AND THE TWO SAWED JOINTS.
5. THE JOINTS SHALL BE CLEANED IN ACCORDANCE WITH THE ITEM 438 AND PRIOR TO BEGINNING OPERATIONS, THE CONTRACTOR SHALL SUBMIT A STATEMENT FROM THE SEALANT MANUFACTURER SHOWING THE RECOMMENDED EQUIPMENT AND INSTALLATION PROCEDURES TO BE USED.
6. THE SAW CUT FOR THE LONGITUDINAL JOINT SHALL BE ONE FOURTH THE SLAB THICKNESS WHEN CRUSHED LIMESTONE IS USED AS THE COARSE AGGREGATE.



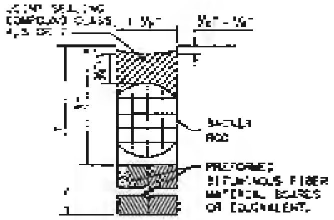
SAWED
LONGITUDINAL JOINT



LONGITUDINAL OR TRANSVERSE
CONSTRUCTION JOINT



TRANSVERSE SAWED
CONTRACTION JOINT



TRANSVERSE FORMED
EXPANSION JOINT

METHOD B: JOINT SEALING COMPOUND

GENERAL NOTES FOR METHOD "B"

1. UNLESS OTHERWISE SHOWN IN THE PLANS, EITHER METHOD "A" OR METHOD "B" MAY BE USED.
2. THE LOCATION OF JOINTS SHALL BE AS SHOWN ELSEWHERE IN THE PLANS.
3. THE ENGINEER SHALL SELECT A TARGET PLACEMENT THICKNESS FOR THE SEALANT DETAILS WHICH SHOW RANGES IN THICKNESS. THE TARGET THICKNESS WILL NORMALLY BE THE MIDPOINT OF THE RANGE.
4. THE JOINT RESERVOIR FOR SEALANT SHALL BE SAWED UNLESS OTHERWISE SHOWN ON THE PLANS FOR THE LONGITUDINAL AND TRANSVERSE CONSTRUCTION AND THE TWO SAWED JOINTS.
5. THE JOINTS SHALL BE CLEANED IN ACCORDANCE WITH THE ITEM 438 AND PRIOR TO BEGINNING OPERATIONS, THE CONTRACTOR SHALL SUBMIT A STATEMENT FROM THE SEALANT MANUFACTURER SHOWING THE RECOMMENDED EQUIPMENT AND INSTALLATION PROCEDURES TO BE USED.
6. THE SAW CUT FOR THE LONGITUDINAL JOINT SHALL BE ONE FOURTH THE SLAB THICKNESS WHEN CRUSHED LIMESTONE IS USED AS THE COARSE AGGREGATE.

PROJECT No. ASA09-051-00
Figure 13A

Texas Department of Transportation
Construction Division (Pavement)

CONCRETE PAVING DETAILS
JOINT SEALS

JS-94

© TxDOT SEPTEMBER 1994
DN: LJB
CK: LJB
DW: BGD
CK: CLC

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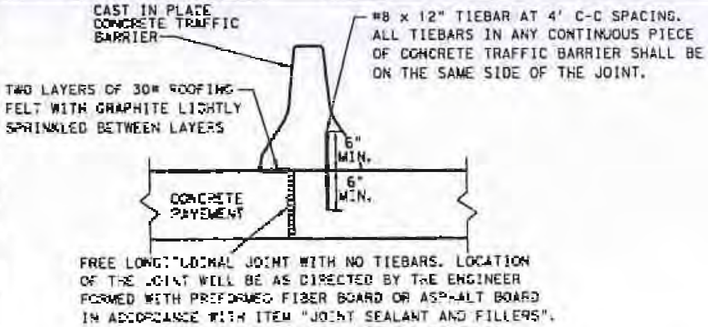
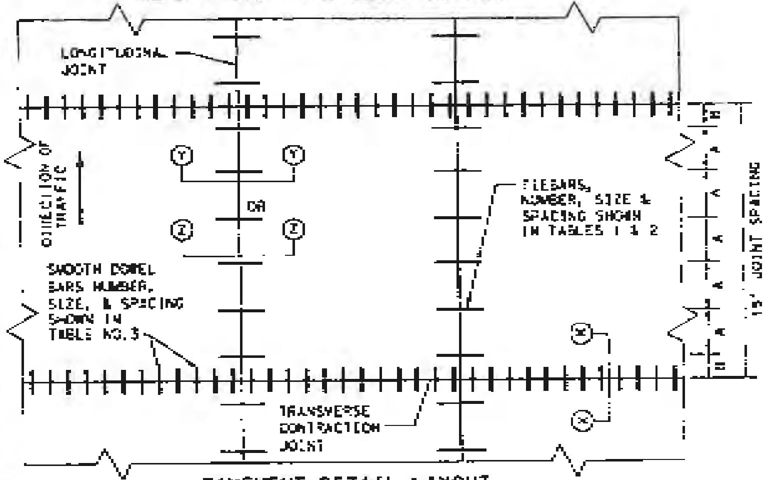


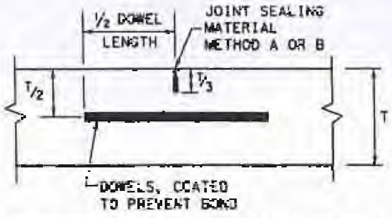
FREE LONGITUDINAL JOINT DETAIL



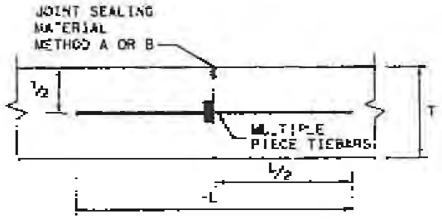
PAVEMENT DETAIL LAYOUT

TABLE NO. 1 TIEBARS REQUIRED FOR LONGITUDINAL JOINT JOINTS FOR EACH 15' SLAB						
ASTM A-615 OR A-616 GRADE 60 STRAIGHT OR MULTIPLE PIECE REINFORCING TIEBARS		CONCRETE SLAB THICKNESS	DISTANCE FROM THE LONGITUDINAL JOINT TO THE NEAREST LONGITUDINAL FREE EDGE			
			< OR =16'	< OR =24'	< OR =36'	< OR =50'
BAR LENGTH "L" INCHES	BAR SIZE	"T" INCHES	REQUIRED NO. OF BARS	REQUIRED NO. OF BARS	REQUIRED NO. OF BARS	REQUIRED NO. OF BARS
42	#5 SHT	8	5	5	6	7
		9	5	4	7	10
		10	5	4	7	11
		11	5	4	8	12
		12	5	6	9	13
		13	5	8	9	13
		14	6	7	10	14
		15	4	8	1	18
50	#6 SHT	8	4	7	3	4
		9	5	7	3	7
		10	5	5	4	6
		11	5	5	6	8
		12	5	3	6	9
		13	5	3	7	10
		14	5	5	7	13
		15	5	4	8	11

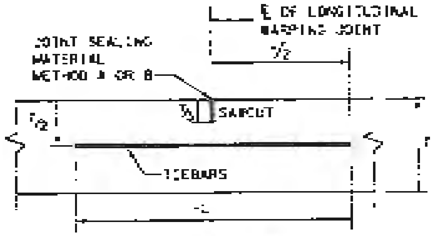
THE DISTANCE TO THE FREE EDGE WILL BE DETERMINED BY THE ENGINEER AND THE DISTANCE WILL BE BASED ON THE NOMINAL WIDTHS OF THE LANES AND SHOULDERS PLUS ANY TIED RAMPS OR CONNECTING ROADWAYS.



TRANSVERSE CONTRACTION JOINT
SECTION X-X



LONGITUDINAL CONSTRUCTION JOINT
SECTION Y-Y



LONGITUDINAL WARPING JOINT
SECTION Z-Z

TABLE NO. 2 TIEBAR SPACINGS		
SPACING REQUIREMENT FOR 15' SLAB FOR REQUIRED NUMBER OF BARS		
REQUIRED NO. OF BARS	REGULAR SPACING "A" INCHES	FIRST AT JOINT "B" INCHES
5	36	18
6	30	15
7	25	12
8	21	10.5
9	19	10
10	16	8
11	15	7.5
12	13	6.5
13	12	6

TABLE NO. 3 DOWELS REQUIREMENTS		
T, IN.	DOWELS (SMOOTH BARS)	
	SIZE AND LENGTH	AVERAGE SPACING (INCHES)
8	1" x 18"	12
9	1 1/8" x 18"	12
10	1 1/4" x 18"	12
11	1 3/8" x 18"	12
12	1 1/2" x 18"	12
13	1 3/4" x 18"	12
14	1 3/4" x 18"	12
15	1 3/4" x 18"	12

GENERAL NOTES

1. CONCRETE SLABS WIDER THAN 100' WITHOUT A FREE JOINT, ARE NOT COVERED BY THIS STANDARD.
2. FOR FURTHER INFORMATION REGARDING THE PLACEMENT OF CONCRETE AND LOAD TRANSFER DEVICES REFER TO THE GOVERNING SPECIFICATIONS FOR "CONCRETE PAVEMENT" AND "REINFORCING STEEL."
3. DETAILS FOR PAVEMENT WIDTH, PAVEMENT THICKNESS, AND CROWN CROSS SLOPE SHALL BE AS SHOWN ELSEWHERE IN THE PLANS.
4. THE DETAIL FOR THE JOINT SEALANT AND RESERVOIR WILL BE SHOWN IN CONCRETE PAVEMENT DETAIL, JOINT SEALANT STANDARD (JS-94).
5. PAVEMENT WIDTHS IN EXCESS OF 16' SHALL BE PROVIDED WITH A LONGITUDINAL JOINT (SECTION Z-Z OR Y-Y). THESE JOINTS SHALL BE LOCATED WITHIN 6" OF THE LANE LINES UNLESS SHOWN ELSEWHERE ON THE PLANS.
6. THE JOINT BETWEEN OUTSIDE LANE AND SHOULDER SHALL BE A LONGITUDINAL WARPING JOINT (SECTION Z-Z) UNLESS OTHERWISE SHOWN IN THE PLANS.
7. THE SPACING BETWEEN TRANSVERSE JOINTS SHALL BE 15 FEET UNLESS OTHERWISE SHOWN IN THE PLANS.
8. WHERE A MONOLITHIC CURB IS SPECIFIED, THE JOINT IN THE CURB SHALL COINCIDE WITH PAVEMENT JOINTS AND MAY BE FORMED BY ANY MEANS APPROVED BY THE ENGINEER.
9. TRANSVERSE CONSTRUCTION JOINTS MAY BE FORMED BY USE OF METAL OR WOOD FORMS EQUAL IN DEPTH TO THE NOMINAL DEPTH OF THE PAVEMENT, OR BY METHODS APPROVED BY THE ENGINEER.
10. THE ENGINEER WILL ADJUST THE REQUIRED NUMBER OF TIEBARS FOR SLABS SHORTER OR LONGER THAN 15'. SPACING "B" WILL BE ADJUSTED TO MAINTAIN A MINIMUM CLEARANCE OF 3" BETWEEN THE TIEBARS AND THE DOWEL BARS AT THE TRANSVERSE JOINT AND THE "A" SPACING WILL REMAIN AS REQUIRED FOR THE PAVEMENT SLAB WIDTH.
11. MULTIPLE PIECE TIEBARS SHALL BE USED AT LONGITUDINAL CONSTRUCTION JOINTS UNLESS OTHERWISE SPECIFIED IN THE PLANS.
12. THE SAW CUT FOR LONGITUDINAL WARPING AND THE TRANSVERSE CONSTRUCTION JOINTS MAY BE ONE FOURTH THE SLAB THICKNESS WHEN CRUSHED LIMESTONE IS USED AS THE COARSE AGGREGATE.

PROJECT No. ASA09-051-00
Figure 13B

Texas Department of Transportation
Construction Division Standard

CONCRETE PAVEMENT DETAILS
CONTRACTION DESIGN
T-8 THROUGH 15 INCHES
CPCD-94

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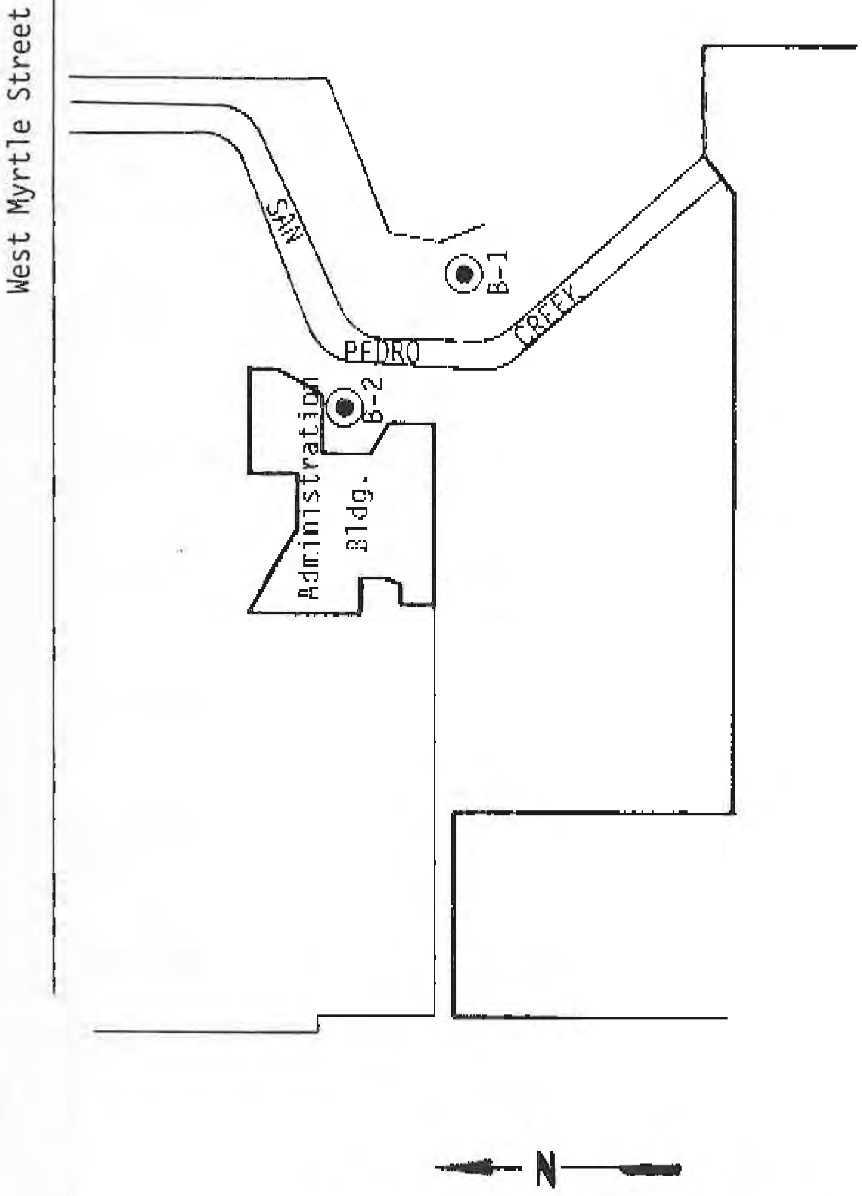
REPORT 8



PLAN OF BORINGS

0 100 200
scale feet

Raba-Kistner Consultants Inc

PROJ. NO. SA0788-0052

PLATE 1

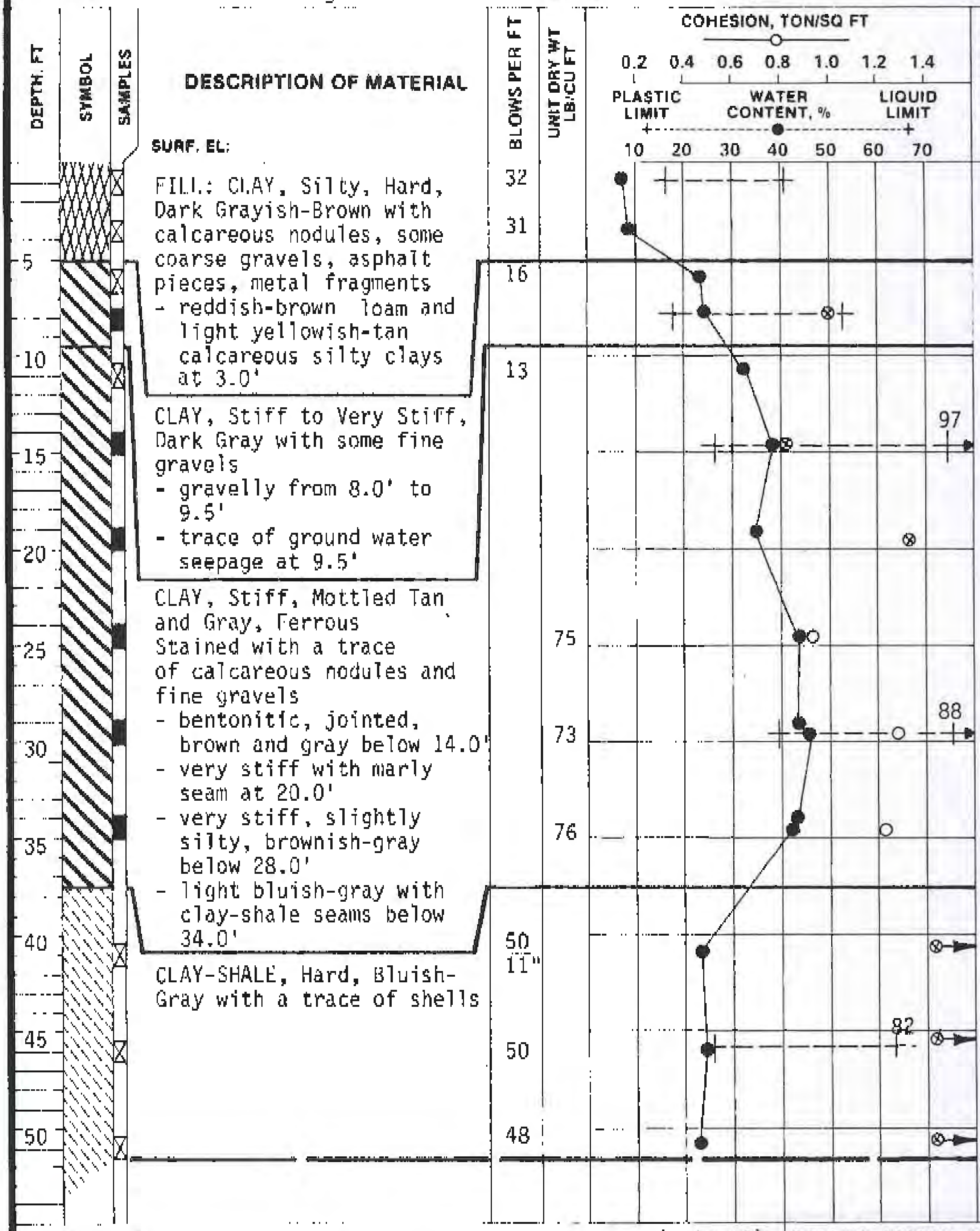
LOG OF BORING NO. B-1

VIA PEDESTRIAN BRIDGE
SAN ANTONIO, TEXAS

Raba-Kistner
Consultants, Inc.

TYPE: Hollow Stem Auger

LOCATION: See Plate 1



DESCRIPTION OF MATERIAL

SURF. EL:

FILL: CLAY, Silty, Hard, Dark Grayish-Brown with calcareous nodules, some coarse gravels, asphalt pieces, metal fragments
- reddish-brown loam and light yellowish-tan calcareous silty clays at 3.0'

CLAY, Stiff to Very Stiff, Dark Gray with some fine gravels
- gravelly from 8.0' to 9.5'
- trace of ground water seepage at 9.5'

CLAY, Stiff, Mottled Tan and Gray, Ferrous Stained with a trace of calcareous nodules and fine gravels
- bentonitic, jointed, brown and gray below 14.0'
- very stiff with marly seam at 20.0'
- very stiff, slightly silty, brownish-gray below 28.0'
- light bluish-gray with clay-shale seams below 34.0'

CLAY-SHALE, Hard, Bluish-Gray with a trace of shells

COMPLETION DEPTH: 51.5'
DATE: 4-19-88

DEPTH TO WATER IN BORING: None Observed (4-19-88)
38.6' (4-21-88)(Bottom @ 46.0")

PROJ. NO. SA0288-0052
PLATE 2

NOTE: These logs should not be used separately from the project report.

RABA & ASSOCIATES CONSULTING ENGINEERS INC.

LOG OF BORING NO. 2

OFFICE FACILITY
SAN ANTONIO TRANSIT AUTHORITY

TYPE: 3" Shelby tube

LOCATION: See Plate 1

DEPTH, FT | SYMBOL | SAMPLES | DESCRIPTION OF MATERIAL | BLOWS PER FT | UNIT DRY WT LB/CU FT | ELEVATION, FT

SURF. EL:

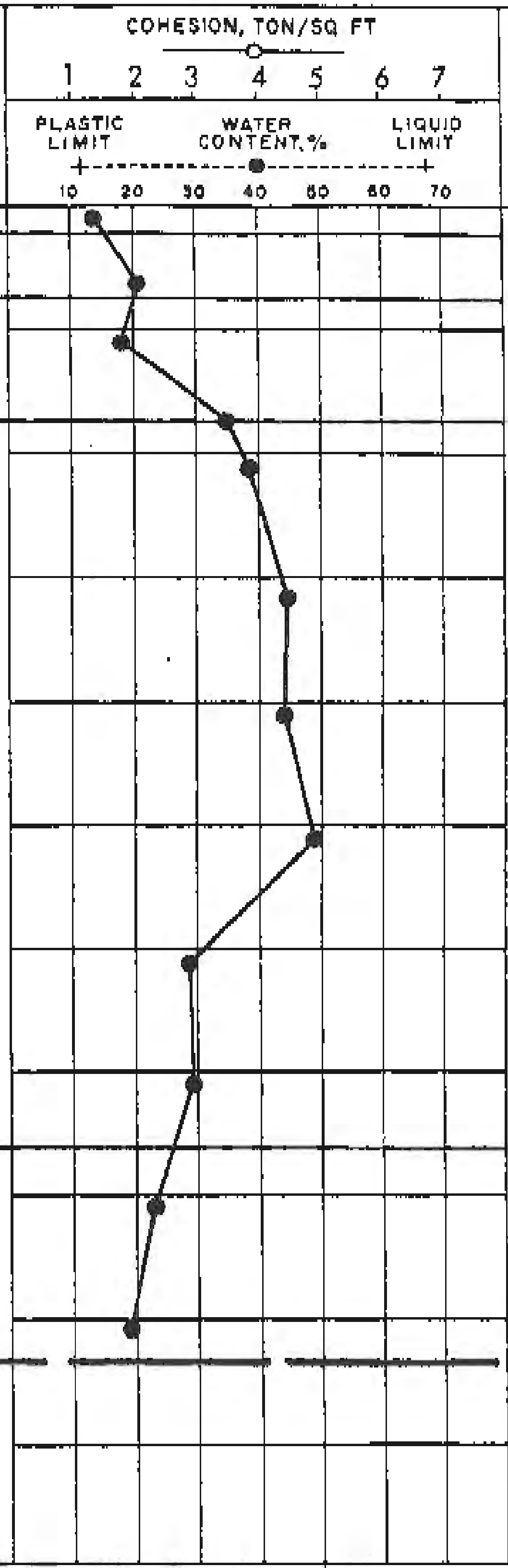
Brown Silty Clay with very fine gravel

Dark Gray Silty Clay

Very Stiff Gray Clay with caliche and occasional tan clay seams
- fine gravel and clay layer at 6' to 7.5'

Stiff Tan and Gray Clay with occasional caliche and organic deposits
- clays darker in color with a jointed structure below 15'
- bentonitic seams from 15' to 24.5'
- bentonitic layer at 24.5' to 27'
- gypsum seams below 29'
- occasional blue clay-shale seams below 34.5'

Very Stiff Blue Clay-Shale
- occasional tan clay seams at 38' to 41'
- occasional pyrite nodules at 45' to 46'



Depths: 5 10 15 20 25 30 35 40 45 50

COMPLETION DEPTH: 46.5'
DATE: 3/15/72

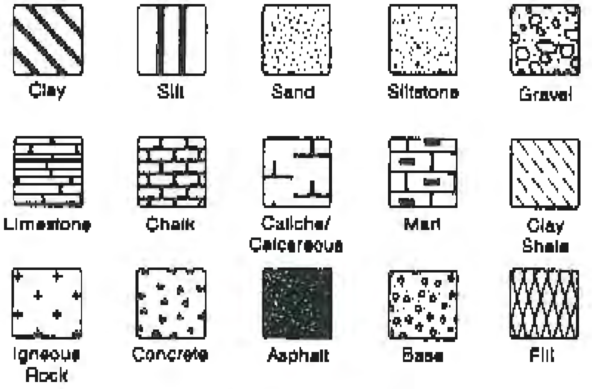
DEPTH TO WATER IN BORING: 6.3'
DATE: 3/22/72

PLATE 3

SYMBOLS AND TERMS USED ON BORING LOGS

SOIL OR ROCK TYPES

(shown in symbols column)



(Predominate Soil Types Shown Heavy)

SAMPLER TYPES

(shown in sample column)

STRENGTH TEST RESULTS

● - Estimated Strength
⬡ - Torvane
○ - Unconfined Compression

TRIAXIAL COMPRESSION

△ - Unconsolidated-undrained
□ - Consolidated-undrained

C - Cohesion (Total)
Φ - Angle of Internal Friction (Total)

C' - Cohesion (Effective)
Φ' - Angle of Internal Friction (Effective)

NOTE:

Values symbolized on boring logs represent shear strengths unless otherwise noted.

TERMS DESCRIBING CONSISTENCY, CONDITION OR TEXTURE

Terms used in this report to describe soils with regard to their consistency or condition are in general accordance with the discussion presented in Article 45 of SOIL MECHANICS IN ENGINEERING PRACTICE, Terzaghi and Peck, John Wiley & Sons, Inc. 1967, using the most reliable information available from the field and laboratory investigations. Terms used for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in Technical Memorandum No. 3-357, Waterways Experiment Station, March 1953.

TERMS CHARACTERIZING SOIL STRUCTURE

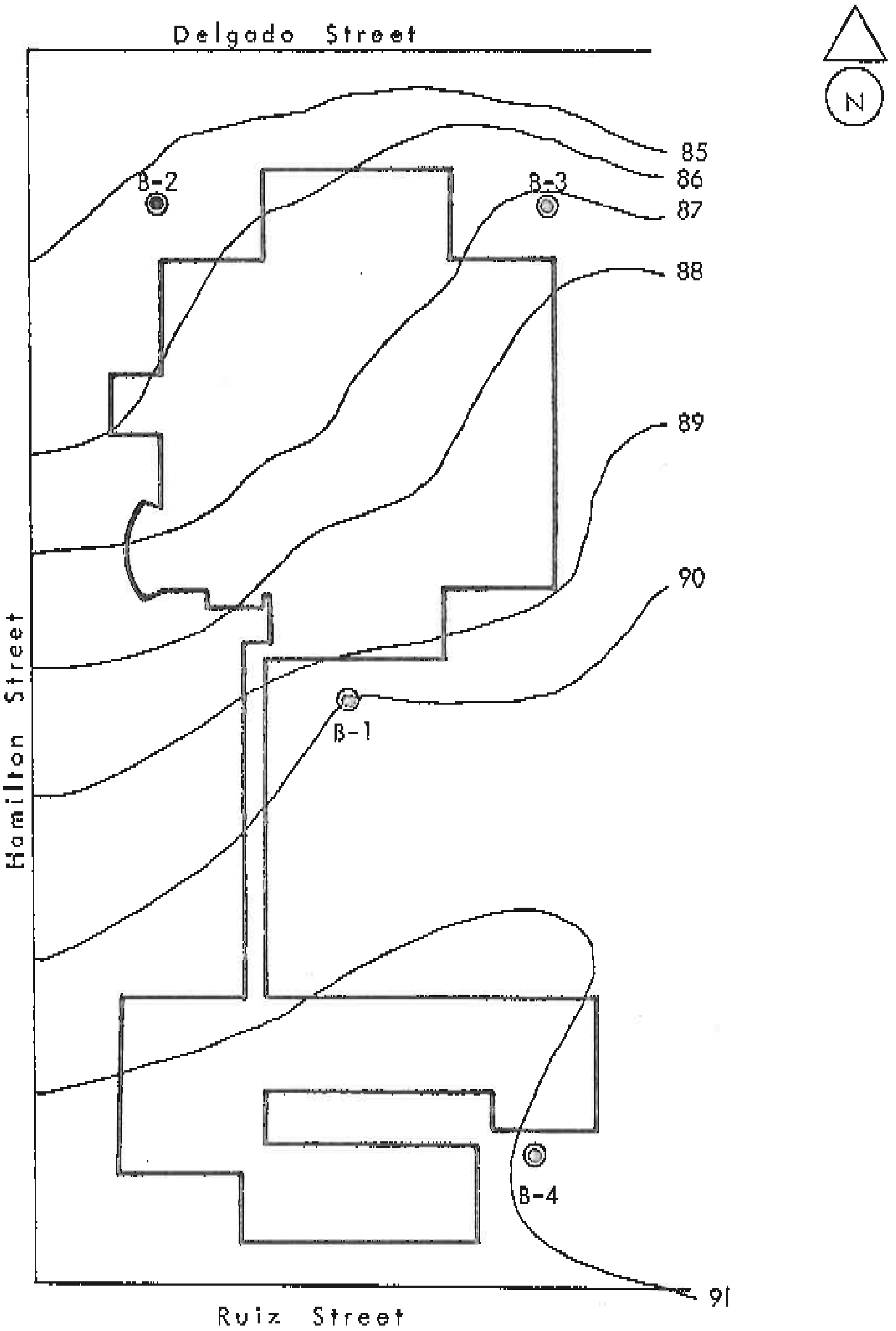
Slickensided	- having inclined planes of weakness that are slick and glossy in appearance.
Fissured	- containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.
Laminated	- composed of thin layers of varying color and texture.
Interbedded	- composed of alternate layers of different soil types.
Calcareous	- containing appreciable quantities of calcium carbonate.
Well graded	- having wide range in grain sizes and substantial amounts of all intermediate particle sizes.
Poorly graded	- predominantly of one grain size, or having a range of sizes with some intermediate size missing.

TERMS DESCRIBING CONSISTENCY OR CONDITION

RELATIVE DENSITY		COHESIVE STRENGTH			PLASTICITY	
Penetration Resistance, blows per foot	Relative Density	Penetration Resistance, blows per foot	Consistency	Cohesion, TSF	Plasticity Index	Degree of Plasticity
0-4	Very Loose	0-2	Very Soft	0-0.125	0-5	None
4-10	Loose	2-4	Soft	0.125-0.25	5-10	Low
10-30	Medium Dense	4-8	Firm	0.25-0.5	10-20	Moderate
30-50	Dense	8-15	Stiff	0.5-1.0	20-40	Plastic
> 50	Very Dense	15-30	Very Stiff	1.0-2.0	> 40	Highly Plastic
		> 30	Hard	> 2.0		

NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above because of planes of weakness or cracks in the soil. The consistency ratings of such soils are based on penetrometer readings.

REPORT 9



PLAN OF BORINGS
Scale: 1" = 100'

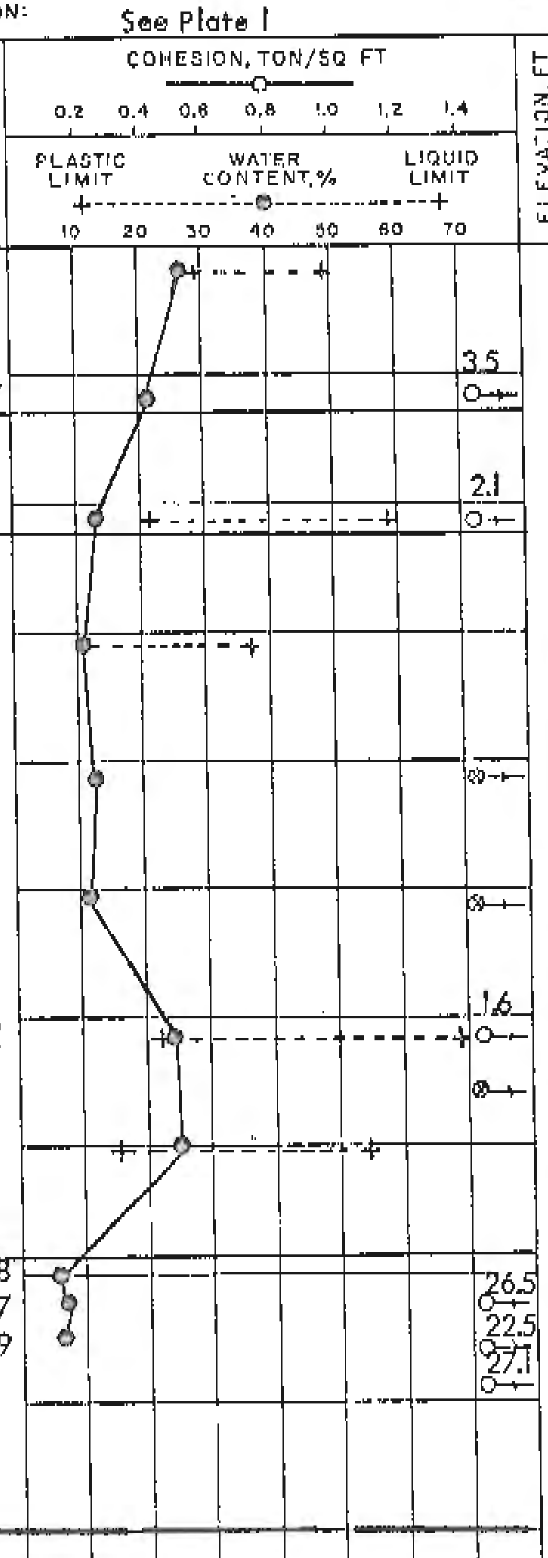
LOG OF BORING NO. 1
IRVING JUNIOR HIGH SCHOOL
SAN ANTONIO, TEXAS

TYPE: 3" Shelby tube
2" Split-spoon & NX Core Barrel

LOCATION: See Plate 1

SURF. EL: 690.0 ± 0.5

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT
0–6	Stiff Dark Gray Clay with some gravel		107
6–11	Very Stiff Tan and Gray Clay		118
11–38.5	Very Stiff Tan and Gray Marly Clay - 2" clay seam at 16' - 4" clay seam at 24' - clay seams from 28.5 to 32' - clay seams at 34 to 36'	50/6"	101
38.5–50	Hard Blue Gray Limy Shale - limestone seams 42 to 46'		148 147 139



COMPLETION DEPTH: 50'
DATE: 7/1/71

DEPTH TO WATER IN BORING: 16.3'
DATE: 7/2/71

PLATE 2

LOG OF BORING NO. 2

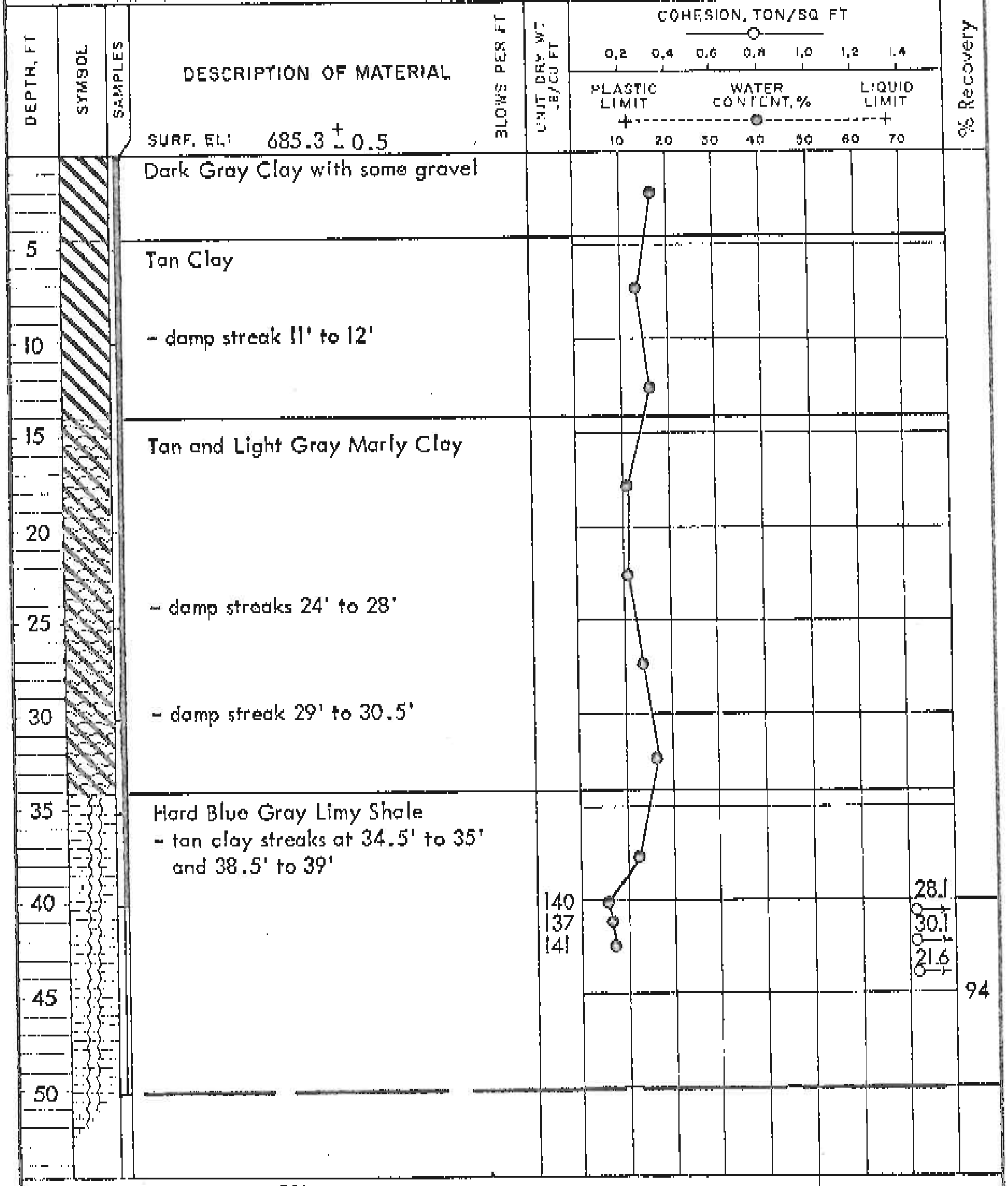
IRVING JUNIOR HIGH SCHOOL
SAN ANTONIO, TEXAS

RABA & ASSOCIATES
CONSULTING ENGINEERS INC.

TYPE: NX Core Barrel

LOCATION: See Plate I

SURF. EL: 685.3 ± 0.5



Dark Gray Clay with some gravel

Tan Clay

- damp streak 11' to 12'

Tan and Light Gray Marly Clay

- damp streaks 24' to 28'

- damp streak 29' to 30.5'

Hard Blue Gray Limy Shale

- tan clay streaks at 34.5' to 35' and 38.5' to 39'

COMPLETION DEPTH: 50'
DATE: 6/30/71

DEPTH TO WATER IN BORING: 17.7'

DATE: 6/31/71

PLATE 3

LOG OF BORING NO. 3

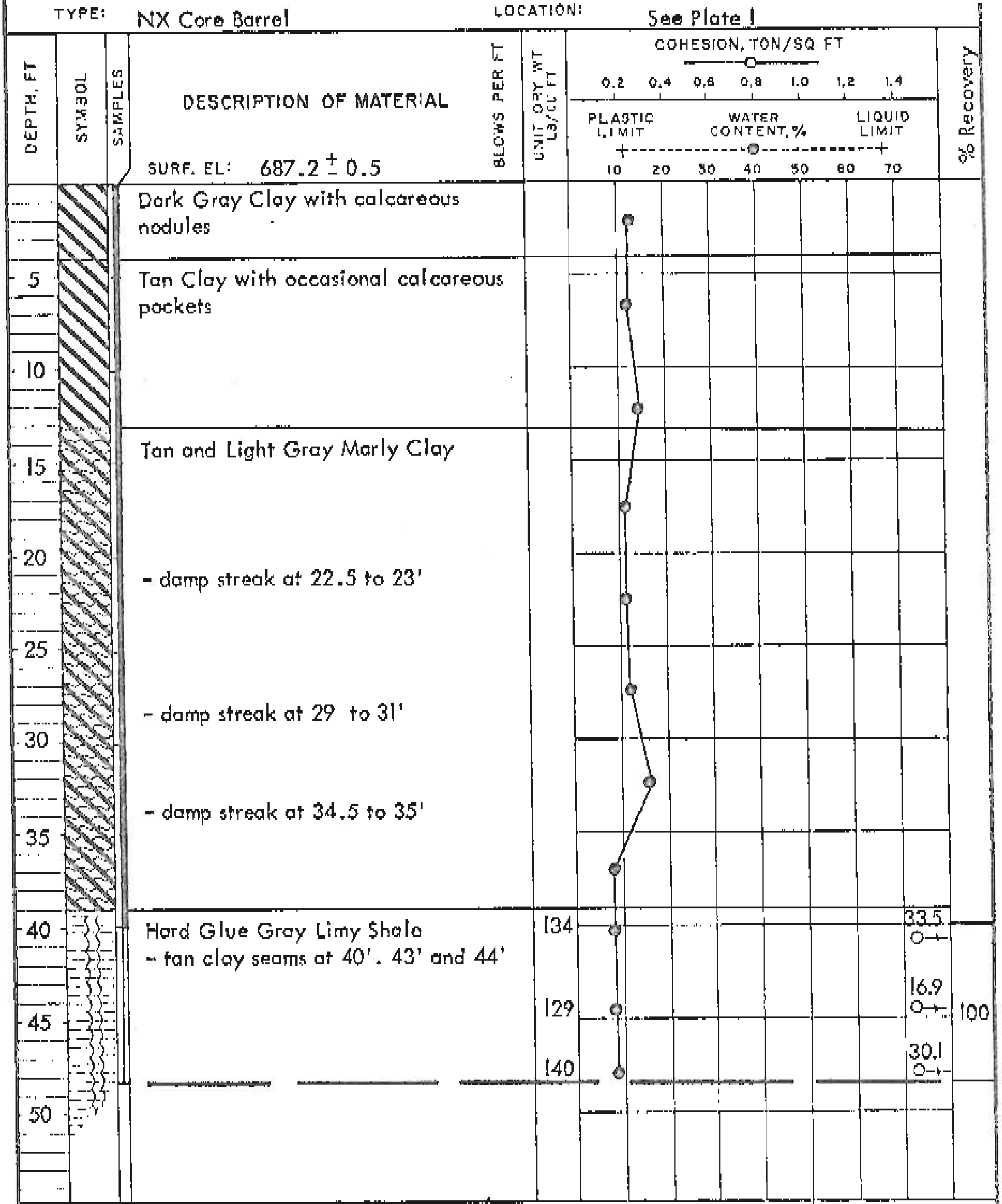
IRVING JUNIOR HIGH SCHOOL
SAN ANTONIO, TEXAS

RABA & ASSOCIATES CONSULTING ENGINEERS INC.

