FEASIBILITY REPORT

FOR

PASEO DE LAS IGLESIAS
TUCSON, ARIZONA

ECONOMIC APPENDIX

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INTRODUCTION

Objective:

The following presents an economic evaluation associated with flood damage reduction along the Paseo de las Iglesias segment of the Santa Cruz (Los Reales Road to Congress Street), the Old West Branch (Irvington Road to 22nd Street), the New West Branch segment of the Santa Cruz River (Valencia Road to Irvington Road), and the Los Reales Area (Los Reales Road to Valencia Road). Also, erosion, environmental restoration, and recreation opportunities will be evaluated only along the Paseo de las Iglesias.

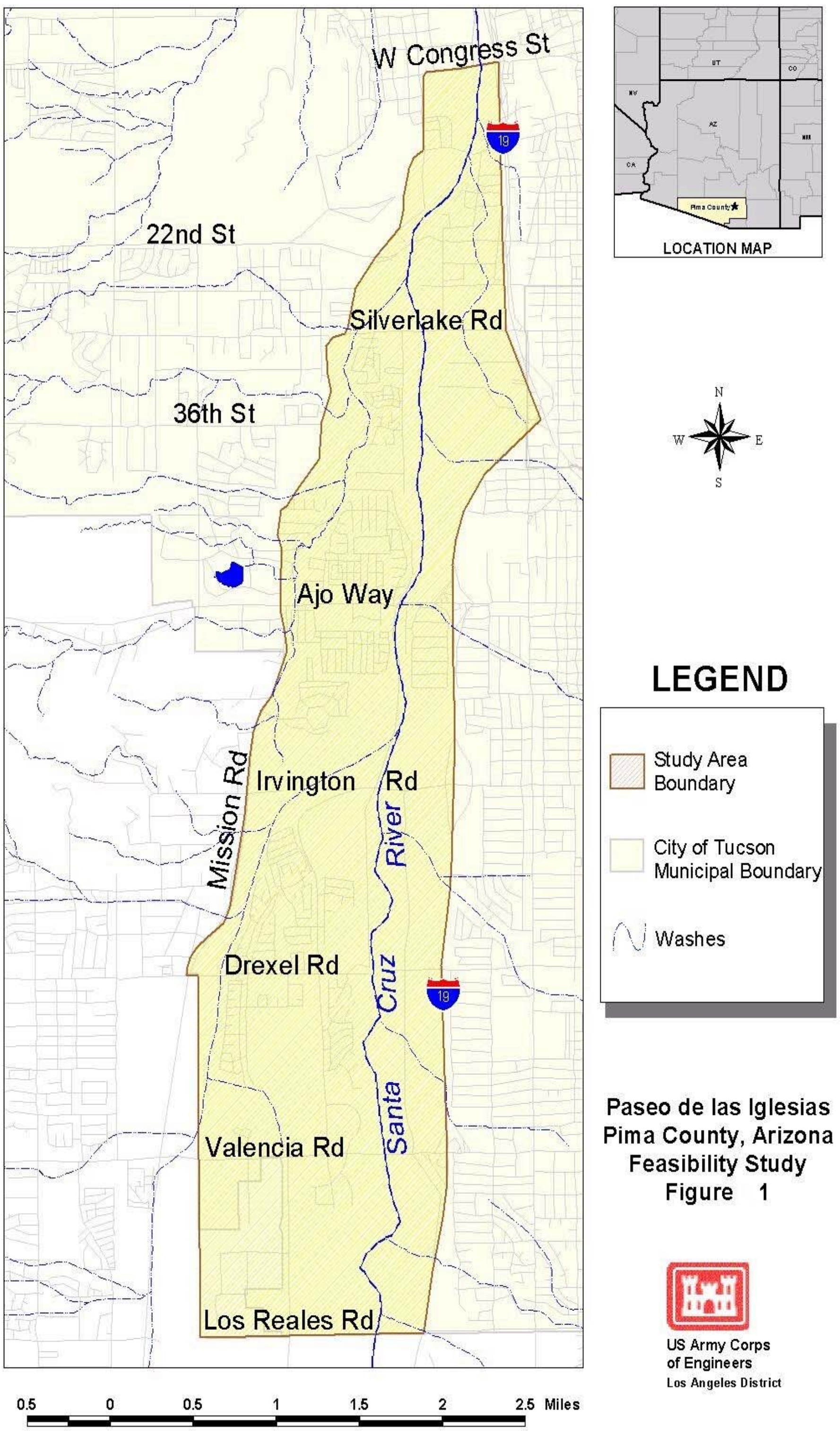
Methodology:

The methodology employed for this economic analysis is in accordance with current USACE Principles and Guidelines and standard economic practices. In agreement with these standards, benefits and costs will be computed at the current 5.625% interest rate, October 2004 price levels, a base year of 2012, and a 50-year period of analysis. In addition, the environmental restoration analysis will be completed in conformance with IWR Report #95-R-1—Evaluation of Environmental Investments Procedures Manual (May 1995).

Study Area:

The Santa Cruz River has its headwaters in the San Rafael Valley in southeastern Arizona. From there, the river flows south into Mexico. After a 35-mile loop through Mexico, it reenters Arizona about six miles east of Nogales. The river continues northward to Tucson then northwest to its confluence with the Gila River 12 miles southwest of Phoenix. The river runs approximately 43 miles north of the US-Mexico border before entering the study area. The Paseo de las Iglesias segment that lies within the study area extends 7 miles along the Santa Cruz River through the urbanized area of metropolitan Tucson. The boundaries are located between Los Reales Road and Congress Street and are considered to be the most suitable for flood damage reduction, bank stabilization, environmental restoration, and recreation opportunities. Other suitable areas for possible flood damage reduction are the Old West Branch of the Santa Cruz River (located along the second western tributary going north (Irvington Road to 22nd Street)) and the New West Branch, including the Los Reales Segment that originates at Los Reales Road and flows north along the first western tributary to the confluence of the Santa Cruz River at Irvington Road.

Figure 1: The Paseo de Las Iglesias, Old and New West Branches, and Los Reales Study Area



History:

The Paseo de las Iglesias, Old and New West Branches, and Los Reales portions of the Santa Cruz Rivers were historically perennial riparian areas of Southern Arizona, with highly productive cottonwoods, willows, and mesquite habitats. These areas were rich in habitat diversity, supporting a wide variety of wildlife species. As the watershed became developed with new homes, industry, and highways (Interstate 19 and Interstate10), riparian habitat degraded significantly displacing the last remnants of riparian vegetation once occupying the region.

Population:

The Paseo de las Iglesias study area is included in the Pima County Metropolitan Statistical Area (MSA). According to the 2000 Census, the Pima County MSA population was 843,746 (16.81% of Arizona population). This population figure for 2000 was 26.5 percent larger than the 666,880 residents in 1990 (18.9% of Arizona Population). During the previous decade, the Pima County MSA increased by 25.5 percent from 531,443 in 1980. In fact, the Pima County MSA has been growing at an average annual compound rate of about 2.3 compared to the national average of 1.1 percent. A summary of Metro Area Data is shown in Table 1 below.

Table 1: Population for Tucson-Pima County MSA

Year	Population
1980	531,443
1990	666,880
2000	843,746

The Pima County population growth illustrated above has been due primarily to net migration into the area. Two main factors contributing to the migration are employment opportunities and the low cost of housing. Because the Pima County area offers high skilled technical and professional jobs and a diversified occupational base, some people may find the area appealing. Residents also can purchase low cost housing, another lure, that may enhance their quality of living.

Employment:

Three primary areas of employment in Pima County are in education, government, and military. First, sources of employment in the educational sector include the University of Arizona, Pima County Community College, and the Tucson Unified School District. Second, government offices offer employment on the state, county, and city level. Third, two military establishments provide further employment opportunities. They are Davis-Monthan Air Force Base and Raytheon Missile Systems Company. All three areas of employment require a higher likelihood of professional and technical skill as well as some college education that account for some of the 24.70% of professional and technical occupations within Pima County.

This demand for high skilled labor may account for the reason why Pima County has enjoyed a low employment rate as much as 1.2 percentage points below Arizona. Table 2 shows major employers, employment type, and number of employees within Pima County. Table 3 lists the occupation type and the percentage of employees per occupation type.

Table 2: Employers, Employment Type, and Number of Employees

Employer	Employment Type	Number of Employees
University of Arizona	University of Colleges	10,520
State of Arizona	Government	9,694
Davis-Monthan Air Force Base	Military	8,352
Tucson Unified School District	Education	8,187
Raytheon Missiles Systems Co.	Military Manufacturing	7,700
Pima County	Government	7,028
City of Tucson	Government	5,497

Table 3: Percentage of Employees Divided by Occupation Type

Occupation Type	Percentage of Total
Managers & Administrative	6
Professional & Technical	25
Sales and Related Occupations	11
Clerical & Administrative Support	17
Service Occupations	20
Agriculture, Forestry & Fishing	1
Production, Maintenance & Material	20
Total	100

Housing Units & The Low Cost Housing:

To accommodate the population expansion in the area, 50,301 housing units were built over the previous nine years. A total of about 348,508 housing units were constructed in Pima County before 1999. This figure is up from 298,207 housing units built before 1990. According to the 1999 American Community Survey Profile for Pima County, Arizona, about 21 percent of the existing housing stock within Pima County has been constructed in the past ten years. Most of the newer homes, constructed in master planned communities, are reasonably priced compared to other metropolitan areas. The average cost of a new single family home is about $109,102, and this is a primary factor making the overall cost of living in Pima County among the lowest of major US metropolitan areas.

WITHOUT PROJECT C O N D I T I O N S

Flood Damage Analysis:

Floodplain Description:

Four floodplains for this analysis are described in detail below. Plates 12 through 16 in the Hydrology and Hydraulics Appendix show each floodplain, plus reach delineations by cross-section.

1. *The Paseo de las Iglesias Segment of the Santa Cruz River*-- Certain areas of Paseo de las Iglesias have been channelized and embanked to combat the destruction resulting from flooding. Soil cement bank protection has been constructed upstream and downstream of the Valencia Road Bridge, from Irvington Road to Ajo Way, and from Silverlake Road up to Grant Road. The stretches of the Paseo de las Iglesias that lack channel stabilization are located from Los Reales Road to Irvington Road and Ajo Way to Silverlake Road. Currently, the Santa Cruz channel contains the 100-year flood throughout most of the study area. However, some localized areas are still susceptible to floods that are lower probability floods. One area is located on the west bank of the river from Congress Street but switches to the east bank toward 22nd Street. A second area is located on both banks of the river south of 22nd Street, but most of the flooding in on the west bank of the river near the Old West Branch of the Santa Cruz River and the Paseo de las Iglesias confluence. A third area is located on both banks of the river just south of Ajo Way. A fourth area susceptible to 500-year flooding is located on the west side of the river south of Drexel Road.

2. *The Old West Branch of the Santa Cruz River*[1]*--T*he Old West Branch, located to the west of the Santa Cruz, is located from Irvington Road to 22nd Street. This river does not have any channel embankment and 100-year flows flood the area between the Old West Branch and the Santa Cruz River. The crossroads where most of the 100-year flood flows is between Silverlake Road and Ajo Way. (Since discharge frequency values other than the 100-year were unobtainable, the US Army Corps of Engineers and the local sponsor have agreed to limit the analysis to 100-year flow data. Analysis up to the 500 year will not be performed for the Old West Branch.)

[1] Analysis is limited along the Old West Branch because previous proposals, by the non-federal sponsor, for structural improvements along the Old West Branch resulted in a high degree of public opposition. A structural improvement may result in the loss of the most highly valued riparian habitat and Mesquite Bosque within the study area. In addition, 73 acres of the Old West Branch channel and floodplain must be maintained as a natural floodplain under the mitigation provisions of an existing Section 404 permit and structural modifications of the natural channel are prohibited.

3. *The New West Branch of the Santa Cruz River*--The New West Branch located to the west of the Santa Cruz from Valencia Road to Irvington Road has been channelized and embanked combating the destruction from flooding. At Irvington Road, the New West Branch channel merges with the Santa Cruz River. The entire stretch contains the 2 through 50-year flood events. Breakouts begin to occur at 100-year flood events resulting in residential flooding.

4. *The Los Reales Area*--A small area just south of the New West Branch between Valencia Road to the north and Los Reales Road to the south experiences shallow flooding.

Reach Delineations:

Economics, Hydrology, and Hydraulics study team members participated in the segmenting of the Santa Cruz, the Old and New West Branches, and Los Reales floodplains into distinct reaches of homogeneous characteristics. Critical factors for differentiation included: the discharge-frequency characteristic, the overflow spatial characteristic, and economic activity. Tables 4 & 5 provide a summary of reach delineations (each starts at the downstream end of each stream and moves upstream), including stream name, and beginning and ending cross-sections for each reach. By segmenting the floodplains into reaches each segment can be described separately and in more detail.

Table 4: Reach Delineation Breakdown: The Santa Cruz Floodplain

Reach Name	Cross Streets	Stream	Beginning Cross-Section	Ending Cross-Section
1 SC	Congress St. 22nd Street	Santa Cruz River	32.61	33.38
2 SC	22nd Street Ajo Way	Santa Cruz River	33.38	35.77
3 SC	Ajo Way Irvington Rd.	Santa Cruz River	35.77	36.63
4 SC[1]	Irvington Rd. Drexel Rd.	Santa Cruz River	36.63	37.87
5 SC	Drexel Rd. Valencia Rd.	Santa Cruz River	37.87	38.96

[1] 4 SC will not be listed on tables following this one because this reach produced no damages.

Table 5: Reach Delineation Breakdown:
The Old & New West Branches and Los Reales Floodplains

Reach Name	Cross Streets	Stream	Beginning Cross-Section	Ending Cross-Section
OWB	22nd Street Ajo Way	Old West Branch	0.50	29.00
1 NWB	Irvington Rd. Drexel Rd	New West Branch	1.00	17.00
2 NWB	Drexel Rd Valencia Rd	New West Branch	17.00	26.00
LR	Valencia Rd. Los Reales Rd.	Los Reales	51.00	78.10

Number of Structures:

Pima County Tax Assessor data aided in further description of the floodplain by providing the number and type of structures affected in each respective floodplain. Because property delineations in the tax assessor's data are by parcel and not by the number of structures, the individual parcel for residential and non-residential categories may include more than one structure. For example, a residential parcel may include more than one apartment building. Likewise, a non-residential parcel may include more than one office building. In these cases, aerial maps and information gathered during the visit to the study area were relied upon to obtain the number of structures by reach and structure type for the 500 year floodplain (100 year floodplain for Old West Branch), shown in Tables 6 and 7. The number of structures shown by frequency is shown in Table 8.

Table 6: Number of Structures by Reach and Structure Type:
The Santa Cruz Floodplain

Reach	Residential			Nonresidential		Total
	SFR	MFR	MH	Commercial	Public	
1 SC	231	13	5	2	0	251
2 SC	103	18	441	15	5	582
3 SC	129	26	594	5	1	755
5 SC	383	1	0	0	0	384
Total	846	58	1040	22	6	1972

Table 7: Number of Structures by Reach and Structure Type:
The Old & New West Branches and Los Reales Floodplains

Reach	Residential			Nonresidential		Total
	SFR	MFR	MH	Commercial	Public	
OWB	52	0	528	2	1	583
1 NWB	0	0	985	0	0	985
2 NWB	140	0	0	0	1	141
LR	44	1	66	6	2	119
Total	236	1	1579	8	4	1828

Table 8: Number of Structures by Frequency for Each Floodplain

Floodplain	50 yr	100 yr	200 yr	500 yr
Santa Cruz	0	0	132	1972
Old West Branch	NA[1]	583	NA	NA
New West Branch	0	222	503	1126
Los Reales	24	47	62	119

[1]NA means overflows were not available for the frequencies listed; therefore structures could not be counted and included in Table 8.

The numbers of structures were evaluated to obtain a dollar value of structures and their contents.

Value of Structures:

The total values of structures in the floodplain were estimated using the following methodology.

1. Data from the field survey was input into the spreadsheet.

2. Square footage estimates were made based upon TRW Redi Real Estate Data Base.

3. The total value of structures was computed using dollars per square foot for each structure and condition type from Marshall and Swift Valuation Service.

4. Structure values were then adjusted to reflect condition and age of structures for depreciated replacement values.

5. Depreciated replacement value were adjusted to reflect local and current cost multipliers for the area.

Value of Contents:

Content values were calculated using the Commercial Content Inventory (CCI) Program developed by Marshall & Swift. To use the program as few as three variables for each business can be input to determine comprehensive equipment and inventory cost estimates. Key inputs include: zip code, square footage, type of establishment, estimated revenue, and the number of employees. Once entered, the program uses an algorithm based on a variety of government, commercial, and proprietary databases.

1. Oxford Information Technology LTd.'s databases include:
    a. Financial statements and balance sheets from over 12 million companies
    a. Services and equipment purchases tracked in over 1,100 industries
    b. Square footage, number of employees, and sales per square foot in six million companies

2. Marshall & Swift / Boeckh's databases include:
    a. Current building cost information for over 150 types of buildings, localized by zip code
    b. Over 32,000 construction component costs and labor rates, localized by zip code.