TYPE: NX Core Barrel

LOCATION: See Plate I

SURF. EL: 687.2 ± 0.5



Dark Gray Clay with calcareous nodules

Tan Clay with occasional calcareous pockets

Tan and Light Gray Marly Clay
- damp streak at 22.5 to 23'
- damp streak at 29 to 31'
- damp streak at 34.5 to 35'

Hard Glue Gray Limy Shale
- tan clay seams at 40', 43' and 44'

COMPLETION DEPTH: 48.5'
DATE: 6/30/71

DEPTH TO WATER IN BORING: 9.7'

DATE: 7/1/71

PLATE 4

LOG OF BORING NO. 4
IRVING JUNIOR HIGH SCHOOL
SAN ANTONIO, TEXAS

RABA
& ASSOCIATES
CONSULTING
ENGINEERS
INC.

TYPE: NX Core Barrel
LOCATION: See Plate I

DEPTH, FT | SYMBOL | SAMPLES | DESCRIPTION OF MATERIAL | BLOWS PER FT | UNIT DRY WT LB/CU FT | % Recovery

SURF. EL: 690.9 ± 0.5

Caliche Gravel Base

Dark Gray Clay

Tan and Gray Clay

Tan and Light Gray Marly Clay

- damp streaks 18 to 20'

- damp streaks 24 to 26'

- damp streak 31 to 32'

- damp streak 51 to 52'

- damp below 57'

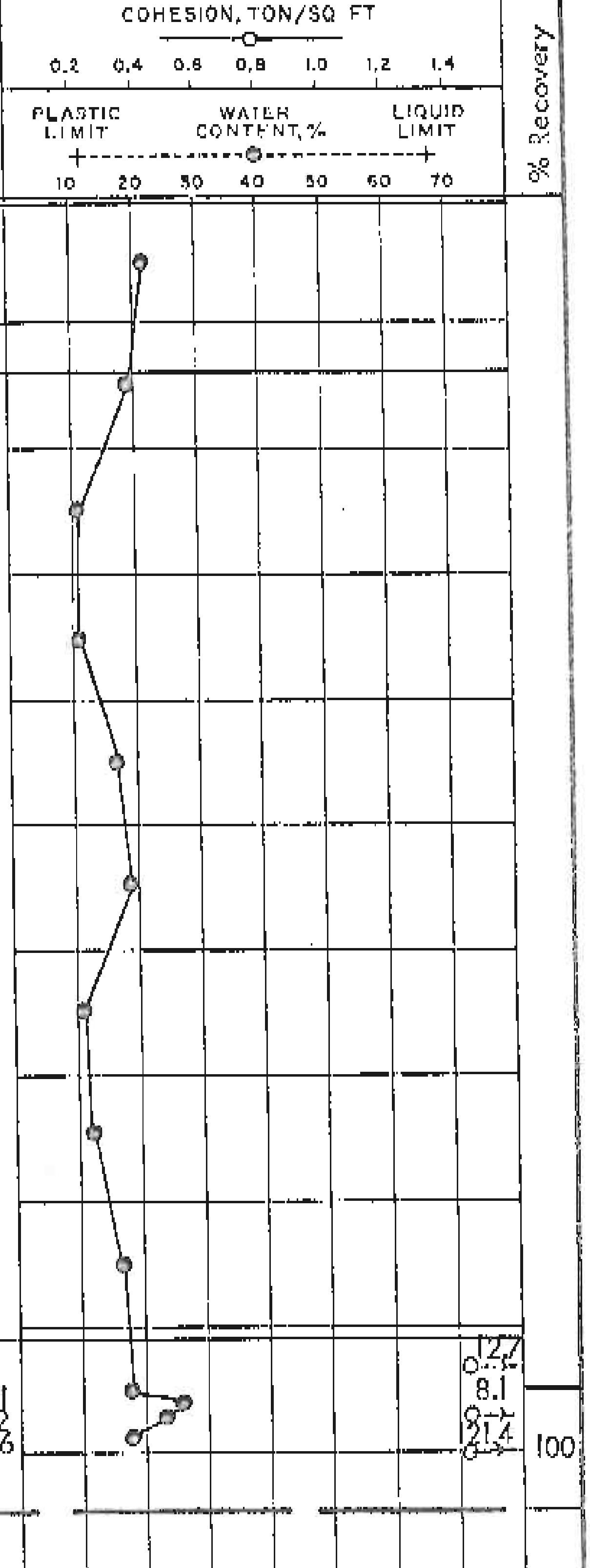
Hard Blue Gray Limy Shale

Unit dry wt: 101, 112, 126

% Recovery: 100

Depth scale: 5, 10, 15, 20, 25, 30, 40, 50, 60, 70

SCALE CHANGE

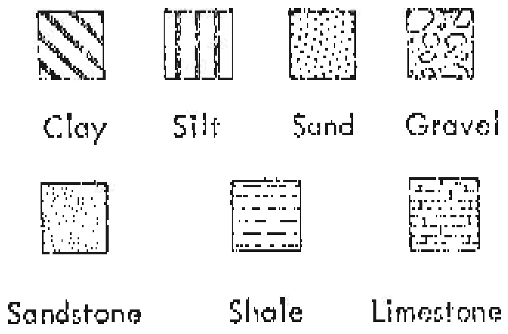


COMPLETION DEPTH: 75'
DATE: 7/1/71
DEPTH TO WATER IN BORING: 11.9'
DATE: 7/1/71
PLATE 5

SYMBOLS AND TERMS USED ON BORING LOGS

SOIL OR ROCK TYPES

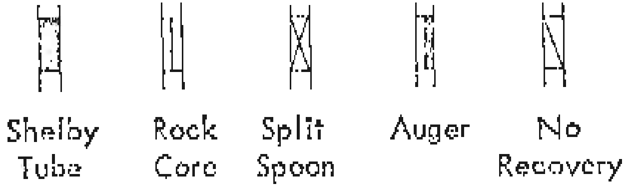
(shown in symbols column)



Predominate Soil Types Shown Heavy

SAMPLER TYPES

(shown in sample column)



STRENGTH TEST RESULTS

⊚ – Estimated Strength
○ – Unconfined Compression

TRIAXIAL COMPRESSION

(Single-Stage Tests)

△ – Unconsolidated-undrained
□ – Consolidated-undrained

(Multiple-Stage Tests)

c – Apparent Cohesion
φ – Apparent Angle of Internal Friction

NOTE:
Values symbolized on boring logs represent shear strengths unless otherwise noted.

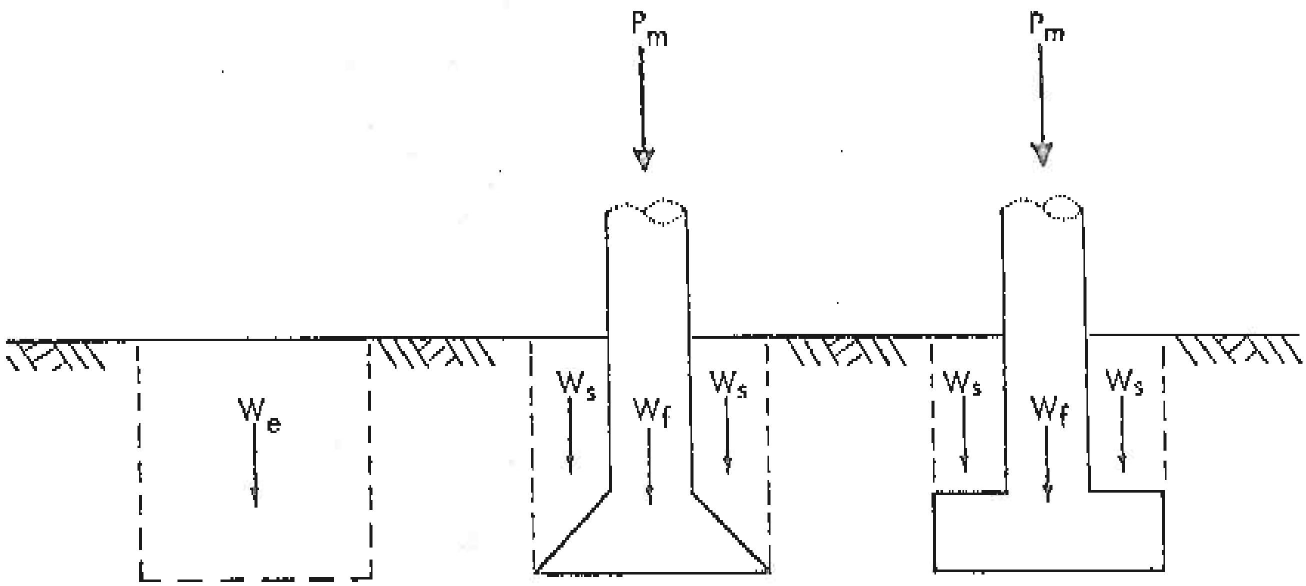
TERMS DESCRIBING CONSISTENCY, CONDITION OR TEXTURE

Terms used in this report to describe soils with regard to their consistency or condition are in general accordance with the discussion presented in Article 45 of SOIL MECHANICS IN ENGINEERING PRACTICE, Terzaghi and Peck, John Wiley & Sons, Inc., August, 1960, using the most reliable information available from the field and laboratory investigations. Terms used for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in Technical Memorandum No. 3-357, Waterways Experiment Station, March 1953.

TERMS CHARACTERIZING SOIL STRUCTURE

Slickensided - having inclined planes of weakness that are slick and glossy in appearance.
Fissured - containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.
Laminated - composed of thin layers of varying color and texture.
Interbedded - composed of alternate layers of different soil types.
Calcareous - containing appreciable quantities of calcium carbonate.
Well graded - having wide range in grain sizes and substantial amounts of all intermediate particle sizes.
Poorly graded - predominantly of one grain size, or having a range of sizes with some intermediate size missing.

COMPUTATION OF BEARING PRESSURES



Gross Bearing Pressure, p, for any column load is the total effective pressure acting on the base of the foundation.

$$p = \frac{1}{A} (P_m + W_s + W_f)$$

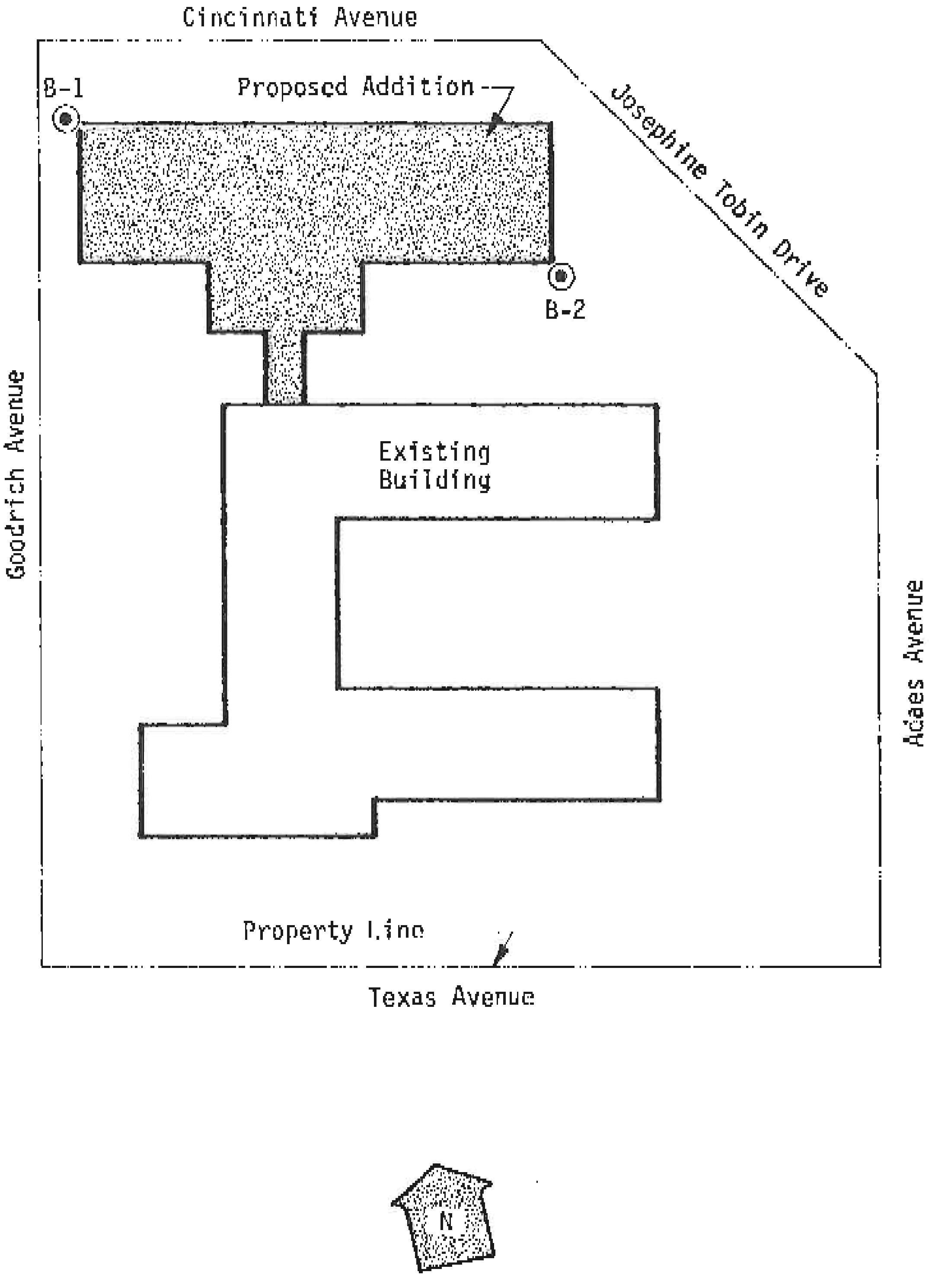
Net Bearing Pressure, p', for any column load is the difference between the gross bearing pressure acting on the base of the foundation and the soil pressure existing at that elevation prior to excavation.

$$p' = \frac{1}{A} (P_m + W_s + W_f - W_e)$$

Where:
A = Area of base of foundation
P_m = Maximum design column load
W_s = Weight of soil located above the foundation *
W_f = Weight of foundation
W_e = Weight of soil located above base of foundation prior to excavation *

* Position of water table must be considered in determining unit weights. Effective, or buoyant unit weights should be used below the highest expected water table.

REPORT 10



PLAN OF BORINGS

Scale: 1" = 30'

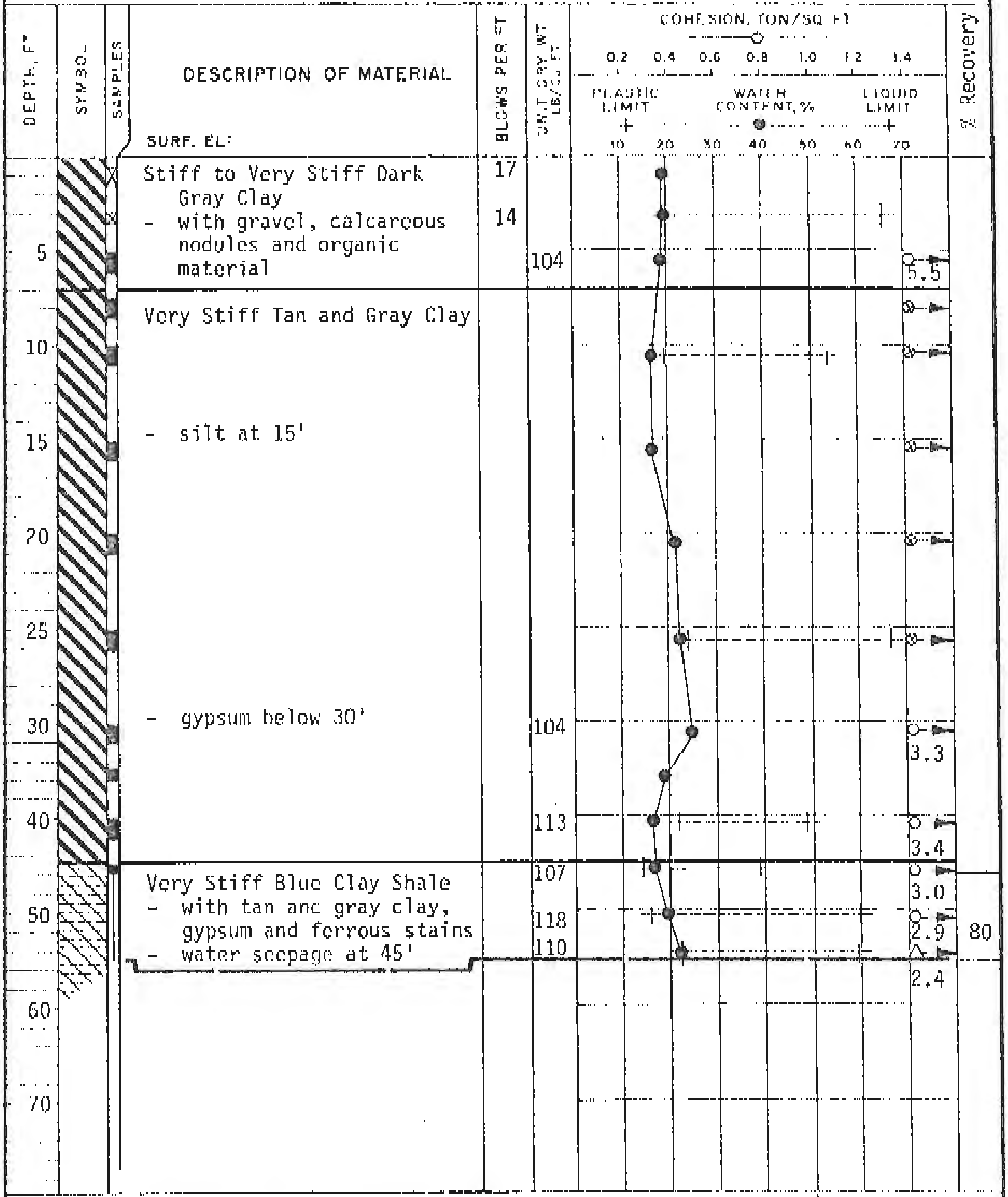
RABA AND ASSOCIATES CONSULTING ENGINEERS, INC.

LOG OF BORING NO. B-1

SARAH ROBERTS FRENCH NURSING HOME
SAN ANTONIO, TEXAS

RABA
& ASSOCIATES
CONSULTING
ENGINEERS
INC.

TYPE: NX Core Barrel, 2" Split Spoon & 3" Shelby Tube LOCATION: See Plate 1



Stiff to Very Stiff Dark Gray Clay
- with gravel, calcareous nodules and organic material

Very Stiff Tan and Gray Clay

- silt at 15'

- gypsum below 30'

Very Stiff Blue Clay Shale
- with tan and gray clay, gypsum and ferrous stains
- water seepage at 45'

*Note Change In Scale

COMPLETION DEPTH: 55'
DATE: 3/15/78

DEPTH TO WATER IN BORING: 45'

DATE: 3/15/78

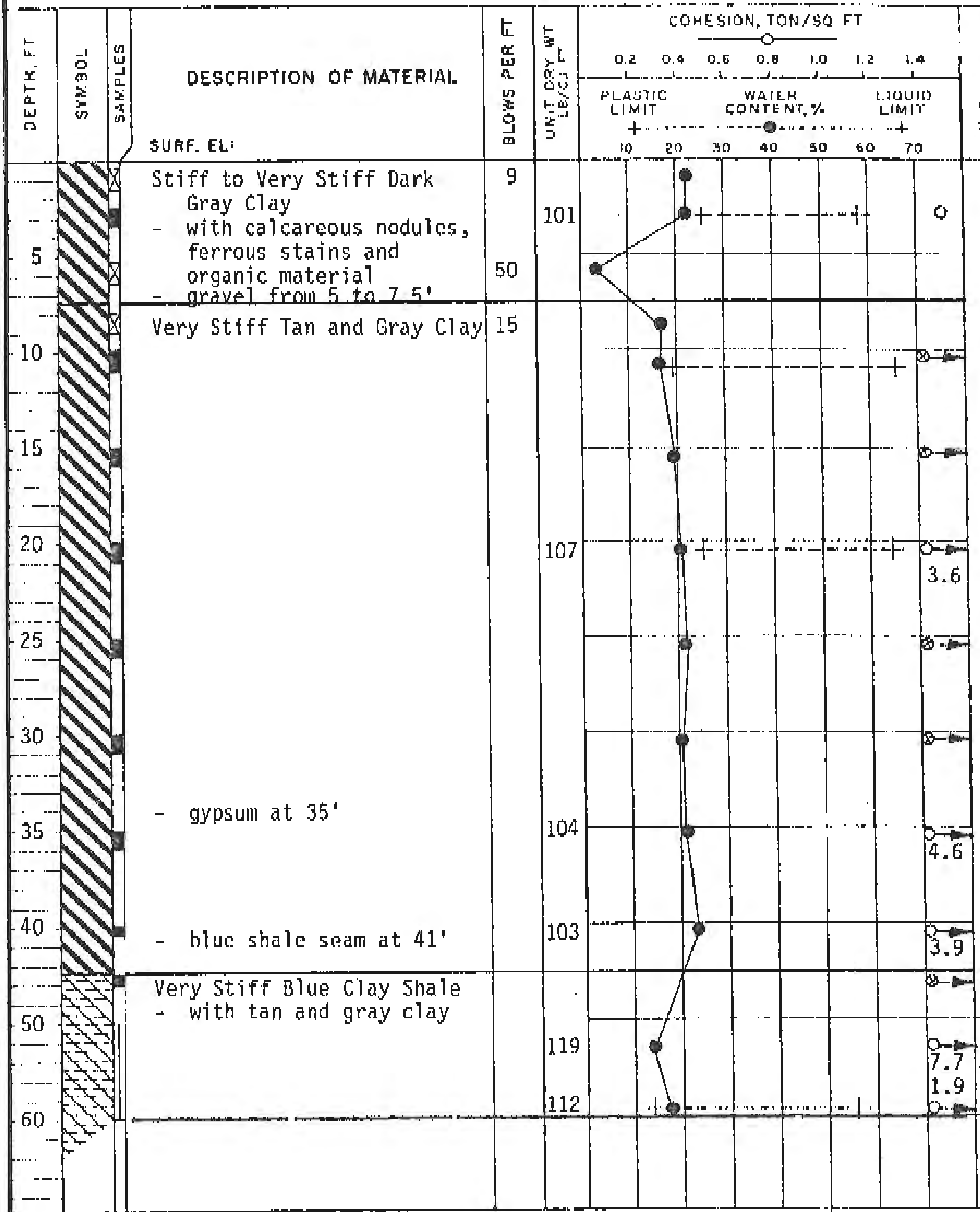
PLATE 2

LOG OF BORING NO. B-2

SARAH ROBERTS FRENCH NURSING HOME
SAN ANTONIO, TEXAS

RABA
& ASSOCIATES
CONSULTING
ENGINEERS
INC.

TYPE: NX Core Barrel,
2" Split Spoon & 3" Shelby Tube
LOCATION: See Plate I



DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT	% Recovery
Stiff to Very Stiff Dark Gray Clay	9			
- with calcareous nodules, ferrous stains and organic material		101		
- gravel from 5 to 7.5'	50			
Very Stiff Tan and Gray Clay	15			
		107	3.6	
- gypsum at 35'		104	4.6	
- blue shale seam at 41'		103	3.9	
Very Stiff Blue Clay Shale - with tan and gray clay		119	7.7 1.9	100
		112		

*Note Change In Scale

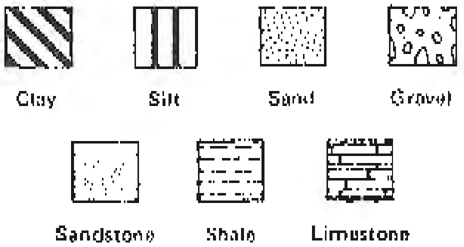
COMPLETION DEPTH: 60'
DATE: 3/16/78

DEPTH TO WATER IN BORING: None Observed DATE: 3/16/78

PLATE 3

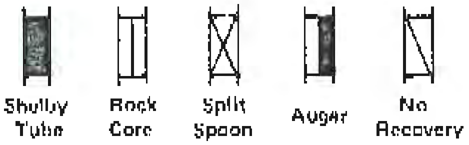
SYMBOLS AND TERMS USED ON BORING LOGS

SOIL OR ROCK TYPES
(shown in symbols column)



(Predominate Soil Types Shown Heavy)

SAMPLER TYPES
(shown in sample column)



STRENGTH TEST RESULTS

⊗ - Estimated Strength
◇ - Torvane
○ - Unconfined Compression

TRIAXIAL COMPRESSION

△ - Unconsolidated-undrained
□ - Consolidated-undrained

c - Cohesion (Total)
ϕ - Angle of Internal Friction (Total)

c' - Cohesion (Effective)
ϕ' - Angle of Internal Friction (Effective)

NOTE:

Values symbolized on boring logs represent shear strengths unless otherwise noted.

TERMS DESCRIBING CONSISTENCY, CONDITION OR TEXTURE

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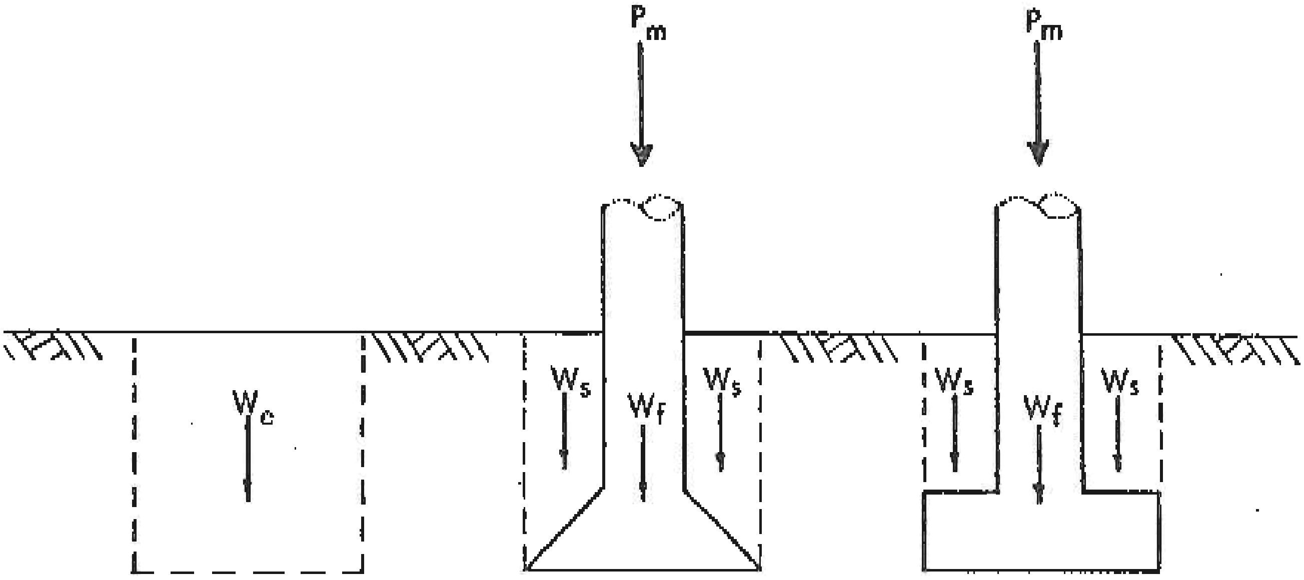
Calcareous	- containing appreciable quantities of calcium carbonate.
Well graded	- having wide range in grain sizes and substantial amounts of all intermediate particle sizes.
Poorly graded	- predominantly of one grain size, or having a range of sizes with some intermediate size missing.

TERMS DESCRIBING CONSISTENCY OR CONDITION

RELATIVE DENSITY		COHESIVE STRENGTH			PLASTICITY	
Penetration Resistance, blows per foot	Relative Density	Penetration Resistance, blows per foot	Consistency	Cohesion, TSF	Plasticity Index	Degree of Plasticity
0-4	Very Loose	0-2	Very Soft	0-0.125	0-5	None
4-10	Loose	2-4	Soft	0.125-0.25	5-10	Low
10-30	Medium Dense	4-8	Firm	0.25-0.5	10-20	Moderate
30-50	Dense	8-15	Stiff	0.5-1.0	20-40	Plastic
> 50	Very Dense	15-30	Very Stiff	1.0-2.0	> 40	Highly Plastic
		> 30	Hard	> 2.0		

NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above because of planes of weakness or cracks in the soil. The consistency ratings of such soils are based on penetrometer readings.

COMPUTATION OF BEARING PRESSURES



Gross Bearing Pressure, p, for any column load is the total effective pressure acting on the base of the foundation.

$$p = \frac{1}{A}(P_m + W_s + W_f)$$

Net Bearing Pressure, p', for any column load is the difference between the gross bearing pressure acting on the base of the foundation and the soil pressure existing at that elevation prior to excavation.

$$p' = \frac{1}{A}(P_m + W_s + W_f - W_e)$$

Where: A = Area of base of foundation
P_m = Maximum design column load
W_s = Weight of soil located above the foundation *
W_f = Weight of foundation
W_e = Weight of soil located above base of foundation prior to excavation *

* Position of water table must be considered in determining unit weights. Effective, or buoyant unit weights should be used below the highest expected water table.

LIME SLURRY PRESSURE INJECTION SPECIFICATIONS

FOR THE

INFLATABLE PACKER SYSTEM

SCOPE: The work consists of application of lime slurry into the ground at specified intervals within specified areas of the project.

EQUIPMENT: Equipment shall be suitable for the work, as approved by the Geotechnical Engineers. Equipment shall be constructed to provide a positive seal for preventing the slurry from flowing out onto the ground and shall have controls and gages for setting of pressure and determination of pressure.

a. Packers of an acceptable type and length with a minimum diameter of 4 inches shall be utilized by the contractor to prevent slurry from flowing out onto the ground surface.

b. Mixer tanks shall be approved by the Geotechnical Engineers and shall be continuously agitated to insure uniformity of mixture.

LIME SLURRY:

a. The lime slurry shall be a pumpable suspension of hydrated lime in water. The water or liquid portion of the slurry shall not contain dissolved material in sufficient quantity and/or nature injurious or objectionable for the purpose intended. The solids portion of the mixture, when considered on the basis of "solids content", shall consist principally of hydrated lime of a quality and fineness sufficient to meet THD Item 264, Type A as to chemical composition and residue.

b. Proportion lime slurry within the range of two and one-half (2 ½) to three (3) pounds of hydrated lime per gallon water. Check specific gravity of slurry with Ertco Hydrometer No. 2545 or equivalent. Specific gravity readings shall range from 1.14 to 1.16.

c. A surfactant (wetting agent) approved by the Geotechnical Engineer shall be used in the lime slurry, according to manufacturer's recommendations, but in no case shall proportions be less than one (1) part per fifteen hundred (1500) gallons of water.

PROCEDURE:

a. The subgrade should be shaped to rough designed grades and scarified or plowed so that excess slurry will be trapped within the building area.

b. Pre-drill holes to accommodate the contractor's inflatable packers to * feet. The spacing for injections shall not exceed five (5) feet on center in each direction, and extending a minimum of five (5) feet beyond the limits of the building.

c. Set and inflate packer to seal hole.

d. Inject each hole through a packer at a minimum pressure of fifty (50) psi and a maximum of two hundred (200) psi pump pressure, adjusted to disperse the maximum possible volume of slurry, and continue to inject slurry to refusal, as defined by the Geotechnical Engineer.

e. The lime slurry shall be continuously agitated to insure uniformity of mixture. Specific gravity checks should be made at both mixer tanks and at injectors no less than one (1) test per four (4) hours of agitation.

f. The contractor will insure that lime slurry is applied evenly across the scarified or plowed subgrade during the stabilization process. The excess slurry ponded on the ground surface shall be scarified into the soil and the soil-lime mixture recompacted to subgrade specifications prior to placement of fill, if required.

INSPECTION AND CONTROL:

a. The work will be under the direct inspection of a representative of the Geotechnical Engineer who will measure the specific gravity of the mixture, determine suitable operation of the equipment used, and determine the point of injection refusal.

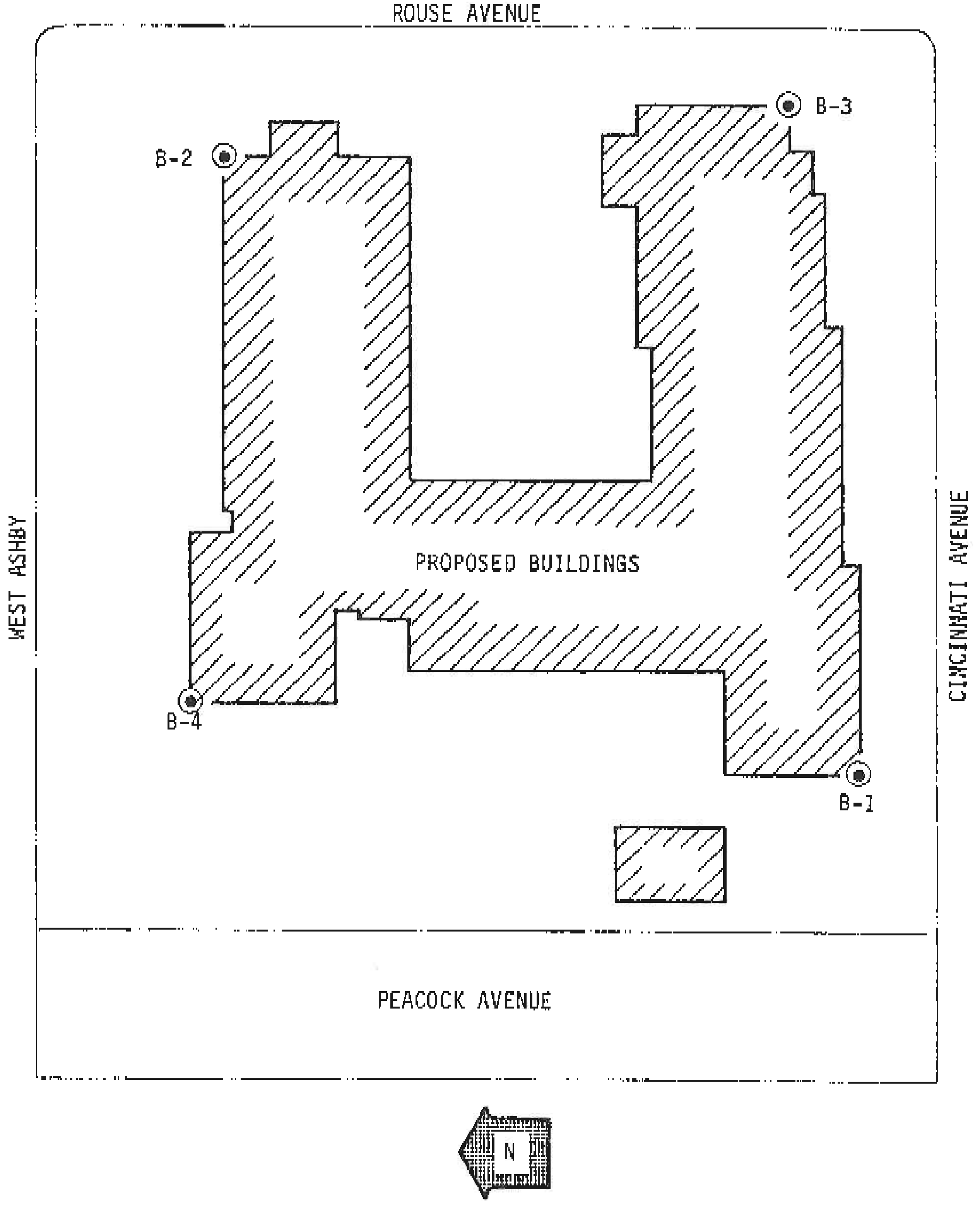
b. Acceptance of the soil stabilization shall be on the basis of continuous on site inspection by a representative of the Geotechnical Engineer. The contractor may be required to inject portions of the site with lime slurry more than once to meet the approval of the Geotechnical Engineer.

c. The Geotechnical Engineer will be provided weight certificates of all lime devlivered to the site for use in stabilization. No lime or lime slurry will be removed from the site for use on other projects.

<u>* Note</u> See depth recommended in this report.

Revised March 7, 1978

REPORT 11



PLAN OF BORINGS
SCALE: 1" = 50'

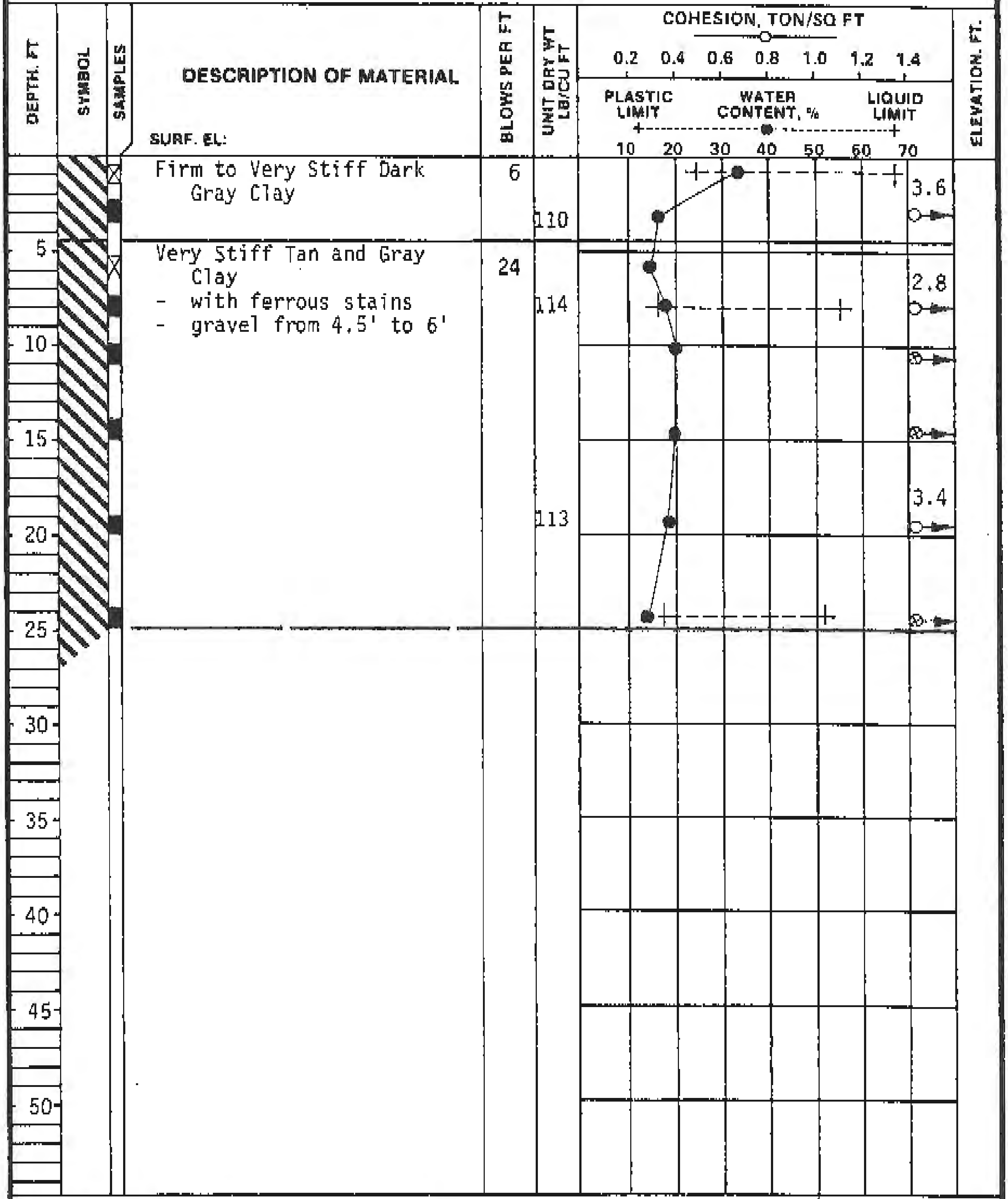
PLATE 1

Raba
Kistner
Consultants,
Inc.

LOG OF BORING NO. B-1
WILLIAM BOOTH APARTMENTS
SAN ANTONIO, TEXAS

TYPE: 2" Split Spoon
3" Shelby Tube

LOCATION: See Plate 1



Firm to Very Stiff Dark Gray Clay — 6 — 110

Very Stiff Tan and Gray Clay — 24 — 114 — 113
- with ferrous stains
- gravel from 4.5' to 6'

COMPLETION DEPTH: 25'
DATE: 2/18/80

DEPTH TO WATER IN BORING: None Observed
DATE: 2/19/80

PLATE 2

Raba Kistner Consultants, Inc.

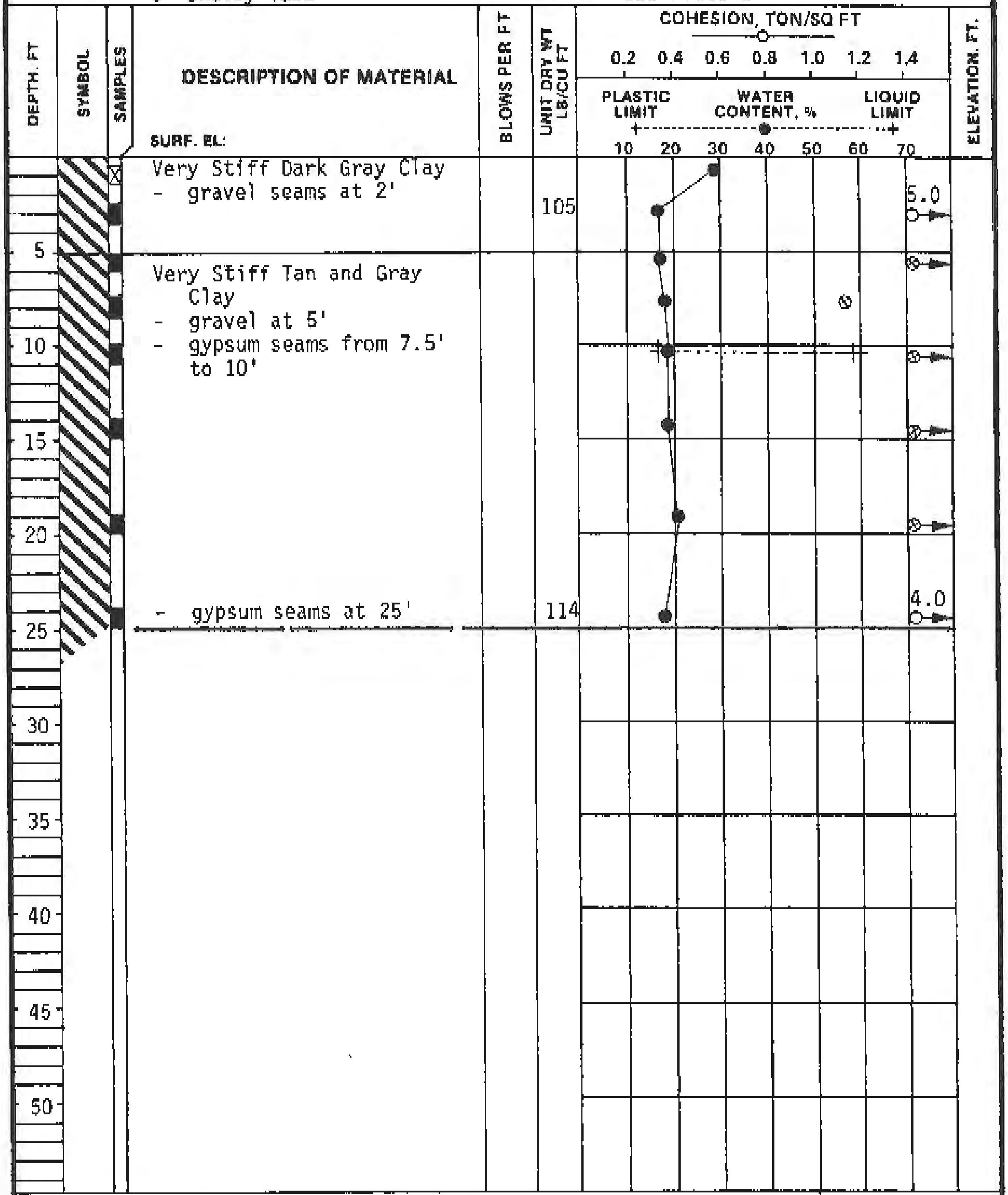
LOG OF BORING NO. B-2

WILLIAM BOOTH APARTMENTS
SAN ANTONIO, TEXAS

TYPE: 2" Split Spoon
3" Shelby Tube

LOCATION: See Plate 1

SURF. EL:



Very Stiff Dark Gray Clay
- gravel seams at 2'

Very Stiff Tan and Gray Clay
- gravel at 5'
- gypsum seams from 7.5' to 10'
- gypsum seams at 25'

COMPLETION DEPTH: 25'
DATE: 2/18/80

DEPTH TO WATER IN BORING: 21.7'
DATE: 2/19/80

PLATE 3

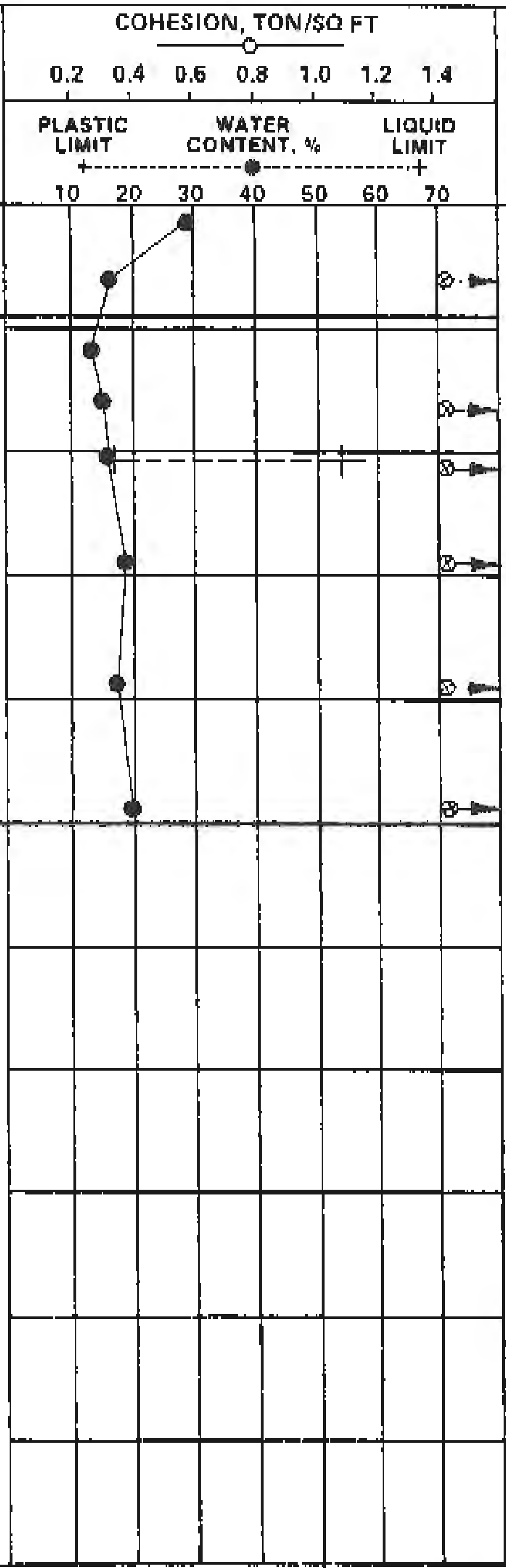
Raba Kistner Consultants, Inc.

LOG OF BORING NO. B-3
WILLIAM BOOTH APARTMENTS
SAN ANTONIO, TEXAS

TYPE: 2" Split Spoon
3" Shelby Tube

LOCATION: See Plate 1

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL SURF. EL:	BLOWS PER FT	UNIT DRY WT LB/CU FT
			Firm to Very Stiff Dark Gray Clay	9	
5			Very Stiff Tan and Gray Clay - gravel from 4.5' to 6.5' - gravel at 7.5'	26	
10					
15					
20					
25					
30					
35					
40					
45					
50					



ELEVATION, FT.

COMPLETION DEPTH: 25'
DATE: 2/18/80

DEPTH TO WATER IN BORING: 23.1'
DATE: 2/19/80

PLATE 4

Raba Kistner Consultants, Inc.

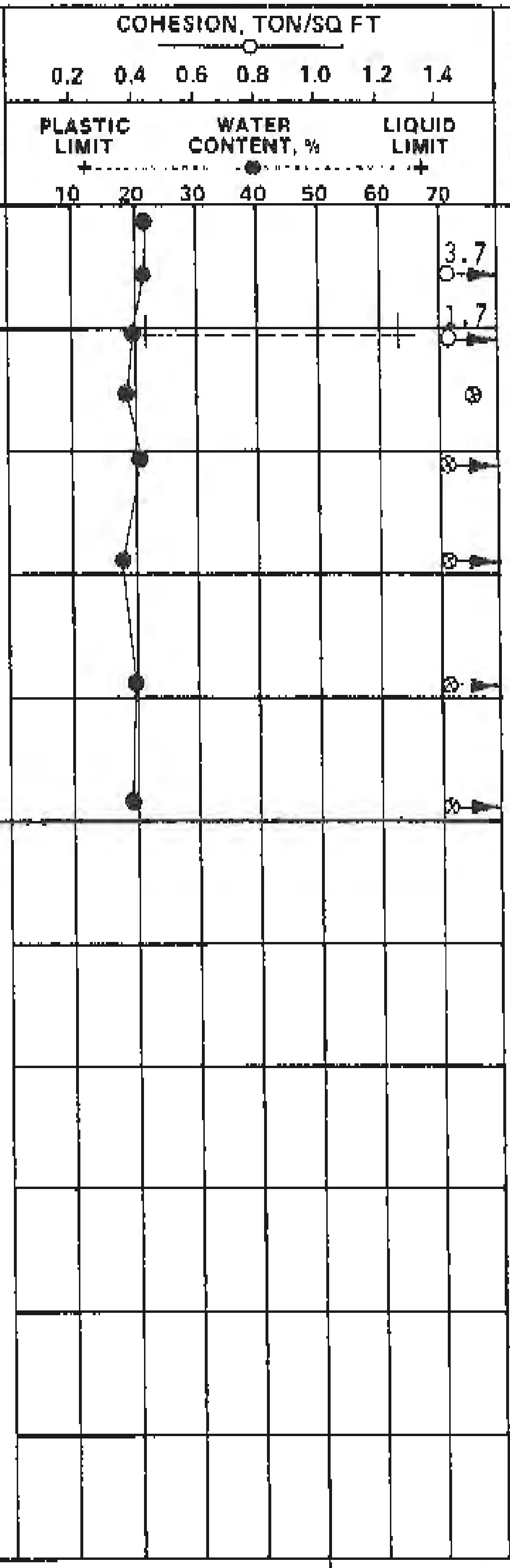
LOG OF BORING NO. B-4
WILLIAM BOOTH APARTMENTS
SAN ANTONIO, TEXAS

TYPE: 2" Split Spoon
3" Shelby Tube

LOCATION: See Plate 1

SURF. EL:

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT
0–5	Stiff to Very Stiff Dark Brown Clay	16	99
5–25	Very Stiff Tan and Gray Clay		107



COMPLETION DEPTH: 25'
DATE: 2/18/80

DEPTH TO WATER IN BORING: 22.3'

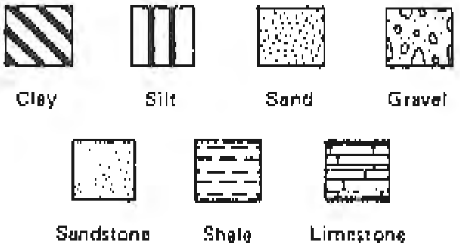
DATE: 2/19/80

PLATE 5

SYMBOLS AND TERMS USED ON BORING LOGS

SOIL OR ROCK TYPES

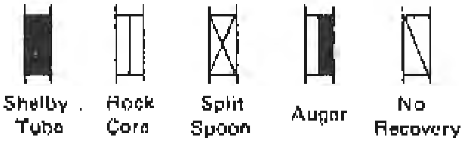
(shown in symbols column)



(Predominate Soil Types Shown Heavy)

SAMPLER TYPES

(shown in sample column)



STRENGTH TEST RESULTS

⊗ - Estimated Strength
◇ - Torvane
○ - Unconfined Compression

TRIAXIAL COMPRESSION

△ - Unconsolidated-undrained
□ - Consolidated-undrained

C - Cohesion (Total)
Φ - Angle of Internal Friction (Total)

C' - Cohesion (Effective)
Φ' - Angle of Internal Friction (Effective)

NOTE:

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Well graded	- having wide range in grain sizes and substantial amounts of all intermediate particle sizes.
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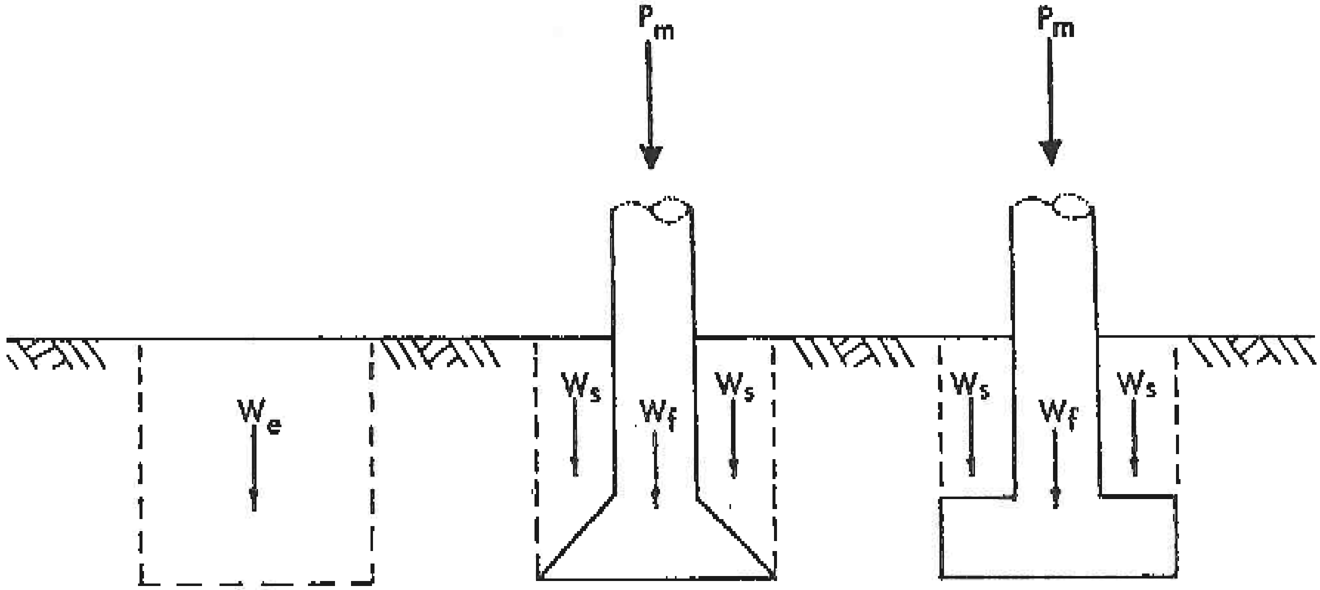
TERMS DESCRIBING CONSISTENCY OR CONDITION

RELATIVE DENSITY		COHESIVE STRENGTH			PLASTICITY	
Penetration Resistance, blows per foot	Relative Density	Penetration Resistance, blows per foot	Consistency	Cohesion, TSF	Plasticity Index	Degree of Plasticity
0-4	Very Loose	0-2	Very Soft	0-0.125	0-5	None
4-10	Loose	2-4	Soft	0.125-0.25	5-10	Low
10-30	Medium Dense	4-8	Firm	0.25-0.5	10-20	Moderate
30-50	Dense	8-15	Stiff	0.5-1.0	20-40	Plastic
> 50	Very Dense	15-30	Very Stiff	1.0-2.0	> 40	Highly Plastic
		> 30	Hard	> 2.0		

NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above because of planes of weakness or cracks in the soil. The consistency ratings of such soils are based on penetrometer readings.

COMPUTATION OF BEARING PRESSURES



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Where:
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* Position of water table must be considered in determining unit weights. Effective, or buoyant unit weights should be used below the highest expected water table.

LIME SLURRY PRESSURE INJECTION SPECIFICATIONS

FOR THE

STRAIGHT PIPE INJECTION SYSTEM

SCOPE: The work consists of application of lime slurry into the ground at specified intervals within specified areas of the project.

EQUIPMENT: Equipment shall be suitable for the work, as approved by the Geotechnical Engineers prior to the commencement of work. Equipment shall be constructed to provide straight pipe injection to the depth specified and shall inject through a positive seal for preventing the slurry from flowing out onto the ground and shall have controls and gauges near the point of injection for setting of pressure and determination of pressure.

a. Injection pipes shall be spaced five (5) feet on centers.

b. Nozzles on injection pipes shall be designed with a hole pattern that will uniformly disperse the lime slurry radially.

c. Injection pressure shall be adjusted to disperse as large a volume of lime slurry as possible within a pressure range of fifty (50) to two hundred (200) pounds per square inch at the injector.

d. Mixer tanks shall be approved by the Geotechnical Engineers and shall be continuously agitated to insure uniformity of mixture.

e. Plugs of a suitable type shall be utilized by the Contractor in the injector holes to prevent the slurry from flowing out of the subgrade onto the ground surface.

LIME SLURRY:

a. The lime slurry shall be a pumpable suspension of hydrated lime in water. The water or liquid portion of the slurry shall not contain dissolved material in sufficient quantity and/or nature injurious or objectionable for the purpose intended. The solids portion of the mixture, when considered on the basis of "solids content", shall consist principally of hydrated lime of a quality and fineness sufficient to meet THD Item 264, Type A as to chemical composition and residue.

b. Proportion lime slurry within the range of two and one-half (2½) to three (3) pounds of hydrated lime per gallon water. Check specific gravity of slurry with Ertco Hydrometer No. 2545 or equivalent. Specific gravity readings shall range from 1.14 to 1.16.

c. A surfactant (wetting agent) approved by the Geotechnical Engineer shall be used in the lime slurry, according to manufacturer's recommendations, but in no case shall proportions be less than one (1) part per fifteen hundred (1500) gallons of water.

PROCEDURE:

a. General: Injection pipes, spaced as specified, shall be forced downward, injecting the lime slurry at approximately twelve (12) inch intervals to refusal or ten (10) gallons, whichever is greater, for a total depth of * feet.

b. Injection Spacing shall not exceed five (5) feet on centers both ways within an area defined by lines five (5) feet outside of all building lines.

c. The lime slurry shall be continuously agitated to insure uniformity of mixture. Specific gravity checks should be made at both mixer tanks and at injectors no less than one (1) test per four (4) hours of agitation.

d. The excess slurry ponded on the ground surface shall be scarified into the soil and the soil-lime mixture recompacted to subgrade specifications prior to placement of fill, if required.

INSPECTION AND CONTROL:

a. The work will be under the direct inspection of the Geotechnical Engineer, who will measure the specific gravity of the mixture, determine suitable operation of the equipment used, and determine the point of injection refusal.

b. Acceptance of the soil stabilization shall be on the basis of continuous on site inspection by a representative of the Geotechnical Engineer. The contractor may be required to inject the site or portions of the site with lime slurry more than once to meet the approval of the Geotechnical Engineer.

c. The Geotechnical Engineer will be provided weight certificates of all lime delivered to the site for use in stabilization. No lime or lime slurry will be removed from the site for use on other projects.

* Note See depth recommended in this report.

Revised March 7, 1978

LIME SLURRY PRESSURE INJECTION SPECIFICATIONS

FOR THE

INFLATABLE PACKER SYSTEM

SCOPE: The work consists of application of lime slurry into the ground at specified intervals within specified areas of the project.

EQUIPMENT: Equipment shall be suitable for the work, as approved by the Geotechnical Engineers. Equipment shall be constructed to provide a positive seal for preventing the slurry from flowing out onto the ground and shall have controls and gauges for setting of pressure and determination of pressure.

a. Packers of an acceptable type and length with a minimum diameter of 4 inches shall be utilized by the contractor to prevent slurry from flowing out onto the ground surface.

b. Mixer tanks shall be approved by the Geotechnical Engineers and shall be continuously agitated to insure uniformity of mixture.

LIME SLURRY:

a. The lime slurry shall be a pumpable suspension of hydrated lime in water. The water or liquid portion of the slurry shall not contain dissolved material in sufficient quantity and/or nature injurious or objectionable for the purpose intended. The solids portion of the mixture, when considered on the basis of "solids content", shall consist principally of hydrated lime of a quality and fineness sufficient to meet THD Item 264, Type A as to chemical composition and residue.

b. Proportion lime slurry within the range of two and one-half (2½) to three (3) pounds of hydrated lime per gallon water. Check specific gravity of slurry with Ertco Hydrometer No. 2545 or equivalent. Specific gravity readings shall range from 1.14 to 1.16.

c. A surfactant (wetting agent) approved by the Geotechnical Engineer shall be used in the lime slurry, according to manufacturer's recommendations, but in no case shall proportions be less than one (1) part per fifteen hundred (1500) gallons of water.

PROCEDURE:

a. The subgrade should be shaped to rough designed grades and scarified or plowed so that excess slurry will be trapped within the building area.

b. Pre-drilled holes to accommodate the contractor's inflatable packers to * feet. The spacing for injections shall not exceed five (5) feet on center in each direction, and extending a minimum of five (5) feet beyond the limits of the building.

c. Set and inflate packer to seal hole.

d. Inject each hole through a packer at a minimum pressure of fifty (50) psi and a maximum of two hundred (200) psi pump pressure, adjusted to disperse the maximum possible volume of slurry, and continue to inject slurry to refusal, as defined by the Geotechnical Engineer.

e. The lime slurry shall be continuously agitated to insure uniformity of mixture. Specific gravity checks should be made at both mixer tanks and at injectors no less than one (1) test per four (4) hours of agitation.

f. The contractor will insure that lime slurry is applied evenly across the scarified or plowed subgrade during the stabilization process. The excess ponded on the ground surface shall be scarified into the soil and the soil-lime mixture recompacted to subgrade specifications prior to placement of fill, if required.

INSPECTION AND CONTROL:

a. The work will be under the direct inspection of a representative of the Geotechnical Engineer who will measure the specific gravity of the mixture, determine suitable operation of the equipment used, and determine the point of injection refusal.

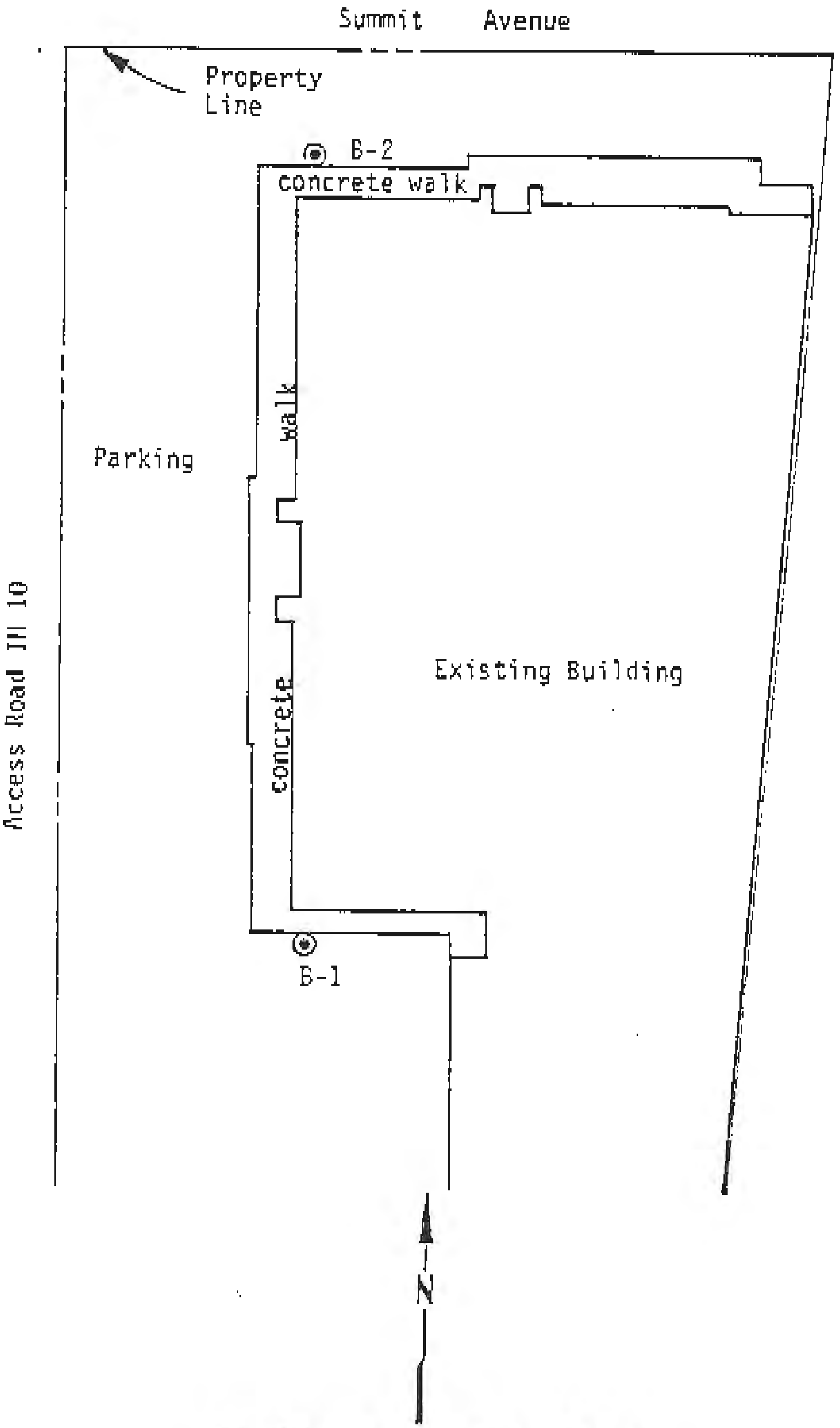
b. Acceptance of the soil stabilization shall be on the basis of continuous on site inspection by a representative of the Geotechnical Engineer. The contractor may be required to inject portions of the site with lime slurry more than once to meet the approval of the Geotechnical Engineer.

c. The Geotechnical Engineer will be provided weight certificates of all lime delivered to the site for use in stabilization. No lime or lime slurry will be removed from the site for use on other projects.

* Note See depth recommended in this report.

Revised March 7, 1978

REPORT 12



PLAN OF BORINGS

Raba-Kistner Consultants Inc

Proj. No. ASA92-007-00

PLATE 1

LOG OF BORING NO. B-1
CENTER FOR HEALTH CARE SERVICES
SAN ANTONIO, TEXAS

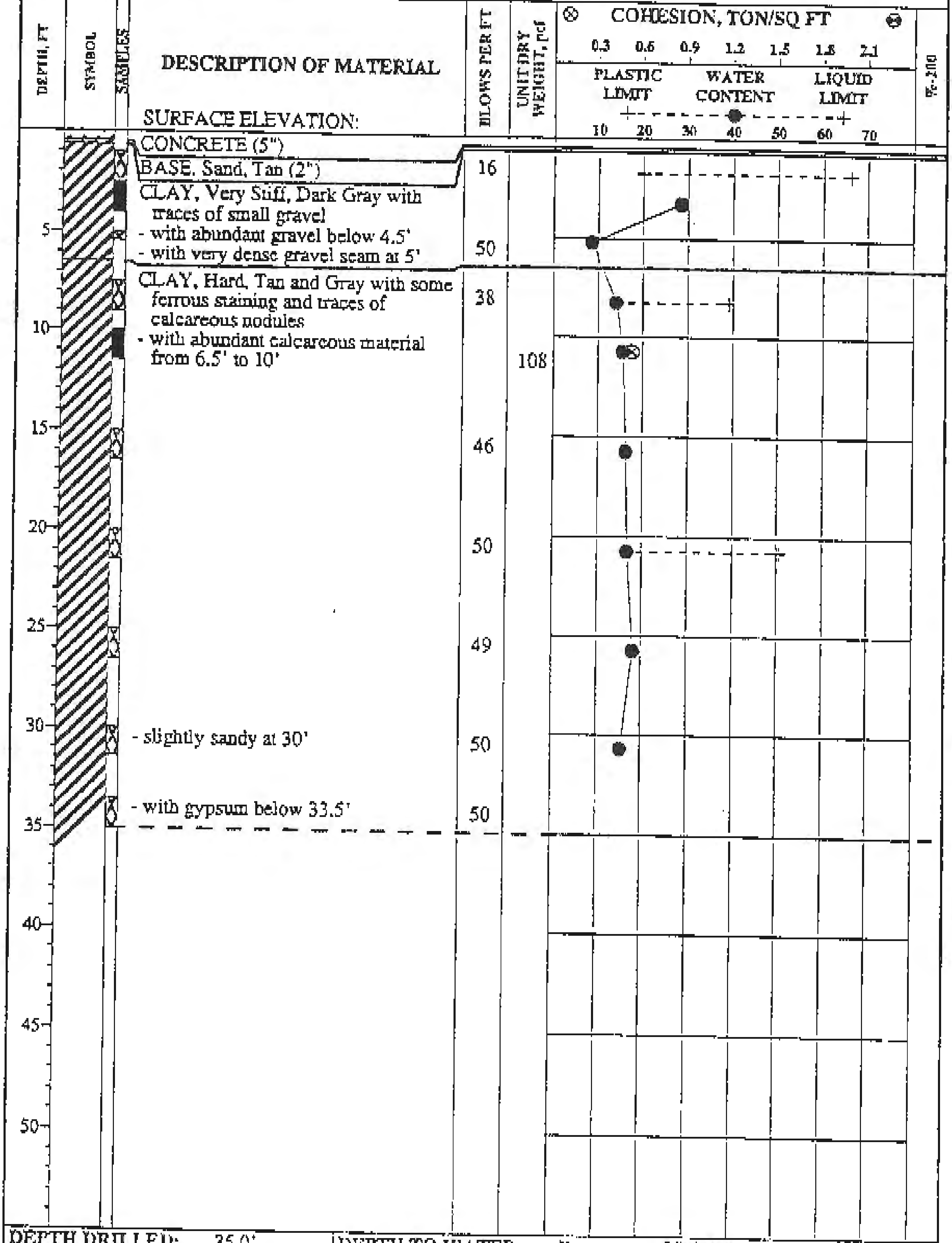
Raba-Kistner
Consultants, Inc.

DRILLING METHOD: Hollow Stem Auger

LOCATION: See Plate 1

SURFACE ELEVATION:

DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf
CONCRETE (5")		
BASE, Sand, Tan (2")	16	
CLAY, Very Stiff, Dark Gray with traces of small gravel - with abundant gravel below 4.5' - with very dense gravel seam at 5'	50	
CLAY, Hard, Tan and Gray with some ferrous staining and traces of calcareous nodules - with abundant calcareous material from 6.5' to 10'	38	
		108
	46	
	50	
	49	
- slightly sandy at 30'	50	
- with gypsum below 33.5'	50	



NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT.

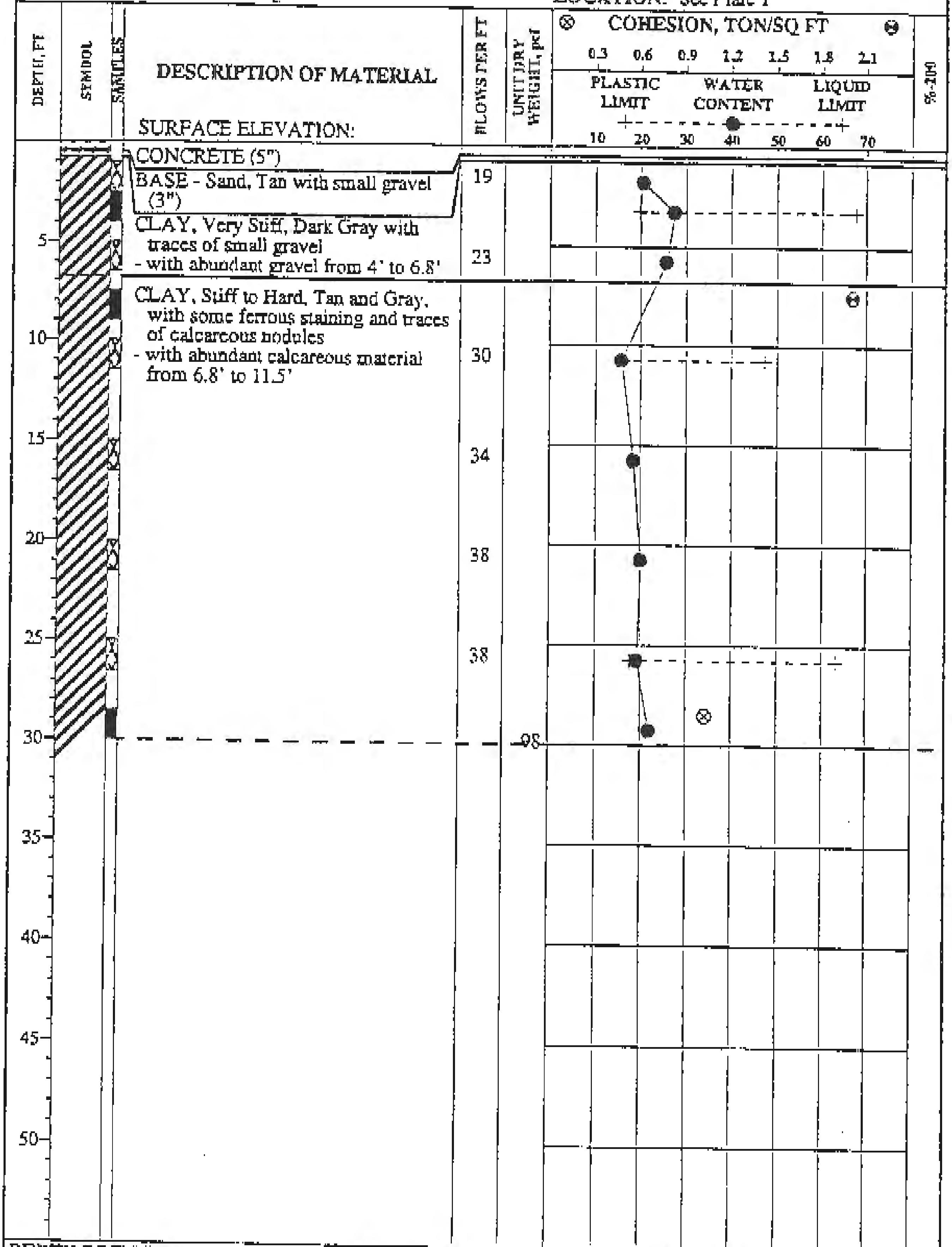
DEPTH DRILLED: 35.0'
DATE DRILLED: 1/28/92
DEPTH TO WATER: Dry
DATE MEASURED: 1/28/92
PROJ. No. ASA92-007-00
PLATE 2

LOG OF BORING NO. B-2
CENTER FOR HEALTH CARE S VICES
SAN ANTONIO, TEXAS

Raba-Kistner
Consultants, Inc.

DRILLING METHOD: Hollow Stem Auger

LOCATION: See Plate 1



CONCRETE (5")

BASE - Sand, Tan with small gravel (3")

CLAY, Very Stiff, Dark Gray with traces of small gravel
- with abundant gravel from 4' to 6.8'

CLAY, Stiff to Hard, Tan and Gray, with some ferrous staining and traces of calcareous nodules
- with abundant calcareous material from 6.8' to 11.5'

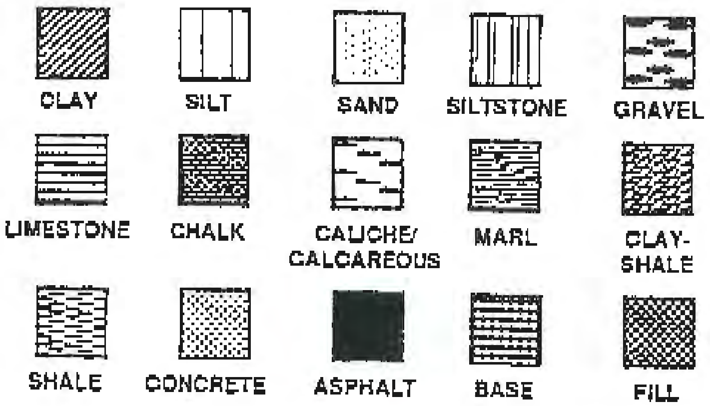
NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT.

DEPTH DRILLED:	30.0'	DEPTH TO WATER:	Dry	PROJ. No.	ASA92-007-00
DATE DRILLED:	1/28/92	DATE MEASURED:	1/28/92	PLATE	3

TERM AND SYMBOLS USED C BORING LOGS

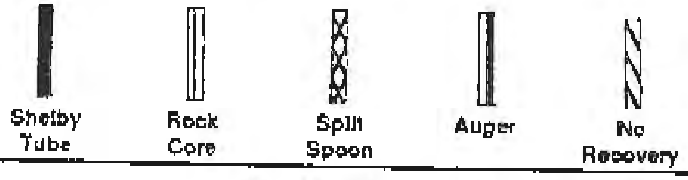
SOIL OR ROCK TYPES

(shown in symbols column)



SAMPLER TYPES

(shown in sample column)



STRENGTH TEST RESULTS

⊖ Pocket Penetrometer

○ Torvane

⊗ Unconfined Compression

TRIAXIAL COMPRESSION

△ Unconsolidated-undrained

□ Consolidated-undrained

C Cohesion (Total)

Φ Angle of Internal Friction (Total)

C' Cohesion (Effective)

Φ' Angle of Internal Friction (Effective)

NOTE: Values symbolized on boring logs represent shear strengths unless otherwise noted.

TERMS DESCRIBING CONSISTENCY, CONDITION OR TEXTURE

Terms used in this report to describe soils with regard to their consistency or conditions are in general accordance with the discussion presented in Article 45 of SOIL MECHANICS IN ENGINEERING PRACTICE. Terzaghi and Peck, John Wiley & Sons, Inc. 1967, using the most reliable information available from the field and laboratory investigations. Terms used for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in Technical Memorandum No. 3-357, Waterways Experiment Station, March 1953.

TERMS CHARACTERIZING SOIL STRUCTURE

Slickensided	having inclined planes of weakness that are slick and glossy in appearance
Fissured	containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical
Laminated	composed of thin layers of varying colors and texture
Interbedded	composed of alternate layers of different soil types
Calcareous	containing appreciable quantities of calcium carbonate
Well graded	having wide range in grain sizes and substantial amounts of all intermediate particle sizes
Poorly graded	predominantly of one grain size, or having a range of sizes with some intermediate size missing

TERMS DESCRIBING CONSISTENCY OR CONDITION

RELATIVE DENSITY

Penetration Resistance blows per ft.	Relative Density
0-4	Very loose
4-10	Loose
10-30	Medium Dense
30-50	Dense
>50	Very Dense

COHESIVE STRENGTH

Penetration Resistance, blows per ft.	Consistency	Cohesion TSF
0-2	Very Soft	0-0.125
2-4	Soft	0.125-0.25
4-8	Firm	0.25-0.5
8-15	Stiff	0.5-1.0
15-30	Very Stiff	1.0-2.0
>30	Hard	>2.0

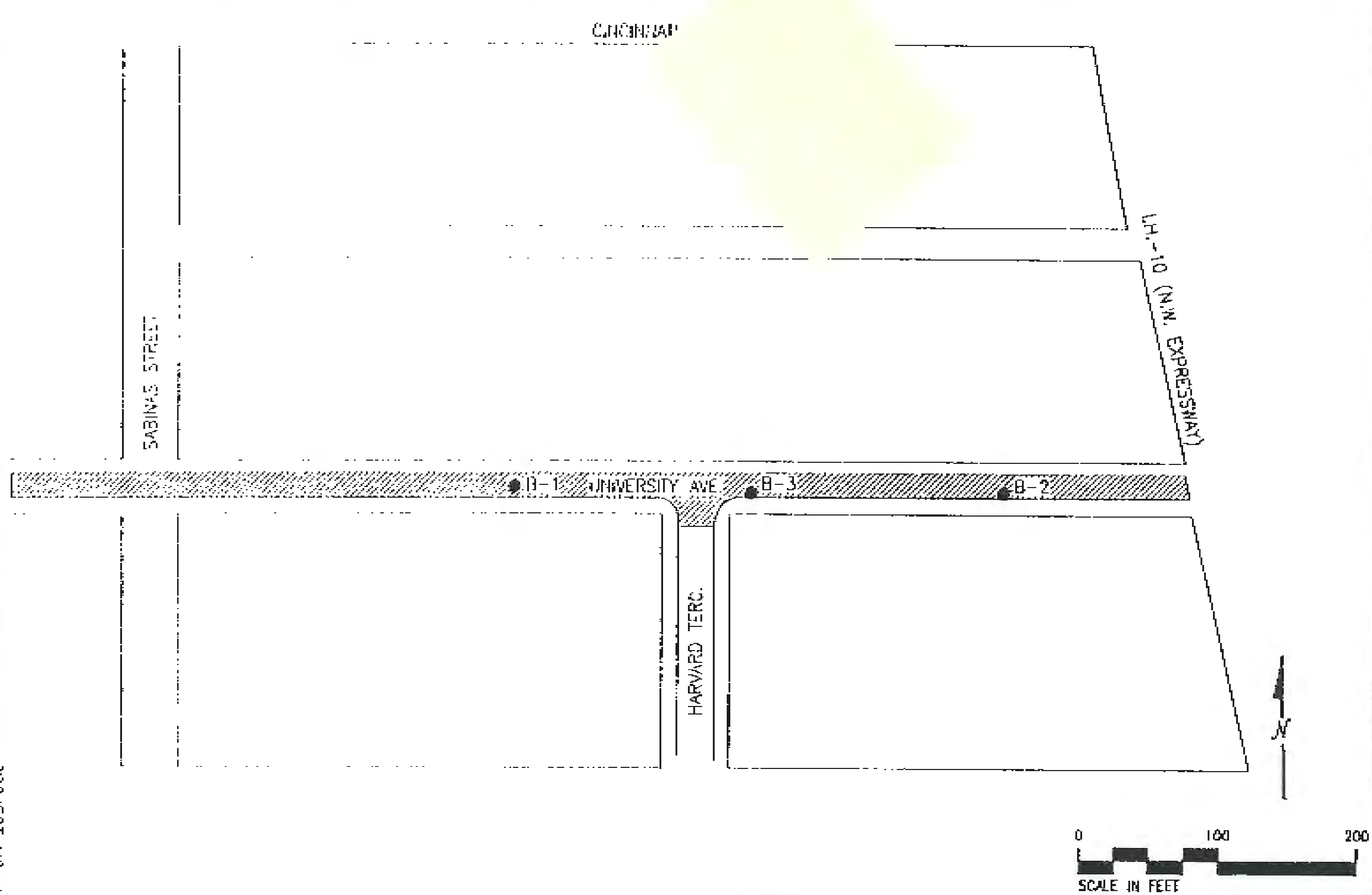
PLASTICITY

Plasticity Index	Degree of Plasticity
0-5	Non-Plastic
5-10	Low
10-20	Moderate
20-40	Plastic
>40	Highly Plastic

NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above because of planes of weakness or cracks in the soil. The consistency ratings of such soils are based on penetrometer readings.

Proj. No. ASA92-007-00

REPORT 13



BORING LOCATION MAP
UNIVERSITY AVE. STREET IMPROVEMENT – SABINAS ST TO IH-10
SAN ANTONIO, TEXAS

Raba-Kis. er Consultants.Inc.