Content ratios were then derived as a percentage of corresponding replacement values of structures. The following ratios were applied in Table 9.

Table 9: Content Ratios

Category	Structure Type	Ratio
SFR	SFR	0.50
MFR	Duplex	0.50
	Apartment	0.50
	Motel	0.50
	Triplex	0.50
MH	MH	0.50
Commercial	Retail	0.94
	Service Station	1.07
	Office	0.41
	Industry	1.07
	Warehouse	1.72
	Restaurant	0.30
	Dental Office	0.32
Public	Government	0.24
	Church	0.24

Tables 10 and 11 provide a detail of the total structure value and content value by category and reach for the 500-year floodplain (100 year floodplain for the Old West Branch).

Table 10: Structure & Content Values: The Santa Cruz Floodplain (October 2004 Price Levels)

Reach	Residential			Nonresidential		Total
	SFR	MFR	MH	Commercial	Public	
1 SC Structure	$16,217,337	$9,167,975	$160,906	$324,718	$0	$25,870,937
1 SC Content	$8,108,581	$4,583,988	$80,453	$119,336	$0	$12,892,358
2 SC Structure	$6,293,536	$10,676,129	$16,457,456	$3,087,051	$630,018	$37,144,190
2 SC Content	$3,146,768	$5,338,065	$8,228,728	$3,364,992	$151,204	$20,229,757
3 SC Structure	$9,516,644	$11,923,417	$22,166,892	$1,761,999	$2,783,569	$48,152,521
3 SC Content	$4,758,322	$5,961,708	$11,083,446	$2,591,465	$668,057	$25,062,998
5 SC Structure	$32,081,040	$1,558,322	$0	$0	$0	$33,639,362
5 SC Content	$16,040,416	$779,161	$0	$0	$0	$16,819,577
Total	$96,162,644	$49,988,765	$58,177,881	$11,249,561	$4,232,848	$219,811,699

Table 11: Structure & Content Values: The Old & New West Branch and Los Reales Floodplains (October 2004 Price Levels)

Reach	Residential			Nonresidential		Total
	SFR	MFR	MH	Commercial	Public	
OWB Structure	$2,929,776	$0	$19,703,904	$1,022,924	$90,308	$23,746,912
OWB Content	$1,464,888	$0	$9,851,952	$961,548	$22,577	$12,300,965
1 NWB Structure	$0	$0	$36,758,230	$0	$0	$36,758,230
1 NWB Content	$0	$0	$18,379,115	$0	$0	$18,379,115
2 NWB Structure	$10,187,398	$0	$0	$0	$3,090,101	$13,277,499
2 NWB Content	$5,093,699	$0	$0	$0	$741,624	$5,835,323
LR Structure	$3,904,143	$161,454	$2,490,025	$3,137,369	$566,562	$10,259,553
LR Content	$1,952,072	$80,727	$1,245,012	$4,268,656	$135,974	$7,682,441
Total	$25,531,976	$242,181	$88,428,238	$9,390,497	$4,647,146	$128,240,038

Structure & Content Damages:

Without project structure and content damages were computed utilizing the HEC-FDA (Hydologic Engineering Center - Flood Damage Analysis) model. The model computes equivalent annual damages based upon the following input parameters.

1. Structure data includes: structure name, category (SFR, MFR, MH, Commercial, and Public), stream location, bank, stream name, number of structures, ground elevation, first floor elevation, structure value, and content value.

   This data was developed in a Microsoft Excel spreadsheet, converted into a text file, and imported into the HEC-FDA program.

2. Hydrologic and Hydraulic data includes: frequency-discharges and stage-discharge relationships. This data, furnished by Engineering Division, was developed utilizing the HEC-2 Water Surface Profiles program. The output files were imported into the HEC-FDA program. Data was input for the base.

3. Depth-damage relationships for residential structures were obtained from Economic Guidance Memorandum (EGM) 01-03: Generic Depth-Damage Relationships. Commercial and MH depth damage relationships were obtained by FEMA and entered directly into the program.

4. Risk and Uncertainty (R&U) variables. The two variables subject to R&U variations for the economic determination of stage-damage functions are first floor elevation (FFE) and depreciated replacement cost (DRC). For FFE uncertainty, a normal distribution with a mean of 0 and a standard deviation of .6 feet was assumed (based upon guidance contained in EM 1110-2-1619). For DRC uncertainty, a normal distribution with a mean of 0 and a standard deviation of 10% of structure base value was assumed (based upon variations in Marshall & Swift valuation multipliers for various structure types and conditions. Assuming a normal distribution with a mean of 0 and a standard deviation of 10% of structure base value was assumed.

   The hydrologic engineering relationships allowed by the HEC-FDA model to fluctuate are frequency-discharge and stage-discharge. For the frequency-discharge relationship, a statistical distribution was computed. This method is called the "graphical" approach, based upon data contained in the water surface profiles and equivalent record lengths for each reach, was furnished by Engineering Division. For the stage-discharge relationship, a normal distribution is assumed.

Exceedance Probabilities for the Santa Cruz River (SC), the Old West Branch (OWB) and the New West Branch (NWB), and the Los Reales (LR) areas are shown by probability for each reach in Tables 12 and 13 and 14. The tables show that damages have less than an assigned probability likelihood of exceeding the associated damage amount. For example, Reach 1 along the Santa Cruz River has a .004 probability likelihood of exceeding $7,871,050.

Table 12: Santa Cruz Floodplain Exceedance Probabilities for Each Reach

Reach	133 Year	250 Year	500 Year
1SC	$1,671,380	$7,871,050	$14,257,150
2SC	$2,364,620	$12,165,630	$23,545,430
3SC	$3,304,470	$36,951,080	$55,670,380
5SC	$2,833,510	$7,660,270	$16,543,640

Table 13: Old & New West Branches
Floodplain Exceedance Probabilities for Each Reach

Reach	100 Year	133 Year	250 Year	500 Year
OWB	$4,275,909	NA	NA	NA
1 NWB	$9,341,250	$9,487,850	$9,510,580	$9,510,580
2 NWB	$3,591,640	$3,956,910	$3,956,910	$3,956,910

Table 14: Los Reales Floodplain Exceedance Probabilities for Each Reach

Reach	50 Year	66 Year	100 Year	133 Year	250 Year	500 Year
LR	$1,293,880	$1,304,440[1]	$1,304,440	$1,304,440	$1,304,440	$1,304,440

[1]The stage discharge function shows the same standard deviations and same stages for discharges corresponding to the 250- and 500-year event for 4 NWB, 133-, 250-, and 500 year event for 5 NWB, and for discharges corresponding to the 66- through 500-year event for 6 LR; therefore, computed damages are the same.

The HEC-FDA model computes expected annual damages using a Monte Carlo simulation process. Expected annual damages are calculated for a 2012 base year by damage reach in multiple iterations using standard discounting procedures. Future conditions are assumed to be the same as Base Year.

Table 15: Total Without Project Condition Expected Annual Damages

Santa Cruz River		Old & New West Brach Rivers And Los Reales Floodplains	
Reach	Base Year	Reach	Base Year
1 SC	$69,870	OWB	$406,212
2 SC	$110,950	1 NWB	$141,330
3 SC	$258,480	2 NWB	$64,260
5 SC	$81,940	LR	$107,740
Total	$521,250	Total	$719,542

Tables 16 and 17 summarize without project expected annual damages by reach for base year conditions for the Santa Cruz, the Old & New West Branches, and Los Reales floodplains, respectively.

Table 16: Without Project Conditions:
The Santa Cruz Floodplain Expected Annual Damages

Reach	Residential			Nonresidential		Total
	SFR	MFR	MH	Commercial	Public	
1 SC	$38,030	$29,390	$310	$2,140	$0	$69,870
2 SC	$24,770	$39,730	$24,970	$19,770	$1,710	$110,950
3 SC	$27,690	$97,960	$106,150	$15,600	$11,100	$258,480
5 SC	$77,810	$4,140	$0	$0	$0	$81,940
Total	$168,300	$171,210	$131.42	$37,510	$12,810	$521,250

Table 17: Without Project Conditions
The Old & New West Branch Rivers and Los Reales Floodplain Expected Annual Damages

Reach	Residential			Nonresidential		Total
	SFR	MFR	MH	Commercial	Public	
OWB	$48,075	$0	$357,820	$317	$0	$406,212
1 NWB	$0	$0	$141,330	$0	$0	$141,330
2 NWB	$51,000	$0	$0	$0	$13,260	$64,260
LR	$99,320	$3,190	$3,100	$980	$1,150	$107,740
Total	$198,395	$3,190	$622,910	$1,297	$14,410	$719,542

Emergency Response Damages:

Due to the limited amount of information available concerning emergency response costs along the Santa Cruz River, the Old West Branch, and the New West Branch areas, emergency response cost estimates will be based on estimates derived in the January 1993 Flood Damage Summary Report written by the Pima County Department of Transportation and Flood Control District. In the report, Pima County has provided limited information on the emergency response cost to residents as they evacuate, relocate and, reoccupy their residence during a flood event. Based on the experience of residents who were flooded in the 1993 flood, the temporary relocation cost was approximately $1,400 per resident. This number was applied to the number of residences in the 500-year floodplain and was used along with a non-damaging frequency of a 100-year event (Paseo de las Iglesias) and 25-year event (New West Branch including Los Reales) to perform equivalent annual damages. The equivalent annual damages (EAD) to residents due to flooding along the Paseo de las Iglesias portion of the Santa Cruz River is $11,043, along the Old West Branch of the Santa Cruz River is $77,539, and along the New West Branch including the Los Reales area of the Santa Cruz River is $33,117.

Traffic Damages:

Typically, expected annual traffic damages are estimated based upon delineations of floodplain areas with inundation levels exceeding one foot and durations of flooding. However, Hydrology and Hydraulics used the steady state or peak flow method in computing overflows. This method does not allow for a means to estimate durations of flooding by flooding event; therefore, traditional methods of computing traffic damages will not be used. Instead, traffic damages are estimated as a single event assuming traffic flow will be disrupted for a day no matter what the duration. Even if the duration is of a 500-year flood lasts less than a day, traffic is expected to be affected and roads blocked for approximately a day.

Vehicle delay and operation damages are calculated using procedures detailed in US Army Corps of Engineers Guidance entitled ER 1105-2-100. The procedures used to determine vehicle delay and operation costs are detailed below.

Vehicle Delays:

1. Vehicles per Day * Detour Miles = Total Vehicle Detour Miles

2. Total Vehicle Detour Miles/ 55 mph = Time of Total Detour Vehicles

3. Time of Total Detour Vehicles * Traffic Delay Costs (derived using a predetermined percentage of before tax income depending on the purpose of the trip and time of delay) = Potential Damages Resulting from Delays

Operating Costs:

1. Operating Costs (determined by the American Automobile Association) * Vehicles per Day * Detour Miles = Total Operating Costs

According to this analysis, the Santa Cruz River could cause temporary closures of Drexel Road, Ajo Way, Silverlake Road, 22nd Street, and Congress Street. These roads carry 5,400, 34,600, 12,000, 21,700, and 17,200 vehicles per day respectively, while vehicle detour miles traveled from closures along these roads are: 2.7, 3.7, 7.0, 7.9, and 10.0, respectively. Total vehicle detour miles traveled per day are: Drexel Road: 14,580, Ajo Way: 128,020, Silverlake Road: 84,000, 22nd Street: 171,430, and Congress Road: 172,000. At a detour speed limit of 55 miles per hour, the time involved is 265 along Drexel Road, 2,327 along Ajo Way, 1,527 hours along Silverlake Road, 3,116 hours along 22nd Street, and 3,127 hours along Congress Road. Using a traffic delay cost of $1.40 and $7.06 per hour depending on the length of the delay, potential damages resulting from delays are $371, $3,257, $10,780, $21,998, $22,076 respectively for the five roads. At an operation cost of 38 cents per mile, the potential annual damage is $216,611. Total vehicle delay and operation damages equal $275,093 while average annual vehicle delay and operation damages equal $24,134.

Table 18: Vehicle Delay and Operation Damages

Street	Vehicle Delay Damages	Vehicle Operation Damages	Total
Drexel Road	$371	$5,540	$5,911
Ajo Way	$3,257	$48,648	$51,905
Silverlake Road	$10,780	$31,920	$42,700
22nd Street	$21,998	$65,143	$87,141
Congress Street	$22,076	$65,360	$87,436
Total	$58,482	$216,611	$275,093
Expected Annual Damages[1]	$3,556	$20,578	$24,134

[1]EAD determined based upon 100-year non-damaging and delays based upon 500-year flood.

Erosion Analysis:

Background:

This bank erosion study is limited to the Santa Cruz River. The Old West Branch was not analyzed due to environmental and public acceptability constraints. The New West Branch and Los Reales channels have existing structural bank protection and were not analyzed.

History:

The following describes the channel changing process that occurred along the Santa Cruz River. Between 1915 and 1929, extensive arroyo widening occurred during 1914 through 1915 floods throughout the Congress Street area. During this time the Congress Bridge was destroyed. Between 1930 and 1959, extensive widening occurred between Speedway Boulevard and Grant Road (The area is north of the study area.) and channel degradation began during the later years. Between 1960 and 1986 the arroyo widths were generally stable. There was apparent narrowing at some locations caused by channels and landfill operations. As much as 15 ft of channel incision occurred. There was substantial channel bank wall migration along unprotected segments as a result of the 1983 flood.

Existing Bank Protection:

Excluded from the lateral erosion analysis assessment were the areas where the banks have already been stabilized with soil cement. These specific areas are located along both sides of the Santa Cruz River channel from Congress Street to 300 feet upstream to Silverlake Road and between Ajo Way and Irvington Road and near Valencia Road.

Damage Analysis:

In the areas without bank protection, the channel will eventually migrate and erode the foundation material below adjacent single-family residences and mobile homes. Below is Table 19 which shows the number of structures affected by reach.

Table 19: Affected Structures Along the Santa Cruz River

Reach	Cross Streets	Number of Structures Affected
SC 2	22nd Street Ajo Way	53
SC 4	Irvington Road Drexel Road	7
SC 5	Drexel Road Valencia Road	10
Total		70

Structure and content values are computed for affected structures and are estimated upon square footage obtained from tax assessor records. (Steps 1 through 5 were followed from the flood control analysis section, value of structures subsection on Page 8). For single- family residences average square footage is 1,555 while average square footage for mobile homes is 1,250. Total structure and content value and average structure and content value are listed in Table 20.

Table 20: Structure & Content Values of Affected Structures

Reach	Number	Total Structure Value[1]	Total Content Value	Average Structure Value	Average Content Value
SC 2	53	$1,977,854	$988,927	$37,318	$18,659
SC 4	7	$832,594	$416,297	$118,942	$59,471
SC 5	10	$1,189,420	$594,710	$118,942	$59,471
Total		$3,999,868	$1,999,934	$275,202	$137,601

[1]Sturcture Value includes an $11,000 demolition cost.

With structure and content value determined, damages can be assessed using an estimated erosion rate detailed in Table 21 and setback distances. Table 21 summarizes the amount of bank erosion between 1941 and 2002. The erosion rate per year for each bank was determined by dividing the migration amount by the number of years between the photographs. In other words, the migration rate was placed in linear form from the historical data.

Table 21: Bank Erosion Between 1941-2002

Year	Bank Width[1]	Lt. Bank Erosion	Rt. Bank Erosion	Lt. Bank Erosion Rate Per Year	Rt Bank Erosion Rate Per Year
Station 34.43					
1941	180				
1960	130	40	60	2	3
2002	650	350	170	8	4
Station 35.66					
1941	220				
1960	250	420	380	22	20
2002	330	380	460	9	11
Station 37.50					
1941	610				
1960	360	340	680	18	36
2002	890	380	850	9	20

[1]Bank width does not increase over time because the channel does not remains stationary and does not increase uniformly. The Santa Cruz River meanders and changes locations over time. Over time one bank may decrease in width while the other may increase. For this reason, erosion for the left and right bank also does not add up to bank width.

The determination of setback distances, the distances from the edge of structures to the bank sides, is estimated from aerial photographs. For this analysis, a ten-foot minimum is assumed before a particular structure will be vulnerable to slippage or collapse into the Santa Cruz River. Once erosion line reaches within 10 feet of the structure it is considered totally destroyed and demolished. This study also assumes homeowners will have enough time to remove half of their personnel contents from their homes before the homes are destroyed. In addition, this study assumes homeowners will be responsible for demolition of these homes when the property setback distance equals the vulnerable distance. Demolition costs are estimated to be $11,000 per structure. Relocation is also assumed because a portion of the homeowners is expected to relocate at an estimate of $10,000 per structure.

The setback distance is divided by the annual erosion rate for a given location to compute how many years it will take before a structure is destroyed. In that given year, the structure is considered destroyed and demolished. The present value is than taken and annualized over 50 year using the current discount rate of 5.625%. Table 22 shows annualized damages for affected structures in three reaches.