PROJECT NO. AS495-005-00

LOG OF BORING NO. B-1

UNIVERSITY AVE STREET IMPROVEMENT - SABINAS ST TO IH-10

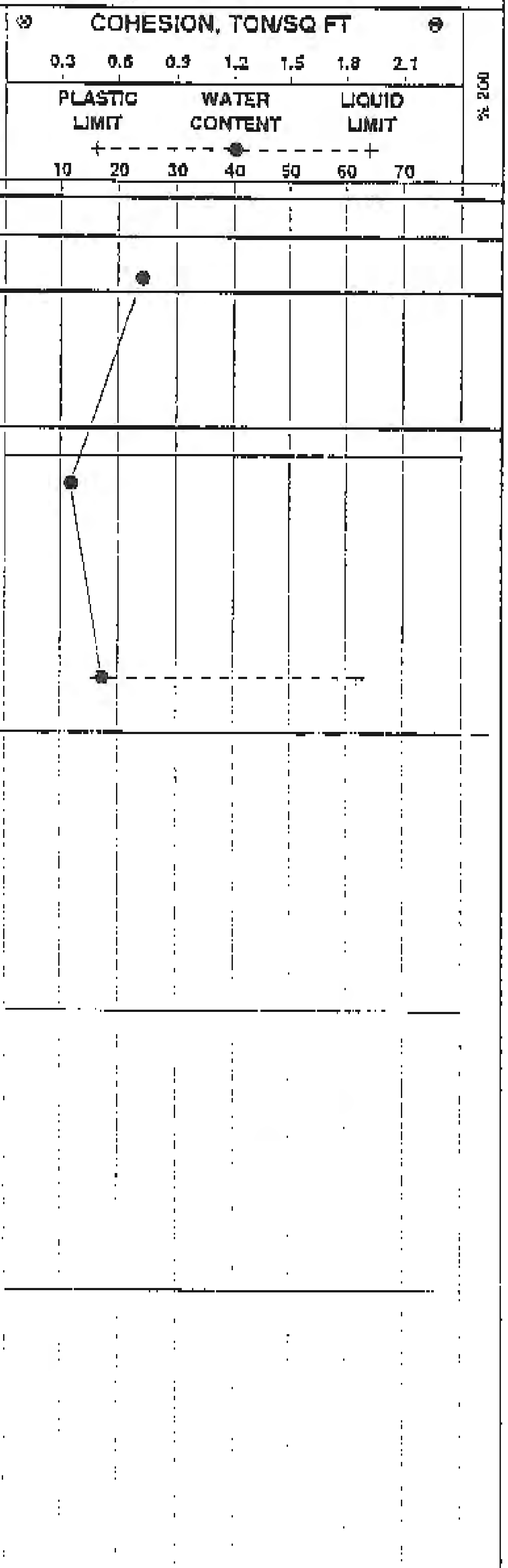
SAN ANTONIO, TEXAS

Raba-Kistner
Consultants, Inc.

DRILLING METHOD: Hollow Stem Auger

LOCATION: See Plate 1

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf
	SURFACE ELEVATION:		
	ASPHALTIC CONCRETE (4")		
	BASE MATERIAL (8")		
	CLAY, Hard, Dark Gray with a trace of fine gravel	37	
	GRAVEL, Clayey, Very Dense, Tan with abundant chert fragments	50/5"	
5	CLAY, Very Stiff, Tan and Gray - with small chert fragments and calcareous pockets from 4.5' to 6.5'	22 26 28	
10			
15			
20			



DEPTH DRILLED:	10.0'	DEPTH TO WATER:	Dry	PROJ. No.	ASA95-505-00
DATE DRILLED:	1/31/95	DATE MEASURED:	1/31/95	PLATE	2

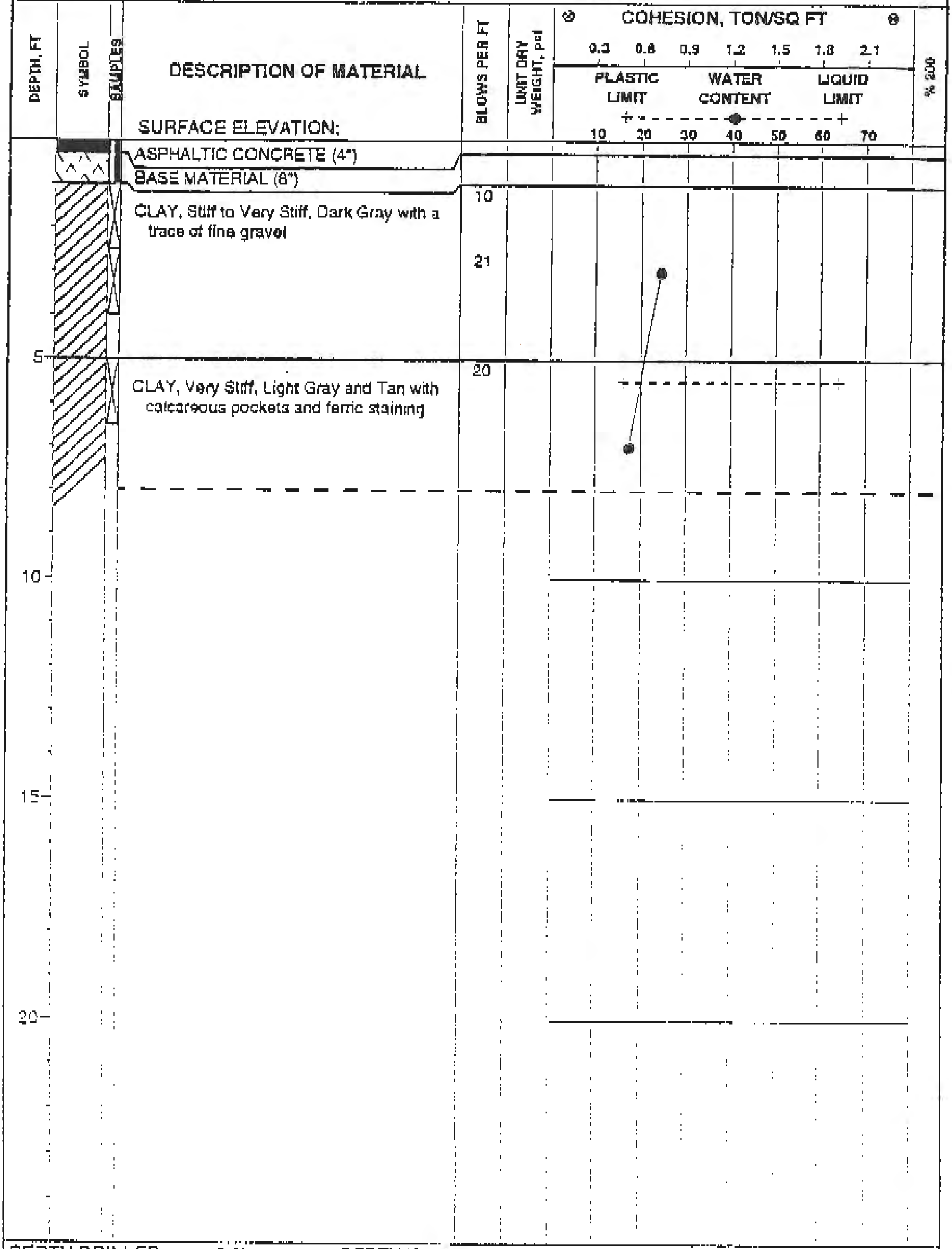
NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT.

LOG OF BORING NO. B-2
UNIVERSITY AVE STREET IMPROVEMENT - SABINAS ST TO IH-10
SAN ANTONIO, TEXAS

Raba-Kistner
Consultants, Inc.

DRILLING METHOD: Hollow Stem Auger

LOCATION: See Plate 1



NOTE: THESE LOGS SHOULD NOT B[illegible]ED SEPARATELY FROM THE PROJECT REPORT.

DEPTH DRILLED:	8.0'	DEPTH TO WATER:	Dry	PROJ. No.	ASA95-005-00
DATE DRILLED:	1/31/95	DATE MEASURED:	1/31/95	PLATE	3

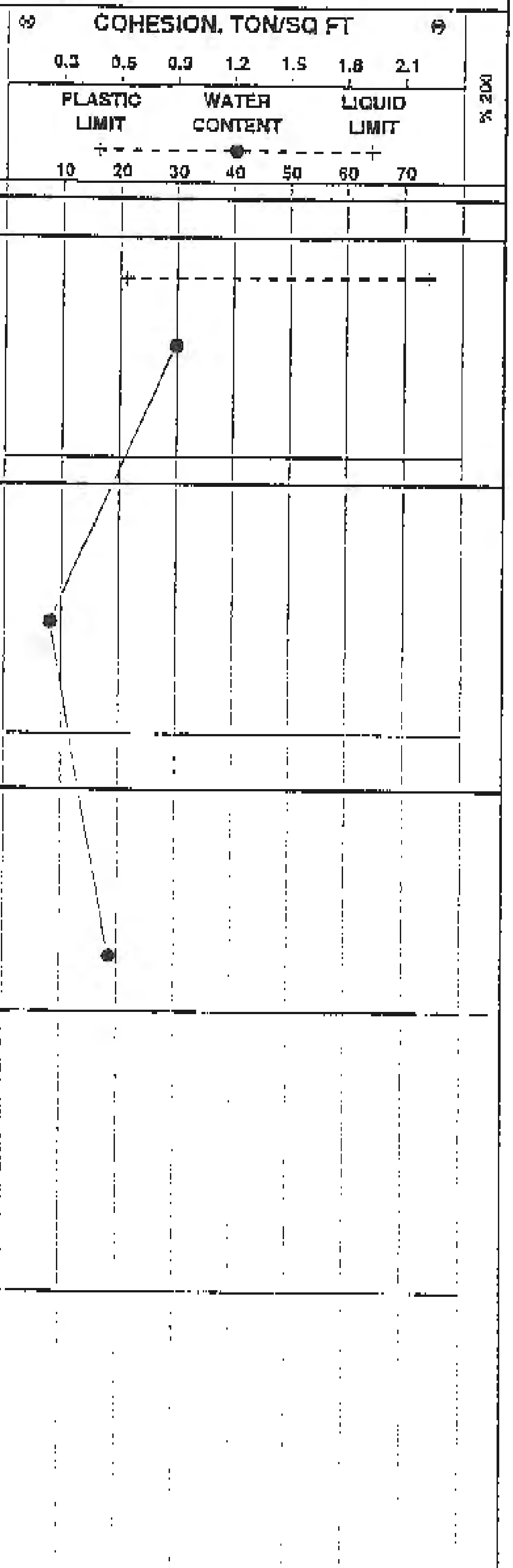
LOG OF BORING NO. B-3
UNIVERSITY AVE STREET IMPROVEMENT - SABINAS ST TO IH-10
SAN ANTONIO, TEXAS

Raba-Kistner
Consultants, Inc.

DRILLING METHOD: Hollow Stem Auger

LOCATION: See Plate 1

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf
			SURFACE ELEVATION:		
			ASPHALTIC CONCRETE (4")		
			BASE MATERIAL (8")		
			CLAY, Stiff, Dark Gray with a trace of fine gravel	9	
				13	
5					
			GRAVEL, Clayey, Very Dense, Tan with abundant chert fragments	50/11"	
				50	
10				50	
			CLAY, Hard, Tan to Tan and Gray		
				31	
15					
20					

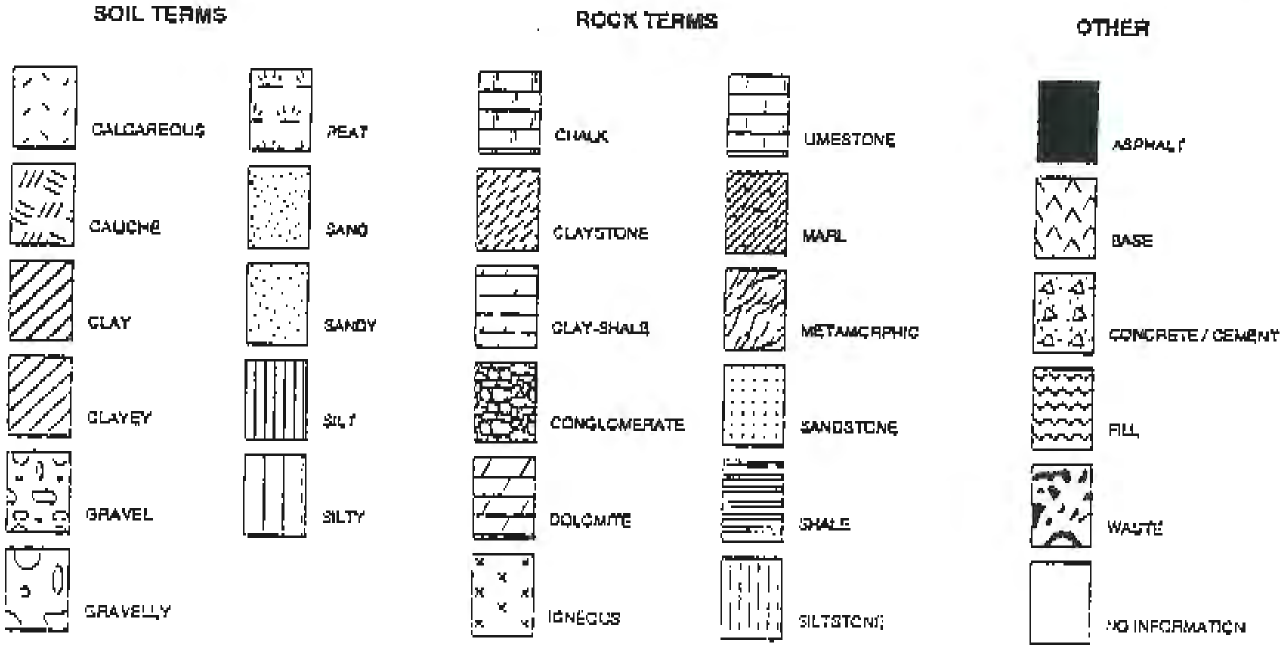


NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT.

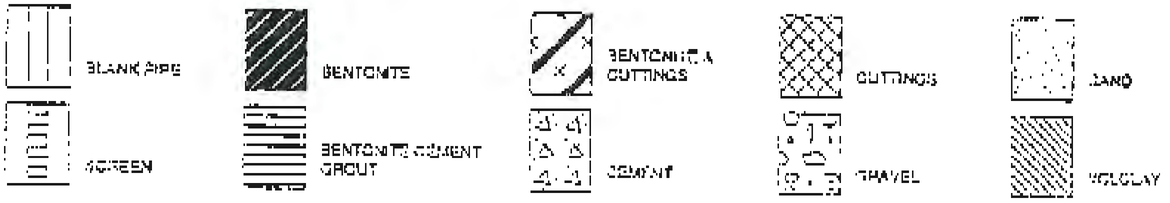
DEPTH DRILLED: 15.0'
DATE DRILLED: 1/31/95
DEPTH TO WATER: Dry
DATE MEASURED: 1/31/95
PROJ. No. ASA95-005-00
PLATE 4

KEY TO TERMS AND SYMBOLS

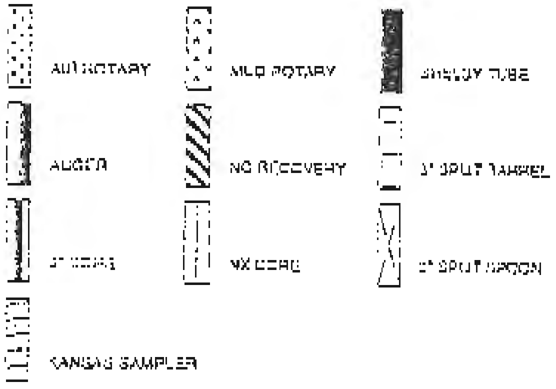
MATERIAL TYPES



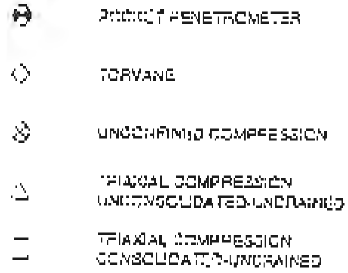
WELL CONSTRUCTION AND PLUGGING MATERIALS



SAMPLE TYPES



STRENGTH TEST RESULTS



NOTE: VALUES SYMBOLIZED ON BORING LOGS REPRESENT SHEAR STRENGTHS UNLESS OTHERWISE NOTED

KEY TO TERMS & SYMBOLS (CONT'D)

TERMINOLOGY

Terms used in this report to describe soil with regard to their consistency or conditions are in general accordance with the discussion presented in Article 45 of SOILS MECHANICS IN ENGINEERING PRACTICE, Terzaghi and Peck, John Wiley & Sons, Inc., 1967, using the most reliable information available from the field and laboratory investigations. Terms used for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in American Society for Testing and Materials D487-85 and D2488-84, Volume 04.08, Soil and Rock; Dimension Stone; Geosynthetics; 1990.

RELATIVE DENSITY

Penetration Resistance Blows per ft	Relative Density
0-4	Very Loose
4-10	Loose
10-30	Medium Dense
30-50	Dense
>50	Very Dense

COHESIVE STRENGTH

Resistance Blows per ft	Consistency	Cohesion TSF
0-2	Very Soft	0-0.125
2-4	Soft	0.125-0.25
4-8	Firm	0.25-0.5
8-15	Stiff	0.5-1.0
15-30	Very Stiff	1.0-2.0
>30	Hard	>2.0

PLASTICITY

Plasticity Index	Degree of Plasticity
0-5	None
5-10	Low
10-20	Moderate
20-40	Plastic
>40	Highly Plastic

ABBREVIATIONS

B = Benzene
T = Toluene
E = Ethylbenzene
X = Total Xylenes
BTEX = Total BTEX
TPH = Total Petroleum Hydrocarbons
ND = Not Detected
NA = Not Analyzed
OVA = Organic Vapor Analyzer
ppm = Parts Per Million

Qum, Qas, Qal = Quaternary Alluvium
Qat = Low Terrace Deposits
Qbc = Beaumont Formation
Qt = Fluviatile Terrace
Qso = Seymour Formation
Qle = Leona Formation
QTu = Uvalde Gravel
Ewi = Wilcox Formation
Emi = Midway Group
Kknm = Navarro Group and Marlbrook Marl
Kpg = Pecan Gap Chalk
Kau = Austin Chalk

Kef = Eagle Ford Shale
Kbu = Buda Limestone
Kdr = Del Rio Clay
Kgt = Georgetown Formation
Kpe = Person Formation
Kek = Kainer Formation
Kes = Escondido Formation
Kw = Walnut Formation
Kgr = Glen Rose Formation
Kgrl = Lower Glen Rose Formation
Kgru = Upper Glen Rose Formation
Kh = Hensell Sand
Psa = San Angelo Formation

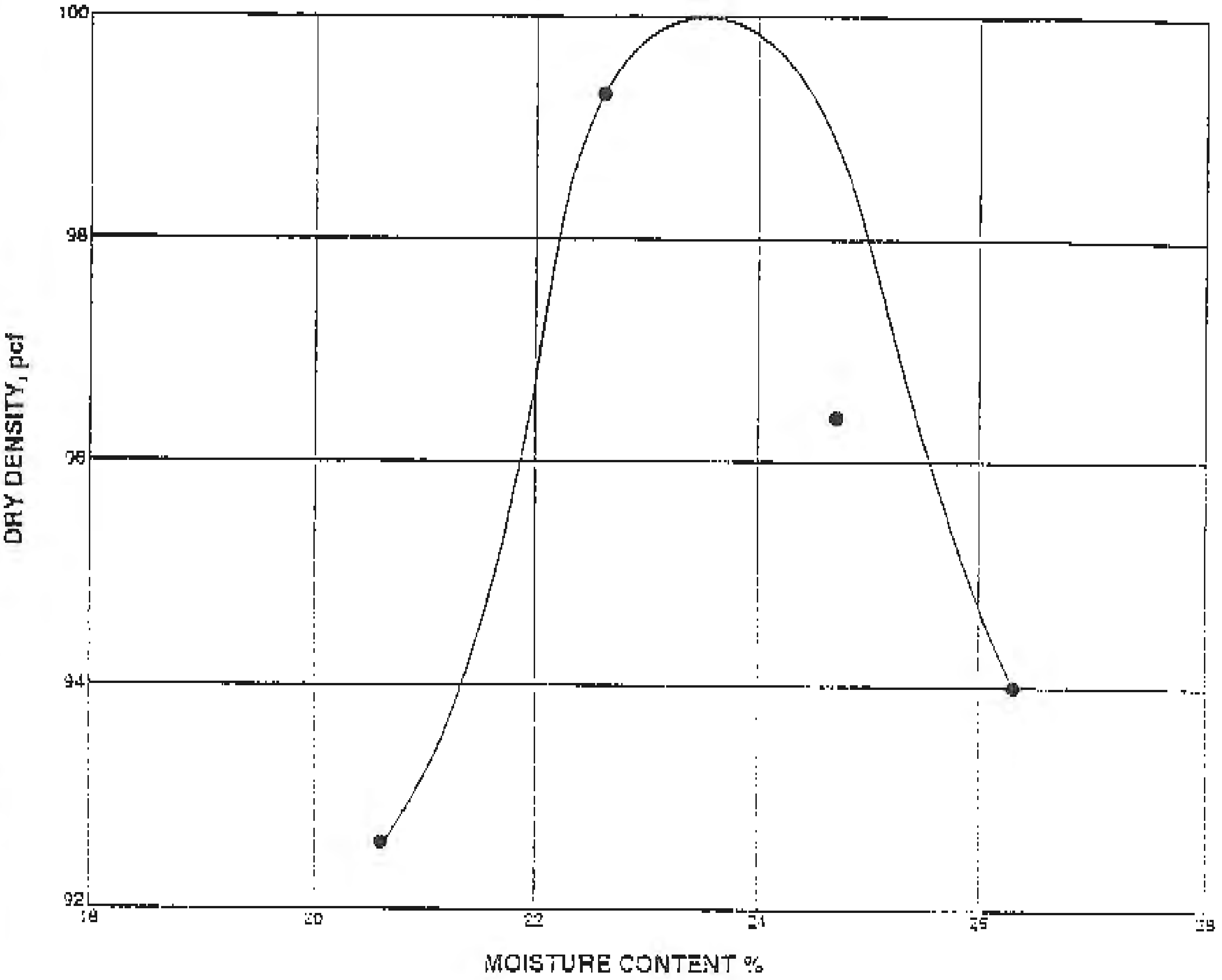
RESULTS OF SOIL SAMPLE ANALYSES

PROJECT NAME:	UNIVERSITY AVE STREET IMPROVEMENT - SABINAS ST TO IH-10	
PROJECT LOCATION:	SAN ANTONIO, TEXAS	Pg 1 of 1
FILE NAME:	UNIVAVE.WQ1	02/03/95

BORING NUMBER	SAMPLE DEPTH (FT)	BLOWS PER FT	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	USCS
B-1	0.00 to 1.00						
	1.00 to 2.50	37	24.1				
	2.50 to 3.00	50/5"					
	5.00 to 6.50	22	11.7				
	7.50 to 8.50	26					
	8.50 to 10.00	28	17.1	62	16	46	CH
B-2	0.00 to 1.00						
	1.00 to 2.50	10					
	2.50 to 4.00	21	24.2				
	5.00 to 6.50	20		64	16	48	CH
	6.50 to 8.00		17.2				
B-3	0.00 to 1.00						
	1.00 to 2.50	9		74	21	53	CH
	2.50 to 4.00	13	29.7				
	5.00 to 6.40	50/11"					
	7.50 to 9.00	50	7.9				
	10.00 to 11.50	50					
	13.50 to 15.00	31	18.4				

MOISTURE-DENSITY RELATIONSHIP

UNIVERSITY AVE STREET IMPROVEMENT - SABINAS ST TO IH-10
SAN ANTONIO, TEXAS

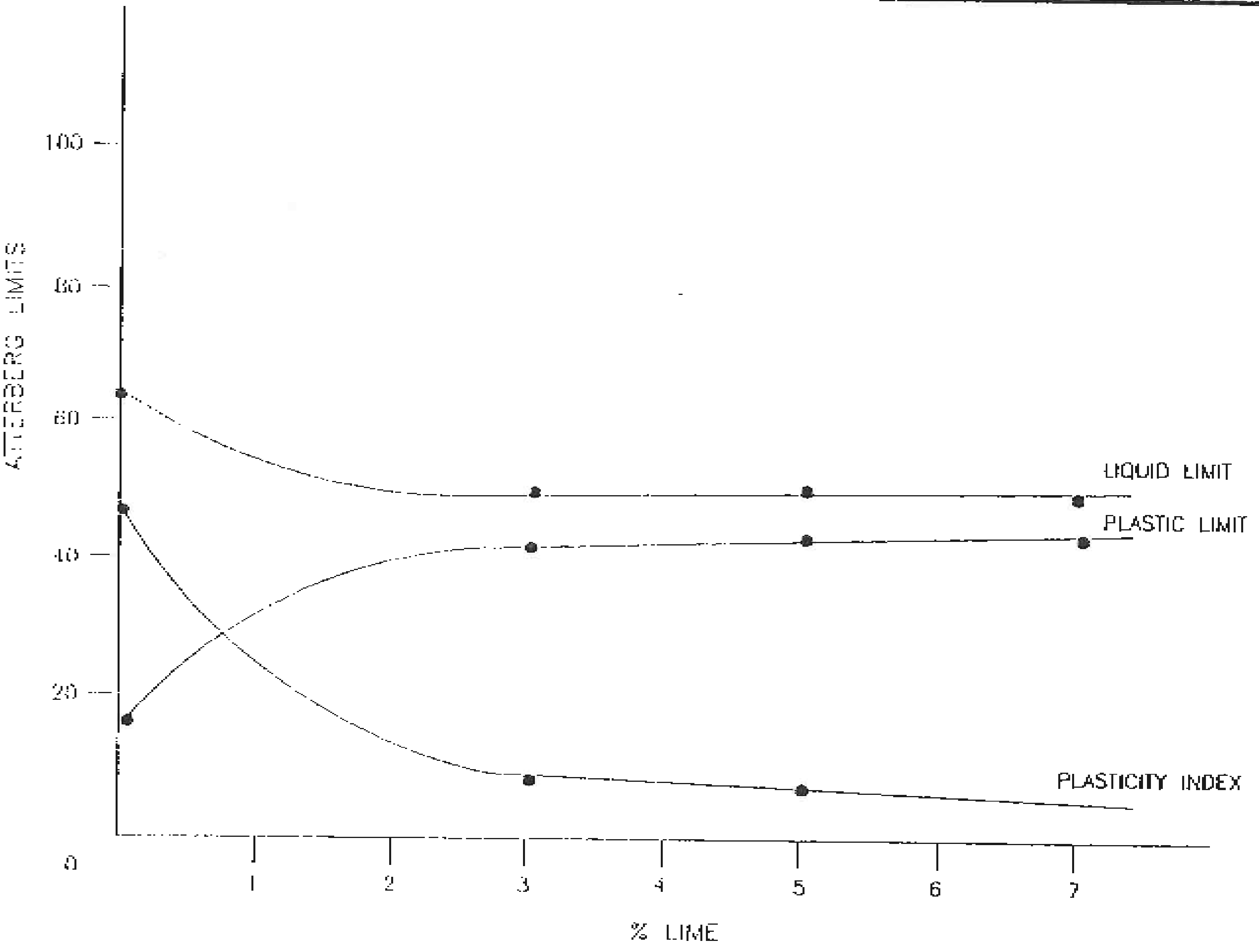


Material Description: CLAY, Dark Gray with a trace of fine gravel
Maximum Dry Density: 100.0 pcf
Optimum Moisture: 23.7%
Compaction Series: THD 6.63 ft-lbs/cu in.
Liquid Limit: 64
Plasticity Index: 47
Sample Date: 1/31/95
Sampled by: Drill Crew
CBR: 2.0%, 3.8%, 3.6% (Remolded to 79.2%, 90.3%, 99.0% of Max. Dry Density at 24.8%, 24.0%, 24.2% Moisture Content and Soaked for 96 Hours)
Moisture Content: 35.5%, 32.0%, 31.6% Respectively (Top 1")
34.9%, 27.6%, 24.8% Respectively (Middle)
Percent Swell: 2.7, 0.3, 3.1 Respectively

Laboratory No. 4-119157
02/20/95

Raba-Kistner Consultants, Inc.

PROJECT No. ASA95-005-00



LIME SERIES CURVE
UNIVERSITY AVE STREET IMPROVEMENT – SABINAS ST TO IH-10
SAN ANTONIO, TEXAS

Raba-Kistner Consultants,Inc.

PROJECT No. ASA95-005-00

WESTSIDE CREEKS ECOSYSTEM RESTORATION

Appendix G: Hazardous, Toxic and Radioactive Waste

HAZARDOUS, TOXIC AND RADIOACTIVE WASTE TECHNICAL APPENDIX

The US Army Corps of Engineers, Fort Worth District, (USACE) awarded a Task Order to Gulf South Research Corporation, Inc. (GSRC) to conduct a Phase I Environmental Site Assessment (ESA) for all study areas in the West Side Creek (WSC) Project. As required by the performance work statement, GSRC conducted the ESA in accordance with ASTM E1527-05. The purpose of the ESA was to assess the environmental condition of the proposed project areas and to identify actual or potential environmental contamination within the WSC project area.

The ESA addressed the following WSC areas, see Figure 1:

- San Pedro Creek (SP) - from its confluence with the San Antonio River to the Camp Street bridge crossing, approximately 2.4 miles.
- Apache Creek (AP) - from its confluence with San Pedro Creek to Southwest 19th Street bridge crossing , approximately 2.7 miles.
- Alazán Creek (AL) - from its confluence with Apache Creek to the Josephine Tobin Drive South bridge crossing, approximately 3.3 miles.
- Martinez Creek (MA) - from its confluence with Alazán Creek to the Hildebrand Avenue bridge crossing, approximately 2.7 miles.

The ESA also included an Environmental Data Resources, Inc. (EDR) database report which identifies areas having reported spills and or current activities which could result in contaminated areas.

On 22 October 2012 GSRC, USACE and San Antonio River Authority representatives met on-site at an abandoned railroad yard which the EDR database indicated could be a site of potential contamination. From that site they proceeded along the San Pedro Creek to its confluence with the San Antonio River. The project delivery team (GSRC and USACE personnel, i.e. the PDT) then proceeded to assess the remaining creeks.

During each assessment the PDT visually inspected each stream corridor for any significant readily visible indicators of adverse environmental conditions, such as soil or water staining or sheens, dead or distressed vegetation, discarded barrels or other chemical containers, and debris and trash.

The PDT also inspected properties adjacent to the stream corridors, to the extent possible from outside the property boundaries, for any visible potential sources of environmental contamination or risk to the stream corridors. When necessary the PDT interviewed available owners or managers of suspect adjacent properties to clarify any environmental conditions observed.

The PDT took photographs of the stream corridors, any environmental conditions observed, and any suspect adjacent properties. All photographs are referenced to aerial photography of each stream corridor and are included in the ESA report for each creek. There are four ESA reports; they are not included in this appendix.

Figure 1. Westside Creeks Ecosystem Restoration HTRW Area

The ESA results are summarized as follows:

Alazán Creek, Apache Creek and Martinez Creek. The PDT did not observe any recognized environmental conditions (RECs) on the project area or RECs on adjacent properties with a potential to migrate into or affect the project area, and no historical records searched indicated any other environmental concerns for the subject property. No additional assessments or studies for hazardous and toxic substances or waste are recommended for these properties based on this information.

San Pedro Creek. The PDT observed a REC on an adjacent property with potential to migrate into the project area, and historical records searched indicated environmental concerns for the subject property. Figure 1 shows the approximate location of this site. Since the WSC project construction will not disturb the east creek bank in the vicinity of the Sloan Market Yard site additional assessment is not recommended.

However, if future activities will disturb the east creek bank it is recommended that an additional assessment for hazardous and toxic substances or waste be conducted focused on characterizing any materials that would be disturbed by such activities. This additional assessment, if required, should focus on soils and potential for affecting impacts from contaminated groundwater (if any) to the stream that might be affected by the activities.

The ESA contractor has reported that historical aerial photos indicate activities suggesting the site was in full operation as a railroad yard as late as 1985, and some related activities continued until 1995.

A TCEQ closure report put Activity and Use Limitations on the property as a condition of closure due to the presence of VOCs and metals in the groundwater and soils, indicating the possibility of subsurface contamination along San Pedro Creek.

WESTSIDE CREEKS ECOSYSTEM RESTORATION

Appendix H: Cultural

CULTURAL RESOURCES APPENDIX

Cultural resources can be defined as the broad pattern of events, real properties, and cultural life ways or practices that have significance to humans. Buildings and places where significant events occurred, archeological sites containing significant information about human activities, traditional places or activities that hold special significance, and folkways which are practiced as either cultural or life sustaining, are all part of the broad category features of groups of people. The potential cultural resources within the Westside Creeks (WSC) project areas are expected to be archeological, consisting primarily of evidence associated with the presence of prehistoric and historic peoples. These types of historic properties are evaluated for eligibility or listing in the National Register of Historic Places (NRHP). Section 106 (16 U.S.C. 470*f*) of the National Historical Preservation Act (NHPA) requires that Federal agencies consider their undertakings, or projects, and the potential of those undertakings to impact NRHP eligible or listed properties through the procedures found in 36 CFR Part 800 (*Protection of Historic Properties*). These consultations must include the Texas State Historic Preservation office (SHPO) and federally recognized Native American tribes potentially affected by the proposed action. USACE has begun consultation with the SHPO and affected Native American tribes, which includes the development of a Programmatic Agreement to ensure compliance with Section 106 of the NHPA.

Within the WSC study area, the San Antonio Channel Improvement Project (SACIP) greatly altered the original course of the creeks under study. For this reason, the WSC are considered to be highly disturbed. The Area of Potential Effects (APE) for archaeological resources lies within the existing right of way of the SACIP. The limits of the APE for view shed impacts to above ground and architectural properties is ½ mile of the SACIP boundary, since proposed construction activities are unlikely to be perceived beyond this point.

ARCHITECTURAL RESOURCES

As part of the Conceptual Plan for the WSC study, the San Antonio River Authority (SARA) conducted a reconnaissance level survey of known and potential NRHP - eligible architectural resources within the APE. The survey identified several areas with high potential for cultural significance as well as several well documented resources, especially on San Pedro creek near downtown San Antonio. Resources such as Governor’s Palace, Military Plaza and the Aztec Theater, which are eligible for listing on the National Register of Historic Places, were identified.

There is little to no potential to effect above ground resources, specifically buildings and structures along the WSC. The limit for Area of Potential Effects (APE) for architectural resources and associated view sheds is up to ½ mile from the existing boundary of the SACIP. However, ecosystem restoration along the creeks is not considered to be an adverse effect to the view shed. No above ground resources are located within the proposed construction footprint for any of the WSC alternative plans. The Texas Historical Commission (THC) has concluded that no additional above-ground identification efforts are required for the WSC APE.

ARCHEOLOGICAL RESOURCES

A check of the THC data files was conducted to gather information on any and all previous investigations within the WSC. The effected portions of Apache Creek, Martinez Creek, San

Pedro Creek, and Alazán Creek were examined for known resources and previous survey work. The data search was limited to the existing SACIP right of way since physical impacts are not expected beyond that limit.

The THC records search revealed that no survey has been conducted within the WSC study area. Therefore, there is a reasonable likelihood for the presence of significant archaeological sites. Recent construction activities along portions of the San Antonio River have turned up several deeply buried archaeological sites, despite thorough surveys conducted during the planning and design stages. This is evidence that the creation of the SACIP channel did not necessarily destroy all deposits present, suggesting that sites of varying significance may be present throughout the region.

However, consultation with the THC and review of maps of the area prior to the construction of the SACIP reveal that the WSC were significantly altered, and in some cases moved all together from their natural state. Whatever plan is selected, above the No Action plan, will call largely for excavations no deeper than 18 inches within the current SACIP footprint to remove the existing soil and seed bank from the side slopes. In an alluvial setting such as this, soil deposition builds rapidly and as a result, culture bearing deposits become deeply buried in a short time. Along the San Antonio main stem, archaeological deposits were found some four feet below the current ground surface. At the most shallow, artifacts considered not to be *in situ* were recovered from two feet below the present day surface. In addition, deep auger testing in some areas along the San Antonio River within the SACIP footprint revealed a disturbed construction matrix at depths up to 8 feet below the surface. This information has led the THC and USACE to agree that an archaeological survey aimed at an 18-24 inch construction depth is unlikely to identify significant cultural resources that would be impacted by construction. In areas where deeper excavation for a pilot channel may be required, the likelihood of encountering archaeological sites is also very low. If the channel is in a new location as a result of SACIP construction, then that construction, along with utility placement, will have disturbed any cultural deposits. In areas where the current channel is more or less in its natural placement, archaeological sites are unlikely to be encountered during pilot channel excavation as prehistoric and historic people utilized the banks of rivers and tributaries, in lieu of the channel beds.

USACE will have an archaeological monitor on site during soil removal and excavation activities. The monitor will be able to identify any cultural material that may be exposed during construction and evaluate the significance of the materials as they are revealed. A monitor is routinely on-site during construction to look for and evaluate inadvertent discoveries of cultural materials during construction. The presence of the monitor is not considered to add any additional risk to the construction schedule than would be accounted for during any USACE construction activities.

WESTSIDE CREEKS ECOSYSTEM RESTORATION

Appendix I: Socio-Economics

SOCIO-ECONOMIC APPENDIX

INTRODUCTION

The purpose of this appendix is to provide a socio-economic description of the Westside Creeks study area and an analysis of flood risk management damages and benefits.

DEMOGRAPHIC PROFILE

STUDY AREA

The study area comprises approximately 12 square miles along San Pedro, Apache, Alazán, and Martinez Creeks in San Antonio, Bexar County, Texas. The three creeks, known locally as the Westside Creeks, are tributaries of the San Antonio River and are located to the west of the downtown area of San Antonio. The study area is primarily urban residential with business districts with some manufacturing facilities. The San Antonio area is serviced by Interstate Highway (IH)-10 and IH-35 and US Highway 90. Figure 1 shows the study area delineation.

POPULATION

TOTAL POPULATION AND GROWTH

San Antonio, with a population of 1,327,407, is the 7th largest city in the United States. The 2010 population for the study area is estimated at 77,782 persons, and projected to be 82,115 by 2016. Based on 2010 numbers, the study area comprises approximately 6% of the total population of San Antonio and 5% of the total population of Bexar County. The population of the city of San Antonio makes up 7% of the total population of Texas, and is the second largest city by population in the state, with Houston being the largest. Populations and projections for these geographical areas are presented in Table 1. Projections to 2040 for the study area were not available, but would likely have similar growth patterns to the county and city. With an annualized growth rate of 1.2%, San Antonio is expected to grow by 41% between 2010 and 2040. Bexar County has an annualized growth rate of 0.9% and is expected to grow by 31% over the same period. For comparison, Texas is expected to grow by 78% with an annualized growth rate of 1.9%.

Table 1. Population and Projections

Geographical Area	2010	2016	2040
Texas	25,145,561	27,505,386	44,872,038
Bexar County	1,714,773	1,900,877	2,253,060
San Antonio city	1,327,407	1,452,140	1,872,964
Westside Creeks Study Area	77,782	8,115	

Source: ESRI Community Analyst citing U.S Bureau of the Census, 2010 Census of Population and Housing(2010 and 2016 figures); Texas State Data Center (2040 projections for Texas and Bexar County); Texas Water Development Board (2040 projection for San Antonio)

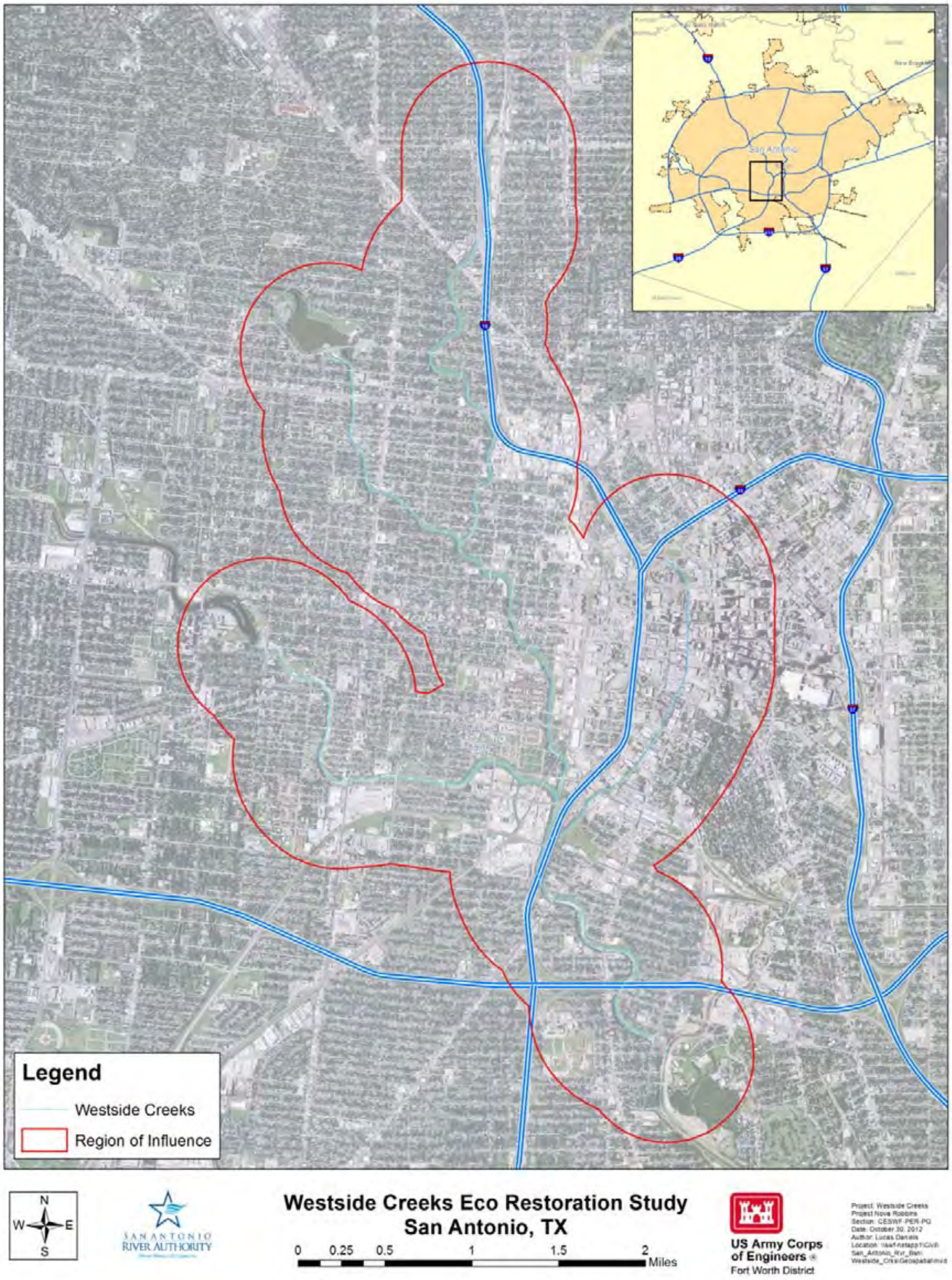


Figure 1. Westside Creeks Study Area

RACE AND ETHNICITY

In the 2010 census, approximately 72% of the population in the study area identified themselves as White, 3% as Black, 1% as American Indian, less than 1% each for Asian and Pacific Islander, 20% as other, and 3% as two or more races. For the city of San Antonio, the race composition is 73% White, 7% Black, 1% American Indian, 2% Asian, less than 1% Pacific Islander, 14% other, and 3% two or more races. For Bexar County, the composition is 73% White, 8% Black, 1% American Indian, 2% Asian, less than 1% Pacific Islander, 13% other, and 4% two or more races. The composition for Texas is 70% White, 12% Black, 1% American Indian, 4% Asian, less than 1% Pacific Islander, 11% other, and 3% two or more races. For Whites, the study area's composition is similar to the other geographical areas. The percentage of Blacks is smaller than the other areas, while the percent of other race is considerably greater in the study area.

Eight-nine percent of the study area population identified themselves as Hispanic. For the city of San Antonio, 63% of the population considered themselves of Hispanic origin, 59% in Bexar County, and 38% for Texas. As shown, the study area is considerably more Hispanic than the other geographical areas. Tables 2 and 3 show the 2010 population by race and Hispanic Origin, respectively.

Table 2. 2010 Population by Race

Geographical Area	White	Black	American Indian	Asian	Pacific Islander	Some Other Race	Two or More Races
Texas	17,701,552	2,979,598	170,972	964,596	21,656	2,628,186	679,001
Bexar County	1,250,252	128,892	14,475	41,739	2.350	217,389	59,676
San Antonio city	963,413	91,280	11,800	32,254	1,504	181,625	45,531
Westside Creeks Study Area	55,972	2,616	1,058	267	40	15,597	2,233

Source: ESRI Community Analyst citing U.S Bureau of the Census, 2010 Census of Population and Housing

Table 3. 2010 Hispanic Origin Population

Geographical Area	Hispanic Origin
Texas	9,460,921
Bexar County	1,006,958
San Antonio city	838,952
Westside Creeks Study Area	69,538

Source: ESRI Community Analyst citing U.S Bureau of the Census, 2010 Census of Population and Housing

AGE

The percent distribution of the population by age group is almost identical among all the geographical areas. Approximately 16% are under nine years of age, 15% between 10 and 19, 23% between 20 and 34, 12% between 35 and 44, 23% between 45 and 64, and 11% 65 or older. Table 4 shows the population by age group for the geographical areas. Median ages for the areas are 32.3 for the study area, 32.8 for San Antonio, 32.9 for Bexar County, and 33.6 for Texas.

Table 4. 2010 Population by Age Group

Geographical Area	0-9	10-19	20-34	35-44	45-64	65+
Texas	3,856,707	3,765,007	5,430,552	3,458,382	6,033,027	2,601,886
Bexar County	260,394	260,777	386,722	230,754	400,243	175,883
San Antonio city	199,799	199,907	304,784	175,669	308,644	138,604
Westside Creeks Study Area	12,444	11,500	17,735	9,681	17,719	8,703

Source: ESRI Community Analyst citing U.S Bureau of the Census, 2010 Census of Population and Housing

HOUSEHOLDS

Table 5shows the number of households and household characteristics for the geographical areas. There are 23,932 households in the Westside Creeks study area. The average household size in the study area is 2.96, which is slightly larger than for the other three areas. In all areas, most households, ranging from 72 to 76%, consist of two or more people, and the majority of the households are made up of family members. Approximately 11% of the households in the study area are multigenerational, considerably more than in the other areas, which range from 6 to 7%.

Table 5. 2010 Households and Household Characteristics

Geographical Area	Households	Average Household Size	1 Person Households	2+ Person Households	Family Households	Non-Family Households	Multi-generational Households
Texas	8,922,933	2.75	24.2%	75.8%	69.9%	5.9%	5.8%
Bexar County	488,942	2.75	25.3%	74.7%	68.4%	6.3%	6.5%
San Antonio city	407,775	2.71	26.9%	73.1%	66.3%	6.8%	6.7%
Westside Creeks Study Area	23,932	2.96	27.8%	72.3%	66.4%	5.9%	10.6%

Source: ESRI Community Analyst citing U.S Bureau of the Census, 2010 Census of Population and Housing

EDUCATION

Table 6 shows the percent of the population 25 years of age and older by highest level of education. In the Westside Creeks study area, almost 50% of the population had less than a high school degree or GED. This is significantly greater than for the city, county and state. The proportion of population with a high school diploma or GED as their highest level of education is similar for all of the geographical areas, ranging from 26 to 29%. However, for persons achieving associate, bachelor's, or graduate degrees, the study area has a significantly lower percent of its population with associate' degrees or higher.

Table 6. Percent of Population 25 Years and Older by Highest Level of Education

Geographical Area	Less than High School Diploma	High School Diploma	Associate Degree	Bachelor's Degree	Master's, Professional or Doctorate Degree
Texas	20.3%	26.6%	6.6%	17.1%	8.4%
Bexar County	18.6%	27.3%	7.1%	15.8%	8.7%
San Antonio city	20.8%	27.4%	6.7%	15.0%	8.1%
Westside Creeks Study Area	49.6%	29.2%	3.0%	3.8%	2.1%

Source: ESRI Community Analyst citing U.S Bureau of the Census, 2010 Census of Population and Housing

INCOME

Comparing median household incomes for 2010, the figure for the study area is almost 50% less than the other geographic areas, whose median household incomes are similar. The median household income in the study area is $22,749, compared to the mid $40,000's for the other areas. Per capita income is also approximately 50% less in the study area than in the other geographical areas, with only $12,813.

Table 7. 2010 Median Household and Per Capita Incomes

Geographical Area	Median Household Income	Per Capita Income
Texas	$47,753	$24,332
Bexar County	45,689	23,545
San Antonio city	42,612	22,457
Westside Creeks Study Area	22,739	12,813

Source: ESRI Community Analyst citing U.S Bureau of the Census, 2010 Census of Population and Housing

In the study area, 53% of households have household income of less than $25,000, and 33% have incomes less than $15,000. This shows that for the study area, incomes are more tightly grouped at the lower end of the spectrum, while in the other areas, household incomes are more evenly distributed from the lower end to $149,999. Table 8 shows the percent of households by household income range for all of the study areas.

Table 8. Percent of Households by Income Range

Geographical Area	Less than $15,000	$15,000-24,999	$25,000-34,999	$35,000-49,999	$50,000-74,999	$75,000-$99,999	$100,000-149,999	$150,000-199,999	$200,000 and Greater
Texas	14.2%	11.9%	11.1%	14.5%	17.9%	11.5%	11.2%	3.9%	3.8%
Bexar County	14.0%	12.5%	11.6%	15.3%	18.3%	11.0%	10.3%	3.6%	3.4%
San Antonio city	15.3%	15.3%	12.2%	15.6%	17.8%	10.3%	9.5%	3.2%	2.8%
Westside Creeks Study Area	32.9%	20.3%	15.5%	13.4%	10.8%	3.7%	2.3%	0.6%	0.5%

Source: ESRI Community Analyst citing U.S Bureau of the Census, 2010 Census of Population and Housing

HOUSING

There are an estimated 26,989 housing units in the Westside Creeks study area. Approximately 90% are occupied which is consistent with the other geographical areas. For all of the areas, vacancy rates range from 8 to 11%. In the study area, 50% of the occupied units are owner-occupied, and 50% are renter occupied. Ownership rates are slightly higher in the other three geographical areas with 57% ownership in San Antonio, 61% in Bexar County, and 64% in Texas. This information is presented in Table 9.

Table 9. 2010 Housing Units and Characteristics

Geographical Area	Housing Units	Percent Occupied	Percent Vacant	% Owner Occupied	% Renter Occupied
Texas	9,977,436	89.4%	10.6%	63.7%	36.3%
Bexar County	662,872	91.9%	8.1%	60.5%	39.5%
San Antonio city	524,246	91.5%	8.5%	56.5%	43.5%
Westside Creeks Study Area	26,989	89.4%	10.6%	49.5%	50.5%

Source: ESRI Community Analyst citing U.S Bureau of the Census, 2010 Census of Population and Housing

BUSINESS AND EMPLOYMENT

BUSINESS MAKEUP

There are an estimated 3,109 business establishments in the Westside Creeks study area. About 15% are classified as other services under the North American Industry Classification System (NAICS). The second largest sector is retail which represents 14% of all establishments. Professional, Scientific, and Technical Services make up 11% followed by Accommodation and Food Services with 9% and Health Care & Social Assistance with 8%. Almost 7% of establishments are Public Administration while Construction and Wholesale Trade make up 6% each. The remaining categories make up 5% or less of the total number of establishments. Table 10 provides similar data for Texas, Bexar County, and San Antonio for comparison.

Table 10. Number of Business Establishments and Percent Distribution Among NAICS Classification for 2012

NAICS Classification	Texas	Bexar County	San Antonio	Westside Creeks Study Area
Total Number of Businesses	919,059	55,001	45,786	3,109
Agriculture, Forestry, Fishing & Hunting	0.8%	0.3%	0.2%	0.1%
Mining	0.6%	0.3%	0.3%	0.1%
Utilities	0.3%	0.1%	0.1%	0.0%
Construction	7.9%	7.9%	7.1%	5.7%
Manufacturing	3.5%	3.0%	3.0%	3.9%
Wholesale Trade	4.9%	4.3%	4.5%	5.8%
Retail Trade	15.1%	15.0%	15.1%	14.0%
Transportation & Warehousing	2.4%	1.8%	1.7%	1.3%
Information	1.8%	1.8%	1.9%	1.4%
Finance & Insurance	6.4%	6.8%	7.0%	5.2%
Real Estate, Rental & Leasing	5.7%	6.4%	6.5%	3.3%
Professional, Scientific, & Tech Services	8.9%	10.0%	10.2%	11.3%
Management of Companies & Enterprises	0.1%	0.1%	0.1%	0.0%
Administrative, Support, Waste Management Services	3.9%	4.3%	4.2%	3.3%
Educational Services	2.5%	2.5%	2.4%	2.0%
Health Care & Social Assistance	6.9%	7.7%	8.2%	8.1%
Arts, Entertainment, & Recreation	1.6%	1.7%	1.6%	1.7%
Accommodation & Food Services	6.9%	8.1%	1.0%	9.0%
Other Services	13.8%	13.6%	13.5%	14.9%
Public Administration	3.2%	1.5%	1.4%	6.6%
Unclassified Establishments	2.6%	2.8%	2.7%	2.4%

ESRI Community Analyst, citing Infogroup

EMPLOYMENT

In terms of employment, 17% of those working in the Westside Creeks study area are employed in the Public Administration sector. Educational Services is the second largest employer in the study area making up 15% of all employees followed by Health Care and Social Assistance with 13%. Retail Trade accounts for 9% of employment in the study area. The remaining sectors make up 5% or less each of total employment in the study area. Table 11 provides similar information for Texas, Bexar County, and San Antonio for comparison.

Table 11. Number of Employees and Percent Distribution Among NICS Classification for 2012

NAICS Classification	Texas	Bexar County	San Antonio	Westside Creeks Study Area
Total Number of Employees	10,872,751	766,747	664,366	53,558
Agriculture, Forestry, Fishing & Hunting	0.3%	0.1%	0.1%	0.0%
Mining	0.8%	0.2%	0.2%	0.1%
Utilities	0.6%	0.3%	0.3%	0.0%
Construction	6.3%	4.9%	4.4%	3.5%
Manufacturing	8.0%	6.6%	7.1%	4.9%
Wholesale Trade	5.2%	3.8%	4.1%	4.6%
Retail Trade	13.4%	13.9%	13.9%	8.9%
Transportation & Warehousing	2.9%	2.2%	2.3%	0.9%
Information	1.9%	1.8%	1.1%	1.2%
Finance & Insurance	4.1%	4.1%	4.3%	3.3%
Real Estate, Rental & Leasing	2.8%	3.2%	3.2%	1.0%
Professional, Scientific, & Tech Services	6.8%	6.4%	6.8%	5.1%
Management of Companies & Enterprises	0.2%	0.2%	0.3%	2.4%
Administrative, Support, Waste Management Services	3.1%	5.4%	5.5%	3.0%
Educational Services	9.4%	10.1%	13.8%	14.8%
Health Care & Social Assistance	11.1%	14.2%	1.6%	13.4%
Arts, Entertainment, & Recreation	1.4%	1.7%	1.6%	0.6%
Accommodation & Food Services	9.6%	11.6%	12.0%	10.3%
Other Services	5.8%	5.3%	5.1%	4.6%
Public Administration	5.3%	3.0%	2.9%	16.7%
Unclassified Establishments	0.9%	0.9%	0.9%	0.8%

ESRI Community Analyst, citing Infogroup

According to the Texas Workforce commission, the September unemployment rate for Texas was 6.3%, Bexar County was 6.1%, and San Antonio was 6.0%. Data specific to the study was not available, but would be expected to be representative of the county and city and therefore in the 6.0% range.

SOCIO-ECONOMIC SUMMARY

Approximately 78,000 persons or 6% of the population of San Antonio lives within the 12 square mile Westside Creeks study area. The population is predominantly of Hispanic Origin (89%), and 72% of the population considered themselves as White on the 2010 census. With regards to age, the two largest age groups are 20-34 and 45-64. Sixteen percent are under nine years of age, and 11% are 65 years or older. The median age is 32.3 years.

Seventy-two percent of the households in the study area are predominantly made up of 2 or more persons family households and have a higher multi-generational makeup than the state, county, or city. Eighty-nine percent of the available housing units are occupied, and 50% are owner occupied; however, the ownership rate is 3% less than the city of San Antonio and 9% less than Bexar County.

The study area shows to have attained less education when compared to San Antonio, Bexar County, and Texas. Almost 50% of those 25 years of age and older have less than a high school education, 29% have only a high school diploma, and 9% possess an Associate's degree or higher.

Similarly, the study area shows to be poorer than the city, county and state. With a median household income of $23,000, the income shows to be about half of what is experienced in the other geographical areas. Per capita income ($12,813) is also about half of per capita incomes in the other geographical areas.

Service sector and retail establishments make up the largest number of employers in the study area; however, most people working in the study area are in either public administration, educational services, or health care. The unemployment in the area is around 6.0%

ENVIRONMENTAL JUSTICE CONCERNS

In accordance with Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations," data were compiled to help assess the potential impacts to minority and low-income populations within the study area. Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies.

With respect to minority race and ethnicity, 89% of the study area's population identifies themselves as Hispanic. Additionally, the study area shows to be considerably poorer than the City of San Antonio and Bexar County. Therefore, any study recommendations could potentially impact both minority and low income populations. However, since one of the constraints of the study is to maintain water surface elevations there is no anticipated adverse flood risk impacts to this population. Also, an ancillary benefit of the ecosystem restoration is to reconnect the neighborhoods divided by earlier channel modifications in the creeks. With recreation also being considered benefits would not only accrue to the local neighborhoods, but to the city as a whole. Given these expectations, no economic justice concerns are anticipated.

FLOOD RISK MANAGEMENT

Though earlier channel modifications and permanent removal of structures reduced flood risk in the Westside Creeks study area, there are residual damages and structures within the 100 year flood plain delineation. To determine if the remaining flood risk would support federal investment a preliminary analysis was performed with information available before funds were expended to develop complete structure files and HEC-FDA models.

Using GIS, building footprints, stream banks, the 100 year flood plain delineation based of FEMA DFIRM mapping, and contours were added as layers. The depth of flooding within the flood plain was determined by the difference between the water surface elevation and the top of stream bank at cross-sections along each creek and estimated separately for left and right banks. Flooding would only occur if the water surface elevation exceeded the stream bank. During initial site visits in 2010, it was noted that structures along the creeks were predominantly of pier-and-beam construction and had finished floor elevation between 1.5’ and 3.0’. Using contour files, a ground elevation was assigned to each structure as well as stream cross sections.

Median flood depths are shown in Table 12. The median depth ranged from 1.6 feet to 2.3 feet. This would place water at or only slightly above finished floor elevations for 50% of the structures remaining in the 100 year flood plain. Based on information from the Bexar County Appraisal District, the average age of a home was 60 years, and the average 2010 valuation was $52,300. Since damages would accrue to less that 50% of the remaining structures and the structures would have a low depreciated replacement value when considering age, observed condition, and values, the PDT along with the local sponsor feel that remaining damages would not support any significant structural alternative, and real estate acquisition costs would not likely support a non-structural measure.

Table 12. Estimation of Depths of Flooding Above Ground Surface Elevation in the Westside Creeks Study Area

Creek	Minimum Flooding Depth (feet)	Maximum Flooding Depth (feet)	Median Depth
Alazán Creek	0.0033	5.6	1.56
Apache Creek	0.0039	6.9	1.40
Martinez Creek	0.0008	7.1	2.03
San Pedro Creek	0.0485	5.1	1.67

WESTSIDE CREEKS ECOSYSTEM RESTORATION

Appendix J: Recreation

RECREATION APPENDIX

WESTSIDE CREEKS DRAFT RECREATION PLAN

Recreation development provides opportunities that significantly benefit communities. The social, cultural, scientific, and education values of these recreation opportunities were considered throughout recreation formulation for the Westside Creeks Ecosystem Restoration and Recreation project in San Antonio, Texas.

RECREATION AUTHORITY

The legislative basis for Federal participation in recreation development is found in Section 4 of the Flood Control Act of 1944, as amended, the Federal Water Project Recreation Act of 1965 (Public Law 89-72), and the Water Resources Development Act of 1986 (Public Law 99-662). These give broad authority to include recreation as a project purpose. The authority to include recreation as a project purpose falls within WRDA 2000 as stated below:

> Additional authorization and guidance for the proposed ancillary recreation resources development is contained in the CECW-AG, 11 June 1998 Memorandum, Policy Guidance Letter No. 59, Recreation Development at Ecosystem Restoration Projects and EP 1165-2-502. Despite austere budgets and policy requirements, recreational developments can and do contribute to community health and well being (CECW, 1998). The recreation resources that are being proposed as part of the San Antonio Channel will comply with the inclusion of the WRDA 2000, SEC. 335. The project for flood control, San Antonio channel, Texas, authorized by section 203 of the Flood Control Act of 1954 (68 Stat. 1259) as part of the comprehensive plan for flood protection on the Guadalupe and San Antonio Rivers in Texas, and modified by section 103 of the Water Resources Development Act of 1976 (90 Stat. 2921), is further modified to include environmental restoration and recreation as project purposes.

FEDERAL INTEREST

The primary Federal interest for the WSC study is contribution to National Ecosystem Restoration (NER) through restoration of degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition. National Economic Development (NED) benefits which were also evaluated in this study include recreation. Recreation benefits were found to be justified and the recreation plan is included in the recommendation.

STUDY OBJECTIVE

ECOSYSTEM RESTORATION (ER) OBJECTIVE

Restore to the extent practicable, a sustainable, dynamic, riverine ecosystem providing habitat for aquatic and riparian dependent migratory and native resident bird species in the Westside Creeks study area. The study area is shown in Figure 1.

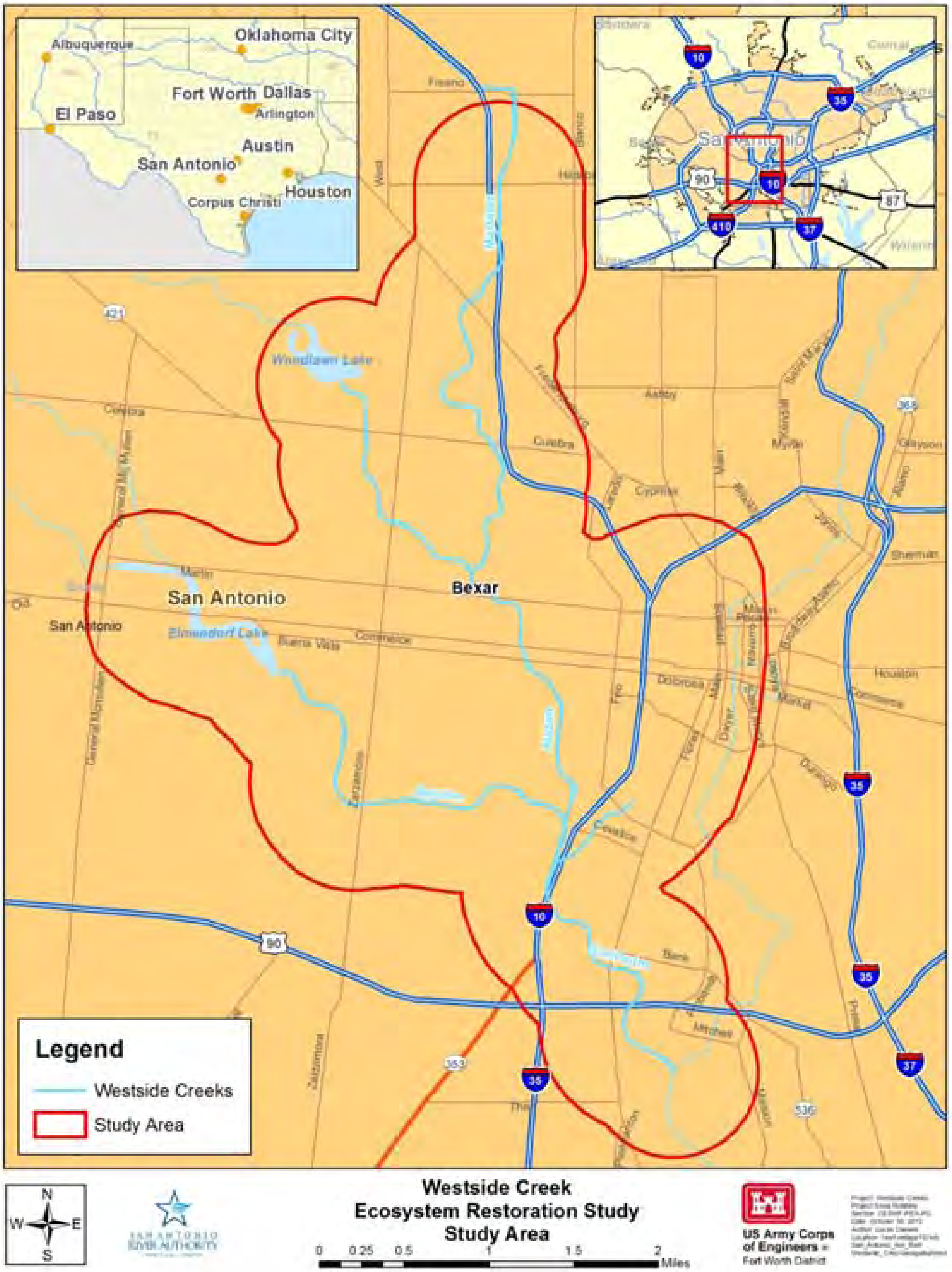


Figure 1. Westside Creeks Study Area

RECREATION OBJECTIVE

Maximize to the extent practicable recreation benefits along the Westside Creeks compatible in scope and scale of the project's ecosystem restoration objectives and consistent with national, regional, and local recreation goals.

STUDY AREA BACKGROUND

WESTSIDE CREEKS HISTORY

The Westside Creeks are located just west of downtown San Antonio in an area at the northern part of the Rio Grande Plain and the adjacent Edwards Plateau. Elevations in the project area range from approximately 720 feet along Fredericksburg Road to approximately 570 feet at the confluence of San Pedro Creek with the San Antonio River. Martínez Creek flows in to Alazán Creek, which flows into Apache Creek, which in turn flows into San Pedro Creek.

The evolution of the Westside Creeks (Alazán, Apache, Martinez, and San Pedro Creeks) over the last half-century is largely due to shifts in urbanization and in flood risk reduction and maintenance practices. Historically the area was known with a more natural stream consisting of a baseflow channel, a wider channel, and a large floodplain. Straightening and channelization of the creeks yielded grass-lined trapezoidal channels that delineate most of the creeks, dramatic concrete banks, and underground bypass tunnels (San Pedro Creek) which ultimately disconnected the historically tied communities. The communities hope the project will restore former historical and cultural connections that originally tied them with the river.

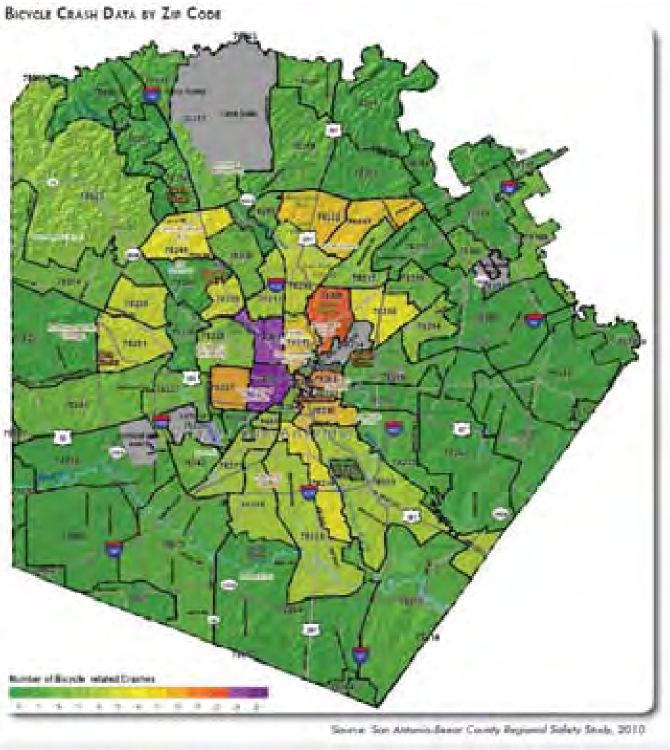
As part of a coordinated approach to address drainage issues in San Antonio, SARA initiated a San Antonio River Watershed Master Plan that provided the opportunity to explore ecosystem restoration improvements to these four creeks. This master plan allows the creeks to meet multiple objectives of improving both the ecosystem habitat and sustainability of the creeks while promoting recreation benefits for the adjacent neighborhoods and region.

Given the importance of the Westside Creeks Ecosystem Restoration and Recreation Project, the community, stakeholders, and other public groups have been heavily involved in developing community visions and prioritization perceived as essential for the community-Westside Creeks symbiotic relationship. The outcome of these public workshops, the Westside Creeks' visions were developed under four frameworks that apply to each creek and serve as guiding principles from which all other design decisions are to be made. One of the four visions is "connections". This vision relates directly to the benefits offered by recreation resources. The creation of recreation resources connecting neighborhoods and creeks is an elevated need communicated universally by the communities bounding the Westside Creeks.

WESTSIDE CREEKS COMMUNITIES

The WSC is bound by a community recognized as being one of the largest Hispanic communities in San Antonio. According to the U.S Census data (2000), approximately 89 percent of the population in the communities identified themselves as Hispanic compared to San Antonio's total Hispanic population of approximately 59 percent. The median household incomes of tracts in the Westside Creeks area also tend to be lower than that of the entire City varying as much as 30% lower. For more information on the socio-economics of the Westside Creeks population as it relates to the city and county, see the Socio-Economic appendix.

A large number of San Antonio's population ride their bikes for many reasons e.g. entertainment, exercise, and commuting to work. The majority these bicyclists (95%) are classified as a less confident adult rider and children who are less comfortable riding on streets than on designated facilities such as bike lanes or trails. A study by the City of San Antonio (San Antonio Bike Plan 2011) suggests that bicyclists in the WSC area are forced to use roads for transportation purposes since an alternate transportation route e.g. trail is not available for work commuters. This condition is reasoned to be a cause of the most bicycle-related crashes in San Antonio.



Source: San Antonio-Bexar County Regional Safety Study, 2010

Figure 2. Bicycle Crash Data by Zip Code

The American Obesity Society declared San Antonio, Texas the heaviest city in the United States. According to statistics from the U.S. Center for Disease Control, 31 percent of its residents are obese and 65 percent are overweight: the worst record in the nation. Metro Health, the San Antonio Metropolitan Health District whose mission is to provide leadership and services for San Antonio and Bexar County to prevent illness and promote healthy behaviors, states that the WSC study area is within a zone of school districts which have a 37-67 percent obesity rate among children.

INTRODUCTION TO RECREATION PROPOSED FOR THE WSC STUDY

This recreation appendix for the Westside Creeks project report contains the description of the proposed recreation elements and conceptual plan. The objective of the proposed recreation concept is to identify the restoration compatible recreation that is ancillary and complimentary to the proposed project. The recreation elements proposed are incidental benefits and would not be used in the justification of the recommended plan. Recreation costs have been included in the

U.S. Army Corps of Engineers (USACE), Fort Worth District, Microcomputer Aided Cost Engineering System (MCASES) costs. A determination of recreation facility design standards to meet USACE and local code requirements will be gauged. SARA will operate and maintain the proposed recreational features. Adjustments may be made to the dollars spent depending on Congressional funding, sponsor budget, and project design.

PROPOSED RECREATION OVERVIEW

The WSC study Ecosystem Restoration Recommended Plan (Alternative 6) would include the following features:

- Riparian
- Pilot Channel
- 30 trees per acre
- 70 trees per acre
- Slackwater
- Wetland
- Recreation Components
- Project Monitoring Plan
- Draft Operation Manual
- OMRR&R

The recreation plan would be incorporated into all of the features. The recreation facilities proposed would include: trailheads with and without vehicular parking, shade structures with interpretive boards, and an estimated 14 miles of designated multi-use trails atop and within embankments. A trail will be provided on one side of the creek where appropriate to provide access for walking, running, bike riding, bank fishing, wildlife watching, and environmental interpretation with no associated recreation cost. Gathering areas would provide ample areas for visitors and the community to congregate to bird watch, bike, and hike. Proposed project trails would provide pedestrians access to community attributes such as schools, parks, churches, cemeteries, and places to shop and work.

Proposed recreation facilities and activities would be ancillary to the proposed Westside Creek ER project and work harmoniously with project purposes. The proposed project recreation facilities would help to fill the San Antonio Park & Recreation System Strategic Plan 2006 regional deficits and link with other regional recreation facilities. Since it is anticipated that the WSC trails would connect with the expanding linear greenway park system and extend points of destination, a larger pool of visitors outside of the communities bounding the WSCs is expected at the proposed project recreation facilities.

No additional real estate is required for the proposed recreation features since all proposed features will be located on project fee title lands. The real estate is to be verified in the Real Estate appendix of the Westside Creek report. All recreation features will be compatible with the environmental goals and objectives of the proposed project, and will not detract from the environmental or socioeconomic benefits generated by the proposed project.

RECREATION FACILITIES MANAGEMENT OVERVIEW

Recreational features would be cost shared 50 percent Federal and 50 percent non-Federal. The nonfederal sponsor SARA will be responsible for 100 percent of the recreation operations, maintenance, repair, rehabilitation and replacement (OMRR&R) as outlined in the USACE Planning Guidance Notebook (Engineering Regulation [ER] 1105-2-100, Apr 2000m page E-287), ER 1165-2-400, Paragraph 7 page 6, and the USACE/SARA Cooperative Agreement.

RELATIONSHIP TO OTHER PLANS AND STUDIES

In addition to meeting the Corps' mission for ecosystem restoration and recreation, this study also addresses the missions of other federal and state agencies . National and regional agencies have missions outlining goals, objectives, strategies, and initiatives to encourage action for the benefit of the Nation’s health, safety, and overall sense of wellbeing, all of which are outcomes to the WSC recreation project.

TEXAS PARKS AND WILDLIFE

The following are TPWs major goals and objectives for the next ten years, revised and last adopted January 2005. Only those applicable to the WSC project are listed.

Goal 1: Improve access to the outdoors
Objectives
1.1 Identify opportunities to expand outdoor recreation, water access, hunting, and fishing on both public and private lands and waters.
1.5 Promote awareness and support of safe and responsible use of the outdoors.
Goal 2: Preserve, Conserve, manage, operate and promote agency sites for recreational opportunities, biodiversity, and the cultural heritage of Texas.
Objectives
2.3 Develop interpretive, educational and recreational programs at agency sites that demonstrate and promote understanding of the importance of natural and cultural resource conservation.
2.4 Protect, maintain, and restore appropriate terrestrial and aquatic habitat on agency sites.
2.5 Develop criteria for a statewide historic sites system in conjunction with the Texas Historic Commission.
2.7 Promote energy conservation and the use of alternative energy systems and programs.
Goal 4: Increase participation in hunting, fishing, boating and outdoor recreation
Objectives
4.1 Increase opportunities for youth to participate in outdoor recreation.
4.2 Promote and expand outdoor recreational activities.
4.3 Develop strategies to recruit, inform and retain new, lapsed and current outdoor users.
4.4 Increase access to and safety on public waters.
4.5 Promote outdoor recreation opportunities in urban areas.

Goal 5: Enhance the quality of hunting, fishing, boating and outdoor recreation.
Objectives
5.3 Develop private/public partnerships to maintain, enhance, and restore ecosystems and promote outdoor recreational opportunities.
5.5 Restore aquatic and terrestrial habitat where feasible to sustain and enhance healthy ecosystems.
Goal 7: Maintain or improve water quality and quantity to support the needs of fish, wildlife and recreation
Objectives
7.1 Promote watershed and range management practices that improve water quality and quantity.
7.2 Promote cross-agency and stakeholder cooperation that enhances water quality, quantity and habitat.
7.3 Incorporate instream flow and freshwater inflow needs into water permitting, planning, development and management processes.
7.4 Incorporate fish, wildlife, and recreation needs into the Regional Water Planning process.
7.5 Promote understanding of and support for the water needs of fish, wildlife and outdoor recreation.
7.6 Work with stakeholders to ensure that Water Quality Standards increasingly incorporate biological data to protect the health and productivity of Texas waters.
7.7 Encourage the conversion or transfer of existing unused water rights to the Texas Water Trust to protect instream uses

UNITED STATES DEPARTMENT OF TRANSPORTATION (USDOT)

USDOT's goals seek to reduce traffic crashes involving pedestrians and bicyclists simultaneously increasing trips made by bicycling and walking (Bicycle and Pedestrian Program). For more information see the Other Social Effects appendix.

SAN ANTONIO MASTER PLAN 2011

The San Antonio Master Plan 2011 contains vision statements, goals, objectives, and policies that encourage an active and safe city through sustainable urban design of its trails system (San Antonio Comprehensive Master Plan Framework). For more information see the Other Social Effects appendix.

SAN ANTONIO PARKS AND RECREATION SYSTEM STRATEGIC PLAN 2006-2016

The Parks and Recreation System Strategic Plan 2006-2016 fully supports the goals and objectives related to Neighborhoods and Urban Design sections which supports recreation goals for the study area (San Antonio Parks and Recreation Department). For more information see the Other Social Effects appendix.

BICYCLE MOBILITY ADVISORY COMMITTEE (BMAC)

The City of San Antonio's mission statement regarding bicycles in the City is a key component of BMAC's San Antonio Bike Plan 2011 plan, and in summary states a significant goal of increasing bike ridership for daily travel and improving cycling safety by making the bike network accessible, direct, and continuous (Bicycle Mobility Advisory Committee). The Westside Creeks project would help satisfy this goal. For more information see the Other Social Effects appendix.

SA 2020

Initiated by the Mayor's office in 2010, San Antonio (SA) 2020 creates a vision of what the citizens of San Antonio want to achieve by 2020 (SA2020). SA 2020 includes recommendations for many areas, including arts and culture, downtown development, economic competitiveness, education, family well-being, health and fitness, environmental sustainability, neighborhoods and growth management and transportation. The vision includes more walkable neighborhoods, a significant reduction in youth and adult obesity, and environmental friendly transportation.

MISSION VERDE SUSTAINABILITY PLAN

The Mission Verde Sustainability Plan (MVSP) was adopted in 2009 by the City of San Antonio to address the challenge of meeting the city's needs today without compromising those of future generations of San Antonio (Mission Verde Sustainability Plan). The plan focuses on economic sustainability; its intent is to "invest in energy saving initiatives that would save the consumer and the community money, and serve as a catalyst for job creation and innovation." Among the initiatives of the Mission Verde plan is to create an integrated and efficient multi-modal transportation system.

THE WESTSIDE CREEKS RESTORATION PROJECT CONCEPTUAL PLAN 2011

San Antonio River Authority embarked upon efforts with the City of San Antonio and Bexar County to engage the local community and other stakeholders to collect the local community ideas, concerns, and opportunities. It was important to determine the project's core values, which would resonate as themes throughout key messages for the identified core community values. The Westside Creeks Conceptual Plan showcases a series of workshops geared towards over 400 community participants and stakeholder's to establish priorities for the future of the Westside Creeks. The following table represents the communities' core values identified in the Westside Creeks Restoration Project Conceptual Plan consistent with the WSC Recreation study:

Westside Creeks Restoration Project Conceptual Plan 2011
Historic Theme
Return the roots and the history of the creeks so future generations can make connections to their history.
Cradle to Grave Theme
This theme reflects the core value that the creeks should be accessible, safe, and usable for all members of society, regardless of age or other demographic factors.
Rebirth Theme
This theme was raised by several WCROC members. This process will essentially give new life to the creeks, effectively generating a new perception of the Westside Community. This project also presents an opportunity to reintroduce the Westside of San Antonio to the rest of the City as a place that is ecologically-sound, safe and inviting.
Bringing Nature Back Theme
This theme symbolizes a return to the natural beauty that once was, focused on the importance of bringing plants and animals back to the creeks. It also voices the need to create a biologically sound and environmentally sustainable vision.
Connections Theme
The core value here is the importance of the creeks as a way of connecting points of interests, transportation networks, and the Westside to the rest of San Antonio. The general feeling was that even though the creeks are on the Westside, they will be used by people from all parts of the city and county.

Other programs and committees have applicable interests in recreation component to the WSC project. As part of the public involvement and site analysis process for the Westside Creeks Restoration Project Conceptual Plan, various key stakeholders were interviewed about opportunities and challenges for this project. The stakeholders selected were in addition to the various groups identified to participate on the WCROC and should be mentioned here:

Westside Creeks Restoration Oversight Committee (WCROC)
Residents and Neighborhood Groups
Business Owners and Business Groups
Elected Officials
San Antonio
Bexar County
Technical Officials
Bexar County officials
City of San Antonio
San Antonio River Authority
Media
Westside Service Organizations
Schools and Universities
Our Lady of the Lake University
St. Mary’s University
General Public

BENEFIT EVALUATION PROCEDURE

STUDY AREA DEFINITION

The proposed Westside Creeks recreation benefit analysis study area includes the dense residential development within the defined West Subarea in the San Antonio Park & Recreation System Strategic Plan for 2006-2016 (San Antonio Park & Recreation System Strategic Plan, 2006). This West Subarea is of similar characteristics and quality and represents the alternative recreation opportunities for the Westside Creeks study area. The System Strategic Plan is utilized to identify the recreation baseline for Westside Creeks recreation planning. The Plan identified recreation deficits and the acreages for general park needs. Based on the statistics in the report, the national average is 16 acres of park land per 1,000 residents. The following chart summarizes the park land needs of the West Subarea (based on June 2005 park acreage figures).

Table 1. West Subarea Land Acquisition Needs Identification

	2004 Inventory (acres)	Current Service Ration (Acres/Pop.)	2005 Estimated Population 211,824		2010 Estimated Population 210,396		2015 Estimated Population 210,970	
			Acres/ Goal	Excess/ Def.	Acres/ Goal	Excess/ Def.	Acres/ Goal	Excess/ Def.
Total City-Owned Park Acres	602.26	2.84/1,000	3,389	-2,787	3,366	-2,764	3,376	-2,774
Total Public Park Acres[1]	641.85	3.03/1,000	3,389	-2,747				

[1] Based on June 2005 Park Acreage, including City, County, State, Federal, and Incorporated Cities park land

In June 2005, the City owned 602.26 acres of park land, or 2.84 acres per 1,000 residents in the West Subarea. Based on the national average of 16 acres per 1,000 residents, a deficiency of 2,787 acres exists. Park acres of other public entities impact this total only minimally. Based solely on City population projections and park acreage figures (assuming no further acquisition), there will be a deficit of 2,764 acres by the year 2010. The System Strategic Plan's general priorities for recreation activities are considerations for the Westside Creeks project recreation study.

San Antonio, the largest city in Bexar County and the second most populous incorporated place in Texas, grew by 16.0 percent per the 2010 Census counts. In comparison to the other Top Ten cities in the U.S., San Antonio experienced the most population growth from 2000 to 2010. San Antonio is expected to grow by 41% between 2010 and 2040, an annualized growth rate of 1.2%. Bexar County is expected to grow by 31% over the same period, with an annualized growth rate of 0.9%. For comparison, Texas is expected to grown by 78%, an annualized growth rate of 1.9%. The population growth of San Antonio would only add to the calculated existing recreation deficits for the study area. Population projects per Census 2010 are presented in Table 2.

Table 2. Study Area Population Through 2040

Geographical Area	2010	2016	2040
Texas	25,145,561	27,505,386	44,872,038
Bexar County	1,714,773	1,900,877	2,253,060
San Antonio city	1,327,407	1,452,140	1,872,964
Westside Creeks Study Area	77,782	82,115	

Source: ESRI Community Analyst citing U.S Bureau of the Census, 2010 Census of Population and Housing(2010 and 2016 figures); Texas State Data Center (2040 projections for Texas and Bexar County); Texas Water Development Board (2040 projection for San Antonio)

EXISTING RECREATION RESOURCES

Existing recreational facilities inventoried in the COSA Parks and Recreation System Strategic Plan provides opportunities for linkages into recreation programs and creek-based greenway parks with the proposed Westside Creeks project. Recreation facilities within the COSA include: 8 natural and wilderness areas, 81 hiking and biking trails, 41 miles of developed greenway trails, 3 Neighborhood Fishin' programs, and 243 city parks. Bexar County offers an additional 24 parks comprising community parks, open space, special use facilities, joint-sponsorship facilities, and civic centers. The COSA and Bexar County park websites are http://www.sanantonio.gov/parksandrec/default.aspx and http://www.bexar.org/parks.

Recreation facilities within the more immediate Westside Creeks ER and Rec project area include: 7 Downtown Runs and Walks and Bike Rides, several downtown bike racks, several traversing on-road bike facilities, and approximately 20 City of San Antonio and Bear County parks and greenways. All of these neighboring parks are open to the public free of charge; however, several community centers charge rental fees when applicable.

PROPOSED RECREATION

The City of San Antonio and its residents desire recreation features as part of recommended restoration plan. Recreation features include a multi-use concrete trail, shade shelters, day use facilities, and directional and interpretive signage.

The recreational features are compatible with the recommended restoration project, and would serve the surrounding neighborhoods and region by providing non-consumptive recreational opportunities and eventual links to proposed trails and adjacent parks. The recreational features would not detract from the goals of the recommended restoration plan. The formulation of the recreational features is based on the guidance defined in Policy Guidance Letter No. 59, Recreation Development at Ecosystem Restoration Projects. The formulation of recreational features was conducted within the following framework:

- are totally ancillary, i.e. project was not formulated solely for recreation;
- would take advantage of the project's recreation potential;
- are not vendible; and
- would not exist without the project.