Table 22: Present Value and Annualized Damages for Affected Structures

Reach	Present Value	Annualized Damages
SC 2	$671,329	$40,379
SC 4	$82,558	$4,966
SC 5	$130,482	$7,848
Total	$884,370	$53,193

Environmental Restoration Analysis:

Hydrogeomorphic (HGM) Description:

The HydroGeoMorphic Assessment of Wetlands approach (HGM) was developed specifically to reduce the level of variability exhibited by significant changes in wetland function. HGM identifies groups of wetlands that function similarly using three criteria (geomorphic setting, water source, and hydrodynamics) that fundamentally influence how wetlands function. Regional Guidebooks include a thorough characterization of the regional wetland subclass in terms of its geomorphic setting, water sources, hydrodynamics, vegetation, soil, and other features that were taken into consideration during the classification process. Classifying wetlands based on how they function, narrows the focus of attention to a specific type or subclass of wetland, the functions that wetlands within the subclass are most likely to perform, and the landscape/ecosystem factors that are most likely to influence how wetlands in the subclass function.

Arizona Riverine Model Development

Since there is not a regional guidebook completed specifically for the arid riverine environment in Arizona, existing models were studied. The focus was narrowed to how the functions of a particular riverine overbank subclass would perform and the characteristics of the ecosystem and landscape controls of those functions. Since the riverine over bank subclass is the most applicable to the environment, the riverine overbank subclass was further modified to apply to Arizona's low gradient rivers.

A workshop was held to bring together regional experts and seek their input on modifying the model to be applicable to Arizona Rivers. Workshop participants included the Environmental Lab (EL) of the Engineering Research and Development Center (ERDC), the US Army Corps of Engineers (Los Angeles District Corps staff), local sponsor representatives from the City of Phoenix, City of Tucson, Town of Marana, Pima County Flood Control District, and Salt River Pima Maricopa Community, Arizona Game and Fish Department, U.S. Fish and Wildlife Service, and representatives from the scientific community.

The workshop identified ten functions that were deemed important to the success of the riverine overbank subclass. They were selected on the basis of their representation of ongoing critical ecosystem processes within the riverine overbank. The top three functions rated according to their importance in the riverine overbank subclass are Functions 2, 4, and 8.

Table 23: Riverine Overbank Subclass Functions

Functions Related to the Hydrologic Processes	Description
1. Maintenance of Characteristic Dynamics	The physical processes and structural attributes that maintain characteristic channel dynamics. These include flow characteristics, bedload, in-channel coarse woody debris, and potential coarse woody debris inputs, channel dimensions, and other physical features (e.g. bank vegetation, slope).
2. Dynamic Surface Water Storage and Energy Dissipation	The dynamic water storage and dissipation of energy at bank full and greater discharges. These are a function of channel width, depth, bedload, bank roughness (coarse woody debris, vegetation, etc.), presence and number of in-channel coarse woody debris jams, and connectivity to off channel pits, ponds, and secondary channels.
3. Long Term Surface Water Storage	The capability of a wetland to temporarily store (retain) surface water for long durations; associated with standing water not moving over the surface. Water sources may be overbank flow, overland flow, and/or channelized flow from uplands, or direct precipitation.
4. Dynamic Subsurface Water Storage	The availability of water storage beneath the wetland surface. Storage capacity becomes available due to periodic draw down of water table.
Functions Related to Biogeochemical Processes	**Description**
5. Nutrient Cycling	The abiotic and biotic processes that convert elements from one form to another; primarily recycling processes.
6. Detention of Imported Elements and Compounds	The detention of imported nutrients, contaminants, and other elements or compounds.
7. Detention of Particles	The deposition and detention of inorganic and organic particulates (>0.45 um) from the Water column, primarily through physical processes.
Functions Related to Habitat	**Description**
8. Maintain Characteristic Plant Communities	The species composition and physical characteristics of living plant biomass. The emphasis is on the dynamics and structure of the plant community as revealed by the species of trees, shrubs, seedlings, saplings, and herbs and by the physical characteristics of the vegetation.
9. Maintain Spatial Structure of Habitat	The capacity of a wetland to support animal populations and guilds by providing Heterogeneous habitats.
10. Maintain Interspersion and Connectivity	The capacity of the wetland to permit aquatic organisms to enter and leave the wetland via permanent of ephemeral surface channels, overbank flow, or unconfined hyporheic gravel aquifers. The capacity of the wetland to permit access of terrestrial or aerial organisms to contiguous areas of food and cover.

All ten functions are associated with each cover type. Cover types are designated by Partial Wetland Assessment Areas (PWAAs). They are homogenous zones of vegetation, geographic similarities, and physical conditions that make the area unique. PWAAs are defined on the basis of species recognition and dependence, soils types, and topography. Out of nineteen designated cover types, four major cover types are ranked in order as follows:

1. *Mesquite Woodlands (Bosque)*--Mesquite woodlands historically occurred over large areas within the river floodplain and on higher terraces along Arizona rivers. These communities have been nearly eliminated from these riparian ecosystems by changes to natural processes.

2. *Cottonwood-Willow Gallery Forest*--Cottonwood-Willow forest is representative of high-quality riparian habitat in Arizona. Riparian habitats are defined as habitats or ecosystems that are associated with adjacent bodies of water (rivers, lakes, or streams) or are dependent on the existence of perennial or ephemeral surface or subsurface water drainage. In terms of height, basal area, and density, Fremont Cottonwood (*Populus fremontii, sp.*) and Gooding's Willow (*Salix gooddingii*) are dominant canopy species in the Cottonwood-Willow associations with many of the original stands being replaced by the invasive and non-native Salt Cedar (*Tamarix, sp.*). They are further characterized by having diverse assemblages of plant and animal species in comparison with adjacent upland areas. These plant species are also found in habitats that are narrow, linear strands of vegetation oriented in the main direction of water flow that may occur in riverine flood channels and along the banks of streams.

3. *Scrub-Shrub Vegetative Associations*--Scrub-Shrub plant communities are common along Arizona Rivers and streams, and are often present within the active channel. They are dominated by various combinations of Burrobush (*Hymenoclea, sp.)*, Bursage (*Ambrosia dumosa*), Quailbush (*Atriplex lentiformis*), Four-wing Saltbush (*Atriplex canescens*), and occasionally by Creosote bush (*Larrea tridentata*). Many of these areas have been highly disturbed from off-road vehicle traffic and sand and gravel mining activities, and contain little or no vegetation cover.

4. *Riverbottom*--The riverbottom had gravel and sandbars within the channel and any grassland or other emergents existing within the channel.

Table 24 shows a more detailed breakdown of cover type by PWAA. Of the 5,005 acres in the Paseo de las Iglesias study area, the US Army Corps of Engineers, LA District identified 19 distinct cover types. These cover types and their respective without project baseline acreages can be found in the table below.

Table 24: Detailed Breakdown of Cover Type by PWAA

Number	Code	Partial Wetland Assessment Areas (PWAAs)	Target Year PWAAs (PWAA Relative Acres)				
			Yr 0	Yr 1	Yr 6	Yr 26	Yr 51
1	AGCROP	Farms and Cropland—Dairy, Cotton, and Alfalfa; Hobby Farms, Fallow Grounds	416.00	416.00	354.00	354.00	354.00
2	BUFFER	Existing Buffer Zones—Mesquite, Ironwood, Rabbitbush, Quailbush, Cat-claw Arcacia, Palo Verde, and Creosote	0.00	0.00	0.00	0.00	0.00
3	CTWFOR	Existing Cottonwood-Willow Forest in the Study Area	0.00	0.00	0.00	0.00	0.00
4	DESERT	Desert Areas—Cacti, Rabbitbush, Acacia, and Creosote	237.00	237.00	159.00	81.00	0.00
5	DITCHES	Ditches	99.00	99.00	115.00	131.00	148.00
6	MESQUITE	Existing Mesquite Woodlands—on the Terraces and in the Project Area	160.00	160.00	73.00	0.00	0.00
7	NEWBUFFER	Newly Developed Upland Buffer Zones—Mesquite, Ironwood, Rabbitbush, Quailbush, Cat-claw Acacia, Palo Verde, and Creosote	0.00	0.00	0.00	0.00	0.00
8	NEWCWWFOR	Newly Developed Cottonwood—Willow Forests in Project Area	0.00	0.00	0.00	0.00	0.00
9	NEWMESQUIT	Newly Developed Mesquite Woodlands—on the Terraces and in the Project Area	0.00	0.00	0.00	0.00	0.00
10	NEWOPENWATER	Newly Developed Open Water Areas in the Project Area	0.00	0.00	0.00	0.00	0.00
11	NEWRVRBOTTOM	Newly Developed River Bottom Areas in the Project Area—Largely Unvegetated (Includes Emergents)	0.00	0.00	0.00	0.00	0.00
12	NEWSCRUB	Newly Developed Scrub—Shrublands in the Project Area	0.00	0.00	0.00	0.00	0.00
13	OPEN WATER	Existing Open Water Areas in the Project Area	0.00	0.00	0.00	0.00	0.00
14	PARKS	Parks and Recreation Areas	86.00	86.00	86.00	86.00	86.00
15	RIVERBOTTOM	Existing River Bottom Areas in the Project Area—Largely Unvegetated (Includes Emergents, Low Flow Channel, and shallow pools)	173.00	173.00	173.00	173.00	173.00
16	SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Project Area	0.00	0.00	0.00	0.00	0.00
17	SCRUBSHRUB	Existing Scrub-Shrublands in the Project Area—Rabbitbush, Quailbush, Ironwood, Saltbush, Desert Broom, and Burrobrush	256.00	256.00	172.00	86.00	0.00
18	SOILCEMENT	Existing Soil Cement Areas on the Slopes of the Project Area	21.00	21.00	32.00	32.00	32.00
19	URBAN	Existing Residential, Industrial, and Transportation Avenue, Bare Earth, Landfills	3557	3557	3841	4062	4212
Total			5005	5005	5005	5005	5005

Table 24 shows that out of the four main categories of cover types, Mesquite woodland, the most valuable, is expected to decline by approximately half by target year (TY) 6 before declining to zero by TY 26 while Cottonwood forest, ranked second, will remain at zero throughout the project life. The third rated cover type, Scrub-Shrub, will maintain the same PWAA until TY 1 than decline by one third by TY 6 and than decline another one third by TY 26. Scrub-Shrub will eventually decline to zero by year 50. The forth and last rated cover type, riverbottom, will remain at 173 throughout the project life.

HGM Methodology

In HGM, wetland functions represent the currency or units of the wetland system for assessment purposes, but the integrity of the system is not disconnected from each function, rather it represents the collective interaction of all wetland functions. Functional capacity is simply the ability of a wetland to perform a function compared to the level of performance in reference standard wetlands. The HGM methodology is based on a series of predictive Functional Capacity Indices (FCIs). An index capacity is how a wetland performs a function relative to other wetlands from a regional wetland subclass in a reference domain. FCIs are by definition scaled from 0.0 to 1.0. An index of 1.0 indicates that a wetland performs a function at the highest sustainable functional capacity, the level equivalent to a wetland under reference standard conditions. An index of 0.0 indicates the wetland does not perform the function at a measurable level and will not recover the capacity to perform the function through natural processes.

HGM combines both the wetland functionality (FCIs) and quantity (PWAA) of a site to generate a measure of change referred to as Functional Capacity Units (FCUs). Once the FCI and Partial Wetland Assessment Area (PWAA) quantities have been determined, the FCU values can be mathematically derived with the following equation: FCU = FCI x Area (measured in acres). Under the HGM methodology, one FCU is equivalent to one optimally functioning wetland acre. HGM can be used to evaluate future conditions and the long-term effects of proposed alternatives by generating FCUs for wetland functions over several TYs. In such analyses, future wetland conditions are estimated for both the without project and with project conditions. Projected long-term effects of the project are reported in terms of Average Annual Functional Capacity Units (AAFCUs) values. Table 25 below shows AAFCUs by function for the Paseo de las Iglesias study area.

HGM will be used to evaluate future conditions and the long-term affects of proposed alternatives by generating FCUs for wetland functions over the project life. In such analyses, future conditions are estimated for both the without project and with project conditions. Projected long-term outputs of the project are reported in terms of AAFCUs. Outputs of each alternative will be compared with the goal to maximize project benefits.

Table 25: FCI, Applicable Acres, and AAFCUs by Function

Target Year	Function Name	Weighted Functional Capacity Index (FCI)	Applicable Acres	Cumulative Average Annual Functional Capacity Units (CUM AAFCUs)	Average Annual Functional Capacity Units (AAFCUs)
0	Fxn 01: Maintenance of Characteristic Dynamics	0.200	589.00	117.80	59.91
1	Fxn 01: Maintenance of Characteristic Dynamics	0.200	589.00	503.50	
6	Fxn 01: Maintenance of Characteristic Dynamics	0.200	418.00	1354.00	
26	Fxn 01: Maintenance of Characteristic Dynamics	0.200	259.00	1080.00	
51	Fxn 01: Maintenance of Characteristic Dynamics	0.200	173.00	-	
0	Fxn 02: Dynamic Surface Water Storage/Energy Dissipation	0.692	589.00	407.86	204.12
1	Fxn 02: Dynamic Surface Water Storage/Energy Dissipation	0.692	589.00	1761.30	
6	Fxn 02: Dynamic Surface Water Storage/Energy Dissipation	0.708	418.00	4682.08	
26	Fxn 02: Dynamic Surface Water Storage/Energy Dissipation	0.673	259.00	3558.96	
51	Fxn 02: Dynamic Surface Water Storage/Energy Dissipation	0.643	173.00	-	
0	Fxn 03: Long Term Surface Water Storage	0.188	589.00	110.75	56.32
1	Fxn 03: Long Term Surface Water Storage	0.188	589.00	473.37	
6	Fxn 03: Long Term Surface Water Storage	0.188	418.00	1272.96	
26	Fxn 03: Long Term Surface Water Storage	0.188	259.00	1015.36	
51	Fxn 03: Long Term Surface Water Storage	0.188	173.00	-	
0	Fxn 04: Dynamic Subsurface Water Storage	0.000	589.00	0.00	0.00
1	Fxn 04: Dynamic Subsurface Water Storage	0.000	589.00	0.00	
6	Fxn 04: Dynamic Subsurface Water Storage	0.000	418.00	0.00	
26	Fxn 04: Dynamic Subsurface Water Storage	0.000	259.00	0.00	
51	Fxn 04: Dynamic Subsurface Water Storage	0.000	173.00	-	
0	Fxn 05: Nutrient Cycling	0.339	589.00	199.88	72.97
1	Fxn 05: Nutrient Cycling	0.339	589.00	861.98	
6	Fxn 05: Nutrient Cycling	0.346	418.00	1970.75	
26	Fxn 05: Nutrient Cycling	0.227	259.00	689.07	
51	Fxn 05: Nutrient Cycling	0.014	173.00	-	
0	Fxn 06: Detention of Imported Elements and Compounds	0.297	589.00	174.93	79.39
1	Fxn 06: Detention of Imported Elements and Compounds	0.297	589.00	745.25	
6	Fxn 06: Detention of Imported Elements and Compounds	0.295	418.00	1893.48	
26	Fxn 06: Detention of Imported Elements and Compounds	0.262	259.00	1235.25	
51	Fxn 06: Detention of Imported Elements and Compounds	0.191	173.00	-	
0	Fxn 07: Detention of Particles	0.329	589.00	193.61	95.15
1	Fxn 07: Detention of Particles	0.329	589.00	843.62	
6	Fxn 07: Detention of Particles	0.342	418.00	2213.83	
26	Fxn 07: Detention of Particles	0.309	259.00	1601.39	
51	Fxn 07: Detention of Particles	0.282	173.00	-	
0	Fxn 08: Maintain Characteristic Plant Communities	0.168	589.00	98.72	41.18
1	Fxn 08: Maintain Characteristic Plant Communities	0.168	589.00	419.51	
6	Fxn 08: Maintain Characteristic Plant Communities	0.166	418.00	1013.73	
26	Fxn 08: Maintain Characteristic Plant Communities	0.131	259.00	567.98	
51	Fxn 08: Maintain Characteristic Plant Communities	0.075	173.00	-	
0	Fxn 09: Maintain Spatial Structure of Habitat	0.204	589.00	120.40	51.19
1	Fxn 09: Maintain Spatial Structure of Habitat	0.204	589.00	514.30	
6	Fxn 09: Maintain Spatial Structure of Habitat	0.204	418.00	1249.72	
26	Fxn 09: Maintain Spatial Structure of Habitat	0.162	259.00	726.36	
51	Fxn 09: Maintain Spatial Structure of Habitat	0.103	173.00	-	
0	Fxn 10: Maintain Interspersion and Connectivity	0.197	589.00	115.88	49.33
1	Fxn 10: Maintain Interspersion and Connectivity	0.197	589.00	475.39	
6	Fxn 10: Maintain Interspersion and Connectivity	0.180	418.00	1152.25	
26	Fxn 10: Maintain Interspersion and Connectivity	0.159	259.00	772.06	
51	Fxn 10: Maintain Interspersion and Connectivity	0.125	173.00	-	

Recreation Analysis:

For the purpose of this analysis, local parks will be surveyed to show existing recreation in the area. One more park, the Santa Cruz River Park will be added to the list and discussed in detail because a portion of it exists within the Paseo de las Iglesias study area. The Santa Cruz River Park may represent a model for a possible future plan to extend the existing park within the Paseo de las Iglesias study area. Another possible future plan, identified by the City of Tucson, to restore a segment of the Paseo de las Iglesias that lies within the Rio Nuevo District may overlap in some aspects with the scope of this Feasibility Study. The future recreational needs of the Paseo de las Iglesias can be supported through a discussion of recreational demand and the unit day value method.

Parks Within Study Area:

The following shows the names of parks in close vicinity to the Paseo de las Iglesias. (See addendum for a complete list of County and City Parks in the Pima County/Tucson metropolitan area.)

Sentinel Peak Park--Sentinel Peak Park is located at 1000 S. Sentinel Peak Road and is a regional park approximately 272.93 acres.

El Presidio Plaza Park--El Presidio Plaza Park is located at 160 W. Alameda Street and is classified as a neighborhood park. It has drinking fountains, dusk to dawn lights, and public art. The area of the park is 2.75 acres.

Oaktree Park--Oaktree Park is located at 5433 S. Oaktree Drive. It has a basketball court, a multiple use field, two picnic sites, a playground, a ramada, a drinking fountain, and a BBQ grill. This neighborhood park is about 7.29 acres.

Ormsby Park--Ormsby Park, a neighborhood park, is located at 24^{th} street and Verdugo Avenue. The facilities include: bathrooms, a recreation center, a basketball court, a picnic site, a playground, a softball field, a volleyball court, two drinking fountains, and a BBQ grill. These facilities are on a 4.77 acres parcel.

Richey Elementary School--Richey elementary school is located at 2209 N. 15^{th} Avenue. Even though, the park is part of the school grounds it is still considered a neighborhood park. The park offers two basketball courts, a multi-use path, a playground, a ramada. Total acres equal 3.67.

Veinte De Agosto Park--Veinte De Agosto Park is located at the intersection of Broadway Boulevard and Church Avenue. This neighborhood park offers public art on 1.02 acres.

Garden of Gethsemane--The Garden of Gethsemane, a mini park on .27 acres, is located at 602 W. Congress Avenue. It has life-size concrete religious statues on display.

Verdugo Park--Verdugo Park is located at the intersection of 19th street and Verdugo Avenue. It is a mini park, approximately .47 acres, with a picnic site, a playground, a drinking fountain, and a BBQ grill.

John F. Kennedy Park--John F. Kennedy Park is located at Ajo Way and Mission Road and is considered a metro park. The park has two basketball courts, five restrooms, soccer fields, private boating, fishing lake, a basketball court, two multi-use fields, an amphitheatre, six picnic sites, three playgrounds, thirty nine ramadas, a swimming pool, two tennis courts, seventeen drinking fountains, and forty five BBQ grills. The park encompasses 167.59 acres.

Paseo De Los Arboles Commemorative Park--The Park is located on the west side of the Santa Cruz River Park and Irvington. The Park offers a multi-use trail and water fountains.

Paseo De Lupe Eckstrom (Tucson Diversion Channel)--Paseo De Lupe Eckstrom Park is located at 10th avenue near 39th street. The park is ADA accessible. It also has a multi-use path, restrooms, drinking fountains, picnic areas, ramadas, and public art.

Cardinal Neighborhood Park--Cardinal Neighborhood Park is located at 6925 S. Cardinal Avenue. The park has baseball and softball fields, a walking path, a playground, a picnic area, an exercise station, a horseshoe pit, a lighted basketball court, a ramada, restrooms, and drinking water fountains.

Mission Ridge Neighborhood Park--At 3300 W. Tucker Street, Mission Ridge Neighborhood Park has basketball courts, a baseball field, a picnic area, a ramada, a playground, restrooms, and drinking water fountains.

Winston Reynolds-Manzanita District Park--Located at 5200 S. Westover Avenue, the park has tennis courts, a volleyball court lighted baseball, football, and soccer fields, a lighted basketball court, a playground, a swimming pool, ramadas, a BMX track, a concession building, horseshoe pits and restrooms.

Santa Cruz River Park:

In addition to the parks listed above, there is one more park: the Santa Cruz River Park. The Santa Cruz River Park is located west of Interstate 10 and 19. It was constructed in stages. The most recent section, Silverlake Road to Grant Road (Congress to Silverlake is within the study area), was completed in 1993. This river park includes pedestrian and bicycle trails, a frisbee golf course, exercise courses, restrooms, drinking fountains, ramadas, picnic sites, BBQ grills, playgrounds, parking, and art projects. The section between Irvington Road and Ajo Way (all within the study area) was completed in 1992 and includes pedestrian and bicycle trails, a picnic area, and an exercise course.

Table 26 lists visitation figures for the Santa Cruz River Park River Park by month for three years, 1999 through 2001. The Pima County Parks and Recreation Department provided this data. It was collected through the use of a laser counting device located at one point along the Santa Cruz River Park. The data shows attendance figure declined substantially along the Santa Cruz River Park.

Table 26: Attendance Figures for the Santa Cruz River Parks

Month	Santa Cruz River Park		
	1999	2000	2001
January	21,682	3,667	3,588
February	16,530	5,272	3,546
March	18,721	6,437	4,584
April	13,288	5,017	4,186
May	Broken	3,507	4,155
June	9,633	3,961	3,229
July	10,113	2,058	1,321
August	7,471	4,936	2,531
September	9,256	2,364	3,143
October	8,502	4,302	2,126
November	2,794	2,798	2,533
December	4,670	4,286	1,683
Totals	122,660[1]	48,605	36,625

[1] The large drop in attendance from 1999 to 2000 may be due to the completion of the Rillito River Park a larger park located northeast from the Santa Cruz River Park. Also, there may be an error in the method used to calculate attendance during 1999.

Future river parks are planned for Tanque Verde Creek and Pantano Wash. Design work has been completed for sections of River Park along Canada del Oro from Thornydale Rd. to Magee Rd., along Tanque Verde Creek from Sabino Canyon to Tanque Verde Rd. and along Pantano Wash from Tanque Verde Rd to Golf Links Rd. Together the Santa Cruz, Rillito, Tanque Verde Creek, and Pantano Wash River Parks will function as one large unified trail system.

Future Recreation Facilities:

The City of Tucson has produced the Rio Nuevo Master Plan, which will create "a network of unique experience areas, linked by shaded plazas which connect new cultural, civic, entertainment, and business uses interwoven in a historically accurate and aesthetically pleasing manner throughout the Rio Nuevo District." Some of the environmental restoration and recreation aspects of this plan may be applied to future plans detailed later in the Feasibility process. The boundaries of this revitalization effort are Congress Street to the North, 22nd Street to the South, I-10 to the East, and Mission Road to the West.

Central to this project is the Santa Cruz River that may be converted into a linear greenbelt. Included in this effort are restored river terraces, islands and sandbars, and new weirs and ponds to slow and collect reclaimed water to ensure a healthy ecosystem and wildlife corridor through the core of downtown Tucson. Cottonwoods, Willows, Arizona Ash and other riparian trees and shrubs are planned for planting along the River to provide habitat for wildlife and contribute to pollination and seed dispersal.

Sentinel Peak Mountain over looks the City of Tucson and is included in the Rio Nuevo Plan. The proposal is to restore the mesquite shrub land that existed when Indian burials occurred there. Additionally, the plan proposes that the mountain be connected to the river through the creation of restored mesquite/paloverde upland habitat. This upland habitat will function as a wilderness park with nature paths that cross a series of carefully recreated habitats that interpret the pertinent Sonoran Habitats.

At the base of Shook-Shon Mountain, a natural Cienega of Sonoran Desert Marsh will be created to provide a watering hole for reintroduced wildlife. This Cienega will function as a sanctuary for flora and fauna and provide opportunities for interactive recreation such as bird watching and learning.

As part of the recreation development effort detailed by the City the following three parks have been introduced as part of the Rio Nuevo Project. They are located in close proximity to and immediately west of the Santa Cruz River. They are not likely to be a part of plan development for this Feasibility Study because they are not directly related to the restoration project along the Santa Cruz River..

1. Tucson Origins Cultural Park (2002-2005)
   Requiring: approx. 10 acres
   Attendance: 200,00 visitors per year

2. Sentinel Peak Nature Park (2006)
   Requiring: approx. 20-30 acres
   Attendance: 100,000 visitors per year

3. Rancho Chuk-Shon (2003-2006)
   Requiring: approx. 2-3 acres
   Attendance: 50,000-100,000 visitors per year

Recreation Demand:

Many factors contribute to make the proposed riparian habitat area along the Paseo de las Iglesias and New and Old West Branch study areas attractive in terms of recreation potential and unmet demand. They include:

1. *Recreation Experience*--Proposed general recreation activities that may be included in plans formulated later in the study process include trails for hiking, biking, and jogging. These activities are the fastest growing activities throughout Arizona according to the Arizona Trails 2000 document. Throughout Arizona walking and hiking ranks at 78% annually followed by bicycling at 36% and jogging at 28%. All activities rank higher than the national average except for jogging. Nationally, walking ranks at 67%, hiking at 33%, bicycling at 31%, and jogging at 70%. Among the activities identified, most have significant unmet demand.

2. *Availability of Opportunity*--In the past, demand for trail opportunities was fulfilled by the County's many back trails. But, as the County continues to grow, the demand has increased for urban trails and other recreation opportunities close to home. Future facilities along the Paseo de las Iglesias and New West Branch would likely provide opportunity for many urban individuals to recreate close to their homes, work, and downtown. Currently, several parks exist within on hour of travel time and a few exist within 30 minutes travel time for most urban individuals living in Tucson, but only one river park trail system exists which will provide a unique availability. According to Arizona Trails 2000 published under the authority of the Arizona State Parks Board, the number one reason given by trail users for preferring a particular area is its proximity to home (56%).

3. *Carrying Capacity*--As previously discussed, Pima County has experienced rapid population growth. Pima County's MSA population is 843,746 at year 2000 and is expected to reach 1,518,000 by year 2025—a difference of 674,254 over 25 years. With this increase in population comes and increased demand for recreational facilities proposed for this study. At present, facilities at the park are adequate to conduct activities and promote public health and safety at the park, but as population grows, the need for more facilities may grow.

4. *Accessibility*--According to 43% of the Arizona Tails 2000 survey respondents, loss of access to trails is the top three most important issues facing trails today. This is not the case for the facilities that are easily and quickly accessible to the public. There are also two interstates (10 and 19) and several crossroads that intersect the study areas. This provides a park area in high demand with considerable access not only by automobile but also by pedestrians.

5. *Environmental*--As demonstrated earlier, there are several recreation areas located in the study area. Of these parks, there are no significant thriving riparian areas. The Paseo de las Iglesias and New and Old West Branch Areas of the Santa Cruz have pockets of riparian vegetation but remain significantly degraded and are not considered to be a thriving habitat for plants and animals. Other parks in the area have dessert terrain and are not in riparian areas. This lack of riparian habitat is expected to result in significant unmet recreational demand.

According to County and City officials with the Park and Recreation Department the use of population based standards represents one of the most widely used methods for assessing community demand and the need for open space and recreation. This is attributed to the fact that they are easily understood and convenient. Such standards are considered most useful as a means for determining whether the supply of recreational resources is lacking behind demand that is supported by population growth. These standards also aid in supporting visitation data. The City of Tucson Parks and Recreation Department describes national standards for park type (mini park, neighborhood park, community park, metro park, and regional park) that have been established. The National Recreation and Parks Association (NRPA) set these standards. They are compared to current service levels and set by the City of Tucson for the Core/Mid City region and the Edge/Future City region. The following tables summarize this data.

Table 27: Park Type, Standard Park Size, and Service Radius

Park Type	Park Size	Service Radius
Mini Park	0-1 acre	¼ mile
Neighborhood Park	1-15 acres	½ mile
Community Park	15-40 acres	1 mile
Metro Park	40-200 acres	2 ½ miles
Regional Park	>200 acres	7 miles

Table 28: Recreation Demand

Facility Type	Current Ratio	National Guidelines	COT Core/Mid-City Guidelines	COT Edge/Future City Guidelines
Mini Park[1]	.01 ac/1,000	N/A	N/A	N/A
Neighborhood Park	1.1 ac/1,000	2.5 ac/1,000	2.5 ac/1,000	2.5 ac/1,000
Community Park	1.0 ac/1,000	3.0 ac/1,000	3.0 ac/1,000	3.0 ac/1,000
Metro Park	3.0 ac/1,000	N/A[2]	3.0 ac/1,000	3.5 ac/1,000
Regional Park	1.3 ac/1,000	2.0 ac/1,000	1.0 ac/1,000	2.0 ac/1,000
Total	5.9 ac/1,000	10.0 ac/1,000	9.5 ac/1,000	11.0 ac/1,000

[1]N/A is placed in the row of cells for mini park because the City of Tucson Park and Recreation Department no longer plans to construct this type of park; therefore, any acre per population guideline is no longer applicable.

[2]There are no national guidelines for metro park, so this guideline is not applicable.

As the above data indicates, the current ratio of acres per 1,000 population is lower in most cases than the National and City Guidelines. A lack of sufficient recreation resources exists for all the types of parks except for metro and regional parks. Currently, existing metro parks have met population needs in the core/mid-city area but not the edge/future city region. Regional parks have also met demand for the Core/Mid City area but not the Edge/Future City. Unless a significant number of recreation facilities are built, the projected population growth (2010) will make the existing deficit and surplus become worse.

Table 29: Additional Park Facilities Needed to Achieve Guidelines

Facility Type	Existing 2001	COT Core/Mid-City 2010	COT Edge/Future City 2010	Total 2010
Mini Park	5 acres	N/A	N/A	N/A
Neighborhood Park	515 acres	176 acres	333 acres	509 acres
Community Park	504 acres	745 acres	364 acres	1,109 acres
Metro Park	1,450 acres	0 acres	188 acres	188 acres
Regional Park	619 acres	0 acres	0 acres	0 acres
Total	3,093 acres	921 acres	885 acres	1,806 acres
Multi-Use Path				37 miles

Table 29 shows an estimate of the additional park facilities needed to achieve demand guidelines by 2010. For most of the facility types there is a need for additional parks except for Metro and Regional parks. Metro parks have met guidelines for the Core/Mid-City area so no new projections were estimated. Regional parks, on the other hand, have not met guidelines for both Core/Mid-City and Edge/Future City, but the City of Tucson Parks Department has decided to limit additional parks in this category. The estimated number of total park acres needed to fill demand by 2010 is 1,806. Also, an estimate of 37 miles of multi-use path is needed by 2010 to meet demand guidelines. The need will be even higher throughout the study period.

Unit Day Value Method:

For this analysis the Unit Day Value (UDV) method is used for the economic evaluation of the recreational features along the Paseo de Las Iglesias. The method uses administratively set dollar values to determine the worth of recreational experiences and calculates the value of recreation. This value is an approximation of the area under the site demand curve or otherwise known as willingness to pay. To obtain this value you must first select specific points from a range of values provided in Planning, Principles, and Guidelines (ER-1105-2-100). A table of criteria and point values is shown below:

Table 30: Criteria and Point Values

Criteria	Key Variable	Range of Point Values
Recreation Experience	Number of key activities	0-30
Availability of Opportunity	# of similar opportunities nearby	0-18
Carrying Capacity	Adequacy of facilities for activities	0-14
Accessibility	Ease if access to and within site	0-18
Environmental	Esthetic quality of site	0-20
Total		0-100

Second, point values for without project conditions are calculated and converted into equivalent dollar amount. Based upon the total number of points assigned, the equivalent dollar amount is obtained. UDVs range from \$3.00 to \$9.01 per recreation day. This dollar amount is the value per visit of UDV. Third, the value is multiplied by the annual number of visitors to get an estimate of annual recreation value.

Evaluation of the Paseo de las Iglesias Study Area:

Point values for the existing Santa Cruz River Park of which a portion is located within the Paseo de las Iglesias study area are estimated with the aid of Pima County Park and Recreation Department, available literature describing the nature of recreation in the area, and site visits made by the US Army Corps of Engineers study team. These numbers do not consider any possible future expansion of the park and are assigned using information described earlier on Page 27 in this report under the recreation demand section of the report.

Table 31: Point Values for Without Project Conditions
Paseo de las Iglesias

Recreation Criteria	Value Range	Point Values
Recreation Experience	0-30	8
Availability of Opportunity	0-18	3
Carrying Capacity	0-14	6
Accessibility	0-18	8
Environmental	0-21	2
Total		27

The point values described above are totaled and converted into equivalent a UDV amount. The total point value from Table 31 is 27 for the five recreational criteria. The equivalent UDV amount for 27 points is $4.33. This UDV amount represents how much a visit to the park is worth in dollar amount for the without project condition.

Because visitation figures already exist for a portion of the Paseo de las Iglesias, they will be applied, but they will be altered slightly, first to eliminate double counting and second to project visitation growth. First, visitation figures are divided in half to eliminate double counting. This seems to be a reasonable assumption given the nature of trail usage. When a visitor begins to use a trail and crosses the laser beam counter he will inevitably cross it again when he returns. Second, visitation is projected over 50 years by using annual compound rates for population growth. These adjusted visitation figures will than be compared to capacity limits established by the National Recreation Parks Association (NRPA). The capacity limit set by NRPA is 14,600 users per mile per year. If visitation reaches the capacity figures established by the NRPA visitation is assumed to remain constant. The rational used is: visitation will increase at a decreasing rate until a capacity threshold is reached. At the threshold visitation begins to remain stable, all else being equal. But, after projections were made, visitation figures did not reach the capacity threshold; therefore, projections continued to increase over the 50-year period of analysis.