Recreation conceptual planning for the Westside Creeks project involved developing criteria that were sensitive to project hydrology/hydraulics and ecosystem restoration resources. The criteria were tested against the Westside Creeks project area, and the outcome of this exercise concluded with verifying that these criteria were applicable to the WSC project area with unique yet management site specific exceptions. These criteria used to develop the recreation conceptual plan are as follows:

- Create linear, undisrupted pathways for cohesive trail corridors
- Coordinate with local, city, and state recreation master plans to tie into existing trail
- Create connections to parks, community/recreation centers, schools, libraries, churches, bus stops, and community centers with places to work, shop, and play.
- Trail on one side of creek, not both
- No dead ends

Figure 3. Apache Creek Recreation Trails

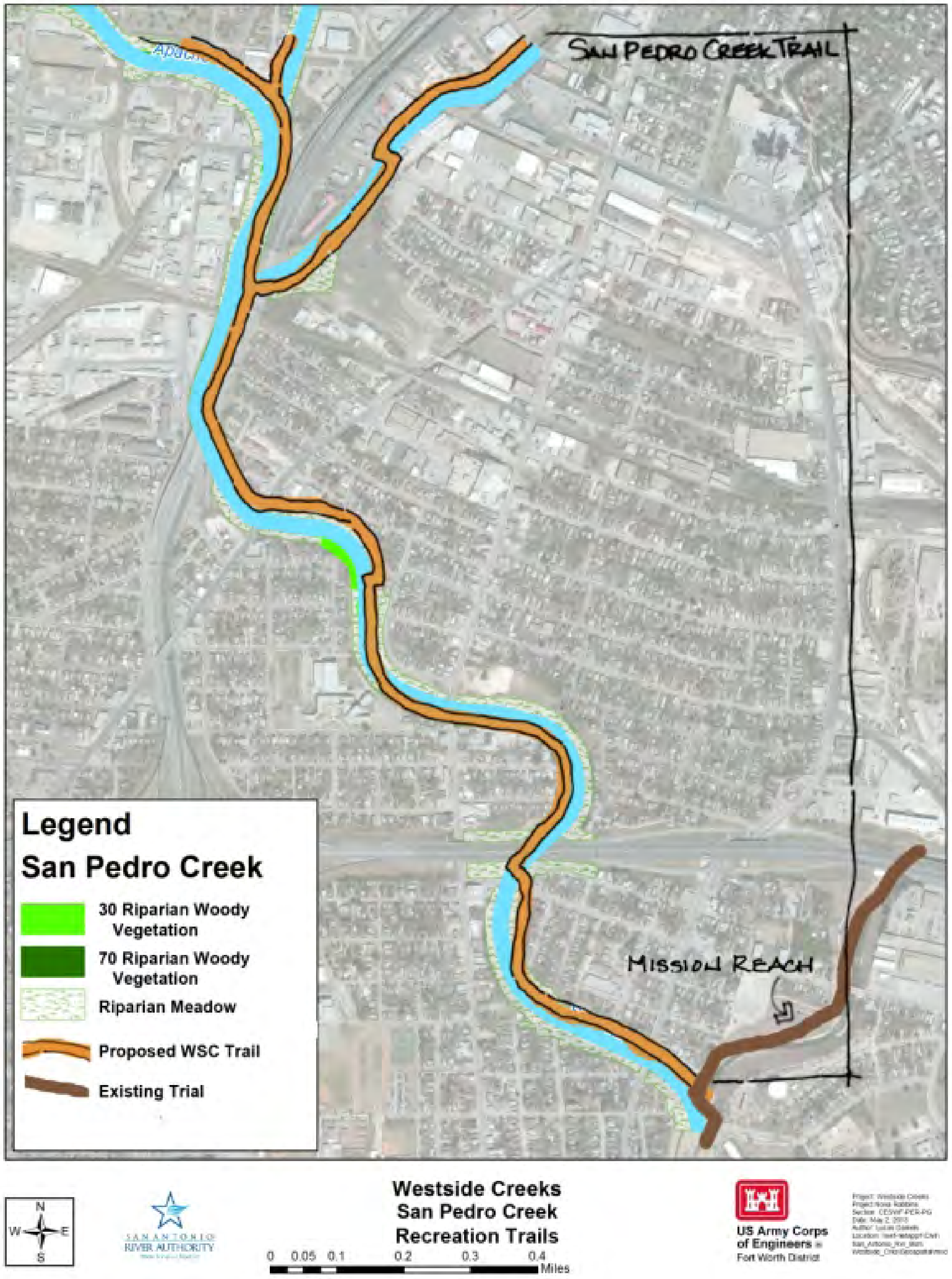


Figure 4. San Pedro Creek Recreation Trails

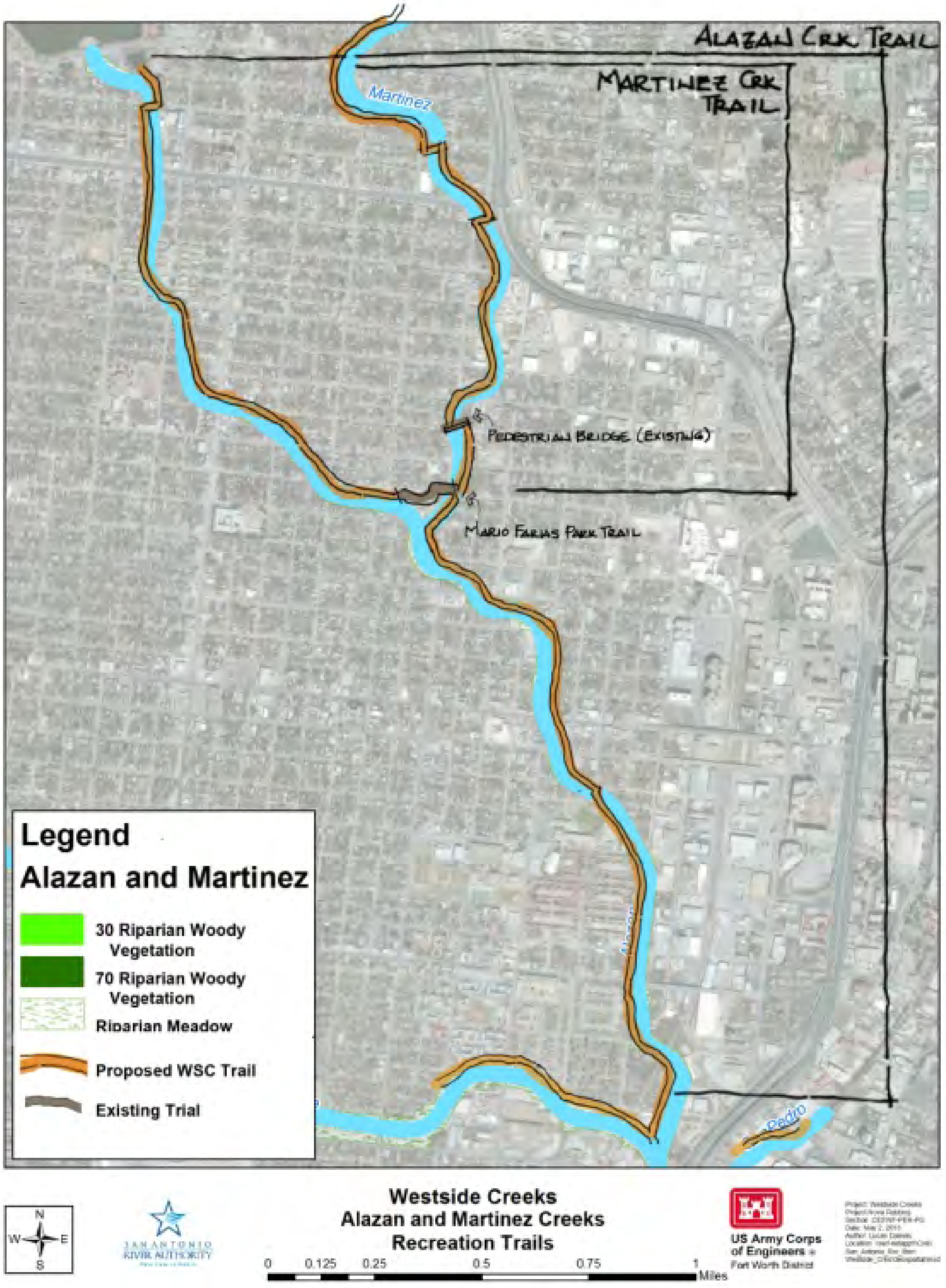


Figure 5. Alazan and Martinez Creek Recreation Trails

This section includes a description of recreation conceptual planning of multi-use trails, low-water crossings, and trailhead entrances.

MULTI-USE TRAILS

The main recreation component proposed for the Westside Creeks project is 44,600 linear feet of 10-foot wide multi-use trails incorporated into the current and planned City of San Antonio Mission Trail System. From an environmental perspective, recreation features are located to avoid adverse impacts to riparian vegetation. Not only will the trails enhance the visitation experience by taking advantage of the natural values the project ecosystem restoration features and by providing access to and along the project ecosystem restoration features, but it is anticipated to encourage social, cultural, scientific, and educational encouragement of the ecosystem restoration project. The development of these facilities will not involve extensive structural modification of the terrain but will require cut and fill adjustments to comply with American Disabilities Act (ADA) criteria. Accompanying facilities will include rest areas, picnic tables, water fountains, pedestrian bridges, interpretive signs, and gathering areas. OMRR&R costs would cover trash pickup, mowing where applicable, and facility repair, rehabilitation, and replacement. The following graphic represents the criteria utilized in developing the conceptual trail plan.

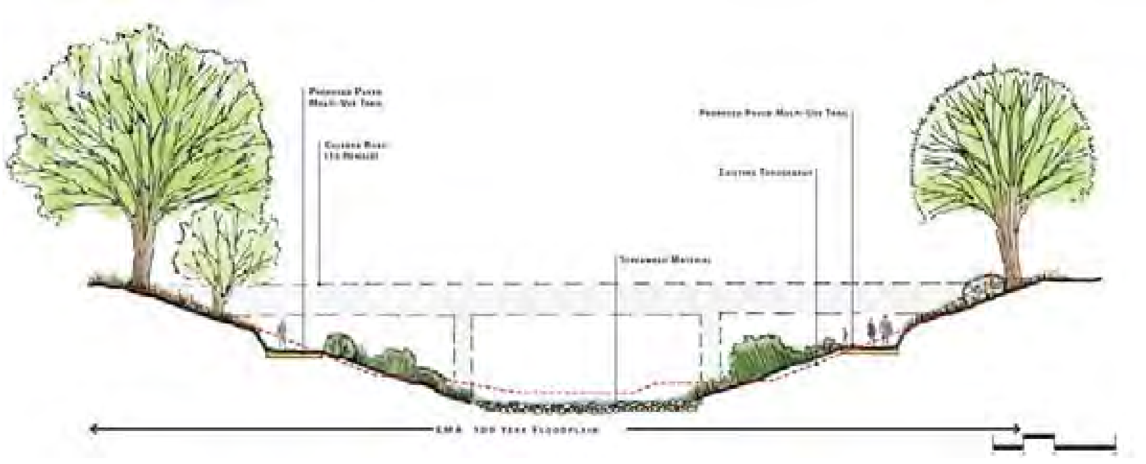


Figure 6. Typical Multi-Use Trail Cross Section

TRAILHEAD ENTRANCES

Trailhead entrances are a significant component proposed for the WSC ER and Rec project and will be adapted to promote a strong physical connection from the local communities as well as for visitors.

This section lists fourteen (14) trailheads and a register of neighborhood amenities within a half a mile unless otherwise noted. This is based on generally accepted walkabilitydesign practices dependent on assumptions about how far pedestrians are willing to walk. See Figure 8 for proposed trailhead locations.

Trailheads – These measures are evaluated by creek and neighborhood amenities within a half mile, a planning measure defined on acceptable walking distances. Trailheads meet the recreation objective and take advantage of the opportunity to connect communities socially and culturally while providing educational opportunities.

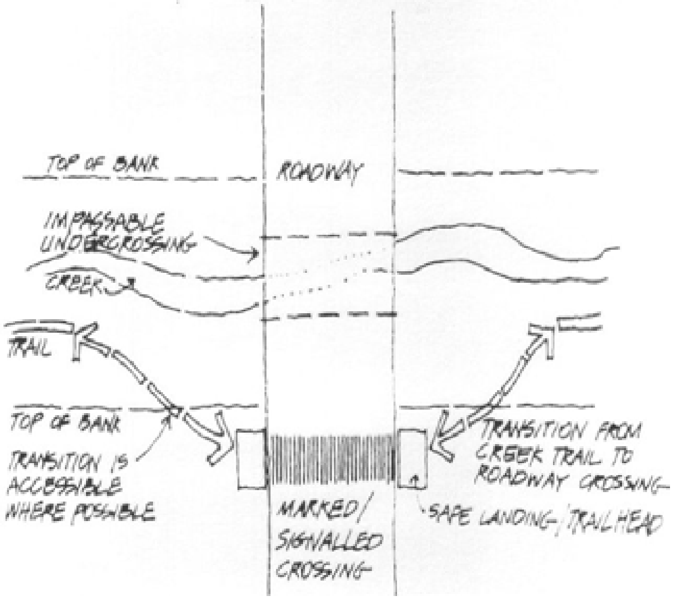


Figure 7. Example Trailhead Connection at Roadway Park (San Antonio Linear Park Development Program)

San Pedro Creek Recreation Trailhead SP1 – This trailhead ties into the existng trails at Concepcion Park located at the terminus of Riverview Drive. This location would provide access to one of the San Antonio Missions National Historic Parks and the Pro Vida Academy Charter High school, and Knox Early Childhood Center.

San Pedro Creek Recreation Trailhead SP2 – A trailhead would be located on the south side of San Pedro Creek on South Flores Street. This trailhead would provide access to Brisco Academy, San Antonio Technology Academy, St. Philip of Jesus Catholic School, and Harris Middle School.

San Pedro Creek Recreation Trailhead SP3 – A trailhead at this location would provide a midway ½ mile access point between San Pedro Creek Recreation Trailhead SP2, San Pedro Creek Recreation Trailhead SP4, and Apache Creek Recreation Trailhead AP1. It would be located on the southeast side of San Pedro's confluence with Apache Creek. This is the location of the community-visioned Southgate Catalyst Site as established in the Westside Creeks Conceptual Plan.

San Pedro Creek Recreation Trailhead SP4 – This trailhead would provide the terminus for the recreation trails on San Pedro Creek. IT would be located at Camp Street. An on-road bike facility is located approximately 0.3 miles to the southeast as well as the Downtown San Antonio Riverwalk and several other tourist attractions. From this trailhead location, seven designated Downtown Runs, Walks, and Bike Rides can be accessed within one mile. This is the location of the community-visioned Arts District Catalyst Site as established in the Westside Creeks Conceptual Plan.

Alazán Creek Recreation Trailhead AL1 – The trailhead would be west of Alazán Creek at Guadalupe Street. From here, users would have access to four schools within one mile: Navarro

Academy, JT Brackenridge Elementary School, Tafolla Middle School, and Sidney Lanier High School. The San Antonio Natatorium and the on-road bike facility at Guadalupe Street can also be accessed from this trailhead.

Alazán Creek Recreation Trailhead AL2 – This trailhead would tie into Smith Park at Buena Vista Street. An on-road bike facility begins here, and five other on-road bike faculties can be easily accessed from this location. Public facilities within a mile of this site include Escuala de las Americanas, the University of Texas-San Antonio Downtown, Brazan Branch Library, and the site of the historic Battle of Alazán. This is the location of the community-visioned Alazán Plaza Catalyst Site as established in the Westside Creeks Conceptual Plan.

Alazán Creek Recreation Trailhead AL3 – A trailhead located near Mario-Farias Park at Leal Street's existing pedestrian bridge would provide access to three schools within a half mile: Margil Elementary School, David Crocket School, and James Bowie Elementary School. This is the location of the community-visioned Farias/Crocket Catalyst Site as established in the Westside Creeks Conceptual Plan.

Alazán Creek Recreation Trailhead AL4 – From this trailhead on North Calveras, users would have access to on-road bike facilities, David Crocket School, Irving Middle School, and Ogden Elementary School.

Alazán Creek Recreation Trailhead AL5 – This location on West Poplar Street would provide access to Irving Middle School, Ogden Elementary School, and West End Park.

Alazán Creek Recreation Trailhead AL6 – This upstream terminus of the trails on Alazán Creeks would be located in Woodlawn Lake Park, providing access to Nelson Elementary School, Little Flower Catholic School, and a network of on-road bike facilities.

Apache Creek Recreation Trailhead AP1 – With an existing trail system in place along Apache Creek, the only trailhead recommended for Apache Creek would be located approximately midway between San Pedro Creek Trailhead SP3 and the east end of the existing San Pedro Trail. This trail would be located on Brazos Street north of the creek. [south trinity has on-road bike facility] The following public parks can be accessed within half a mile from this trailhead location: Patrolman, Guadalupe Martinez, Amistad Park, Excobar Field, and Cassiano Park. Additionally, Our Lady of the Peace Catholic School, Cooper Middle School, Barkley Ruiz Elementary School, and Estrada Achievement Center can be found within close proximity. The trailhead would also provide access to San Fernando Cemetery No. 1, a historic resource potentially eligible for listing in the NRHP. This is the location of the community-visioned Memorial Avenue Catalyst Site as established in the Westside Creeks Conceptual Plan.

Martinez Creek Recreation Trailhead MA1 – In association with Alazán Recreation Trailhead AL4 above, this trailhead approximately half a mile upstream at West Poplar Street would provide access to on-road bike facilities and access to Will Ojeda Park.

Martinez Creek Recreation Trailhead MA2 – This trailhead, located at Cincinnati Avenue, would provide access to nelson Elementary School, Little Flower Catholic School, Beacon Hill Elementary School, KIPP Aspire Academy, and Higgs Carter King Gifted and Talented. This is the location of the community-visioned Cincinnati Gardens Catalyst Site as established in the Westside Creeks Conceptual Plan.

Martinez Creek Recreation Trailhead MA3 – Located at the Martinez Creek terminus south of I-10 at West Woodlawn, this trailhead would provide access to numerous on-road bike facilities as well as a future trail project proposed by the city to extend the Beacon Hill Neighborhood Linear

Park. This is the location of the community-visioned Fredericksburg Transit-Oriented Development/Old Spanish Catalyst Site as established in the Westside Creeks Conceptual Plan.

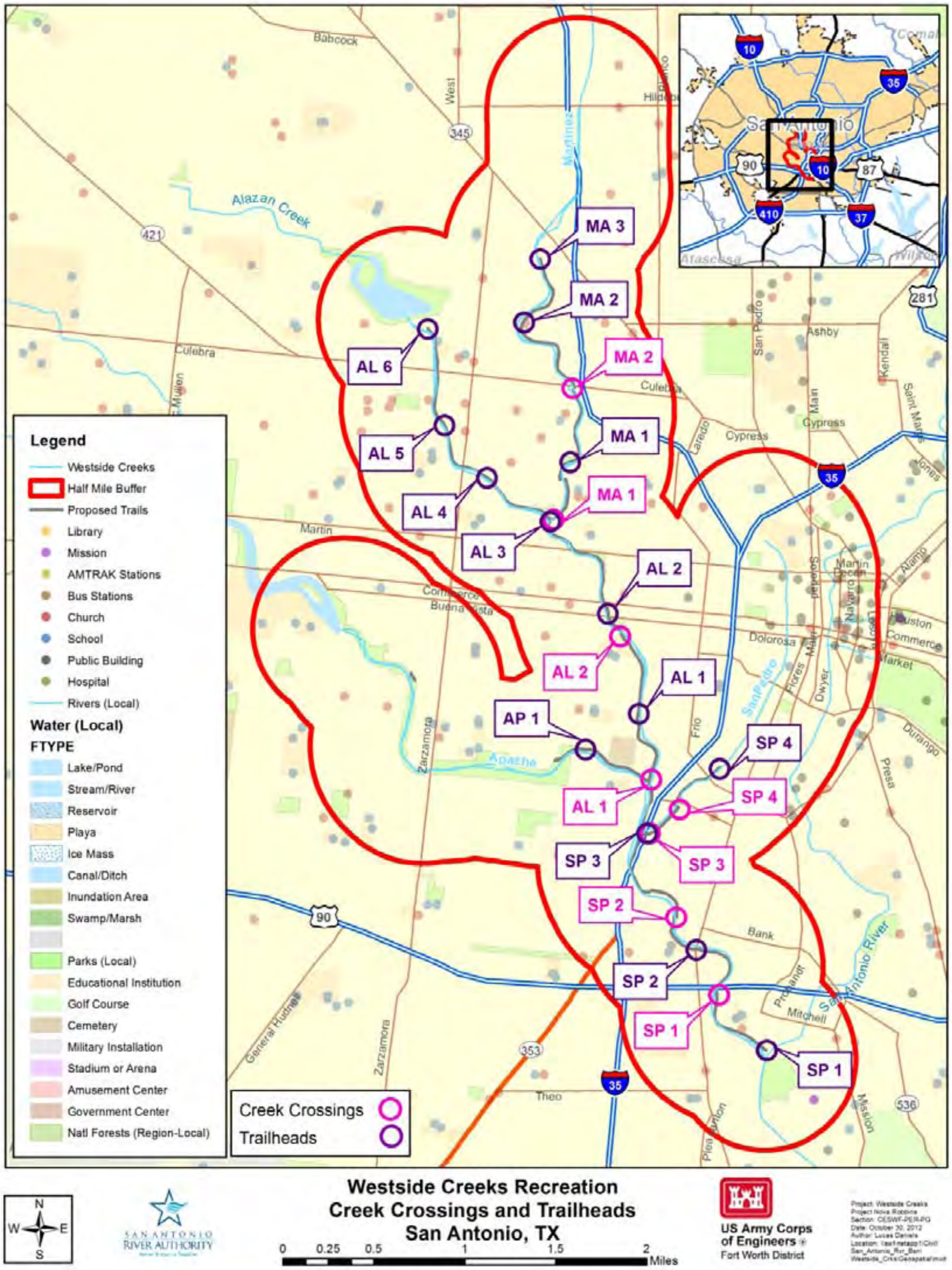


Figure 8 Trails - Locations of Proposed Creek Crossings and Trailheads

CREEK CROSSINGS

Access to the creek and other neighborhood amenities would be made available by the establishment of strategically locating creek crossings along the creek's trails. These eight (8) proposed crossings are minimal in number. The below descriptions depict the significance of crossing the creeks at the documented location. Generally, when a creek must be crossed and a vehicular bridge is adjacent, the crossing would be located south of the bridge to minimize hydraulic impacts. See Figure 8 for corresponding spatial distributions of trails at proposed creek crossings.

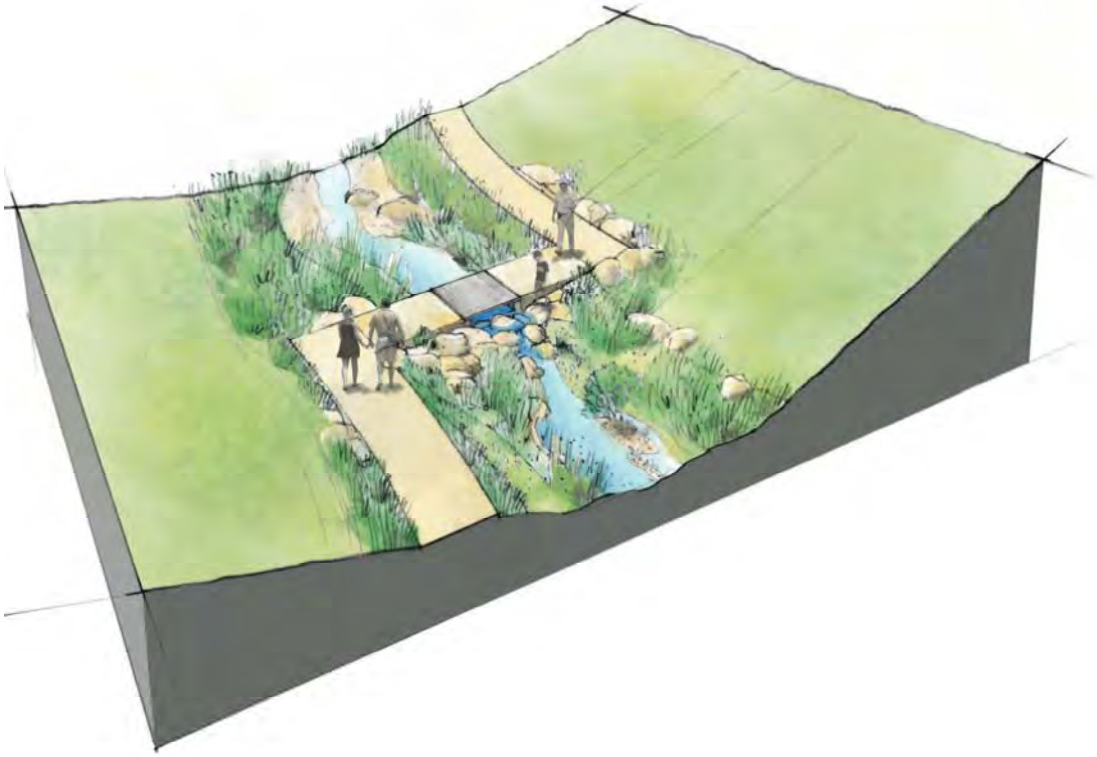


Figure 9. Example of Low Water Trail Crossing (Westside Creeks Restoration Project Conceptual Plan)

<u>San Pedro Creek Crossing 1</u> – This creek crossing would be located south of West Mitchell Street and I10 to provide access to both the Harris Middle School on the west side of San Pedro north of this crossing as well as Conception Park and other public amenities south of the crossing.

<u>San Pedro Creek Crossing 2</u> – Located just north of Harris Middle School a creek crossing would allow access to this school south of the crossing on the west side of the creek as well as pockets of residential neighborhoods north of the crossing on the east side of the creek. Opposite the neighborhoods are industrial conditions less desirable for locating a trail.

<u>San Pedro Creek Crossing 3</u> – This creek crossing would be located on the San Pedro Creek at the confluence with Apache Creek to provide access south of crossing to San Pedro Creek and north of crossing on Apache Creek's east side which has more space for trail placement versus the limited ROW on the west side of Apache Creek north of this crossing.

San Pedro Creek Crossing 4 – A creek crossing located at south of West Cevallos Street would be optimal at this location to move the trail to the northwestern side of San Pedro creek due to extreme ROW limitations on the southeast side of the creek.

Alazán Creek Crossing 1 – The creek crossing would tie the east side of Apache Creek to the south of the crossing with the northern side of Apache Creek's confluence with Alazán Creek to allow access to the greater number of residential neighborhoods as well as tie-in to the existing Apache Creek Trails. Tying into the northern side of the existing Apache Trails would maximize access to the greatest number of parks available in this area.

Alazán Creek Crossing 2 – This creek crossing would be located south of Buena Vista Street to allow access to the neighborhoods along the west side of Alazán Creek south of this crossing to public amenities north of the crossing such as Smith Park, John Tobin, and the proposed trailhead (Alazán Creek Recreation Trailhead 2) connecting Buena Vista Street's on-road bicycle facilities.

Martinez Creek Crossing 1 – The Alazán Creek Trail would cross Martinez Creek at the creeks' confluence. This crossing would allow access to Mario Farias Park and Willie Ojeda north of the confluence with the parks south of the crossing as well as provide the greatest opportunity to tie in the communities along Martinez Creek north of this crossing to the trails and associated parks. Note: the Martinez Creek Trail would utilize the pedestrian bridge located at Arbor Place to gain access to the west side of Martinez Creek north of the bridge and east of Martinez Creek south of the bridge.

Martinez Creek Crossing 2 – Due to ROW constraints to the north, a creek crossing would be located south of Culebra Road to transition the trail south of the crossing from the west side to the creek's east side north of the crossing. Note: An at-street crossing is unavoidable at this N. Sabinas Street location due to the confining limits of the creek's retaining walls.

Alazán Creek Crossings – No creek crossings located along Alazán Creek.

Shade Structures

Shade structures are proposed at trailheads and throughout the project at overlook locations, picnic/bench areas, and water fountain areas only where trees are deemed unfeasible. The quantity of shade structures are determined to be approximately six (6) throughout the Westside Creeks project.

INTERPRETIVE BOARDS

Interpretive signs are proposed throughout the project to take advantage of the educational value of the ecosystem restoration but not distract from them. The interpretive markers and display boards should interfere with neither the restored habitat nor the developed vistas. Way-finding signs are proposed at approximately fifty (50) trailheads and various locations along the trails to instruct users on navigating the trails, locations of recreation and community amenities relative to their position, and care and conduct while using the trails to preserve access, health, safety, and the restoration measures.

Minimum signage information shall include, as adopted from the City of San Antonio's Planning and Design Guidelines for Creek-Based Greenways:

Trailheads

- Trail Name
- Trailheads Upstream &
- Downstream
- Mileage (from Trailhead to
- Trailhead)
- Trail Map
- Accessibility Rating
- Flood Hazards

Trail-side Signs

- Trail Name
- Milepost
- Facilities Ahead

Safety Signage

- Food Hazards and Warnings
- Nearest Exit

OTHER RECREATION AMENITIES

Benches, water fountains, picnic tables, and trash receptacles are proposed along the trails throughout the WSC project. Benches, picnic tables, and associated trash receptacles will be complemented with shade from the proposed woody riparian vegetation or shade structures and situated toward advantageous vistas. Water fountains will be located largely equidistant from one another throughout the project. These day use facilities at various locations would provide approximately twenty-three (23) picnic tables, fifteen (15) water fountains, fifteen (15) benches, and twenty three (23) trash receptacles.

RECREATION BENEFITS

NATIONAL PERSPECTIVE

The national economic development (NED) benefit evaluation procedures contained in ER 1105-2-100 (22 Apr 2000), Appendix E, Section VII, include three methods of evaluating the beneficial and adverse NED effects of project recreation: travel costs method (TCM), contingent valuation method (CVM), and unit day value (UDV) method.

The UDV method was selected for estimating recreation benefits for the WSC recreation study. When the UDV method is used for economic evaluations, planners will select a specific value from the range of values provided annually. Application of the selected value to estimate annual use over the project life, in the context of the future with- and future without project framework of analysis, provides the estimate of recreation benefits.

FUTURE WITH- AND WITHOUT PROJECT CONDITIONS (FWPC AND FWOPC)

FWOPC

Since 2000, San Antonio voters have supported three 1/8 of a cent sales tax propositions to fund the Linear Creekway Parks Development Program which was designed to acquire open space and create linear parks along Salado Creek, Leon Creek, Medina River, and the San Antonio River. The sales tax funding was approved in 2000 (Proposition 3) for $20 million, in 2005 (Proposition

2) for $45 million, and in 2010 (Proposition 1) for $45 million. The Linear Creekway Parks Development Program has paid for land acquisition, design, and construction of linear creekway hike and bike trails throughout the city of San Antonio. In 2000, the program focused on the Salado and Leon Creeks. In 2005, the program expanded to include the Medina and San Antonio Rivers, and in 2010 the program expanded again to include the Westside Creeks. All five creeks are U.S. Army Corps of Engineers-engaged projects. Of the $45 million passed in 2010, $10,116,980 has been allocated for the Westside Creeks to develop a (San Antonio River Authority) demonstrating the City's goal to link the Salado and Leon Creeks to the San Antonio and Medina Rivers, as well as the Westside Creeks to the San Antonio River.

Currently the Westside Creeks project area is devoid of recreation trails with the exception of Apache Creek Trails and parks beyond the project ROW. If the Linear Creekway Parks Development Program and the Westside Creeks Ecosystem Restoration projects do not expand trails into the Westside Creeks area, the recreation conditions are expected to not change from the current activity level of no recreation for the project area. This FWOPC would provide neither access to the creeks nor a connection to other adjacent trails and parks.

FWPC

Proposed general recreation includes access to walking, running, bike riding, bird watching, gathering, bank fishing, and environmental interpretation. Recreational use is measured by annual visits where a visit consists of one person on a day trip. Annual visits to the WSC study area with a WSC project, or future with project conditions (FWPC), does not assume transfer of ownership or reauthorization from substitute recreation resources (for more information, see Value of Recreation Use Diminished with Project section below). Annual visits to the WSC study area without the WSC project, or FWOPC, assumes complete removal of the project via deauthorization for general recreation.

EXPECTED ANNUAL VISITS

Economic justification is based on an evaluation of competing facilities, existing and expected future use with and without the recommended plan, and unfulfilled demand. According to the Texas Parks and Wildlife Department (TPWD), Land and Water Resources Conservation and Recreation Plan, which identifies population, usage, and demand trends within the study area, the demand for recreation facilities, such as trails and opportunities for bird watching, is steadily increasing. The San Antonio Parks and Recreation System Strategic Plan 2006 and TPWD also state that San Antonio ranks below average for all outdoor activities. Additionally, the Westside Creeks trails would offer safe routes to community schools, provide access to recreation, and safe routes to work. Considering the increased demand, the deficit in outdoor activities and the disposition of a larger trail network to increase participation to a regional scale, a maximum participation rate is applied to the potential users. These users are the communities of the Westside Creeks (estimated population projection of 82,115 by 2016) and a portion of the City of San Antonio's population (estimated population projection of 1,452,140 by 2016). Applying the maximum participation rates to the population of potential users, the recreation resources would be used to capacity from the time it becomes available to the public through the period of analysis.

Current standards from the Texas Outdoor Recreation Plan dated 1994 indicate the type of trail proposed will accommodate 57,662 visitors per year per mile of trail for the pedestrian trail. For a 44,600-foot multi-use pedestrian trail, the total capacity usage would be approximately 481,000 visitor days per year calculated as follows: (44,600 linear feet / 5,280 linear feet per mile) times

(57,000 visitors per year per mile) equals approximately 481,000 visitors per year, as represented in Table 3.

Table 3 Annual Visits to the WSC Study Area

Recreation Category	Annual Visits
FWOPC General Recreation	0
FWPC General Recreation	481,000

VALUE OF RECREATION USE DIMINISHED WITH PROJECT

There are several substitute sites within an hour drive and within a half-hour drive of the Westside Creeks study (Appendix A List of Substitute Recreation Sites) area that offer the same types of general recreation opportunities which would typically be causation for transferred or diminished recreation visits. The effect of the WSC recreation project affords trail users from existing substitute sites the ability to access the Westside Creeks project and other nearby existing parks. As a result, regional substitute sites would experience an increase in visitation. Without the linear connectivity of the WSC project to these other trails in linear greenway parks such as Mission Reach and the downtown San Antonio walk and bike routes, substitute sites will not experience their own heightened value as a result of access provided by a future with the Westside Creeks project. In other words, substitute and nearby sites would experience greater participation owning to the implementation of the Westside Creeks project.

As a result, no general recreation visits would be transferred or diminished since a future with the Westside Creeks project would incentivize users to continue trekking connected trails for the purpose of exercise, exploration, alternative routes for transportation, and leisure activities because this is the nature of providing access to a larger network of trails.

POTENTIAL RECREATION USE IN THE STUDY AREA

The future without project condition analysis for the Westside Creeks study area does not include existing recreation value as lands within the project are devoid of recreation opportunities and lack connectivity to neighboring parks and other recreation facilities. The future with-project condition would foster recreation value of the area based on the UDV method. Table 4 illustrates the method of assigning a point rating to a particular general recreation activity. “General” refers to a recreation day involving primarily those activities that are attractive to the majority of outdoor users and that generally require the development and maintenance of convenient access and adequate facilities. The table shows the point values assigned to general recreation including five criteria: (1) the quality of the recreation experience as affected by congestion; (2) availability of substitute areas in terms of travel time; (3) carrying capacity determined by level of facility development; (4) accessibility as affected by road and parking conditions; and (5) environmental quality based on aesthetics. The WSC study area is rated on a 100-point scale. The total possible points that can be assigned to each criterion are as follows: (1) Recreation Experience – 30; (2) Availability of Opportunity – 18; (3) Carrying Capacity – 14; (4) Accessibility – 18; and (5) Environmental – 20.

Table 4. Recreation Point Value Assignment

Criteria	Judgment factors				
I. Recreation experience	Two general activities	Several general activities	Several general activities: one high quality value activity	Several general activities; more than one high quality high activity	Numerous high quality value activities; some general activities
Point Value: 10 of 30	0-4	5-10	11-16	17-23	24-30
II. Availability of opportunity	Several within one hour travel time; a few within 30 minutes travel time	Several within one hour travel time; none within 30 minutes travel time	One or two within one hour travel time; none within 45 minutes travel time	None within one hour travel time	None within two hour travel time
Point Value: 6 of 18	0-3	4-6	7-10	11-14	15-18
III. Carrying capacity	Minimum facility for development for public health and safety	Basic facility to conduct activity(ies)	Adequate facilities to conduct without deterioration of the resource or activity experience	Optimum facilities to conduct activity at site potential	Ultimate facilities to achieve intent of selected alternative
Point Value: 9 of 14	0-2	3-5	6-8	9-11	12-14
IV. Accessibility	Limited access by any means to site or within site	Fair access, poor quality roads to site; limited access within site	Fair access, fair road to site; fair access, good roads within site	Good access, good roads to site, fair access, good roads within site	Good access, high standard road to site; good access within site
Point Value: 18 of 18	0-3	4-6	7-10	11-14	15-18
V. Environmental	Low esthetic factors that significantly lower quality	Average esthetic quality; factors exist that lower quality to minor degree	Above average esthetic quality; any limiting factors can be reasonably rectified	High esthetic quality; no factors exist that lower quality	Outstanding esthetic quality; no factors exist that lower quality
Point Value: 9 of 20	0-2	3-6	7-10	11-15	16-20

Point value assignments for Table 4 are based on Economic Guidance Memorandum (EGM) 09-03. The Criteria and Judgment Factors for General Recreation were used as the basis of the estimated point values for the proposed recreation area. Judgment factors were reviewed after conducting site visits, coordination with local agencies, and evaluating the Westside Creeks Conceptual Plan and City of San Antonio Park Usage report. The Westside Creeks Conceptual Plan showcases a series of workshops geared towards over 400 community participants and stakeholder's to establish priorities for the future of the Westside Creeks. The following selection factors were used for the criteria outlined in Table 4.

I. <u>Recreation Experience</u>: The Westside Creeks recreation project would provide a linear park, a pedestrian-friendly transportation corridor, and a source of recreational opportunity throughout the community. The recreation facilities would give residents and visitors access to the restored creeks, providing additional mobility for the community through safe walk and bike paths that will connect the Westside to the San Antonio River and to the larger trail networks. The trail would be a continuous trail capable of supporting pedestrians and bicyclists in improving their options for recreation, fitness, environmental education, alternative transportation, and restore a sense of permanence, history, culture, and community for a growing urban populous. Even though these activities are considered significant by the community, the point value rating is estimated as a midpoint on the judgment factor scale because these activities are regarded as general activities common to the region, not uncommon high-value, water-oriented activities. Point Value: 10 out of 30.

II. <u>Availability of Opportunity</u>: The availability of opportunity rating is based upon current local recreation facilities near the project area within the proposed recreation resource location. At the high end of the scale are those recreational facilities which are a geographical rarity; these are sites for which there is no close substitute within a 2 hour travel time. The primary purpose of the recreation resource at Westside Creeks project location chiefly embraces community participation with the expectation of a number of visitors from the region. Although the proposed recreation facilities would provide a high value of availability to the local community due to accessibility to other similar projects, alternative facilities exist regionally for the proposed recreation facilities. Scores for this judgment factor are therefore expected to be mid to low scale. Point Value: 6 out of 18.

III. <u>Carrying Capacity</u>: The proposed Westside Creeks project recreation resources carrying capacity point values are estimated to improve with the recreation component implementation. The general recreation values are based on the ultimate use of the site potential, without overuse of the proposed recreation resources, and needless to say, without misuse of the proposed ecosystem restoration resources. Access to the creeks for multi-use trail activities and environmental observation comprise a large part of the projected recreation resources use, and the trails are considered to be optimum facilities to conduct recreation activity at the site's potential without interference with the ecosystem restoration project. Peak use is conservatively projected to occur during more than half of the calendar year since the project area is, at worst, subject to warm to cool winters with cool to cold nights. Point Value: 9 out of 14.

IV. <u>Accessibility</u>: The accessibility rating is based upon the availability of proposed trailheads, intersecting street gateways, and existing and planned greenway trail connections in good condition that would provide access to the proposed recreation facilities. Trailheads are proposed throughout the Westside Creeks project area at existing parks, schools, churches, and optimal intersecting street gateways. The WSC trails system is proposed to tie into other similar projects, such as the recently completed trail along Elmendorf Lake and the ongoing Linear Creekways Initiative. Point Value: 18 out of 18.

V. <u>Environmental</u>: The environmental quality rating is based upon the aesthetic values of the proposed WSC project recreation resource facilities, project lands, and the ease of correcting any limiting aesthetic factors. The proposed ecosystem restoration project site would provide aesthetic values that would enrich an urban stream providing above average aesthetic quality; any limiting factors can be reasonably rectified. Point Value: 9 out of 20.

Current standards indicate this type of trail will accommodate 57,662 visitors per year per mile of trail for the pedestrian trail. For a 44,600-foot multi-use pedestrian trail, the total capacity usage would be approximately 481,000 visitor days per year calculated as follows: (44,600 linear feet / 5,280 linear feet per mile) times (57,000 visitors per year per mile) equals approximately 481,000 visitors per year. The point values assigned on the applicable criteria and assigned points are as follows:

• Recreation Experience:	10 points
• Availability of Opportunity:	6 points
• Carrying Capacity:	9 points
• Accessibility:	18 points
• Environment	9 points
	52 Points

Table 5 Conversion of Points to Dollar Values

Point Values	General Recreation Values (1)
0	$ 3.72
10	$ 4.42
20	$ 4.89
30	$ 5.58
40	$ 6.98
50	$ 7.91
60	$ 8.61
70	$ 9.08
80	$ 10.01
90	$ 10.70
100	$ 11.17

VALUE OF USE WITH THE PROJECT

The value of a day of general recreation at the proposed Westside Creeks study was determined for each activity using the guidelines for the Assigning Points for the General Recreation in Table 5. The points were then converted to dollar values based on the EGM 12-03, Unit Day Values for Recreation for Fiscal Year 2012, which is based on ER 1105-2-100. Table 5displays the point value conversion to a unit day value in fiscal year 2012 (FY12) dollar amounts. The 52 points generated a user day value of $8.05, thus the annual benefit for the trails and day use facilities is estimated to be $3,872,050 since 481,000 visitors per year times $8.05 is approximately $3,872,050.