Table 32: Projected Visitation

Location	Original 2001	Half 2001	2012	2020	2030	2040	2050	2060	2062
Santa Cruz River Park (one bank)	36,625	18,312	23,015	26,338	31,174	35,824	39,966	43,712	44,502
Annual Growth Rate			1.021	1.017	1.017	1.014	1.011	1.009	1.009

To calculate the recreational value for with project conditions, the UDV is multiplied by annual visitation. The product of the UDV and average annual visitations over 50 years can be seen in the below table.

Table 33: Projected Recreation Value

Location	2012	2020	2030	2040	2050	2060	2062
Santa Cruz River Park (one bank)	$99,657	$114,045	$134,985	$155,118	$173,051	$189,272	$192,694

The stream of recreation values over 50 years was discounted (NPV = $2,114,132 (one bank)) and annualized for a recreation value of $120,390. This number is added to 75% its value for an estimate of recreation value along both banks of the Santa Cruz River Park. Recreation is assumed to be metered along the most used bank and to vary along the other bank by 25%. Recreation value is therefore $210,682.

WITH PROJECT CONDITIONS

Introduction:

The proposed alternatives for Paseo de las Iglesias were developed to consider three factors: 1) the evaluation of flood and erosion damage reduction opportunities given the results established in the without project condition; 2) the restoration of the study area to support natural riparian vegetation and wildlife communities; 3) the development of recreation opportunities to minimize the impact of human interference on newly restored habitat.

Evaluation of Flood Damage Reduction Opportunities:

Flood Damage Reduction Evaluation:

The primary purpose of this feasibility study is National Ecosystem Restoration (NER). Flood damage reduction or National Economic Development (NED) opportunities were also evaluated to determine if a federal interest existed in participating in a combined NER and NED plan. Structural and non-structural measures and alternatives were developed and evaluated for four floodplains in the study area (the Santa Cruz River, the Old and New West Branches, and the Los Reales area) to determine if expected annual economic damages for the baseline and without-project conditions were great enough to warrant a detailed analysis. Based on the evaluation and screening processes, flood damage reduction could not be justified as a project purpose within the study area. The results of this evaluation and screening process are summarized in this section.

The total number of structures by flood frequency for each of the above referenced reaches and respective Expected Annual Damages (EAD) are provided in Tables 34 and 35 below:

Table 34: Number of Impacted Structures by Frequency and Floodplain

Floodplain	50 yr	100 yr	200 yr	500 yr
Santa Cruz	0	0	132	1972
Old West Branch	NA[1]	583	NA	NA
New West Branch	0	222	503	1126
Los Reales	24	47	62	119

[1]NA means overflows were not available for the frequencies listed; therefore structures could not be counted and included in Table 1.

Table 35: Total Without Project Condition Expected Annual Damages

Santa Cruz River		Old & New West Brach Rivers and Los Reales Floodplains	
Reach	*EAD*	*Reach*	EAD
1 SC	$69,870	OWB	$406,212
2 SC	$110,950	1 NWB	$141,330
3 SC	$258,480	2 NWB	$64,260
5 SC	$81,940	LR	$107,740
Total:	$521,250	Total:	$719,542

Evaluation of Flood Damage Reduction Measures

A variety of non-structural flood damage reduction measures were identified, which could be used to meet the planning objectives. The initial evaluation of these measures is discussed below.

Non-Structural Flood Damage Reduction Measures:

Floodplain Management Regulations

The City of Tucson and Pima County participate in the National Flood Insurance Program (NFIP), which is administered through the Federal Emergency Management Agency (FEMA). FEMA has published Flood Insurance Rate Maps (FIRMs) for both jurisdictions that identify Special Flood Hazard Areas for the Santa Cruz River and tributaries. For local jurisdictions to maintain eligibility in the NFIP, minimum levels of floodplain management regulations must be adopted and enforced.

Due to the existence of floodplain management regulations and enforcement, this measure was not carried forward for alternative evaluation.

Flood Warning Systems

A flood warning and preparedness system is often the most cost effective flood mitigation measure comprised of computer hardware, software, technical activities and/or organizational arrangements aimed at decreasing flood hazards. Advanced warning is not generally effective in reducing structural damages (outside of sandbagging efforts given early warning); the primary benefits of such a system are credited for providing early evacuation of residents and reduction in damages to vehicles and structure contents.

Pima County owns and operates an extensive flood-warning network. This network operates in the National Weather Service ALERT (Automated Local Evaluation in Real Time) format and is part of the Arizona Statewide Flood Warning System previously developed and constructed by the Corps under Section 205 of the Continuing Authorities Program.

Due to the existence the statewide and local flood warning systems, this measure was not carried forward for alternative evaluation.

Flood Proofing

Flood proofing offers the opportunity to provide flood protection on an individual structure-by-structure basis or a group of structures. Flood proofing techniques typically include buyouts, relocation, elevation, floodwalls or levees, and dry flood proofing. Elevation, buyout, and relocation are the most dependable of these flood proofing methods. Flood proofing costs can vary substantially depending on the type of flood proofing method being considered and the type, size, age, and location of the structure(s). Flood proofing techniques considered for alternative development are:

1) Relocation of Existing Structures: Relocation is perhaps the most dependable flood proofing technique since it totally eliminates flood damages, minimizes the need for flood insurance and allows for the restoration/reclamation of the floodplain. This technique requires the physical relocation of flood prone structures outside of the identified flood hazard area. This also requires purchase of the flood prone property; selecting and purchasing a new site; and lifting/moving the structure to the new site.

2) Buyout or Acquisition: This technique requires the purchase of the flood prone property and structure; demolition of the structure; relocation assistance; and applicable compensation required under Federal and State law. This alternative typically requires voluntary relocation by the property owners and/or eminent domain rights exercised by the non-federal sponsor.

3) Retrofitting or Dry Flood Proofing: Dry flood proofing of existing structures is a common flood proofing technique applicable for flood depths of three (3) feet or less on buildings that are structurally sound. Installation of temporary closures or flood shields is a commonly used flood proofing technique. A flood shield is a watertight barrier designed to prevent the passage of floodwater though doors, windows, ventilating shafts, and other openings of the structure exposed to flooding. Such shields are typically made of steel or aluminum and are installed on structures only prior to expected flooding. However, flood shields can only be used on structures with walls that are strong enough to resist the flood-induced forces and loadings. Exterior walls must be made watertight in addition to the use of flood shields. This technique is not applicable areas subject to flash flooding (less than one hour) or where flow velocities are greater than three (3) feet per second. It would also not be applicable to mobile homes, which comprise sixty-nine percent of the flood prone structures in the study area, due to the type of construction and typical lack of anchoring to a foundation.

Aside from the cost, dry flood proofed homes and businesses can still suffer flood damages due to the potentially incomplete nature of the solution. Enclosures for windows and doors require human intervention in order to fully implement the solution and, this action would have to occur in a relatively short time frame. Due to the incomplete nature and limited applicability of this flood proofing method, it was not carried forward for alternative evaluation.

4) Localized Levees or Floodwalls: Ring levees or floodwalls can be built around individual structures to protect single or small groups of structures. Ring levees are earthen embankments with stable or protected side slopes and a wide top. Floodwalls are generally constructed of masonry or concrete and are designed to withstand varying heights of floodwaters and hydrostatic pressure. Closures (e.g., for driveway access) are typically manually operated based on flood forecasting and prediction that would alert the operator.

Disadvantages of levees or berms are: 1) can impede or divert flow of water in a floodplain; 2) can block natural drainage; 3) susceptible to scour and erosion; 4) give a false sense of security; and 5) take up valuable property space.

Disadvantages of floodwalls are: 1) high cost; 2) closures for openings required, and 3) give a false sense of security.

5) Elevation of Structures: Existing structures can be elevated or raised above the potential flood elevation. Structures can be raided on concrete columns, metal posts, piles, compacted earth fill, or extended foundation walls. Elevated structures must be designed and constructed to withstand anticipated hydrostatic and hydrodynamic forces and debris impact resulting from flooding. The access and utility systems of the structures to be raised would need to be modified to ensure they are safe from flooding.

Structural Flood Damage Reduction Measures:

A variety of structural flood damage reduction measures were also identified, which could be used to meet the planning objectives. The initial evaluation of these measures is discussed below.

Detention:

This measure would require construction of on-line (i.e., in-stream) or off-line regional detention facilities upstream of the study area designed to detain flood flows and release then at a lower rate. There are no lands identified for upstream detention that would provide adequate storage volume to detain the 100 through 500 year flood events. In addition, any such location would fall outside the study area and outside Pima County jurisdiction either on Tribal Lands or in Santa Cruz County. The location of a large-scale detention facility relative to the entire 22,222 square mile contributing watershed would have to be evaluated to determine what impacts, if any, there are on flood hydrographs through the study area. This measure was not carried forward for alternative evaluation.

Lined Channels & Covered Channels:

1) Rectangular Concrete Channels: Preliminary evaluation of this measure revealed no practical location along the large, entrenched Santa Cruz River channel where such a solution would be practical. Rectangular concrete channels are not carried forward for alternative evaluation.

2) Trapezoidal Rip-Rap/Soil Cement/Vegetation Lined Channels: A preliminary evaluation was performed for the potential for utilizing trapezoidal lined channels, due to the reduced construction costs and improved aesthetics of such channels. The Santa Cruz River contains the 100-year flood, and several reaches within the study area are currently protected from erosion with soil cement lined banks. This measure was carried forward for alternative evaluation.

3) Covered Channels: A preliminary evaluation indicated that there is no specific location where covered channels could be utilized and this measure is not carried forward for the alternative evaluation.

Levees and/or Floodwalls:

1) Levees: Levees can provide significant levels of protection in a cost effective manner, however, there are disadvantages such as increases of flood stages, real estate costs and access considerations, environmental impacts, and the potential for failure due to scour/erosion or overtopping. This measure was carried for alternative evaluation.

2) Floodwalls: Consideration was given to protective floodwalls in place of levees. Floodwalls may be provided at a lower cost than levees and provide significant levels of protection over and above the current channels, with or without widening and deepening. This measure was carried forward for alternative evaluation.

Alternative Evaluation and Screening:

Alternatives were evaluated and screened using preliminary cost estimates based on costs developed for similar measures in other studies conducted in the region. Detailed cost estimates were not prepared because none of the alternatives were near enough to being justified to warrant more precise analysis.

Old West Branch (OWB):

The Old West Branch is an entrenched natural channel. The average base width is 20 ft and the average bank height is 10 ft. There is a significant amount of vegetation (e.g., Mesquite) growing along the banks and some vegetation growing in the channel bed. There is a large concrete drop structure at the confluence of with the Santa Cruz River. Bridge crossings are located at Silverlake Road, Ajo Way, and Via Engresso.

Structural flood damage reduction alternatives along the OWB would result in the loss of the most highly valued riparian habitat and Mesquite Bosque within the study area, which is in direct conflict with the primary ecosystem restoration purpose. Previous proposals, by the non-federal sponsor, for structural flood control channel improvements along the OWB resulted in a high degree of public opposition. In addition, 73 acres of the OWB channel and floodplain must be maintained as a "natural floodplain" under the mitigation provisions of an existing USACE Section 404 Permit and structural modifications of the natural channel are prohibited. Based on aforementioned constraints, structural flood damage reduction alternatives for the OWB were not developed and evaluated.

In light of the above, only non-structural flood damage alternatives were evaluated for the OWB. Approximately 583 structures are potentially damaged in the 100-year flood event and the expected annual damages are $406,212. The non-structural alternatives evaluated are:

OWB-1	Buyouts and/or Relocation
OWB-2	Elevation of Structures
OWB-3	Localized Floodwalls or Levees

<u>Alternative OWB-1 (Buyouts/Relocation)</u>: Estimates for structure values (not including relocation assistance and demolition costs) in the OWB 100-year floodplain exceeded $23,000,000 (See Economic Appendix). This figure was then converted to an annual average equivalent value for purposes of comparison on a common basis with the estimate of the average annual benefits. The cost estimate was amortized over a 50-year project life using a financial discount rate of 5.625%. The average annual cost of alternative OWB-1 is $1,383,413. The resulting B/C ratio is .29. Alternative OWB-1 is clearly not economically justified and was eliminated from further consideration.

Relocation would depend on whether alternative sites for 583 structures are available, the willingness of the residents to relocate, and other non-technical factors. There are no identified sites with equivalent zoning, existing infrastructure, and lot configuration that could accommodate relocating 583 structures. Assuming that such relocation sites were available, the cost to relocate these structures was estimated at $10 per square foot to move the structures several miles. 10% contractor profit was also assumed per USACE National Flood Proofing Committee guidelines. Total relocation and profit costs are estimated at $6,400,000. The average annual cost is $384,949 for a B/C of 1.05 at a 5.625% interest rate. Required additional costs not incorporated would include cost of the new lot, new foundations, landscaping, and pertinent indirect costs that are estimated at an additional $15,000 per structure. Based on this required additional costs estimates and lack of relocation sites, relocation was eliminated from further consideration.

<u>Alternative OWB-2 (Elevation)</u>: The economic benefits associated with elevating existing structures are measured by subtracting the value of the expected annual damages under improved conditions from the expected annuals damages under the without project conditions.

Construction costs were estimated for raising structures with piers for manufactured/ mobile homes and stem walls for slab on grade homes. The mobile homes also require adequate tie-downs to prevent flotation. These costs considered the condition of the structure to be raised, the site preparations required, mobilization costs, and the approximate square footage of the structure. A constant cost of per square foot was used whether the structure is raised one foot or three feet. Commonly, the cost per square foot increases for each additional foot the structure is elevated. These cost (per NFPC data) are:

Table 36: Construction Costs Per Square Foot

Wood Frame Building on Piles, Posts or Piers[1]	$26 per square foot
Wood Frame Building on Foundation Walls[1]	$19 per square foot
Brick Building[1]	$32 per square foot

[1]These costs include foundation, extending utilities, and miscellaneous items, such as sidewalks and driveways. They do not include the cost of fill or landscaping.

A profit of 10% also needed to be included, as well as fixed engineering design, mobilization, and relocation cost of $7,000 for the mobile homes and $14,000 for the each single family residential homes. All costs were based on a typical 1,000 square foot wood framed structure.

The cost to elevate 52 SFR and 528 MH residential structures was estimated at $15,451,000. This figure was then converted to an annual average equivalent value for purposes of comparison on a common basis with the estimate of the average annual benefits. The cost estimate was amortized over a 50-year project life using a financial discount rate of 5.625%. The average annual cost of Alternative OWB-2 is $929,353.

The economic justification was determined by subtracting the expected annual costs from the annual benefits. The difference between these two figures represents net benefits associated with the project. If net benefits are zero or positive, then the project is economically justified. The benefit-to-cost ratio is a number representing the expected annual benefits divided by the expected annual costs. An economically justified project will show a benefit-to-cost ratio of 1.0 or greater.

The analysis shows that the net benefits generated by the alternative are -$523,141; therefore, the B/C ratio is .43. Thus, this alternative is not economically justified and was not carried forward.

<u>Alternative OWB-3 (Floodwalls)</u>: Installation of individual or groups of floodwalls or levees was analyzed for the residential structures only. Based on the small lot sizes, configuration of the subdivision(s) and clustered nature of the residential structures, construction of individual floodwalls or ring levees are not physically possible. Floodwalls constructed around the perimeter of individual subdivisions would act as ineffective flow areas that increase water surface elevations and divert flood flows onto adjacent properties, thus inducing damages. Based on this evaluation, this alternative was eliminated from further consideration.

New West Branch (NWB):

The New West Branch (NWB) is an entrenched partially bank protected trapezoidal channel. The channel has a natural bottom with 3 on 1 concrete lined side slopes. The base width varies from 100 to 120 ft. The average bank height is 8 ft. There is a large concrete drop structure/energy dissipator at the confluence of with the Santa Cruz River; with another drop structure located approximately 1,925 feet upstream. Bridge crossings are located at Irvington, Drexel, and Valencia Roads.

503 structures are potentially damaged in the 100- and 200-year flood events and 1,126 structures are damaged in the 500-year event. The total expected annual damages are $205,590. Non-structural alternatives (i.e. dry flood proofing, elevation, and relocation) were eliminated from further consideration based on the non-structural alternatives analysis performed for the 583 structures on the Old West Branch.

Potential structural alternatives evaluated for the New West Branch were:

NWB-1: Channel Dredging,
NWB-2: Reconstruction of Existing Levees, and
NWB-3: Floodwalls.

Alternative NWB-1 (Channel Dredging): The without project hydraulic model was modified to determine the impacts of channel dredging. The following impacts or concerns were identified:

a) Excavation can increase the conveyance of the New West Branch up to the 100-yr flood event only. Up to two (2) ft of excavation is necessary.
b) Excavation alone would not contain the 200- and 500-yr flood events.
c) The existing grade control structure at Station 6.0 would need to be modified (lowered) as well as the existing bank protection.
d) The existing footbridge upstream of Drexel Road would need to be removed or replaced.
e) Excavation may result in undermining of the existing soil cement bank protection. The toe down depth(s) of the existing soil cement bank protection is unknown and cannot be verified. Additional field exploration will be required to determine structural integrity, toe-down depths, and subsurface conditions behind and under the soil cement.

For cost estimating purposes and alternatives analysis, the assumption was made that the existing soil cement would require structural measures to prevent undermining. At this time, a preliminary cost estimate cannot be developed without knowledge of toe-down depth. This alternative is unlikely to be justified even if excavation is the primary cost and structural modifications to the existing bank protection are not required. Cost for excavation alone is estimated at $2,838,486. Annualized over 50 years and a 5.625% interest is $170,730. This estimate does not include modification of the existing grade control structure, removal or replacement of existing pedestrian bridge or bridge improvements to Drexel and Irvington. Benefits were calculated using HEC-FDA without project output and an EAD spreadsheet. Benefits for the New West Branch floodplain are $85,781. If this preliminary analysis showed possible justification HEC-FDA would have been used for detailed analysis. However, the resulting benefit-to-cost ratio for excavation on Alternative NWB-1 is .50. Therefore, this alternative was not economically justified.

<u>Alternative NWB-2 (Replace Levees)</u>: Levees (or berms) currently exist along both channel banks, however they do not contain the 100 to 500-year flows. An analysis was performed to determine what effects raising the existing levees to protect homes would have. As built drawings for the existing levee are not available therefore, for engineering design and cost estimating purposes, the existing levees were assumed to be structurally inadequate and completely new engineering levees were assumed. Due to the high velocities and possibility of run-up at the curve, rigid armoring (i.e., soil cement) would be required on the insides slopes of the levees. Costs for soil cement bank protection assumed a 14-foot bank height and 5-foot toe-down. Major elements include earthwork, borrow material, manufacturing of soil cement, cement materials, handrails, and utility relocations. Lesser items include traffic control, removal of obstructions, clearing/grubbing, and off-site drainage facilities. Typical unit costs for earthwork, manufacturing of soil cement, and cement materials were provided by Pima County.

The cost (excluding additional real estate requirements) for reconstruction of approximately 14,200 lineal feet of new levee system on both sides of channel was estimated at $11,809,801. Annualized cost equal $710,340. With benefits equaling $55,110 for Levee 1, $145,230 for Levee 2, and $169,550 for Levee 3, the resulting B/C ratio for Alternative NWB-2 and NWB-3 (described below) is .12, .25, and .28; therefore, they are not economically justified.

Benefits from the proposed alternative consist of reduction in damages to structures and contents. Damage reduction was measured by a reduction in levee overtopping due to the increased height of a levee or floodwall. Expected annual damages were calculated using the HEC-FDA program developed by the Hydrologic Engineering Center in Davis, California. Benefits derived from flood damage reduction are presented in the following table.

Table 37: Benefits from Flood Inundation Reduction

Reach	Without Project Damages	Damages Prevented Levee 1	Damages Prevented Levee 2	Damages Prevented Levee 3
WB 4	$141,330	$39,180	$122,530	$139,480
WB 5	$ 64,260	$15,930	$22,700	$30,070
Total	$205,590	$55,110	$145,230	$169,550

For better evaluation of alternatives, HEC-FDA results are detailed in the following tables. Table 38 and 39 will display information about the hydrologic and hydraulic performance of each plan while Table 40 and 41 will show economic performance. Before each table is a brief explanation of the statistics represented in the tables that follow.

Statistics shown in Table 38 show the expected annual probability that the capacity of the channel within each reach will be exceeded. The median estimate of annual exceedance probability represents the flood stage at which significant damages begin to occur. Table 38 shows that for the alternatives there is less than a .001 to .003 chance of being overtopped annually. With the introduction of uncertainty these probabilities increase.

Long-Term Risk represents the probability of the target stage being exceeded (or exceeding the capacity of the levee) over a given time period. Table 38 displays the long-term risk for 10, 25, and 50 periods for the without and with project conditions. For the without project conditions, there is over 50% chance that the capacity of both reaches in the study area will be exceeded during a 50 year period of analysis. For the alternatives, long-term risk over a 50-year period of analysis range from 40% to 1% chance that the levee will be exceeded. Exceedance probabilities for the alternatives is lower than the without project condition and the exceedance probabilities increase over time as should be expected.

Table 38: Annual Performance and Equivalent Long-Term Risk

Plan	Annual Estimate of Annual Exceedance Probability	Annual Exceedance Probability With Uncertainty Analysis	Long Term Risk		
			10 Year	25 Year	50 Year
Without Project					
Reach 4	.022	.035	.2979	.5869	.8294
Reach 5	.005	.016	.1511	.3360	.5592
Levee 1					
Reach 4	.001	.011	.1008	.2332	.4121
Reach 5	.003	.011	.1027	.2374	.4184
Levee 2					
Reach 4	.001	.002	.0199	.0491	.0958
Reach 5	.002	.009	.0851	.1994	.03591
Levee 3					
Reach 4	.001	.001	.0028	.0071	.0141
Reach 5	.001	.007	.0674	.1601	.2946

The conditional non-exceedance probability by event represents the probability of a reach containing the given probability event within the target stage. Table 39 shows that the conditional non-exceedance probabilities for the alternative is larger than the without project condition as to be expected. Non-exceedance is greater than 97% contained during the 10-year event and greater than 63% contained during the 500-year event. This means the alternatives proposed perform well in containing most events.

Table 39: Conditional Non-Exceedance by Probability Events

	Conditional Probability of Design Containing Indicated Event					
	10%	4%	2%	1%	.4%	.2%
Without Project						
Reach 4	.8923	.6637	.5131	.4632	.3469	.3162
Reach 5	.9801	.8560	.7216	.6197	.5241	.4811
Levee 1						
Reach 4	.9765	.8954	.8291	.8048	.7451	.7285
Reach 5	.9885	.9081	.8137	.7398	.6691	.6375
Levee 2						
Reach 4	.9964	.9810	.9674	.9623	.9492	.9454
Reach 5	.9908	.9244	.8455	.7839	.7244	.6972
Levee 3						
Reach 4	.9997	.9982	.9967	.9962	.9949	.9944
Reach 5	.9931	.9415	.8787	.8294	.7820	.7603

Finally, the project performance is analyzed in economic terms. Table 40 and 41 presents the probabilities of the value of net benefits and probabilities that the benefit and cost ratio exceeds indicated percentages. All indicators show negative net benefits and a B/C ratio of less than 1 for all the alternatives evaluated.

Table 40: Performance of Net Benefits

Plan	Expected Annual NED Benefits and NED Cost			Probability Net Benefits Exceeds Indicated Percentages		
	Benefits[1]	Costs	Net Benefits	75%	50%	25%
Levee 1	$88,227	$710,340	($622,113)	($674,033)	($673,333)	($557,203)
Levee 2	$178,347	$710,340	($531,993)	($668,093)	($666,073)	($516,883)
Levee 3	$202,667	$710,340	($507,673)	($663,963)	($661,023)	($496,873)

[1]Benefits include emergency response damages. Traffic is not impacted in this area; therefore, traffic damages are not included.

Table 41: Performance of B/C Ratio

Plan	Expected B/C Ratio[1]	B/C >1	Probability Benefit/Cost Ratio Exceeds Indicated Percentages		
			75%	50%	25%
Levee 1	.1242	B/C<1	.0511	.0521	.2155
Levee 2	.2510	B/C<1	.0595	.0623	.2723
Levee 3	.2853	B/C<1	.0653	.0694	.3005

[1]Benefits include emergency response damages. Traffic is not impacted in this area; therefore, traffic damages are not included.

Alternative NWB-3 (Floodwall): Based on the analysis for Alternative NWB-2, a floodwall determined to be impractical given the fact that the costs of floodwalls are typically in the range of five to seven (5-7) times the cost of the soil cement levee.

Santa Cruz River (SCR):

The Santa Cruz River main stem is characterized by a partially bank protected ephemeral river with a narrow 100-year floodplain. There is soil cement bank protection on both banks between Congress Street and Silverlake Road, Irvington Road and Ajo Way, and near Valencia Road. The rest of the study reach is unprotected. The river is entrenched with widths varying from 200 to 1000 ft. Bridge crossings are located at Congress Street, 22nd Street, Silverlake Road, Ajo Way, Irvington Road, Drexel Road, and Valencia Road. The Old West Branch joins the Santa Cruz River between 22nd Street and Silverlake Road. The New West Branch joins the Santa Cruz River between Ajo Way and Irvington Road.

The Santa Cruz River incised channel contains the 2 through 100-year flood events for the majority of the study area and no structures are affected by these flood frequencies. 132 structures are affected in the 200-year flood frequency and 1,972 structures are affected in the 500-year flood frequency. The total expected annual damages are $521,250 (see Table 34) for the four sub-reaches on the Santa Cruz River.

Non-structural Alternatives: Dry flood proofing was not considered due to the fact that 1,040 of the existing 1,972 structures are mobile homes, which are not conducive to this technique. Non-structural alternatives (i.e., dry flood proofing, elevation, and relocation) were eliminated from further consideration based on the costs determined by the non-structural alternatives analysis performed for the 583 structures on the Old West Branch.

Structural Alternatives: Structural alternatives considered for the Santa Cruz River are:

SCRiver-A Channel Improvements / Widening
SCRiver-B Levee or Floodwalls

Table 42: Reach Delineation Breakdown: The Santa Cruz Floodplain

Reach Name	Cross Streets	Stream	Beginning Cross-Section	Ending Cross-Section
1 SC	Congress St. 22nd Street	Santa Cruz River	32.61	33.38
2 SC	22nd Street Ajo Way	Santa Cruz River	33.38	35.77
3 SC	Ajo Way Irvington Rd.	Santa Cruz River	35.77	36.63
4 SC[1]	Irvington Rd. Drexel Rd.	Santa Cruz River	36.63	37.87
5 SC	Drexel Rd. Valencia Rd.	Santa Cruz River	37.87	38.96

[1] 4 SC produced no damages.

Alternative SCRiver-A (Channel Widening): Channel improvements along the Santa Cruz River main stem would entail widening of existing vertical eroded banks and then constructing soil cement bank protection at 1 (horizontal):1 (vertical). Referencing Table 36, both river banks for sub-reaches 1 SC and 3 SC are protected with soil cement and would require removal of the existing soil cement to accommodate channel widening and new soil cement protection would then have to be reconstructed. Sub-reach 2 SC is bank protected from 22nd Street to Silverlake Road.

A preliminary lump sum cost estimate for bank protection was previously developed for the Gila River, Santa Cruz River Watershed Pima County, Arizona Final Feasibility Report (dated August 2001) for the remaining unprotected channel banks. Costs for soil cement bank protection assumed a 20-foot bank height and 10-foot toe-down. Major elements include earthwork, borrow material, manufacturing of soil cement, cement materials, handrails, and utility relocations. Lesser items include traffic control, removal of obstructions, clearing/grubbing, and off-site drainage facilities. Typical unit costs for earthwork, manufacturing of soil cement, and cement materials were provided by the Pima County. The initial cost estimate, not including real estate and contingencies, was in excess of $14,960,000.

Channel widening alone will not provide a complete flood protection solution. The eight (8) existing roadway bridges would require improvements or replacement to convey design floods without overtopping.

Based on expected annual damage levels for the Santa Cruz River sub-reaches, the initial cost estimate of $14,960,000, the impracticality of removing existing soil cement for channel widening, construction of new soil cement, and bridge replacements, Alternative SCRiver-A was not carried forward for detailed evaluation.

Alternative SCRiver-B (Levees or Floodwalls): Based on the cost estimates developed for the New West Branch Alternative NWB-2, construction of levees or floodwalls along both banks of the Santa Cruz River was deemed impractical. In addition, all bridge crossing would have to reconstructed and elevated to accommodate the top of any new levee or floodwall. This alternative was not carried forward.

Los Reales (LR):

The Pima County Department of Transportation (PCDOT) and the Flood Control District (FCD) formed the Los Reales Improvement District in 1987 in order to construct a flood-control levee and associated drainage ways. The purpose of this project was to divert flows around the development and dispose of these flood flows either into the Santa Cruz River or into the New West Branch channel. Along the south boundary of this Improvement District, there is a 4 ft high, 1400 ft long floodwall, which extends between the Tohono O'Odham Indian Reservation Boundary and Indian Agency Road. On the west end of this floodwall, there is a partially lined concrete channel that would divert a portion of the flood flows northward into the New West Branch channel. A partially lined concrete channel is aligned along the south edge of the development and diverts all remainder flood flows into the Santa Cruz River approximately opposite Hughes Wash.

Forty-seven (47) structures are affected in the 100-yeat event and 119 structures are affected (primarily from shallow overland flows) in the 500-year event. Total expected annual damages are $107,740. Alternatives evaluated are:

LR-1 Flood Proofing
LR-2 Elevation of Structures

Alternative LR-1 (Flood Proofing): Sixty-six (66) of the existing structures a classified as mobile homes. Dry flood proofing techniques such as flood shields and sealing of exterior walls would not be applicable for mobile homes due to the type of construction and lack of adequate anchoring to a foundation. Therefore, this alternative was not carried forward.

Alternative LR-2 (Elevation): Costs to properly elevate and anchor the residential structures was estimated at $3,187,000. $191,693 is the annualized costs at a 5.625% interest rate. The resulting benefit-to-cost ration is .56 with benefits potentially equaling $107,740; therefore, this alternative is not economically justified.

Evaluation of Erosion Damage Reduction Opportunities:

Erosion Damage Evaluation:

The bank erosion study was limited to the Santa Cruz River. The New West Branch was not studied since its banks are lined with concrete/soil cement. This was the same case for the Los Reales floodplain. The Old West Branch was not studied due to plan formulation constrains that preclude structural channel modifications.

Santa Cruz River Results:

Approximately 70 structures could be affected based on the historic annual erosion rates, in areas without soil cement bank protection. The total annualized expected annual damages for these 70 structures is estimated at $53,193 (see Table 43). At this level of economic damage, an estimated $963,385 project might be economically justified.

Table 43: Present Value and Annualized Damages for Affected Structures

Reach	Present Value	Annualized Damages
SC 2	$671,329	$40,379
SC 4	$82,558	$4,966
SC 5	$130,482	$7,848
Total	$884,370	$53,193

A preliminary lump sum cost estimate for bank protection was previously developed for the Gila River, Santa Cruz River Watershed Pima County, Arizona Final Feasibility Report, dated August 2001. This estimate for bank protection was made based on similar projects on the study area.

Costs for soil cement bank protection assumed a 20-foot bank height and 10-foot toe-down. Major elements include earthwork, borrow material, manufacturing of soil cement, cement materials, handrails, and utility relocations. Lesser items include traffic control, removal of obstructions, clearing/grubbing, and off-site drainage facilities. Typical unit costs for earthwork, manufacturing of soil cement, and cement materials were provided by the Pima County. The initial cost estimate, not including real estate and contingencies, was in excess of $14,960,000. Based on the low EAD value of $56,440 and a resulting benefit-to-cost ratio of $899,820, a soil cement bank protection project would not be economically justified with a B/C ratio at .06.

Environmental Restoration Analysis:

Alternative Development:

In the process of developing the initial array of alternatives for environmental restoration, the importance of water availability became an important factor even in the early stages of alternative development because of scarcity and cost of water. With this is mind, the US Army Corps of Engineers project team developed three broad concepts of restoration that were characterized by xero (low), meso (medium) and hydro (high) riparian water demand. The three riparian concepts (Xeroriparian, Mesoriparian, and Hydroriparian) are described as follows: Xeroriparian communities experience infrequent flows of shorter duration; Mesoriparian communities experience frequent prolonged water flow; and Hydroriparian communities occur where water flows at all, or nearly all times of the year.

These riparian (xero, meso, and hydro riparian) feature groupings are associated with three regions in the geomorphic setting: the active channel, the adjoining terraces, and the historic floodplain. The active channel refers to the area where water flows most frequently and where perennial flow would be found if it existed. The terraces are the adjacent land features, which are elevated only slightly above the active channel. Lower terraces might be flooded by a 2 through 5 year event and the upper terraces would be flooded by a 5 through 10 year event. The historic floodplain is the area adjacent to the entrenched channel of the Santa Cruz River. Although it has been cut off from the river due to down cutting resulting from human activities, in the past this is the area that would have been flooded by infrequent events in the range of 10 year and greater.

Both riparian and geomorphic concepts were combined by associating water needs with geomorphic settings on the premise that different plant community types grow in different regions of geomorphic setting depending on water availability. Xeroriparian would be found in the upper terraces or the historic floodplain. Mesoriparian plants would be found in the lower or upper terraces and Hydroriparian plants are most often found adjacent to the active channel or in the adjoining lower terraces. While diminished flows might lead to drier communities occurring nearing the active channel one would never expect to find Hydroriparian plants in the historic floodplain or to find a drier community near the channel with a wetter one above it at a greater distance from the channel.