NET PROJECT BENEFITS

Table 6 displays unit costs for recreation features, total and annual costs, total benefits, and benefit-cost ratio used for conducting a benefit-cost analysis. Benefit-cost analysis is a systematic process for calculating and comparing benefits and costs of a project or decision. Costs were annualized using an interest rate of 3.75 percent, over a 50-year period of analysis. The addition of recreation does not increase the Federal cost share by more than 10 percent (ER 1105-2-100, para. 3-7.b.(5)).The annual cost for the recreation component is $281,723. With annual benefits estimated at $3,872,050, net benefits for recreation are $3,590,327. The resultant benefit cost ratio is 13.74 making the recreational features economically justified.

A simplified sensitivity analysis of reduced number of visits was also conducted to determine the minimum benefit cost ratio threshold that the investigation project must meet to be determined if the recreation component of the project provides more benefit than it costs to construct. This threshold is estimated at 240,500 annual visits, half of expected future use with the recommended plan, which would still yield a benefit cost ratio of an acceptable ratio: 7.74. The level of uncertainty that annual visitation will be less than this threshold is very low due to the park and trail deficiency in the region, urban location, and community characteristics. This serves to justify that recreation benefits outweigh its costs.

Table 6 Summary of Recreation Costs

Recreation Item	Unit	Quantity	Total Cost
10-ft trail	LF	44,600	$2,772,529
Shade Structure	EA	6	833,470
Interpretive/Directional Signage	EA	50	3,832
Benches	EA	15	127,636
Water fountains (dog and people)	EA	15	62,105
Picnic tables w/ pads	EA	23	48,393
Trash Receptacles	EA	23	14,623
Subtotal Recreation Features			**3,862,588**
Plans and Specifications			726,773
Supervision and Administration			715,167
Total Recreation			**$5,304,528**

Table 7. Annual Costs, Benefits and Net Benefits for Recreation

Total Recreation Cost First Cost	5,304,528
Annual Interest Rate	0.0375
Period of Analysis (years)	50
Construction Period (months)	18
Compound Interest Factor	18.49
Capital Recovery Factor	0.0445742
Interest During Construction	$1,743,919
Investment Cost	$5,445,361
Interest	$204,201
Principle	$38,522
Annual Operation/Maintenance	$39,000
Total Annual Charges	**$281,723**
Annual Recreation Benefits	**$3,872,050**
Net Annual Recreation Benefits	**$3,3,590,327**
Recreation Benefit-to-Cost Ration	**13.74**

IMPACT OF RECREATION FEATURES ON RESTORATION PROJECT

The recommended recreation plan will not adversely impact the recommended restoration plan. It is only when the ecosystem has value to humans that it will be cared for and sustainability is really achievable. The specific goal of the restoration was to restore to the extent practicable, a sustainable, dynamic, riverine ecosystem providing habitat for aquatic and riparian dependent migratory and native resident bird species in the Westside Creeks study area; the broad goal of the recreation was to maximize quality to the habitat by providing opportunities for the human population to value the restored ecosystem. For the restoration goal to be truly successful, the recreation goal must also succeed. To facilitate achieving both, recreation was developed after the restoration measures were established and the recommended (NER) plan was identified. The recreation NED was determined as an exercise to demonstrate its benefit over its costs. Trails were designed to avoid passing directly through the best habitat types. Not allowing trails to bisect certain vegetation types allows use of the trail while not impacting the more sensitive species that may choose to hide, nest, or forage within the denser vegetation types. Additionally, trails were not allowed to replace vegetation areas directly adjacent to any aquatic areas. Trails, rest stations, pavilions, and other components of the recreation plan will be located to allow human observation, study, exercise, interaction, and appreciation but to not interfere with the functioning ecosystem. Also, the development of trails in the Westside Creeks area strengthens the value of the City of San Antonio’s trail network effort as it connects more parks, community amenities, and regional destinations than trail segments alone.

APPENDIX J-A

List of Substitute Recreation Sites Within a Half Hour Drive of the WSC Study Area

CITY OF SAN ANTONIO FACILITIES

Neighborhood Parks

- Acme
- Alderete
- Amistad
- Benavides, Father
- Collins Gardens
- Farias
- Garcia
- Ingram Hills
- Lee’s Creek
- Los Angeles Heights
- Martinez
- Monticello
- Navarro
- Ojeda
- Seeling
- Van de Walle
- Vidaurri

Community Parks

- Cassiano
- Cuellar
- Elmendorf
- Garza
- Lackland Terrace
- Las Palmas
- Levi Strauss
- Meadowcliff
- Monterrey
- San Juan-Brady
- Slick Creek
- Sunset Hills
- Tobin
- Ward, Joe
- West End
- Westwood Village

Large Urban Parks

- Rosedale
- Woodlawn

Sports Complexes

- Calderon
- Escobar Field
- Northside Tennis Center
- San Antonio Natatorium

Greenways

- Apache Creek
- Leon Creek Greenway South

Special Use Facility

- Levi Strauss Park Hdqtrs.

Urban Spaces

- Catalina
- Smith

BEAR COUNTY FACILITIES

- Rodriguez Park

CITY OF BALCONES HEIGHTS FACILITIES

- Rogiers
- Novack Park

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WESTSIDE CREEKS ECOSYSTEM RESTORATION

Appendix K: Other Social Effects

OTHER SOCIAL EFFECTS

EXECUTIVE SUMMARY

Social well-being factors are constituents of life that influence personal and group definitions of satisfaction, wellbeing, and happiness. The distribution of resources, the character and richness of personal and community associations, the social vulnerability and resilience of individuals, groups, and communities; and the ability to participate in systems of governance are all elements that help define well-being and influence to what degree water resources solutions will be judged as complete, effective, acceptable, and fair. In large measures these issues are the province of the Other Social Effects (OSE) account.

The OSE account has appeared, in various forms and nomenclatures, in federal guidance for many years. What has varied is the “status” of the account—whether required—and its importance—whether considered in formulation and plan selection. EC 1105-2-409, Planning in a Collaborative Environment (EC 409), greatly increases the emphasis and potential application of the OSE account by stating all four accounts (NED, EQ, RED and OSE) will be considered in project analysis and decision making. While OSE is not always accepted as a factor in the decision making and the overall success of a project, next to solid engineering, it may be the most important factor in the success of a project.

The Westside Creeks have attracted humans for over 10,000 years, from Native Americans, to Spaniards, to a variety of European settlers, to San Antonio's current residents. Once the impetus that made life possible for both wildlife and human communities, the creeks have been reduced in their community significance since they were channelized by the USACE in the 1960s and 70s to reduce flood risk. San Antonio River Authority (SARA), working to sustain and enrich life in the San Antonio River Watershed, began restoration work with the San Antonio River Improvements Project, a broader focus from the San Antonio Channel Improvement Project, and has continued this process into the Westside Creeks, leading this project and ensuring extensive community involvement. Through a lengthy public process, particular interest in providing increased opportunities for people to enjoy these urban creeks in a social, cultural, educational, recreational, and historical setting was expressed in such a way that would reunite the once connected community.

Initiated by SARA in 2008 with support from an interdisciplinary consultant team and the Westside Creeks Restoration Oversight Committee (WCROC) (a broad group of several committees such as neighborhood associations, an Audubon Society, historical, conservation, cultural society, school districts, community representatives, and stakeholders), public involvement activities involved the community that lives near the creeks and stakeholders to develop the Westside Creeks Restoration Conceptual Plan and ensure it reflects the local community ideas. The social condition of the Westside Creek communities would benefit from an ecosystem restoration and recreation project to restore its once vital and connected community.

Environmental justice principles demand that all residents need protection from disproportionally high and adverse human health and environmental effects of Federal agency programs and activities on minority populations and low-income populations. The study area is low-income, minority-dominant, and ultra urban with less access to recreation due in part to the channelization of the Westside Creeks compared to the city of San Antonio and nation. This lack of recreational activity opportunities negatively effects the fastest growing populations subject to health risks such as obesity. These poor and minority groups, who have borne more than their share of the negative effects of development, were invited for public participation. Meaningful involvement of all people of the Westside Creeks community was used to develop the goals for the Westside Creek project.

The restored Westside Creeks is worth more to the nation as a vibrant, resilient regional economic hub than what its future would be without an ecosystem restoration and recreation project that affords the community an opportunity to reunite with nature and each other.

The OSE analyses for the Westside Creeks study area reflect a highly complex set of relationships and interactions between the social and cultural settings which are impacted by the study. This report is to account for the social effect outputs attributed to the Westside Creeks ecosystem and recreation plan effects.

INTRODUCTION

The Westside Creeks study area includes 14 miles of Alazán, Apache, Martínez, and San Pedro Creeks, primarily located in the city's urban core. The Westside Creeks, located due west of the vibrant, livable, and economically charged downtown area of San Antonio, are tributaries to the San Antonio River and were previously channelized as part of the San Antonio Channel Improvements federal flood control project in 1954. During public workshops spearheaded by SARA, the communities reflected on the unique and rich history of Westside Creeks prior to the channelization when the creeks were known for swimming, fishing, a source for community gathering, enjoyment, and relaxation. The current condition of the channelized creeks is causation for the community to be physically and psychologically disconnected from other communities and community amenities as well as from the creeks. The outcome of multiple impediments that prevent individuals or groups from participating fully in the social and environmental life of the society in which they live is key to the communities' perspective of their social exclusion. This concept characterizes a form of social disadvantage or obstruction from environmental resources.

Figure 1. 1Channelization of Alazán Creek in the early 20th century

Figure 2.Typical desired natural condition with development & trail amenities (Underlying aerial from the 1960s following Corps channelization of Alazán Creek)

As a result of these conditions, San Antonio River Authority in partnership with an interdisciplinary consultant team, embarked on multiple phases of community engagement to create the Westside Creeks Restoration Conceptual Plan, a plan for restoration of the Alazán, Apache, Martinez, and San Pedro Creeks, to ensure it reflects the local community ideas. This Conceptual Plan documents the communities' input as it relates to improving water quality, increasing biological diversity, providing increased opportunities for people to enjoy these urban creeks, and suggesting redevelopment potential along their margins. Phase 1 of this planning process collected inventory and analysis where Phase 2 identified the overall vision and neighborhood reinvestment priorities for the Westside Creeks through community workshops. The outcome of this two year public participation planning process (six phases), the SARA was able to reduce the amount of years from the typical timeline and cost for the Corps feasibility study. This process also helped to create a reinvestment plan for the entire degraded area. Each phase of the public planning process will be discussed in more detail later in this report. Through a lengthy public process, these goals in the conceptual plan were established for the Westside Creeks Restoration Project:

- Environmental enhancement
- Aquatic and riparian restoration
- Flood control enhancement
- Recreational uses for all ages

- Water quality enhancement
- Low maintenance and sustainable design
- Fluvial geomorphology concepts
- Continuous hike and bike trails
- Transportation connectivity
- Public gathering places
- Cultural/historical awareness
- Public art
- Economic development
- Neighborhood and business connections

Many of these factors will be discussed in more detail throughout this report and will work to highlight the social impacts that should be considered in the analysis of the tentatively selected plan for ecosystem restoration and recreation.

By further study, a future with the Westside Creeks Ecosystem Restoration and Recreation project could contribute to the mitigation of several socially negative circumstances currently exhibited in the study area including the following:

- a comparatively high rate of bicycle crashes,
- the highest rating in child obesity for the city,
- degraded social connectedness and identity, and
- safety.

SCOPE OF REPORT

The necessity of analyzing social effects in addition to the typical economic impacts in the context of water resource planning has become apparent since Ecosystem restoration projects' services have direct or indirect social values that can be described and in some cases quantified (Coles, Loomis and Feather). Although the significance of Other Social Effects (OSE) factors have often been undervalued in the past, the Corps highlights that "next to solid engineering, it [OSE] may be the most important factor in the success of a project" (Dunning and Durden, Handbook on Applying "Other Social Effects" Factors in Corps of Engineers Water Resources Planning.)

> "Today, ecological and social considerations are often of great importance in project planning and should not necessarily be considered secondary to the maximization of economic benefits."
>
> *—National Research Council 1999, p. 4*

This report will discuss the social effect that have occurred in the Westside Creeks area as a result of the degraded creeks, effects that may have otherwise been overlooked by other planning analysis, and show the following:

- The impairment that occurred as a result of the channelization in both a qualitative and quantitative manner.
- The intensive public input process that worked to create a preferred restoration strategy and reinvestment plan for the study area-a process that worked in coordination with the Army Corps of Engineers Feasibility Study.
- The detrimental effects to the future of the City if the ecosystem restoration strategy were not funded and implemented. These effects will be discussed based on the topics of environmental justice and social effects.

PURPOSE

The Westside Creeks study is not formulated for OSE, but procedures are carried out to evaluate OSE benefits from the Westside Creeks tentatively selected plan for ecosystem restoration and recreation. The OSE account provides information about key social concepts and their importance in the Westside Creeks water resources planning.

ARMY CORPS OF ENGINEERS ALTERNATIVES

The Army Corps of Engineers has produced several alternatives for the future ecosystem restoration and recreation of the Westside Creeks. The impacts of the Army Corps of Engineers preferred alternative were examined from the viewpoint of social effects which will be discussed in this report.

COMMUNITY-BASED RESTORATION PLANNING

San Antonio River Authority's multiphase restoration planning efforts are significant to the study of social effects. SARA engaged its citizens on the type of restoration they wanted to improve their social conditions. The citizens desire to be connected to the creeks resulted in a combination of stream restoration approaches, economic development concepts, and recreation concepts. The Westside Creeks Restoration Conceptual Plan identified the public's vision for the Westside Creeks which is to restore ecological functions of the creeks while providing safety from floods, security from crime, connected communities, and celebration of unique identities. When realized, this would ultimately lead to restored and vibrant creek corridors. The Restoration Conceptual Plan also outlines a development of four frameworks of the vision to begin planning:

Water. A return to more natural conditions with a more natural low flow channel and enough flood capacity to maintain or improve the flood risk reduction benefits from the channelization. Opportunities for restoring or enhancing base flow should also be considered, primarily in San Pedro Creek. Additional land might be necessary to accommodate the wider channel and contain the floodplain.

Restoration. A treatment that restores natural processes through stable channel design incorporating meanders, wetlands, pools, riffles and drop structures. The restoration procedure would create channels that are in equilibrium with sediment transport. This restoration should also enhance the ecological functions of the stream with vegetation and wildlife habitat that resembles the pre-channelized state.

Connections. The creation of a continuous multi-use paved trail with neighborhood connections, creek crossings, and pedestrian bridges. Connections from the community into this trail system will range from simple gravel connectors up to trails of the same configuration and materials as the main trail. These connections should incorporate all of the transportation modes in use locally.

Security. Utilization of physical design, increased police patrols and increased public use of the creek corridor to improve creeks' safety. Specific locations will begin with simple features such as uniform lighting, signage, emergency call boxes, increased visibility and reduced understory growth. Basic design elements include clear lines of sight, uniform lighting using a white light source, clear delineation between public and private spaces, public "ownership", and access control.

With a strategy in place, SARA embarked on multiple phases of community engagement for planning future ecosystem and social recovery. The planning process was a partnership among over 50 public groups including neighborhood associations, residents, students, universities, school districts, churches, and many more to make up the Westside Creek Restoration Oversight Committee. SARA assembled a consultant team to work closely with SARA's Intergovernmental and Community Relations Department to execute a public involvement plan that consisted of information gathering through extensive community outreach. The outcome of the community involvement was the Westside Creeks Restoration Conceptual Plan.

The concept plan was developed over a two year period and included the following six phases:

Phase I, Inventory + Analysis

- Existing conditions and planning context were analyzed.
- Identified issues.
- Identified key analysis factors of creek conditions, adjacent land uses, redevelopment potential, restoration potential, flooding issues, connections, environmental hazards, cultural resources, wildlife habitat and public and private security.
- Classified opportunity areas for enhanced recreation and community re-development

Phase II, Vision

- Establish overall vision for the Westside Creeks
- Developed individual framework plans for each creek
- Refined the concepts to achieve a feasible plan

Phase III, Restoration Concepts

- Developed restoration concepts for each creek
- Coordination with other projects and teams (e.g. Watershed Master Plan, Linear Creek Greenways Program, etc.)

Phase IV, Catalyst Sites

- Identified and programmed catalyst sites by the community for further development are supported by opportunities for neighborhood redevelopment and recreation enhancements to revitalize the communities.
- Planned for key considerations including the enhancement and beautification of the creeks, trails, parks and open spaces; providing and supporting transportation connectivity, ADA compliance, and historical context; and adjacent land uses.

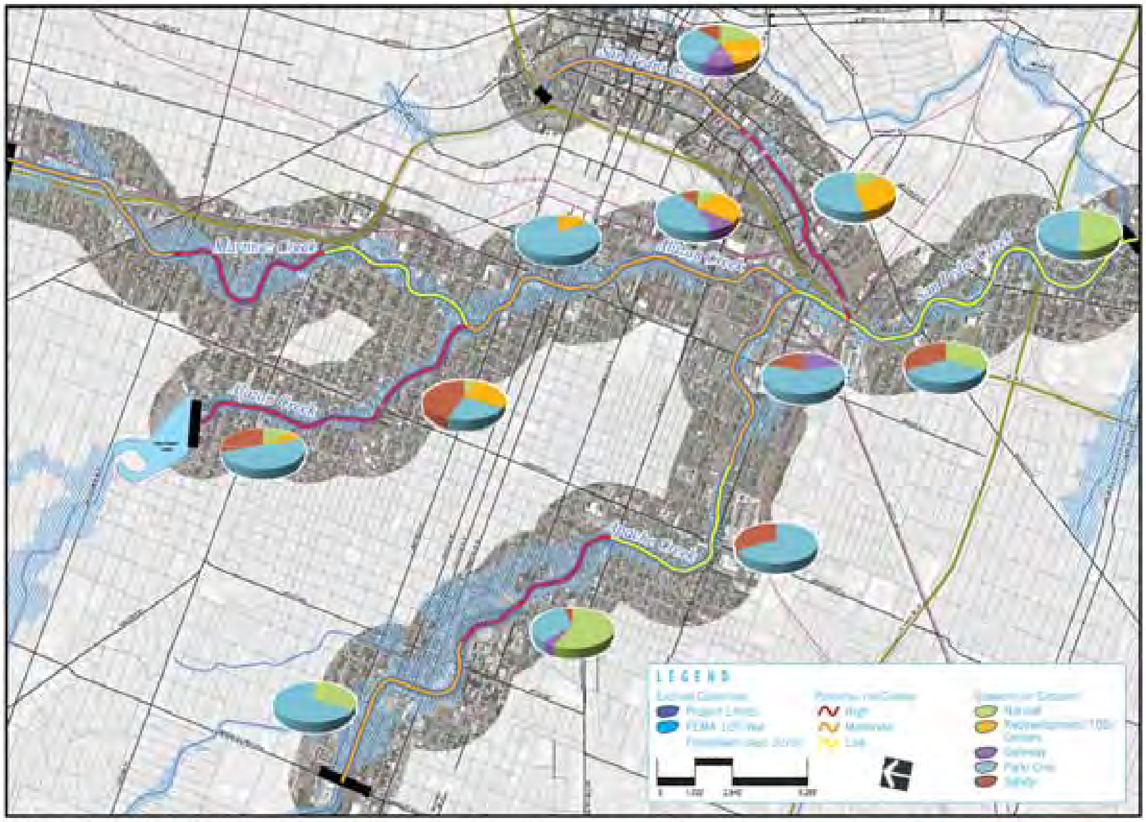
Phase V, Design Elements

- Defined typical design elements
- Established best management practices

Phase VI, Implementation

- Developed an implementation plan identifies opportunities
- Addressed the multiple organizational partnerships and potential funding opportunities

From April 2009 through February 2010, SARA held a series of public and stakeholder workshops that engaged over 400 residents in setting the vision and establishing priorities for the future of Alazán, Apache, Martinez, and San Pedro Creeks including community revitalization. The first public workshop, Public Workshop #1 – Prioritization, revealed neighborhood's most challenging issues and promising opportunities. From these public comments, a pie chart explains breakdown of comments by percentage. Comments fell under five priority categories: Natural, Redevelopment/Transit Oriented Design (TOD)/Centers, Gateway, Park/Civic and Security. The segment which received the largest percentage of comments fell into the "Park" category.



Public Workshop #1: Change Priority Analysis

Figure 3. Public Workshop Priority Analysis (from Westside Creeks Restoration Conceptual Plan)

Public Workshop# 2 – Catalyst Site Development was to educate the public regarding the vision development and to discuss concept alternatives. The third and final workshop for the Conceptual Design Phase, Public Workshop #3 – Plan Frameworks, and served to collect public feedback to make final refinements to the Draft Conceptual Design.

This transparent public process resulted in a plan for the ecological restoration of the streams, mitigation of existing flood hazards, and access along and across the streams. Considerable effort was expended by community members in the long range planning of economic opportunities that was publically agreed should be available from this project. A number of long-term design elements based on land use were developed to address connectivity and security. These elements were designed to increase access and usage by the public while maintaining the flood hazard reduction and ecological functions of the restored creeks. As described below, the social restoration design included the development of catalyst sites based on public workshops and stakeholder input.

Figure 4 Economic development opportunities provided by community members' long-range planning efforts - sample

Through investment in planning, SARA lead the San Antonio community through the conceptual planning process and helped to establish implementation considerations to the restoration project. As part of the process, funding options were provided for the long-term implementation of the plan as well as identification of phasing and schedule.

It was important for the local community and stakeholders to determine the project's core values which resonate as themes throughout key messages by the community. The following table represents the communities' core values identified in the Westside Creeks Restoration Project Conceptual Plan consistent with the WSC Recreation study:

Westside Creeks Restoration Project Conceptual Plan 2011
Historic Theme
Return the roots and the history of the creeks so future generations can make connections to their history.
Cradle to Grave Theme
This theme reflects the core value that the creeks should be accessible, safe, and usable for all members of society, regardless of age or other demographic factors.
Rebirth Theme
This theme was raised by several WCROC members. This process will essentially give new life to the creeks, effectively generating a new perception of the Westside Community. This project also presents an opportunity to reintroduce the Westside of San Antonio to the rest of the City as a place that is ecologically-sound, safe and inviting.
Bringing Nature Back Theme
This conceptualizes a return to the creek's former natural beauty. It is focused on the importance of bringing plants and animals back to the creeks. It voices the need to create a biologically sound and environmentally sustainable vision.
Connections Theme
The theme here is the importance of the creeks as a way of connecting points of interests, transportation networks, and the Westside to the rest of San Antonio. The consensus was that even though the creeks are on the Westside, they will be used by people from all parts of the city and county.

Other programs and committees have applicable interests in recreation component to the WSC project. As part of the public involvement and site analysis process for the Westside Creeks Restoration Project Conceptual Plan, various key stakeholders were interviewed about opportunities and challenges for this project. The stakeholders selected were in addition to the various groups identified to participate on the WCROC and are identified here:

Westside Creeks Restoration Oversight Committee (WCROC)
Residents and Neighborhood Groups
Business Owners and Business Groups
Elected Officials
San Antonio
Bexar County
Technical Officials
Bexar County officials
City of San Antonio
San Antonio River Authority
Media
Westside Service Organizations
Schools and Universities
Our Lady of the Lake University
St. Mary’s University
General Public

RELATIONSHIP TO OTHER FEDERAL AND LOCAL PLANNING

The WSC project is a multi-benefit project meeting not only the Corps' mission for ecosystem restoration and recreation but also other federal and state agencies’ missions. The following national and regional agencies have missions specifying goals, objectives, strategies, and initiatives to encourage action for the benefit of the Nation’s health, safety, and overall sense of wellbeing, all of which are outcomes of the WSC ecosystem restoration and recreation project.

EXECUTIVE ORDER 12898

This order which was issued by President Clinton on February 11, 1994, calls for federal agencies to develop strategies to identify and address disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority and low-income populations. It provides procedures on federal actions to address Environmental Justice for such populations. Environmental Justice focuses on the fair distribution of environmental benefits and burdens.

UNITED STATES DEPARTMENT OF TRANSPORTATION (USDOT)

On April 22, 1994, the Federal Highway Administrator and National Highway Traffic Safety Administrator submitted the final report of the *National Bicycling and Walking Study (NBWS)* from the Department of Transportation to the U.S. Congress (Bicycle and Pedestrian Program). The study contained two overall goals:

USDOT NBWS Goals
Double the percentage of total trips made by bicycling and walking in the United States from 7.9 percent to 15.8 percent of all travel trips
Simultaneously reduce by 10 percent the number of bicyclists and pedestrians killed or injured in traffic crashes.

SAN ANTONIO MASTER PLAN 2011

The City of San Antonio has established several planning resources to further coordinate the city's efforts to plan and provide for future growth and development. The San Antonio Master Plan 2011 contains three major sections: The Vision, Goals and Objectives and Policies (San Antonio Comprehensive Master Plan Framework). The vision is the plan's central purpose and establishes a broad framework for the consistent application of the individual goals, objectives and policies. The goals and objectives assist in achieving its vision. They also provide general guidelines for developing specific policies.

The Vision Statement in the City of San Antonio's 1997 Master Plan outlines the following framework:

- Equal opportunity to all its citizens and equity in the distribution of benefits.
- Safe, dynamic and sustainable neighborhoods which offer employment opportunities, high quality education, adequate and affordable shelters, and health care and recreational amenities.
- A vibrant economic climate which will attract and support a wide diversity of business opportunities and community services within the metropolitan area.
- Balanced and responsible urban design, planning and development, and responsible protection of the city's historical, cultural, and natural resources.
- An open, accessible, responsive, and fiscally responsible government whose structure creates the functional framework to accomplish the vision.

The following table represents the City of San Antonio 2011 Master Plan's goals and objectives which the WSC Recreation project satisfies (all others are not applicable to the study framework):

City of San Antonio Master Plan 2011 **Urban Design Goals and Objectives**
Goal 1: Preserve and enhance the city's urban design.
Objective C
Encourage patterns of urban development that provide a full range of housing choices and promote a sense of community, urban vitality and the efficient provision of infrastructure.
Objective D
Develop criteria and procedures for infill development, or significant new construction in an established area, which will enhance the character of neighborhoods.
Objective E
Apply strategies which will result in all existing and new streetscapes being accessible, safe, and stimulating.
Goal 3: Develop and maintain a diversified and balanced city-wide system of parks and open space.
Objective A
Utilize a planning process which encourages civic participation in the creation of a City park, recreation and open space plan which will: a) Coordinate the acquisition and development of public and private parks and open spaces; b) Develop master plans for existing City parks; c) Complete the development and revitalization of existing parks; d) Ensure that parks are fully accessible to all citizens.
Objective B
Plan and develop a citywide system of linear parks and hike and bike trails which incorporate drainage ways and open spaces to link parks, schools, institutions, and neighborhoods.
Objective E
Involve citizens in the design, development, and maintenance of parks and open spaces.
Goal 4: Plan, locate and maintain infrastructure and utilities to facilitate and maintain safe, healthy and sustainable environments for human activity.
Objective C
Create streetscapes which emphasize both pedestrians and vehicles.
Goal 5: Develop policies for various transportation modes that will increase access to employment centers, community services, culture, recreation, education and commerce; meet the needs of all San Antonians; decrease the reliance on single occupancy vehicles; and promote

transportation safety and efficiency.
Objective A
Develop a transportation plan that promotes safety and links neighborhood destinations throughout the City and allows residents access to regional destinations.
Objective B
Develop a system of complementary transportation modes which supports safe and efficient movement of people and goods, which results in an efficient pattern of urban development, including active and vital neighborhoods.
Objective C
Develop a transportation plan that promotes safety and links neighborhood destinations throughout the city and allows residents access to regional destinations.
Objective D
Expand the overall capacity for the movement of people by including alternative transportation modes in the design of the City's infrastructure and utility systems.
Objective H
Promote the safe use of bicycles as an efficient and environmentally sound means of recreation and transportation by encouraging a citywide network of lanes, trails, and storage facilities.
Objective I
Develop a safe and convenient pedestrian travel network with sidewalks, walkways and trails integrated into the transportation system and neighborhood centers.
Objective K
Accommodate the specific needs of disabled individuals in all transportation modes.

SAN ANTONIO PARKS AND RECREATION SYSTEM STRATEGIC PLAN 2006-2016

As with any function of local government, the ability to plan for the short and long term is critical to meeting community needs. The Parks and Recreation System Strategic Plan 2006-2016 will continue to fully support the goals and objectives stated in the City of San Antonio’s Master Plan Policies adopted in 1997, especially related to Neighborhoods and Urban Design sections (San Antonio Parks and Recreation Department). The purpose of the San Antonio Parks and Recreation System Strategic Plan is to:

1. Update the 1999 Parks and Recreation System Plan by evaluating the Goals and Objectives, Recommendations, and Accomplishments.
2. Continue to develop a coordinated, achievable plan to guide decisions impacting San Antonio’s Parks and Recreation System
3. Integrate pertinent City Master Plan policies and adopted ordinances into ongoing parks and recreation system planning (i.e. Neighborhood Planning Process, Drainage

Regulations Ordinance, Tree Preservation Ordinance, Open Space Plan; and the Unified Development Code)

4. Integrate information and recommendations from other Departmental studies and reports including the Park Police Performance Review, the National Golf Foundation Report, and the After School and Summer Program Monitoring Standards.
5. Ensure adoption of the San Antonio Parks and Recreation System Strategic Plan by the Texas Parks & Wildlife Department to support statewide efforts to improve Texas' parks.
6. Integrate the three volumes of the Parks and Recreation System Plan which include this updated Parks and Recreation System Plan (2005), the Planning and Design Guidelines for Creek Based Greenway Parks (2001), and the Land Use Management Planning Guidelines for Natural Areas (2003).

Strategic Initiatives outline actions and goals to meet San Antonio's needs for facilities and programs in order to create a great Parks and Recreation System. The following table is a synopsis of the City of San Antonio 2005 System Strategic Plan's strategic initiative's consistent with the WSC Recreation study (all others are not applicable to the study framework):

City of San Antonio System Strategic Plan 2006-2016
STRATEGIC INITIATIVE 1: Plan, develop and sustain a diversified, balanced, and well-conditioned citywide system of public parks and recreation facilities.
1. Continue implementation of the Parks and Recreation Strategic System Plan through the public input process.
3. Coordinate with other public and private entities in the acquisition, development and shared use of existing and/or new park and recreation facilities when in the public's best interest.
6. Develop urban, neighborhood, and cultural parks adjacent to and connecting with the San Antonio River Improvement Project and developed Creekways, as a means for citizens to easily access the San Antonio River, Creekways, and individual neighborhood centers.
11. Improve the appearance of urban areas with the increased usage of public art, reforestation, and enhanced landscape planting and maintenance.
STRATEGIC INITIATIVE 2: Ensure equitable access and maximize usage of parks and recreation facilities
1. Assure a city-wide park system that is accessible to everyone regardless of location, physical ability, or income level, specifically addressing underserved areas.
STRATEGIC INITIATIVE 3: Provide quality recreation and cultural program opportunities for all users
2. Provide increased opportunities for youth and adults to participate in our athletic, aquatic, golf cultural and other recreational programs, especially in regards to improving youth physical fitness.
STRATEGIC INITIATIVE 4: Ensure that municipal parks and recreation facilities are safe for all users.
6. Determine deterrent strategies such as lighting, signage, landscaping, design, etc. at facilities in order to reduce graffiti and vandalism.

BICYCLE MOBILITY ADVISORY COMMITTEE (BMAC)

The City of San Antonio's mission statement regarding bicycles in the City is a key component of BMAC's San Antonio Bike Plan 2011 plan, and in summary states a significant goal of increasing bike ridership for daily travel and improving cycling safety by making the bike network accessible, direct, and continuous (Bicycle Mobility Advisory Committee). The following four elements collectively support and work toward achieving the City of San Antonio Master Plan's overarching goals, which the WSC project would help satisfy:

- Bicycle Facilities Network;
- Network Support Facilities;
- Program Recommendations; and
- Implementation.

SA 2020

Initiated by the Mayor's office in 2010, San Antonio (SA) 2020 creates a vision of what the citizens of San Antonio want to achieve by 2020 (SA2020). SA 2020 includes recommendations for many areas, including arts and culture, downtown development, economic competitiveness, education, family well-being, health and fitness, environmental sustainability, neighborhoods and growth management and transportation. The vision includes more walkable neighborhoods, a significant reduction in youth and adult obesity, and environmental friendly transportation.

HEALTHY KIDS HEALTHY COMMUNITIES

The Healthy Kids Healthy Communities initiative is a national program of the Robert Wood Johnson Foundation (RWJF) whose primary goal is to implement healthy eating and active living initiatives that support healthier communities for children and families across the U.S. The program places special emphasis on reaching children who are at highest risk of obesity on the basis of income, race/ethnicity or geographic location. Healthy Kids, Healthy Communities supports a comprehensive, community-based approach that focuses on strategies—especially policy and environmental changes—to advance active living and healthy eating among children and their families. The program includes addressing the obesity problems on the Westside of San Antonio

MISSION VERDE SUSTAINABILITY PLAN

The Mission Verde Sustainability Plan (MVSP) was adopted in 2009 by the City of San Antonio to address the challenge of meeting the city's needs today without compromising those of future generations of San Antonio (Mission Verde Sustainability Plan). The plan focuses on economic sustainability; its intent is to "invest in energy saving initiatives that would save the consumer and the community money, and serve as a catalyst for job creation and innovation." Among the initiatives of the Mission Verde plan is to create an integrated and efficient multi-modal transportation system.

DEFINING THE PROBLEM AND PROJECT OPPORTUNITIES

STUDY AREA

The study area comprises approximately 12 square miles along San Pedro, Apache, Alazán, and Martínez Creeks in San Antonio, Bexar County, Texas. The four creeks, known locally and collectively as the Westside Creeks, are tributaries of the San Antonio River located to the west of the downtown area of San Antonio. The study area is primarily urban residential with business districts and some manufacturing facilities as well. The area is serviced by IH-10, IH-35, and US Highway 90. Figure 5shows the study area delineation.

The community affected by the degraded Westside Creeks is considered those populations within a ten minute walk, or half a mile distance from the creeks.

Figure 5. Westside Creeks Study Area

POPULATION

TOTAL POPULATION AND GROWTH

A socio-economic analysis of the study area, city, county, and state are fully expressed in the Socio-Economic Appendix; however, here the socio-economic statistics are analyzed as it relates to current land issues. In summary, those living in the affected 12 square mile study area are predominantly of Hispanic Origin (89%), are largely of the Baby Boom Generation or Millennials, creating a median age of 32.3 years. The study area population equates to approximately 78,000 persons of which are predominantly of Hispanic Origin (89%), more than the city and state. This community is also family-oriented who, more likely than their counterparts elsewhere, often have parents and perhaps even grandparents and great-grandparents living under the same roof.

Table 1. Population and Projections

Geographical Area	2010	2016	2040
Texas	25,145,561	27,505,386	44,872,038
Bexar County	1,714,773	1,900,877	2,253,060
San Antonio city	1,327,407	1,452,140	1,872,964
Westside Creeks Study Area	77,782	8,115	

Source: ESRI Community Analyst citing U.S Bureau of the Census, 2010 Census of Population and Housing(2010 and 2016 figures); Texas State Data Center (2040 projections for Texas and Bexar County); Texas Water Development Board (2040 projection for San Antonio)

Table 2. 2010 Population by Race

Geographical Area	White	Black	American Indian	Asian	Pacific Islander	Some Other Race	Multiple Races
Texas	17,701,552	2,979,598	170,972	964,596	21,656	2,628,186	679,001
Bexar County	1,250,252	128,892	14,475	41,739	2.350	217,389	59,676
San Antonio city	963,413	91,280	11,800	32,254	1,504	181,625	45,531
Westside Creeks Study Area	55,972	2,616	1,058	267	40	15,597	2,233

Source: ESRI Community Analyst citing U.S Bureau of the Census, 2010 Census of Population and Housing

Table 3. 2010 Hispanic Origin Population

Geographical Area	Hispanic Origin
Texas	9,460,921
Bexar County	1,006,958
San Antonio city	838,952
Westside Creeks Study Area	69,538

Source: ESRI Community Analyst citing U.S Bureau of the Census, 2010 Census of Population and Housing

Table 4. 2010 Population by Age Group

Geographical Area	0-9	10-19	20-34	35-44	45-64	65+
Texas	3,856,707	3,765,007	5,430,552	3,458,382	6,033,027	2,601,886
Bexar County	260,394	260,777	386,722	230,754	400,243	175,883
San Antonio city	199,799	199,907	304,784	175,669	308,644	138,604
Westside Creeks Study Area	12,444	11,500	17,735	9,681	17,719	8,703

Source: ESRI Community Analyst citing U.S Bureau of the Census, 2010 Census of Population and Housing

The study area population shows to have attained less education when compared to San Antonio, Bexar County, and Texas. Almost 50% of those 25 years of age and older have less than a high school education, 29% have only a high school diploma, 9% possess an Associate's degree or higher.

Table 5. Percent of Population 25 Years and Older by Highest Level of Education

Geographical Area	Less than High School Diploma	High School Diploma	Associate Degree	Bachelor's Degree	Master's, Professional or Doctorate Degree
Texas	20.3%	26.6%	6.6%	17.1%	8.4%
Bexar County	18.6%	27.3%	7.1%	15.8%	8.7%
San Antonio city	20.8%	27.4%	6.7%	15.0%	8.1%
Westside Creeks Study Area	49.6%	29.2%	3.0%	3.8%	2.1%

Source: ESRI Community Analyst citing U.S Bureau of the Census, 2010 Census of Population and Housing

Similarly, the study area shows to be poorer than the city, county and state. With a median household income of $23,000, the income shows to be about half of what is experienced in the other geographical areas. Per capita income ($12,813) is also about half of per capita incomes in the other geographical areas.

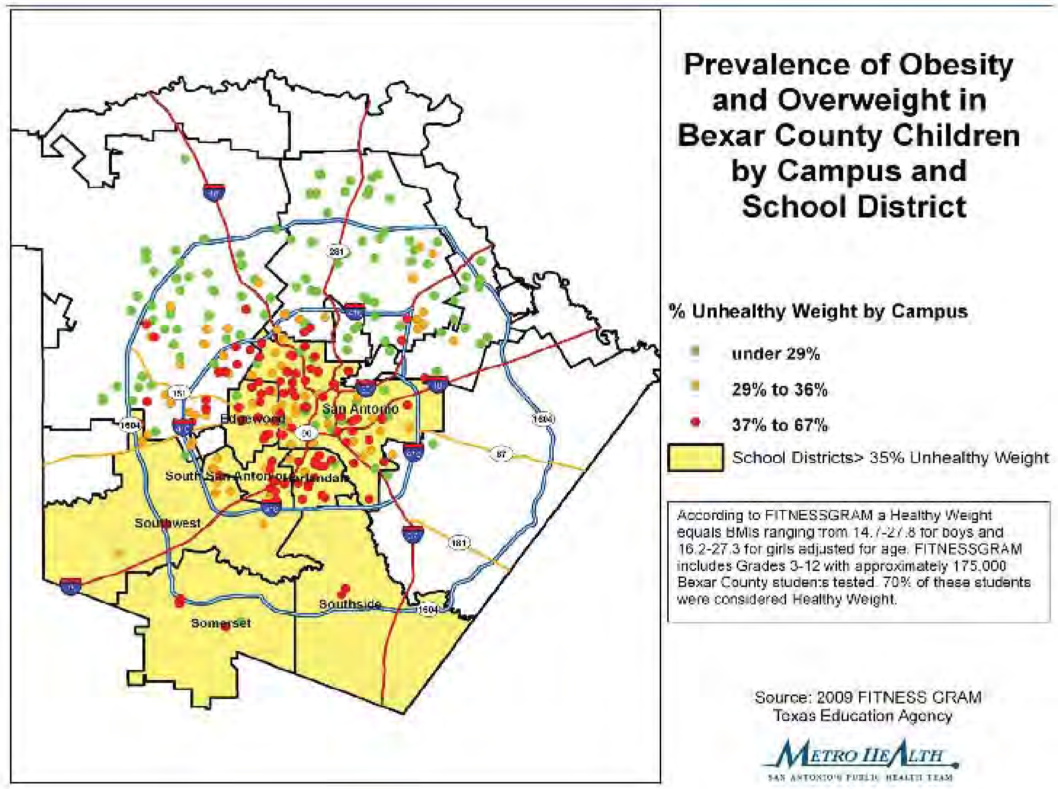
Table 6. 2010 Median Household and Per Capita Incomes

Geographical Area	Median Household Income	Per Capita Income
Texas	$47,753	$24,332
Bexar County	45,689	23,545
San Antonio city	42,612	22,457
Westside Creeks Study Area	22,739	12,813

Source: ESRI Community Analyst citing U.S Bureau of the Census, 2010 Census of Population and Housing

HEALTH

The prevalence of obesity in the United States increased during the last decades of the 20th century (Flegal, Carroll and Ogden, Prevalence and trends in obesity among US adults, 1999-2000; Ogden, Flegal and Carroll). More recently there appears to have been a slowing of the rate of increase or even a leveling off (Flegal, Carroll and Ogden; Ogden, Carroll and Curtin). However, San Antonio and especially the Westside community is experience quite the opposite. The City of San Antonio is tackling obesity, a health condition that is prevalent throughout the city of 1,327,407 residents.   According to statistics from the U.S. Center for Disease Control, 31% of San Antonio's residents are obese and 65% are overweight: the worst record in the nation. In Bexar County, 65.7% of adults are overweight or obese. In Texas, 32.4% of children aged 10-17 are overweight or obese. San Antonio Metropolitan Health District (Metro Health) states that schools within the study area have a 37-67 percent obesity rate among children.



According to FITNESSGRAM a Healthy Weight equals BMIs ranging from 14.7-27.8 for boys and 16.2-27.3 for girls adjusted for age. FITNESSGRAM includes Grades 3-12 with approximately 175,000 Bexar County students tested. 70% of these students were considered Healthy Weight.

Source: 2009 FITNESS GRAM
Texas Education Agency

Figure 6. Prevalence of Obesity and Overweight in Bexar County Children by Campus and School District

According to Metro Health's 2007 *Health Profiles*, of 47,844 clients enrolled in the Women, Infants and Children (WIC) program, 11.3% of children were at risk for being overweight and 11.3% were overweight. As part of a Metro Health program, the body mass index (BMI) of SAISD students was collected in 2007. Of the 19,045 students measured, 29% had a BMI greater than the 95th-percentile. The Youth Risk Behavior Surveillance System (YRBSS) survey administered at 8 local high schools in 2007 indicated that of 1,317 students, 19.1% were overweight and 20.2% were obese.