Using the concepts of riparian communities and geomorphic setting a matrix of grouped features is created. This matrix is included as Table 44. The matrix allowed initial consideration of every potential combination of feature groups, including no action, to create forty-seven potential alternatives.

Table 44: Alternative Features Matrix

	Active Channel Features	Floodplain Terrace Features	Historic Floodplain Features
No Action* (Without Project) *Listed items are anticipated consequences rather than measures to be implemented as in the other rows.	1. Continued instability of channel due to erosion. 2. Continued refuse dumping. 3. Continued degraded habitat.	1. Continued erosion loss of lower terraces creating cliff-like banks. 2. Eventual application of soil cement on unprotected banks armoring entire reach.	1. With expanded soil cement bank protection, continued historic floodplain encroachment by development.
Xero-Riparian (Establishment & Emergency Irrigation)	1. Construct aquitards upstream of existing and new grade control structures. 2. Divert low flow from New West Branch into remnant headwaters of Old West Branch. 3. Plantings of riparian grasses/shrubs	1. Water harvesting from local runoff. 2. Create tributary aquitard deltas with two-tiered aquitards. 3. Plantings on terraces and aquitards.	1. Amend soil with nutrients, moisture trapping, contouring. 2. Water harvesting from local runoff. 3. Replace steep banks with stabilized planted terraces
Meso-Riparian (Irrigation)	1. Construct and provide supplemental irrigation to aquitards upstream of existing and new grade control structures. 2. Introduce periodic flow into the Old West Branch just upstream of its confluence with the Enchanted Hills Wash and on other tributaries downstream of that point. 3. Plantings of riparian grasses	1. Create tributary single-tiered aquitard deltas. 2. Irrigate and plant terraces with mesquite along upper terrace. 3. Stabilize active channel banks by establishing thickly rooted mesquite at the edge of the lower terraces.	1. Amend soil with nutrients, moisture trapping, contouring. 2. Plant and irrigate historic floodplain. 3. Replace steep banks with stabilized planted terraces
Hydro-Riparian (Perennial Flow With Irrigation)	1. Restore perennial flow with multiple points of distribution into the main Santa Cruz and tributary channels. 2. Plant cottonwood-willow bundles at edges of perennial flow where erosion protection needed. 3. Construct perennial channel features (e.g., pools, runs, and riffles).	1. Create tributary aquitard deltas with hydraulic link to perennial flow. 2. Irrigate and plant low terraces with riparian grasses to maintain flood conveyance and discourage colonization by invasive species. 3. Irrigate and plant upper terraces with mesquite/cottonwood-willow.	Hydro Riparian plants do not occur in areas of the floodplain that are not subject to frequent inundation. Even so, measure 3 from the Mesoriparian floodplain is carried forward to mitigate greater erosion risks associated with increased channel roughness in combinations where "No Action" is paired with Perennial Flow.

Table 45: Alternative Screening

Active Channel	Terraces	Floodplain	Screen Out	Reason
No Action	Xero	Xero	Yes	Fails to provide sufficient habitat diversity
No Action	Xero	Meso	Yes	Not Consistent with Natural Pattern
No Action	Xero	No Action	Yes	Fails to provide sufficient habitat diversity
No Action	Meso	Xero		
No Action	Meso	Meso		
No Action	Meso	No Action	Yes	Fails to provide sufficient habitat diversity
No Action	Hydro	Xero	Yes	Not Consistent with Natural Pattern
No Action	Hydro	Meso	Yes	Not Consistent with Natural Pattern
No Action	Hydro	No Action	Yes	Not Consistent with Natural Pattern
No Action	No Action	Xero	Yes	Fails to provide sufficient habitat diversity
No Action	No Action	Meso	Yes	Fails to provide sufficient habitat diversity
Xero	No Action	No Action	Yes	Fails to provide sufficient habitat diversity
Xero	No Action	Xero	Yes	Fails to provide sufficient habitat diversity
Xero	No Action	Meso	Yes	Not Consistent with Natural Pattern
Xero	Xero	No Action	Yes	Fails to provide sufficient habitat diversity
Xero	Xero	Xero		
Xero	Xero	Meso	Yes	Not Consistent with Natural Pattern
Xero	Meso	No Action	Yes	Not Consistent with Natural Pattern
Xero	Meso	Xero	Yes	Not Consistent with Natural Pattern
Xero	Meso	Meso	Yes	Not Consistent with Natural Pattern
Xero	Hydro	No Action	Yes	Not Consistent with Natural Pattern
Xero	Hydro	Xero	Yes	Not Consistent with Natural Pattern
Xero	Hydro	Meso	Yes	Not Consistent with Natural Pattern
Meso	No Action	No Action	Yes	Fails to provide sufficient habitat diversity
Meso	No Action	Xero	Yes	Not Consistent with Natural Pattern
Meso	No Action	Meso	Yes	Not Consistent with Natural Pattern
Meso	Xero	No Action		
Meso	Xero	Xero		
Meso	Xero	Meso	Yes	Not Consistent with Natural Pattern
Meso	Meso	No Action		
Meso	Meso	Xero		
Meso	Meso	Meso		
Meso	Hydro	No Action	Yes	Not Consistent with Natural Pattern
Meso	Hydro	Xero	Yes	Not Consistent with Natural Pattern
Meso	Hydro	Meso	Yes	Not Consistent with Natural Pattern
Hydro	No Action	No Action		
Hydro	No Action	Xero	Yes	Not Consistent with Natural Pattern
Hydro	No Action	Meso	Yes	Not Consistent with Natural Pattern
Hydro	Xero	No Action		
Hydro	Xero	Xero		
Hydro	Xero	Meso	Yes	Not Consistent with Natural Pattern
Hydro	Meso	No Action	Yes	Too much reduction in conveyence
Hydro	Meso	Xero	Yes	Too much reduction in conveyence
Hydro	Meso	Meso	Yes	Too much reduction in conveyence
Hydro	Hydro	No Action		
Hydro	Hydro	Xero		
Hydro	Hydro	Meso		

Alternative Descriptions:

As can be seen in Table 45, combinations of the four riparian categories with the three geomorphic regions form groups of management measures that designate alternatives. The combinations detailed in Table 45 are labeled with letters in this section for simplicity. The letters used are N for no action, X for Xeroriparian, M for Mesoriparian and H for Hydroriparian. Each letter represents a row from the Alternative Features Matrix with the order of the letter aligned to the columns. For example, alternative HMN would be the result of combining Hydroriparian active channel features and Mesoriparian terrace features with no action in the historic floodplain. A brief description of each alternative remaining after prescreening is provided below. (For more detail, view Table 45 for reasons why thirty-three out of forty-seven possible alternatives were screened out of consideration).

No Action Within Active Channel

Alternatives NNN, NMX, and NMM remain after all combinations were made with no action remaining constant in the active channel. NNN calls for no action in the active channel, no action in the terraces, and no action in the historic floodplain. NMX implements no features in the active channel, a Mesoriparian environment in the terraces, and Xeroriparian features for the historic floodplain. NMM does nothing within the channel but implements Mesoriparian action for both the terraces and historic floodplain.

NNN is considered the no action option and is one of the alternatives required by USACE in order to comply with the requirements of NEPA. No Action assumes that no project would be implemented by the federal government or by local interests to achieve the study area planning objectives. No action also takes into account the future without project condition likely to occur over the period of study. The No Action Plan forms the basis from which all other alternative plans are measured.

NMX and NMM, the two other remaining alternatives with no action in the active channel, represent a departure from the screening criteria. These alternatives are not consistent with natural patterns likely to occur given a Mesoriparian environment in the terraces because one would normally find a Hydoriparian or Mesoriparian plant community in the active channel if flow were frequent enough to support a Mesoriparian community on the terraces. However, they remain within consideration because of the need to avoid unacceptable reductions in flood conveyance. By leaving the active channel undisturbed, this has the least possible impact to conveyance.

Common features of both alternatives include:

1. The construction and planting of aquitards at the confluences of 13 tributaries. The aquitard features would involve excavating in the area where the tributaries enter the terraces. Excavation would be to a depth of approximately four feet, a liner membrane would be laid, and the excavated area would be filled with layers of appropriately sized gravel covered with granular fill.

2. The implementation of a permanent irrigation system for Mesoriparian areas. Permanent irrigation would combine construction of feeder pipelines to move water through the project area with use of open channels and level spreaders to distribute water at specific locations. In some cases, such as the tributary aquitards, a simple outflow would be sufficient.

3. The installation of temporary irrigation for Xeroriparian areas and stabilized terraces in areas with steep unprotected banks.

4. The amendment of soil would be common to both Mesoriparian and Xeroriparian areas with the latter having additional surface treatments to improve the grounds ability to concentrate rainfall.

5. The cutting back into the historic floodplain would create gentler and more stabile slopes and would modify reaches of steep natural banks. The method of stabilization would be a function of the amount of land available for the new terrace area. Where available land is not a constraint banks will be graded at a 5-foot horizontal to 1-foot vertical slope and planted. Vegetated slopes of this grade are considered stable. A different treatment will be used in areas where there is not enough land to create a 5:1 slope but sufficient space exists to create slopes between 5:1 and 2:1. In those cases the banks will be laid back to the minimum slope that can be fit into the available space. These slopes will also be vegetated however; a geotextile layer will be installed prior to planting to ensure slope stability. In areas where insufficient space exists to accommodate 2:1 slopes placement of rip rap or soil cement may be necessary for bank protection. Such applications will be decided on a case-by-case basis.

6. The restoration or enhancement of 1,119 acres of habitat. Xeroriparian Shrub (Shrub-Scrub) and Mesquite with a few small pockets of Cottonwood-Willow dominate both NMX and NMM. NMX is comprised of 693 acres of Xeroriparian Shrub, 416 acres of Mesquite and ten acres of Cottonwood-Willow. In NMM the addition of irrigation to the historic floodplain reverses the dominant Xeroriparian plants producing 638 acres of Mesquite, 471 acres of Shrub-Scrub and 10 acres of Cottonwood-Willow.

A difference between NMM and NMX is that for NMX there is no permanent irrigation in the historic floodplain. Two features added to compensate for this are the addition efforts at surface treatment and the creation of a number of shallow depressions to concentrate local run-off.

Xeroriparian Within Active Channel

One alternative including Xeroriparian features in the active channel was carried forward. This alternative, XXX, pairs Xeroriparian channel features with Xeroriparian restorations on the terraces and in the historic floodplain.

Features of alternative include:

1. The construction of a low flow diversion to direct water from the New West Branch back into the Old West Branch.

2. The construction of aquitards on the upstream side of six existing grade structures. The implementation of aquitard features would involve excavating upstream of each grade control structure to a depth of approximately four feet, placing a liner membrane, and filling the excavated area with layers of appropriately sized gravel covered with granular fill. The areas would be seeded with riparian grasses and would be maintained as emergent marsh with larger shrubs or medium sized trees periodically cut back to preclude significant impacts on flood flows. The aquitards would be expanded in size since, without irrigation, plants would be much more dependent on water harvesting.

3. The diversion of low flows would be accomplished by placing a diversions structure in the New West Branch channel to pond low flows through the bank to the newly excavated reach of channel between the NWB bank and remaining OWB channel.

4. The soil amendment of terrace and floodplain areas would include finish grading to provide micro-topography suitable for concentration of rainfall along with placement of rocks and coarse woody debris to facilitate moisture retention and provide sun and wind shade. Also, the off channel areas to concentrate local runoff would be created in the floodplain.

5. The restoration of 1,125 acres of habitat. It is dominated by 867 acres of Xeroriparian shrub (Shrub-Scrub) with 252 acres of Mesquite and 6 acres of Emergent Marsh (riverbottom).

Mesoriparian Within Active Channel

Five alternatives including Mesoriparian features in the active channel were carried forward. Each of these alternatives places Mesoriparian measures in the channel in combination with terrace and floodplain measures described above. They are MXN, MMN, MXX, MMX, and MMM.

Two of the five Mesoriparian channel alternatives (MXN and MMN) have Mesoriparian habitat within the channel and no restoration in the historic floodplain. The difference is the treatment of the terraces. One plan calls for Xeroriparian while the other calls for Mesoriparian restoration treatment for the terraces. Both plans produce only 199 acres of restored or enhance habitat. MXN restores or enhances 6 acres of Emergent Marsh, 174 acres of Xeroriparian Shrub and 19 acres of Mesquite while MMN restores the same 6 acres of Emergent Marsh with the remaining 193 acres consisting of Mesquite.

The other three alternatives (MXX, MMX and MMM) have Mesoriparian restoration within the channel for all three plans while two plans have Xeroriparian treatment in the floodplain and two plans have Mesoriparian improvements along the terraces. One plan has Mesoriparian areas in the floodplain while the remaining plan has Xeroriparian treatment along the terraces. All three plans produce 1,125 acres of restored or enhanced habitat. Alternative MXX is dominated by 862 acres of Xeroriparian Shrub with 257 acres of Mesquite and 6 acres of Emergent Marsh. MMX is predominantly Xeroriparian Shrub at 688 acres with 421 acres of Mesquite, 10 acres of Cottonwood-Willow and 6 acres of Emergent Marsh, MMM continues the trend with Mesquite becoming dominant at 643 acres, 466 acres of Xeroriparian Shrub, 10 acres of Cottonwood-Willow and 6 acres of Emergent Marsh.

The major changes in channel features from the one outlined for the Xeroriparian alternatives consists of deletion of the diversion to the Old West Branch since irrigation reduces the need to establish this link; introduction of irrigation water into the lower reach of the Old West Branch and irrigation of the grade control aquitards. The irrigation would not be constant but would consist of adding water to extend the flow period following natural events. In this way the volume and duration of flow in these areas would be increased to mimic Mesoriparian conditions.

Hydroriparian Within the Active Channel

Six alternatives including Hydroriparian features in the active channel were carried forward. Three of the six alternatives (HNN, HXN and HHN) involve no action in the historic floodplain. The differences occur in the treatment of the terraces. One plan calls for no action, the second plan calls for Xeroriparian, and the third plan calls for Hydroriparian restoration in the terraces. HNN produces 319 restored acres with 122 acres of Mesquite, 69 acres of Cottonwood-Willow, 69 acres of Riparian Shrub and 59 acres of Emergent Marsh. HXN produces 507 restored or enhanced acres with 243 acres of Riparian Shrub, 136 acres of Mesquite, 69 acres of Cottonwood-Willow and 59 acres of Emergent Marsh. HHN produces 487 restored or enhanced acres with 181 acres of Riparian Shrub, 168 acres of Mesquite, 79 acres of Cottonwood-Willow and 59 acres of Emergent Marsh. The other three alternatives are HXX, HHX and HHM. Three use Xeroriparian treatment in the floodplain while one uses Mesoriparian treatment. Two apply restoration of the terraces by Xeroriparian treatment and two by Hydroriparian treatment. HXX produces 1247 restored acres with 867 acres of Riparian Shrub, 253 acres of Mesquite, 69 acres of Cottonwood-Willow and 59 acres of Emergent Marsh. HHX produces 1227 restored or enhanced acres with 805 acres of Riparian Shrub, 284 acres of Mesquite, 79 acres of Cottonwood-Willow and 59 acres of Emergent Marsh. HHM produces 1227 restored or enhanced acres with 577 acres of Riparian Shrub, 512 acres of Mesquite, 79 acres of Cottonwood-Willow and 59 acres of Emergent Marsh.

Implementation of these alternatives involves replacing the channel features with a perennial flow channel. It would require grading the active create low flow averaging six feet in width and one-half foot in depth. Grading would also create depress ional areas on each side of the low flow channel about ten feet in width where soil saturation conditions resulting from infiltration would be conducive to Emergent Marsh. Finally, a band of Cottonwood-Willow varying in width from ten to twenty feet would be positioned adjacent to the emergent marsh to further utilize infiltrating water from the perennial channel.

Because of the conveyance impacts that would result from the creation of perennial flows, terrace features are limited to either Xeroriparian or Hydroriparian. In the Xeroriparian terrace features, both upper and lower level terraces would include finish grading to provide microtopography suitable for concentration of rainfall along with placement of rocks and coarse woody debris to facilitate moisture retention and provide sun and wind shade. In the Hydroriparian terrace features, the upper level terraces are irrigated and planted with Mesquite and pockets of Ccottonwood-Willow. The lower terraces would be planted with riparian grasses and would be maintained as Xeroriparian Shrub with larger shrubs or medium sized trees periodically cut back to retain cross-sectional area for conveyance of larger flood flows.

Finally, the alternatives including no action in the historic floodplain include the stabilized terraces described for the Xeroriparian and Mesoriparian floodplain. While this measure produces significant restoration benefits, it is carried forward her to mitigate greater erosion risks associated with increased channel roughness.