Metro Health serves as the sole public health agency charged with the responsibility of providing public health leadership and programs in San Antonio and the unincorporated areas of Bexar County, Texas with target audiences of children and families. Healthy Kids, Healthy Communities is a national program of the Robert Wood Johnson Foundation (RWJF) whose primary goal is to implement healthy eating and active living initiatives that support healthier communities for children and families across the U.S. The program places special emphasis on reaching children who are at highest risk of obesity on the basis of income, race/ethnicity or geographic location. Healthy Kids, Healthy Communities supports a comprehensive, community-based approach that focuses on strategies—especially policy and environmental changes—to advance active living and healthy eating among children and their families.

In 2009, the Metro Health was selected to receive the Healthy Kids Healthy Communities grant. Metro Health convened a diverse network of partners, called the Healthy Kids Healthy Communities Partnership to plan and implement strategies to increase opportunities for physical activity and access to healthy foods for children and families. The HKHC Partnership will primarily focus their work within the boundaries of the Westside area where the obesity rate continues to increase. Within the study area, almost 30 percent of students in one school district were obese. In addition, a federal health survey of more than 1,300 students at eight local high schools in 2007 found that nearly two out of every five were overweight or obese.

The HKHC Partnership includes the City of San Antonio's Planning & Development Services and Parks & Recreation Departments, the Metropolitan Planning Organization, the University of Texas School of Public Health, VIA Metropolitan Transit, the University of Texas Health Science Center at San Antonio – School of Nursing, the San Antonio Restaurant Association, the Health Collaborative, Texas Public Radio, and several community based organizations located within the target area. Working together, this partnership will focus their efforts on the following goals and tactics:

Goal 1: Develop Partnerships, Build Capacity, and Communicate with Local Stakeholders to Establish Support.

Goal 2: Expand shared use of schools and other public facilities in the target area for after-hours use for physical activity.

Goal 3: Implement the Complete Streets concept in the target area for new development and redevelopment projects.

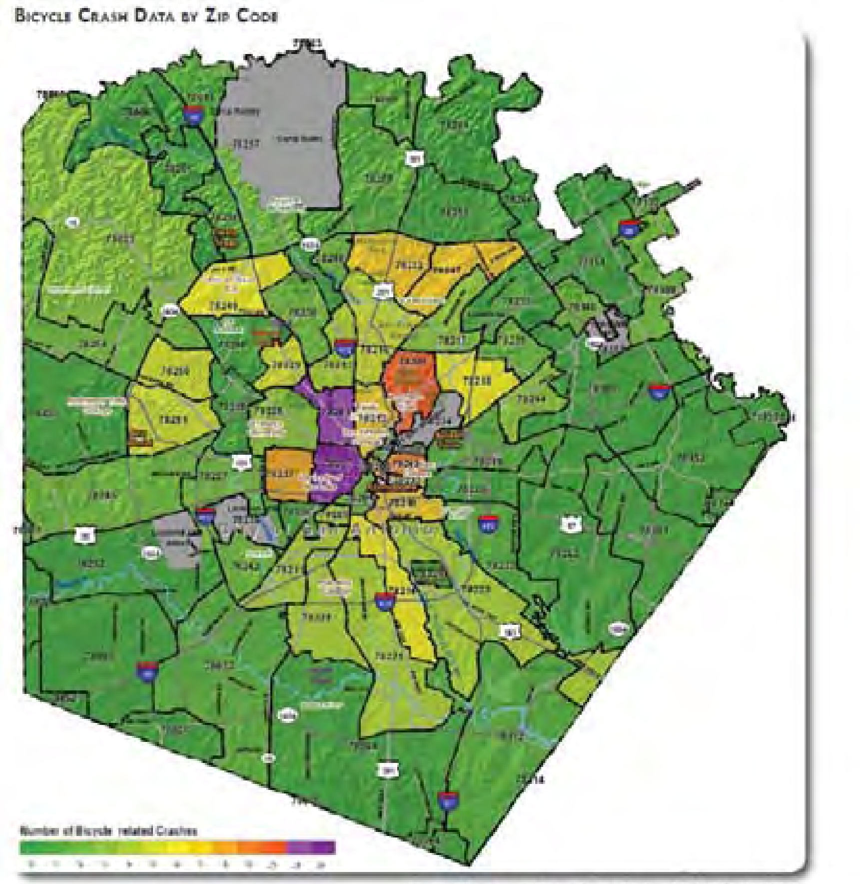
Goal 4: Promote the voluntary adoption and implementation of a healthy menu Initiative by restaurants in the target area through incentives and technical support.

Goal 5: Promote the voluntary adoption and implementation of a healthy selections initiative by corner stores in the target area through incentives and technical support.

SAFETY

Safety is an important social concern with the Westside Creeks communities as expressed in public workshops provided by SARA. Many points were made to illustrate the importance of improving creeks' safety. A built environment in which the residents of the community can easily access the creek-side trails will mean more "eyes on the street", a concept referred to as natural surveillance. Walkability promotes a stronger sense of community, more social interaction and thereby lower levels of crime than is currently experienced (Cozens).

Crime safety is not the only safety concerning the Westside community. The Westside Creeks study area is within an area of San Antonio that suffers the greatest number of bicycle-related crashes in the city. The city averages 148 crashes with injuries per year over the past 3 years and has averaged 2.3 fatalities from bicycle crashes per year over the last 6 years (San Antonio Bike Plan 2011) (see Figure 7).



Source: San Antonio-Bexar County Regional Safety Study, 2010

Figure 7. Bicycle Crash Data by Zip Code

Local and federal agencies have taken steps to try making the city safer for bicyclists using the following criteria; although, Westside is still experiencing the greatest number of bicycle-related crashes.

THE WHITE HOUSE

- Benchmarks of Success: Increase by 50% by 2015 the percentage of children ages 5-18 taking safe walking and biking trips to and from school. An increase of 50% would mean that 19.5% of school trips would be by biking or walking.

CITY OF SAN ANTONIO

- San Antonio Bicycle Plan 2011 helps to supports the city's biking infrastructure with several recommendations.
- San Antonio Mayor Julian Castro's SA 2020 encourages multimodal transportation system linking it to neighborhoods across the city.

- The goal of San Antonio Bikes is to increase bike ridership for daily travel and improve cycling safety by making San Antonio's bike network.
- San Antonio Police Department Bike Rodeo Program reaches out for student participation to improve bicycle safety and skills.
- City of San Antonio launched “Get Cyched” in 2010, a bilingual safety and awareness campaign for bicyclist and motorists.
- Neighborhood Adventures in Bicycle Safety TV was broadcast emphasizing bicycle safety.
- In 2010 the City passed two ordinances that directly affect bicyclists: the Safe passing Ordinance and the BikeLights @ Night Ordinance.
- Mayors Fitness Council has helped spearhead efforts that increase bicycling and walking as part of its mission to improve the health and fitness of San Antonians.
- Metro Health Department has been the source of funding or materials for education and promotion of bicycling and other active living lifestyles in san Antonio.
- The web portal www.sabalance.org was created to learn about access to physical activity opportunities in Sans Antonio.
- In 2010, the Metro Health Department was awarded a Communities Putting Prevention to Work grant to develop Safe Routes to School (SRTS) plans for seven schools in the City of San Antonio. As a part of this process they will be identifying infrastructure improvements needs, opportunities for education, encouragement and information programs.

SAN ANTONIO-BEXAR COUNTY MPO

- San Antonio-Bexar County Metropolitan Planning Organization’s (MPO) Transpiration Policy Board adopted the San Antonio Bike Plan 2011 + Implementation Strategy on March, 5, 2012 to provide safer transportation facilities for bicyclists and to ensure all transportation options are available as well as to improve air quality, the quality of life, and health of residents in San Antonian communities.
- Bexar County uses the Walkable Community Program as a forum of education and promotion. The Walkable Community Program has three components: Walkable Community Workshops, Safety Classes, and Bicycle Rodeos. The program is available to neighborhoods, schools, and community groups to evaluate their community, identify infrastructure improvement to increase bicycling and walking, and to provide education about the benefits of walking and bicycling.
- Walkable community workshops, Safety Classes, bicycle rodeo, MPO Kids in 2010 to outreach to younger bicycle populations, TXDOT, private bicycle advocacy, and others

TENTATIVELY SELECTED PLAN

The Westside Creeks tentatively selected plan is the proposed way forward on developing the future ecosystem restoration and recreation for the study area. This section generalizes this plan for ecosystem restoration and recreation opportunities for which social effects have been identified.

ECOSYSTEM RESTORATION

The ecosystem restoration study defines a plan that restores to the extent practicable, a sustainable, dynamic, riverine ecosystem providing habitat for aquatic and riparian dependent migratory and native resident bird species in the Westside Creeks study area. Recreation is to be maximized to the extent practicable along the creeks as long as the recreation features do not diminish the project's ecosystem restoration objectives. See the Environmental Resources appendix for more information on the ecosystem restoration plan. Social effects are evaluated for all planned project conditions.

MULTI-USE TRAILS

The main recreation component proposed for the Westside Creeks Ecosystem Restoration and Recreation project is 10-foot multi-use trails incorporated into the current and planned City of San Antonio Mission Trail System, as well as, future planned trails by the National Park Service. From an environmental perspective, recreation features are located to avoid adverse impacts to riparian vegetation. The trails would enhance the visitation experience by providing access to the project ecosystem restoration features and it would encourage social, cultural, scientific, and educational encouragement due to the ecosystem restoration project.

TRAILHEAD ENTRANCES

Trailhead entrances are a significant component proposed for the Westside Creeks project and will be adapted to promote a strong physical connection from the local communities as well as for visitors.

These trailheads would allow for safe access for the communities within a half a mile of the Westside Creeks the following public amenities: on-road bike facilities (roads with designated bike lanes), designated tour trails, several cultural sites, a historic park, parks with a variety of facilities such as fitness equipment, historic cemeteries, San Antonio Natatorium, a library, schools, designated Downtown Runs and Bike Rides self-guided tours, the Riverwalk and associated tourist attractions.

EVALUATE PROJECT CONDITIONS AND EFFECTS

Social effects, in a general sense, refers to how the constituents of life that influence personal and group definitions of satisfaction, well-being, and happiness are affected by some condition or proposed intervention. The anticipated social effects from the proposed ecosystem restoration and recreation plan are viewed as three categories: health effects, alternative transportation and safety effects, and the economics of sustainable landscapes. The latter category is further defined by four subcategories: water treatment savings, atmospheric carbon dioxide reduction, air quality improvement, and aesthetic and property value benefits.

HEALTH

A series of research studies from a White House Task Force on Childhood Obesity Report suggests that attributes of our current built environment have had a negative impact on health outcomes, contributing to obesity and related health problems. The existence of safe, convenient, and accessible facilities for walking and biking are likely to increase physical activity and make parents feel more secure about their children's safety. However, they do not by themselves ensure more active lifestyles for residents of such communities. “Social environments” also play a role, including how community members feel about their neighborhood, how secure they feel, and how interested they are in participating in community-based physical activity. Evidence suggests that the combined effect of the built and social environment has an impact on rates of childhood obesity and overweight (Solving the Problem of Childhood Obesity within a Generation).

Providing access to a linear trail system will have the greatest affect on the population within half a mile of the trails. The specific characteristics that seem most relevant to obesity-related health disparities in the United States are proximities/access to supermarkets, exercise facilities, safety. Each of these has been reported to be correlated with body mass index or related behaviors within low-income, minority target groups. A study in Lincoln, Nebraska has identified a cost-benefit ratio of 2.94, which means every $1 investment in trails for physical activity led to $2.94 in direct medical benefit (Wang, Macera and Scudder-Soucie). Since obesity in San Antonio is the highest in the nation, it can be assumed that this cost relationship would be greater in the study area than Nebraska. Since the Westside Creeks recreation project estimates $3,900,000 in trail investment, then (3,900,000 Westside Creeks trail investment times $2.94 in direct medical benefit) an estimated minimum $11,466,000 in direct medical benefit should be observed from construction of the Westside Creeks project.

This figure for direct medical benefit does not include cost savings from bicycle-related crash prevention. See Alternative Transportation and Safety section below on preventable bicycle-related cost with the Westside Creeks project.

ALTERNATIVE TRANSPORTATION AND SAFETY

Trail networks provide alternative transportation links that are currently unavailable. WSC trails would connect to the San Antonio’s Central City Trails, several miles of existing and planning trails located within Central and Downtown San Antonio, to provide the residents who live on the west side of downtown alternative transportation links that are currently unavailable. Residents who live in the west side community outside of downtown San Antonio would be able to walk or bike downtown for work or simply for recreation. These trails would allow residents to circulate through urban areas in a safe, efficient, healthy, and fun way: walking or biking. Residents would be able to move freely along trail corridors without paying increasingly high gas prices and sitting in ever-growing automobile traffic. Regional connectively through transportation can be improved with the WSC project.

Figure 8. San Antonio Greenway System

Improving access to regional resources is proved to increase the number of trips made by foot or bicycle. The City of San Antonio and other local agencies share the same goals as the White House when it comes to bicycling: to double the percentage of trips made by bicycle by 2015. Meeting this goal is important particularly for the Westside Creeks' community. The Westside Creeks area is within the area for the greatest number of bicycle crashes. The West Side area currently averages 148 bicycle-related crashes per year for the past three years (San Antonio Bike Plan 2011). This is reasoned to be related to the amount of residents in the area relying on bicycle to commute for work. A future with creek-side trails is expected to see an increase in trips made by foot and bicycle for a safer route opportunity and commuters and recreationists alike. By assuming the Westside Creeks project aids in meeting the City's and Whitehouse goals by doubling the about of trips made by bike in the area, it can be estimated that the benefits of this safer alternative transportation route opportunity would reduce the number of bicycle-related crashes and deaths by half. The National Safety Council makes estimates of the average costs of bicycle-related injuries to illustrate their impact on the nation's economy. The average economic cost for nonincapacitating bicycle-related injury is $22,300 (Estimating the Costs of Unintentional Injuries). The costs are a measure of the dollars spent and income not received due to accidents, injuries, and fatalities. Therefore if the 148 bicycle-related crashes are reduced by half, then (148 bicycle-related crashes per year divided by 2) times $22,300 per nonincapacitating bicycle-related crash injury equals $1,650,200 per year estimated cost savings for the community.

THE ECONOMICS OF SUSTAINABLE LANDSCAPES

Sustainability can be defined as the ability to “meet the needs of the present without comprising the ability of future generations to meet their own needs.” This definition embraces the definition of sustainable development first put forward by the United Nations World Commission on Environment and Development at the United Nations General Assembly in 1987. Adopting planning and development sustainable practices not only helps the environment but also enhances human health and well-being and can be economically cost-effective. Ecosystem services provide benefits to humankind and other organisms but are not generally reflected in our current economic accounting. In this section on The Economics of Sustainable Landscapes, recognition is given to providing a value of Westside Creeks ecosystem services that supports human health and well-being.

> “The nation behaves well if it treats the natural resources as assets which it must turn over to the next generation increased, and not impaired, in value.”
>
> *- President Theodore Roosevelt*

The communities of Westside Creeks have expressed their desire to approach ecosystem restoration in a sustainable manner in such a way “to make sure that the creeks themselves are biologically sound and that we make it environmentally sustainable.” One of the concepts identified by the public during the Branding and Key Messaging Workshop for SARA’s Westside Creeks Restoration Project was that of “Bringing Nature Back”. This theme means a return to the natural beauty that once was, focused on the importance of creating a biologically sound and environmentally sustainable vision. This 2-year planning process also included a phase aimed at achieving long-term sustainable conditions called Phase II Restoration Concepts.

The remainder of this chapter discusses the additional social benefits of ecosystem restoration. Benefits will result from air cleaning and water treatment savings. Increased recreational opportunities and enjoyment benefits expected from the WSC ecosystem restoration project are expanded on in the Recreation Appendix.

WATER TREATMENT SAVINGS

Urban trees intercept millions of gallons of rainwater each year, preventing runoff from entering storm sewers and saving the city in stormwater management costs. The social benefits that result from reducing peak runoff for the WSC project results in improved water quality. This can translate into improved aquatic habitats, less human disease and illness due to contact with contaminated water, and reduces stormwater treatment costs. Treatment of runoff is one way of calculating the implied value of each tree intercepting stormwater. The average tree intercepts 1432 gallons of stormwater each year, valued at $61 per tree (Peper, McPherson and Simpson).

The riparian woodland measure that supports the Westside Creeks ecosystem restoration objective addresses an average of 50 stems of riparian woody vegetation per acre. Not all woody stems are trees but it can be approximated that on a 50 woody stem per acre basis, 45 are trees. Therefore based on a planting regime of 45 trees per acre, the improved water quality value is approximately $2,745 per acre annually. Since the WSC project proposes 14.3 acres of riparian woody vegetation for the preferred Alternative 6, the improved water quality is approximately valued to $40,000 annually.

ATMOSPHERIC CARBON DIOXIDE REDUCTION

Urban forests in open spaces (versus those near buildings) can reduce atmospheric carbon dioxide (CO2) by directly sequestering CO2 as woody and foliar biomass as they grow. The benefit of reducing atmospheric CO2 is valued at approximately $1.29 per tree (Peper, McPherson and Simpson). Based on a planting regime of 45 stems of riparian woody vegetation per acre (see Water Treatment Savings section above for methodology), the improved water quality value is approximately $58 per acre annually. Since the WSC project proposes 14.3 acres of riparian woody vegetation for the preferred Alternative 6, the CO2 sequestering benefit is valued at approximately $830 annually.

AIR QUALITY IMPROVEMENT

Urban trees in open spaces improve air quality in four main ways:

- Absorbing gaseous pollutants (ozone, nitrogen dioxide) through leaf surfaces
- Intercepting particulate matter (e.g., dust, ash, dirt, pollen, smoke)
- Releasing oxygen through photosynthesis
- Transpiring water and shading surfaces, resulting in lower local air temperatures, thereby reducing ozone levels

The net air pollutants removed, released, and avoided are valued at approximately $9.02 per tree. Although trees vary dramatically in their ability to produce net air-quality benefits, this is a conservative approach to the typical, medium-canopied tree mass. Based on a planting regime of 45 stems of riparian woody vegetation per acre (see Water Treatment Savings section above for methodology), the improved water quality value is approximately $406 per acre annually. Since the WSC project proposes 14.3 acres of riparian woody vegetation for the preferred Alternative 6, the net air-quality benefit is approximately $5,800 annually.

AESTHETIC AND PROPERTY VALUE BENEFITS

Many benefits attributed to urban trees are difficult to translate into economic terms. Beautification, improved human health, shade that increases human comfort, sense of place, and well-being are difficult to price. However, a study by the Center for Urban Forest Research USDA Forest Service considered the value of some of these benefits by capturing property values of the land on which trees stand or to which they are adjacent. Residential properties will realize a greater gain in value the closer they are located to trails and greenspace. This approach has the virtue of capturing what buyers perceive as both the benefits and costs of trees in the sales price. The estimated total annual benefit associated with property value increases and other less tangible benefits is $90 per tree on average (Peper, McPherson and Simpson). Based on a planting regime of 45 stems of riparian woody vegetation per acre (see Water Treatment Savings section above for methodology), the improved water quality value is approximately $4,050 per acre annually. Since the WSC project proposes 14.3 acres of riparian woody vegetation for the preferred Alternative 6, the estimated total annual benefit associated with aesthetics and other perceived human health improvements is approximately $58,000 annually.

FORECASTING FUTURE WITHOUT-PROJECT CONDITIONS

This section presents future conditions concerning the Westside Creeks affected population and related resources as they are projected to exist without Federal action to solve the current problems. This condition is important to the evaluation and comparison of benefits and to identify impacts attributable to proposed federal actions. The without plan condition is the same as the "No Action" alternative that is required to be considered by the federal regulations implementing the National Environmental Policy Act (NEPA).

The environmental setting trends in the future without project conditions are tied to the increase in obesity, high bicycle-related crashes, a lack in regional connectivity for alternative transportation routes, and degraded natural creeks bound by a low income, minority-dominant community. The Westside Creeks would remain channelized providing no access to the trail network for exercise, recreation, and alternate routes to schools, works churches, and locations of cultural significance.

CONCLUSION

The City and SARA will continue to work towards achieving the community's preferred plan for reinvestment and restoration. However, the WSC project is an essential element in achieving the community's vision for the future of Westside Creeks.

	Effects With the WSC Project	Effects Without the WSC Project
Execute Order 12989	Supported	Not supported
USDOT NBWS	Supported	Not supported
SA System Strategic Plan 2005	Supported	Not supported
SA Master Plan 1997	Supported	Not supported
Bicycle Mobility Advisory Committee (BMAC)	Supported	Not supported
SA 2020	Supported	Not supported
Healthy Kids Healthy Communities	Supported	Not supported
Mission Verde Sustainability Plan	Supported	Not supported
Obesity reduction (savings per year)	$11,466,000	$0
Alternative Transportation Route (savings per year)	$1,650,200	$0
Water treatment savings (savings per year)	$40,000	$0
Atmospheric carbon dioxide reduction (savings per year)	$830	$0
Air quality improvement (savings per year)	$5,800	$0
Aesthetics (savings per year)	$58,000	$0
Total Savings per Year	$13,220,830	$0

Comprehensive Approach - SARA has aggressively taken steps of its own to improve the community's circumstances by providing access to a healthy environment along with Westside. The City has brought together all community partners, neighboring communities, the public, and state and federal agencies, forging a partnership to reduce the negative effects to the community of the current conditions of the creeks.

Environmental Justice - Most of the residents in the zone of influence are neighborhoods with a high percentage of the poor, obese, and minority households. A commitment to environmental justice underlies the SARA's approach -- all residents need protection regardless of socioeconomic status and the cost of their home, or its location.

Importance to the Nation – Finally, Westside Creeks is part of a vast public effort to restore the creek's ecosystem as it meanders through some of San Antonio's oldest and proudest neighborhoods containing their own unique, rich history. Investing in the Westside Creeks project will improve access to the creeks, and as a result, improve the outlook of the communities' health, safety, and overall well-being. A healthy, safe Westside Creeks is not just a good investment for Texas or the region; it is a good investment for the nation.

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WESTSIDE CREEKS ECOSYSTEM RESTORATION

Appendix L: Real Estate

REAL ESTATE PLAN

The Real Estate Appendix and associated project costs are still under development. The Fort Worth District is in the process of verifying that the San Antonio River Authority (SARA) already owns the necessary fee lands to support the ecosystem restoration and recreation features of the recommended project plan. Besides the fee owned lands, we are planning for approximately four temporary work easements and at least one temporary disposal easement to be acquired for construction. In addition, there are numerous public utility lines described in the main report that will require adusments to a deeper depth within their current footprint and relocation agreements will be required as part of SARA's Lands, Easements, Right of Way, Relocations, and Disposal (LERRD) requirements.

WESTSIDE CREEKS ECOSYSTEM RESTORATION

Appendix M: Cost Analysis and Detailed Cost Estimate

COST ANALYSIS AND DETAILED COST ESTIMATE APPENDIX

PROJECT GOALS AND OBJECTIVES

The goal is to provide an economical ecosystem restoration project located in San Antonio within the West Side Creeks area. The objectives include (1) Restore to the extent practicable, a sustainable, dynamic, riverine ecosystem providing habitat for aquatic and riparian dependent migratory and native resident bird species in the Westside Creeks study area, (2) Maximize, to the extent practicable, recreation benefits along the Westside Creeks compatible in scope and scale of the project's ecosystem restoration objective and consistent with national, regional, and local recreation goals.

METHODOLOGY

Costs during plan formulation were developed using MII V 4.1 software and the 2010 Cost Book. The effective date of costs was set at October 2012. After the Tentatively Selected Plan (TSP) was chosen and concurred with by USACEHQ, the Fort Worth District upgraded to MII V4.2 and the 2012 Cost Book. Costs for the TSP were estimated again with the newer information, with the effective date remaining at October 2012. This project was determined to be an ecosystem restoration project with National significance. Once the way forward was determined the cost was created using information from the non-federal sponsor, San Antonio River Authority (SARA), H&H and Civil. The project was broken out by the four creeks that make up the project area. It was determined what type of restoration was viable for each reach. The four reaches in the estimate are broken out based on the Civil Works Work Breakdown Structure (CWWBS). Within each reach there are different components estimated that were then placed in the Cost Estimating-Incremental Cost Analysis (CE-ICA) spreadsheet. Based on the CE-ICA a Tentatively Selected Plan (TSP) will be chosen. The CE-ICA is being utilized to show the various opportunities and components available to the project and maximize the benefits. Once the recommended plan is chosen it will be revised to be more specific. The estimate currently includes construction, relocations, plantings, PED and Construction Management costs, and contingency (based on the Abbreviated Risk Analysis).

ASSUMPTIONS AND CONSTRAINTS

The assumption for this project is that all work will be done within the existing right of way and no other Real Estate will have to be acquired at this level. There are some bridges within the construction limits but it is assumed that they will not be impacted by any of the planned restoration. Recreation formulation was dependent on a final TSP, therefore recreation costs reflect costs from the updated MCASES software and cost book. Some feature costs, such as shade structures, were developed from known costs of similar features in the Mission Reach Ecoststem Restoration Project.

RISKS

After having the Project Development Team complete the abbreviated risk analysis for this project it was determined that contingencies for this project range from 5% for slackwater to 29.73% for relocations. The higher risks come from the Project Growth, Construction Elements, Quantities and External Project Risks.

Based on information received from Civil Design there is the possibility that a couple of lift stations may be needed because of the new depth of the utility relocations, in Martinez Creek, but have not been included in the estimate at this time. This was accounted for in the abbreviated cost risk analysis (ARA) and reflected in the contingency.

ALTERNATIVES

From the information developed using the Cost Estimating-Incremental Cost Analysis (CE-ICA) there were six action plans that were determine to be best buys plans. There were 7 plans in total with the first being the no action plan. The other alternatives were a combination of Riparian Meadow, Pilot Channel (with pool riffles and utility relocations), Woody vegetation, Slackwater, and in Martinez a wetland.

RECOMMENDED PLAN

After analyzing the costs and the risks associated with the various alternative, the recommended plan in alternative 6, this includes Riparian Meadow in all 4 creeks, Pilot channel, Woody vegetation and Slackwater in San Pedro, Alazan, and Apache Creeks, to the extent practicable within the study limits, and recreation features (including trails, shade structures, benches, drinking fountains, trashcans and directional signage).

WestSideCreeks-15 July 2013

Revsied as of 15 July 2013

This includes the revised contingencies based on the ARA dated March 2013

Estimated by	
Designed by	
Prepared by	Ninfa Taggart
Preparation Date	5/10/2013
Effective Date of Pricing	10/1/2012
Estimated Construction Time	2,555 Days

Description	Quantity	UOM	ProjectCost
PROJECT SUMMARY - Scope			**50,648,551**
1 TSP - Alternative 6	**1.00**	**LS**	**50,648,551**
1.1 ER Component	**1.00**	**LS**	**45,344,023**
1.1.1 San Pedro Creek	**1.00**	**LS**	**12,817,367**
1.1.2 Apache Creek	**1.00**	**LS**	**5,161,735**
1.1.3 Alazan Creek	**1.00**	**LS**	**13,444,971**
1.1.4 Martinez Creek	**1.00**	**LS**	**4,824,062**
1.1.5 30 Planning, Engineering and Design	**1.00**	**LS**	**4,584,548**
1.1.6 31 Construction Management	**1.00**	**LS**	**4,511,340**
1.2 Recreation Components	**1.00**	**LS**	**5,304,528**
1.2.1 14 Recreation	**1.00**	**LS**	**3,862,588**
1.2.2 30 Planning, Engineering and Design	**1.00**	**LS**	**726,773**
1.2.3 31 Construction Management	**1.00**	**LS**	**715,167**

Description	Quantity	UOM	ProjectCost
PROJECT INDIRECT SUMMARY - System			**50,648,551**
1 TSP - Alternative 6	**1.00**	**LS**	**50,648,551**
1.1 ER Component	**1.00**	**LS**	**45,344,023**
1.1.1 San Pedro Creek	**1.00**	**LS**	**12,817,367**
1.1.1.1 Riparian Meadow	**1.00**	**LS**	**5,641,473**
1.1.1.2 Channel Modification	**1.00**	**LS**	**6,622,544**
1.1.1.3 Woody Veg 70/30 trees	**1.00**	**LS**	**250,244**
1.1.1.4 Slackwater	**1.00**	**LS**	**303,106**
1.1.2 Apache Creek	**1.00**	**LS**	**5,161,735**
1.1.2.1 Riparian Meadow	**1.00**	**LS**	**2,628,329**
1.1.2.2 Channel Modification	**1.00**	**LS**	**2,254,234**
1.1.2.3 Woody Veg 70/30 trees	**1.00**	**LS**	**154,073**
1.1.2.4 Slackwater	**1.00**	**LS**	**125,099**
1.1.3 Alazan Creek	**1.00**	**LS**	**13,444,971**
1.1.3.1 Riparian Meadow	**1.00**	**LS**	**5,826,580**
1.1.3.2 Channel Modification	**1.00**	**LS**	**7,145,180**
1.1.3.3 Woody Veg 70/30 trees	**1.00**	**LS**	**156,315**
1.1.3.4 Slackwater	**1.00**	**LS**	**316,896**
1.1.4 Martinez Creek	**1.00**	**LS**	**4,824,062**
1.1.4.1 Riparian Meadow	**1.00**	**LS**	**4,824,062**
1.1.5 30 Planning, Engineering and Design	**1.00**	**LS**	**4,584,548**
1.1.6 31 Construction Management	**1.00**	**LS**	**4,511,340**
1.2 Recreation Components	**1.00**	**LS**	**5,304,528**
1.2.1 14 Recreation	**1.00**	**LS**	**3,862,588**
1.2.1.1 10' Wide Trails Pedestrian Only	**44,600.00**	**LF**	*62.16* **2,772,529**
1.2.1.2 Shade Structure	**6.00**	**EA**	*138,911.67* **833,470**
1.2.1.3 Interpretive/Directional Signage	**50.00**	**EA**	*76.63* **3,832**
1.2.1.4 Benches	**15.00**	**EA**	*8,509.06* **127,636**

Description	Quantity	UOM	ProjectCost
			4,140.35
1.2.1.5 Water Fountain	**15.00**	**EA**	**62,105**
			2,104.02
1.2.1.6 Picnic Tables	**23.00**	**EA**	**48,393**
			635.79
1.2.1.7 Trash Receptacles	**23.00**	**EA**	**14,623**
1.2.2 30 Planning, Engineering and Design	**1.00**	**LS**	**726,773**
1.2.3 31 Construction Management	**1.00**	**LS**	**715,167**

WESTSIDE CREEKS ECOSYSTEM RESTORATION

Appendix N: Public Communication

DEPARTMENT OF THE ARMY
FORT WORTH DISTRICT, CORPS OF ENGINEERS
P. O. BOX 17300
FORT WORTH, TEXAS 76102-0300

REPLY TO
ATTENTION OF

July 31, 2013

Planning, Environmental, and Regulatory Division

NOTICE OF AVAILABILITY

DRAFT FONSI AND ENVIRONMENTAL ASSESSMENT FOR THE WESTSIDE CREEKS ECOSYSTEM RESTORATION PROJECT, SAN ANTONIO, TEXAS

The public is hereby notified of the availability of the Draft Finding of No Significant Impact (FONSI) and Environmental Assessment (EA) for restoration of the San Pedro, Apache, Alazan, and Martinez Creeks (Westside Creeks) in the City of San Antonio, Texas. The United States Army Corps of Engineers, Fort Worth District and the San Antonio River Authority (SARA), the non-federal sponsor, have prepared the General Re-evaluation Report, Draft FONSI and EA to identify, evaluate, and disclose all associated impacts that would result from the proposed ecosystem restoration of the Westside Creeks.

The Draft FONSI and EA will be available for review at the following locations:

San Antonio River Authority 100 East Guenther St. San Antonio, Texas 78204	Central Library 600 Soledad San Antonio, Texas 78205

The Draft FONSI and EA can also be viewed via the Internet on the Fort Worth District and SARA websites at the following addresses: www.swf.usace.army.mil and www.sara-tx.org.

A 30-day public comment period begins with publication of this Notice of Availability. Please address any comments to Mr. Daniel Allen, CESWF-PER-EC, P. O. Box 17300, Fort Worth, Texas 76102-0300, or email at daniel.allen@usace.army.mil.

E. W. Ver

Eric W. Verwers
Chief, Planning, Environmental, and
Regulatory Division

DEPARTMENT OF THE ARMY
FORT WORTH DISTRICT, CORPS OF ENGINEERS
P. O. BOX 17300
FORT WORTH, TEXAS 76102-0300

REPLY TO
ATTENTION OF

July 31, 2013

Planning, Environmental, and Regulatory Division

Mr. Adam Zerrenner
U.S. Fish and Wildlife Service
10711 Burnet Road, Suite 200
Austin, Texas 78758

Dear Mr. Zerrenner:

The United States Army Corps of Engineers, Fort Worth District (USACE) and the San Antonio River Authority (SARA), the non-federal sponsor, are evaluating the potential environmental consequences resulting from the restoration of the aquatic and riparian ecosystems of San Pedro, Apache, Alazan, and Martinez Creeks (Westside Creeks) in the City of San Antonio, Texas.

USACE has prepared a Draft General Re-evaluation Report, Environmental Assessment (EA) and Draft Finding of No Significant Impact (FONSI) addressing the proposed restoration of the approximately 11.2 miles of the Westside Creeks by constructing a natural stream design pilot channel to restore natural stream processes to the Westside Creeks. The excavation required for the construction of the natural stream design pilot channel provides capacity to incorporate native aquatic and riparian vegetation in the ecosystem restoration without increasing the existing flood protection elevations of the community.

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Eric W. Verwers
Chief, Planning, Environmental, and
Regulatory Division

Enclosures

DEPARTMENT OF THE ARMY
FORT WORTH DISTRICT, CORPS OF ENGINEERS
P. O. BOX 17300
FORT WORTH, TEXAS 76102-0300

REPLY TO
ATTENTION OF

July 31, 2013

Planning, Environmental, and Regulatory Division

Mr. Michael Jansky
Office of Planning and Coordination,
U.S. Environmental Protection Agency, Region 6
1445 Ross Avenue Mail Stop 6ENXP
Dallas, Texas 75202

Dear Mr. Jansky:

The United States Army Corps of Engineers, Fort Worth District (USACE) and the San Antonio River Authority (SARA), the non-federal sponsor, are evaluating the potential environmental consequences resulting from the restoration of the aquatic and riparian ecosystems of San Pedro, Apache, Alazan, and Martinez Creeks (Westside Creeks) in the City of San Antonio, Texas.

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Chief, Planning, Environmental, and
Regulatory Division

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DEPARTMENT OF THE ARMY
FORT WORTH DISTRICT, CORPS OF ENGINEERS
P. O. BOX 17300
FORT WORTH, TEXAS 76102-0300

REPLY TO
ATTENTION OF

July 31, 2013

Planning, Environmental, and Regulatory Division

Mr. Tom Heger
Texas Parks and Wildlife Department
4200 Smith School Road
Austin, Texas 78744

Dear Mr. Heger:

The United States Army Corps of Engineers, Fort Worth District (USACE) and the San Antonio River Authority (SARA), the non-federal sponsor, are evaluating the potential environmental consequences resulting from the restoration of the aquatic and riparian ecosystems of San Pedro, Apache, Alazan, and Martinez Creeks (Westside Creeks) in the City of San Antonio, Texas.

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E. W. Verwers

Eric W. Verwers
Chief, Planning, Environmental, and
Regulatory Division

Enclosures

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE ARMY
FORT WORTH DISTRICT, CORPS OF ENGINEERS
P. O. BOX 17300
FORT WORTH, TEXAS 76102-0300

REPLY TO
ATTENTION OF

July 31, 2013

Planning, Environmental, and Regulatory Division

Ms. Julie Wicker
Texas Parks and Wildlife Department
4200 Smith School Road
Austin, Texas 78744

Dear Ms. Wicker:

The United States Army Corps of Engineers, Fort Worth District (USACE) and the San Antonio River Authority (SARA), the non-federal sponsor, are evaluating the potential environmental consequences resulting from the restoration of the aquatic and riparian ecosystems of San Pedro, Apache, Alazan, and Martinez Creeks (Westside Creeks) in the City of San Antonio, Texas.

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Chief, Planning, Environmental, and
Regulatory Division

Enclosures

DEPARTMENT OF THE ARMY
FORT WORTH DISTRICT, CORPS OF ENGINEERS
P. O. BOX 17300
FORT WORTH, TEXAS 76102-0300

REPLY TO
ATTENTION OF

July 31, 2013

Planning, Environmental, and Regulatory Division

Mr. David W. Galindo
Team Leader, Standards Implementation Team, Water Quality Division
Texas Commission on Environmental Quality
12100 Park Circle 35, Building F P.O. Box 13087, Capital Station
Austin, Texas 78711

Dear Mr. Galindo:

The United States Army Corps of Engineers, Fort Worth District (USACE) and the San Antonio River Authority (SARA), the non-federal sponsor, are evaluating the potential environmental consequences resulting from the restoration of the aquatic and riparian ecosystems of San Pedro, Apache, Alazan, and Martinez Creeks (Westside Creeks) in the City of San Antonio, Texas.

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Chief, Planning, Environmental, and
Regulatory Division

Enclosures

DEPARTMENT OF THE ARMY
FORT WORTH DISTRICT, CORPS OF ENGINEERS
P. O. BOX 17300
FORT WORTH, TEXAS 76102-0300

REPLY TO
ATTENTION OF

July 31, 2013

Planning, Environmental, and Regulatory Division

Mr. Mark Wolfe
State Historic Preservation Office
P.O. Box 12276 Capital Station
Austin, Texas 78711

Dear Mr. Wolfe:

The United States Army Corps of Engineers, Fort Worth District (USACE) and the San Antonio River Authority (SARA), the non-federal sponsor, are evaluating the potential environmental consequences resulting from the restoration of the aquatic and riparian ecosystems of San Pedro, Apache, Alazan, and Martinez Creeks (Westside Creeks) in the City of San Antonio, Texas.

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Chief, Planning, Environmental, and
Regulatory Division

Enclosures

DEPARTMENT OF THE ARMY
FORT WORTH DISTRICT, CORPS OF ENGINEERS
P. O. BOX 17300
FORT WORTH, TEXAS 76102-0300

REPLY TO
ATTENTION OF

July 31, 2013

Planning, Environmental, and Regulatory Division

Honorable Mark Chino, President
Mescalero Apache Tribe
124 Chiricahua Plaza
Mescalero, New Mexico 88340

Dear President Chino:

The United States Army Corps of Engineers, Fort Worth District (USACE) and the San Antonio River Authority (SARA), the non-federal sponsor, are evaluating the potential environmental consequences resulting from the restoration of the aquatic and riparian ecosystems of San Pedro, Apache, Alazan, and Martinez Creeks (Westside Creeks) in the City of San Antonio, Texas.

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E. W. Verwers

Eric W. Verwers
Chief, Planning, Environmental, and
Regulatory Division

Enclosures

DEPARTMENT OF THE ARMY
FORT WORTH DISTRICT, CORPS OF ENGINEERS
P. O. BOX 17300
FORT WORTH, TEXAS 76102-0300

REPLY TO
ATTENTION OF

July 31, 2013

Planning, Environmental, and Regulatory Division

Honorable Wallace Coffey, Chairman
ATTN: Mr. James Arterberry,
Comanche Nation
584 NW Bingo Road HC 32 Box 908
Lawton, Oklahoma 73502

Dear Chairman Coffey:

The United States Army Corps of Engineers, Fort Worth District (USACE) and the San Antonio River Authority (SARA), the non-federal sponsor, are evaluating the potential environmental consequences resulting from the restoration of the aquatic and riparian ecosystems of San Pedro, Apache, Alazan, and Martinez Creeks (Westside Creeks) in the City of San Antonio, Texas.

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Chief, Planning, Environmental, and
Regulatory Division

Enclosures

DEPARTMENT OF THE ARMY
FORT WORTH DISTRICT, CORPS OF ENGINEERS
P. O. BOX 17300
FORT WORTH, TEXAS 76102-0300

REPLY TO
ATTENTION OF

July 31, 2013

Planning, Environmental, and Regulatory Division

Honorable Ron Twohatchet, Chairman
Kiowa Tribe of Oklahoma
Highway 9 West
Carnegie, Oklahoma 73015

Dear Chairman Twohatchet:

The United States Army Corps of Engineers, Fort Worth District (USACE) and the San Antonio River Authority (SARA), the non-federal sponsor, are evaluating the potential environmental consequences resulting from the restoration of the aquatic and riparian ecosystems of San Pedro, Apache, Alazan, and Martinez Creeks (Westside Creeks) in the City of San Antonio, Texas.

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DEPARTMENT OF THE ARMY
FORT WORTH DISTRICT, CORPS OF ENGINEERS
P. O. BOX 17300
FORT WORTH, TEXAS 76102-0300

REPLY TO
ATTENTION OF

July 31, 2013

Planning, Environmental, and Regulatory Division

Honorable Don Paterson, President
Tonkawa Tribe of Oklahoma
1 Rush Buffalo Road
Tonkawa, Oklahoma 74653

Dear President Paterson:

The United States Army Corps of Engineers, Fort Worth District (USACE) and the San Antonio River Authority (SARA), the non-federal sponsor, are evaluating the potential environmental consequences resulting from the restoration of the aquatic and riparian ecosystems of San Pedro, Apache, Alazan, and Martinez Creeks (Westside Creeks) in the City of San Antonio, Texas.

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Enclosures

DEPARTMENT OF THE ARMY
FORT WORTH DISTRICT, CORPS OF ENGINEERS
P. O. BOX 17300
FORT WORTH, TEXAS 76102-0300

REPLY TO
ATTENTION OF

July 31, 2013

Planning, Environmental, and Regulatory Division

Mr. Mark Denton
Texas Historical Commission
P.O. Box 12276
Austin, Texas 78711

Dear Mr. Denton:

The United States Army Corps of Engineers, Fort Worth District (USACE) and the San Antonio River Authority (SARA), the non-federal sponsor, are evaluating the potential environmental consequences resulting from the restoration of the aquatic and riparian ecosystems of San Pedro, Apache, Alazan, and Martinez Creeks (Westside Creeks) in the City of San Antonio, Texas.

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DEPARTMENT OF THE ARMY
FORT WORTH DISTRICT, CORPS OF ENGINEERS
P. O. BOX 17300
FORT WORTH, TEXAS 76102-0300

REPLY TO
ATTENTION OF

July 31, 2013

Planning, Environmental, and Regulatory Division

Ms. Kim Barker
Texas Historical Commission
P.O. Box 12276
Austin, Texas 78711

Dear Ms. Barker:

The United States Army Corps of Engineers, Fort Worth District (USACE) and the San Antonio River Authority (SARA), the non-federal sponsor, are evaluating the potential environmental consequences resulting from the restoration of the aquatic and riparian ecosystems of San Pedro, Apache, Alazan, and Martinez Creeks (Westside Creeks) in the City of San Antonio, Texas.

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