HGM With Project Condition:

With the general trends of the without project condition (i.e. the no action alternative) in mind, the Biological Team developed acreage and variable projections for the fourteen alternatives proposed by the US Army Corps of Engineers, Los Angeles District. When possible, the Team offered suggestions to enhance the alternatives given the goals and objectives developed earlier in the process. As a general rule, the biological team assumed that much of the land made for the project would be converted to productive riparian settings, and the existing Cottonwood and Mesquite would diminish from urban development. Alternatives that incorporated the deployment of detention basins as well as those alternatives that opted for a vegetative watercourse were assumed to have high habitat quality. Regardless of the manner in which it was achieved, the biological team assumed vegetative growth, and the health of wildlife. The biological team also attempted to capture the vegetative succession of this area in increments over time (low quality early in the life of the project, and higher quality later in the life of the project). By restoring, developing, and protecting these areas, the Biological Team assumed the habitat would be buffered from human disturbance factors, thereby improving the overall value of the habitat in the urban setting.

Overall HGM Results:

The overall HGM results per alternative are summarized in Table 46. The results show that alternative HHM (519 AAFCUs)(the restoration alternative calls for Hydroriparian approach in the active channel and in the floodplain terraces and Mesoriparian approaches deployed in the historic floodplain) produced the highest net AAFCUs across the suite of functions. The second and third highest alternatives were HXX (491 AAFCUs) (the restoration alternative calls for Hydroriparian approaches in the active channel and Xeroriparian approach deployed in the floodplain terraces and historic floodplain) and HHX (490 AAFCUs)(the restoration alternative calls for Hydroriparian approaches in the active channel and floodplain terraces and Xeroriparian approach deployed in the historic floodplain). The least productive alternatives were MMN (the restoration alternative calls for Mesoriparian approaches in the active channel and floodplain terraces and no action being taken in the historic floodplain and MXN (the restoration alternative calls for Mesoriparian approach taken in the active channel, Xeroriparian approach deployed in the floodplain terraces, and no action being taken in the historic floodplain. Both least productive alternatives generated 115 and 62 AAFCUs respectively) across the functions evaluated. No alternative resulted in a loss of functionality in the assessment.

Table 46: Alternatives and Average Net AAFCUs

			NET AAFCUs									
			WATER				BIOGEOCHEM			HABITAT		
Alternative Description	Alternative Code	Average Net AAFCUs	FXN 1: CHANNELDYN	FXN 2: WATSTORENR	FXN 3: WATSTORLNG	FXN 4: WATSTORSUB	FXN 5: NUTRIENT	FXN 6: ELEMENTS	FXN 7: DETPARTICL	FXN 8: PLANTS	FXN 9: HABSTRUCT	FXN 10: INTERSPERS
Locations of Activity are	N-M-X	406	527	841	363	211	571	566	603	110	132	137
reported in following	N-M-M	451	703	896	457	320	464	550	721	112	143	149
order:[1]	X-X-X	402	524	836	358	206	579	562	600	109	121	122
1. Active Channel	M-X-N	62	67	114	46	25	115	96	79	26	28	23
Treatment	M-X-X	375	406	810	297	130	670	581	523	103	115	115
2. Floodplain Terrace	M-M-N	115	209	189	129	112	69	112	186	39	54	47
Treatment	M-M-X	409	537	849	369	216	586	569	611	105	125	126
3. Historic Floodplain Treatment	M-M-M	454	713	903	462	326	474	554	728	107	136	138
	H-N-N	155	233	198	165	160	181	178	198	77	91	64
Codes for Selected	H-X-N	188	262	273	164	166	249	233	217	105	124	86
Measures Per Location:	H-X-X	491	473	821	358	210	740	634	560	344	399	372
N = No Action in the	H-H-N	194	284	260	201	187	211	217	249	105	128	96
Location	H-H-X	490	496	812	371	231	706	620	570	353	386	360
X = Xero-Riparian Activities in the Location[2] M = Meso-Riparian Activites in the Location[3] H = Hydro-Riparian Activitites in the Location[4]	H-H-M	519	676	868	467	344	592	604	690	294	340	318

Table 47: Average Net AAFCUs and HGM Ranking

Alternative Description	Alternative Code	Average Net AAFCUs	HGM Ranking
	N-M-X	406	7
	N-M-M	451	5
	X-X-X	402	8
	M-X-N	62	14
Locations of Activity are reported in following order:[1]	M-X-X	375	9
1. Active Channel Treatment 2. Floodplain Terrace Treatment 3. Historic Floodplain Treatment	M-M-N	115	13
	M-M-X	409	6
Codes for Selected Measures Per Location: N = No Action in the Location X = Xero-Riparian Activities in the Location[2]	M-M-M	454	4
M = Meso-Riparian Activites in the Location[3] H = Hydro-Riparian Activitites in the Location[4]	H-N-N	155	12
	H-X-N	188	11
	H-X-X	491	2
	H-H-N	194	10
	H-H-X	490	3
	H-H-M	519	1

Costs:

Cost Engineering provided cost estimates for each alternative. These estimates incorporate all costs associated with each alternative and will be used to perform the incremental cost analysis and to select recommended plans for the Paseo de las Iglesias study area.

Table 48: Costs by Alternative

		NMX	NMM	XXX	MXN	MXX	MMN	MMX	MMM	HNN	HXN	HXX	HHN	HHX	HHM
First Cost															
Construction Costs		$34,957,246	$39,745,057	$28,191,262	$9,806,378	$35,384,625	$9,075,675	$34,012,721	$39,926,981	$24,308,004	$24,259,102	$40,104,369	$34,573,054	$45,159,929	$43,258,505
Real Estate Costs		$14,740,828	$14,740,828	$14,687,660	$2,379,268	$14,687,660	$2,432,436	$14,740,828	$14,740,828	$2,286,224	$4,785,120	$14,873,748	$4,638,908	$14,342,068	$14,342,068
Contingency	25%	$12,424,518	$13,621,471	$10,719,731	$3,046,412	$12,518,071	$2,877,028	$12,188,387	$13,666,952	$6,648,557	$7,261,056	$13,744,529	$9,802,990	$14,875,499	$14,400,143
Planning, Survey, Engineering and Design	10%	$3,495,725	$3,974,506	$2,819,126	$980,638	$3,538,462	$907,567	$3,401,272	$3,992,698	$2,430,800	$2,425,910	$4,010,437	$3,457,305	$4,515,993	$4,325,850
Engineering During Construction	1%	$349,572	$397,451	$281,913	$98,064	$353,846	$90,757	$340,127	$399,270	$243,080	$242,591	$401,044	$345,731	$451,599	$432,585
Supervision and Administration	6.5%	$2,272,221	$2,583,429	$1,832,432	$637,415	$2,300,001	$589,919	$2,210,827	$2,595,254	$1,580,020	$1,576,842	$2,606,784	$2,247,249	$2,935,395	$2,811,803
Adaptive Management	3%	$1,048,717	$1,192,352	$845,738	$294,191	$1,061,539	$272,270	$1,020,382	$1,197,809	$729,240	$727,773	$1,203,131	$1,037,192	$1,354,798	$1,297,755
Total First Costs		$69,288,827	$76,255,092	$59,377,862	$17,242,365	$69,844,204	$16,245,652	$67,914,545	$76,519,793	$38,225,926	$41,278,394	$76,944,042	$56,102,428	$83,635,282	$80,868,710
IDC		$3,765,634	$4,144,229	$3,227,004	$937,069	$3,795,817	$882,901	$3,690,946	$4,158,615	$2,077,461	$2,243,353	$4,181,671	$3,048,994	$4,545,320	$4,394,965
Gross Investment		$73,054,462	$80,399,322	$62,604,865	$18,179,435	$73,640,021	$17,128,553	$71,605,491	$80,678,407	$40,303,387	$43,521,747	$81,125,713	$59,151,422	$88,180,602	$85,263,675
Average Annual Cost		$4,394,110	$4,835,892	$3,765,583	$1,093,464	$4,429,331	$1,030,255	$4,306,957	$4,852,678	$2,424,185	$2,617,764	$4,879,583	$3,557,864	$5,303,923	$5,128,475
O&M															
Annual O&M		$549,915	$550,619	$87,495	$97,737	$152,371	$528,826	$583,460	$559,016	$887,500	$847,357	$942,252	$1,007,112	$1,074,122	$1,308,294
Periodic O&M		$343,948	$338,131	$341,023	$135,173	$341,023	$107,578	$313,427	$307,610	$308,886	$428,928	$434,745	$350,315	$356,132	$350,315
Total O&M		$893,863	$888,749	$428,518	$232,910	$493,394	$636,403	$896,887	$866,625	$1,196,386	$1,276,285	$1,376,997	$1,357,426	$1,430,254	$1,658,608
Total Average Annual Cost		$5,287,973	$5,724,641	$4,194,101	$1,326,375	$4,922,724	$1,666,659	$5,203,844	$5,719,304	$3,620,570	$3,894,049	$6,256,580	$4,915,291	$6,734,177	$6,787,083
Average Annual FCUs		406.00	451.00	402.00	62.00	375.00	115.00	409.00	454.00	155.00	188.00	491.00	194.00	490.00	519.00

Incremental Cost Analysis (ICA) Overview:

IWR-Plan uses two techniques address the question: is the alternative worth it in the cost evaluation process? First, the results of the habitat assessment were compared using Cost Effectiveness Analysis (CEA). When comparing alternatives using CEA, those alternatives that produce increased levels of output (AAFCUs) for the same or lesser costs were considered "effective" solutions and were retained. These alternatives were, in turn, compared on the basis of cost efficiency (i.e. those alternatives that produce similar levels of output (AAFCUs at a lesser expense). The "efficient" solutions were submitted to Incremental Cost Analysis (ICA) (i.e. determining changes in costs for increasing levels of outputs). Once evaluated, through a computer program called IWR-Plan, on the basis of cost effectiveness and incremental cost analysis, the best buy solutions were revealed (those that are both cost effective and incrementally effective).

Final Array of Alternatives (1st Run):

The results of the 1st ICA run are displayed in the Table below along with rankings of average cost (annual costs per AAFCU) and HGM: The top average cost alternative and incrementally effective and efficient solution evaluated was XXX. The second ranked average cost and cost effective plan was MMM; however, MMM did not come out as a best buy. The third ranked average cost plan was not cost efficient and effective as shown in the CEA ranking and did not rank as a best buy plan.

Table 49: Average Cost, ICA and HGM Rankings

Total Average Annual Cost	Average Cost	Cost Effectiveness Analysis (CEA) Ranked by Average Cost	ICA Ranking	HGM Ranking	Alternative	Average Net AAFCUs	Average Annual Cost	Average Cost (Cost Per AAFCU)
1	12	8		14	MXN	62	$1,326,375	$21,393
2	10	6		13	MMN	115	$1,666,659	$14,492
3	13	9		12	HNN	155	$3,620,570	$23,358
4	11	7		11	HXN	188	$3,894,049	$20,713
5	1	1	1	8	XXX	402	$4,194,101	$10,433
6	14			10	HHN	194	$4,915,291	$25,336
7	8			9	MXX	375	$4,922,724	$13,127
8	4	3		6	MMX	409	$5,203,844	$12,723
9	6			7	NMX	406	$5,287,973	$13,024
10	2	2		4	MMM	454	$5,719,304	$12,597
11	3			5	NMM	451	$5,724,641	$12,693
12	5	4		2	HXX	491	$6,256,580	$12,742
13	9			3	HHX	490	$6,734,177	$13,743
14	7	5	2	1	HHM	519	$6,787,083	$13,077

A detailed breakdown of the ICA results is listed below in Table 50.

Table 50: Final Incremental Cost Analysis Results

Alt.	AAFCUs	Annual Cost	Average Cost	Incremental Cost	Incremental Output	Incremental Avg. Cost
XXX	402	$4,194,101	$10,433	$4,194,101	402	10,433
HHM	519	$6,787,083	$13,077	$2,602,982	117	22,247

Figure 2: Final Incremental Cost Results For Paseo de Las Iglesias (Incremental Average Cost by Incremental Output)

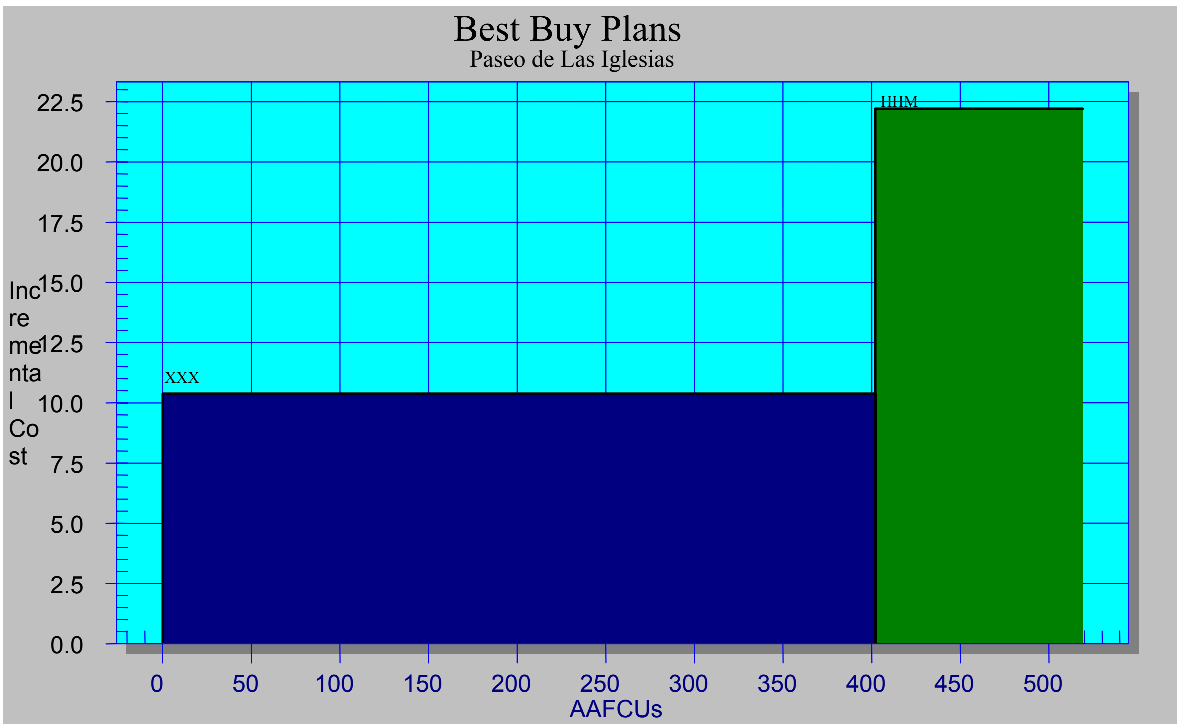
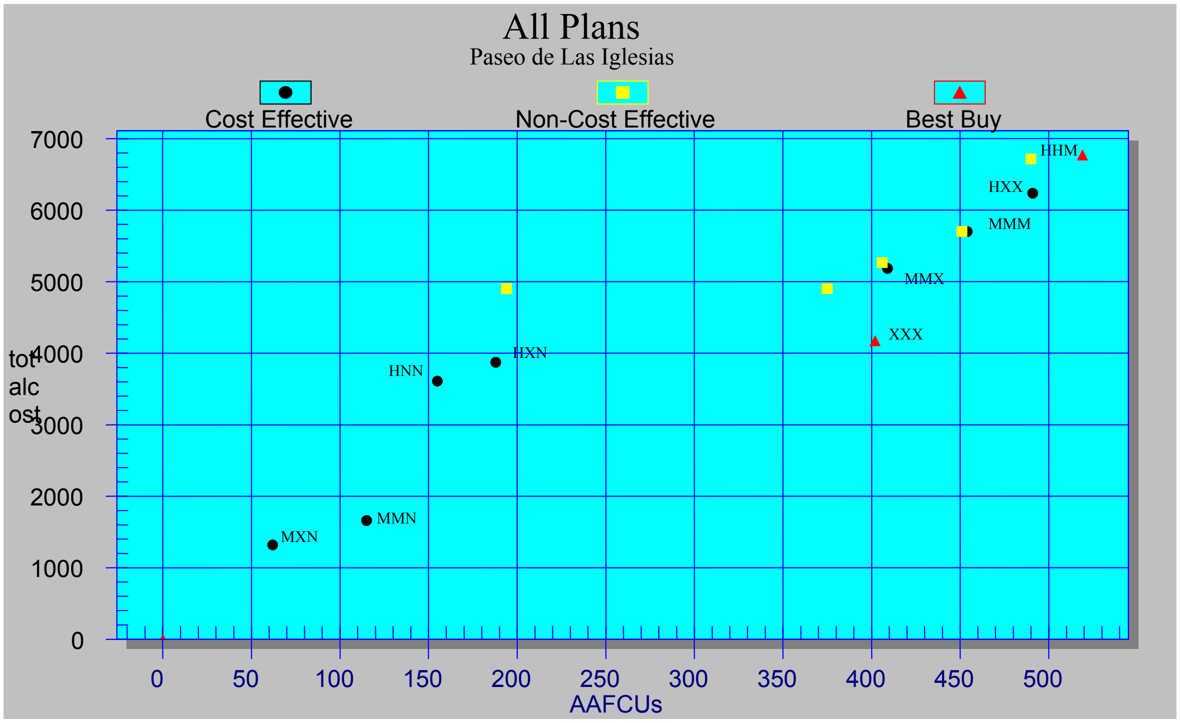


Figure 3: All Plans Differentiated
(CEA Plans and Best Buy Plans Labeled)



The incremental cost analysis indicates that alternatives listed in Table 45 are cost efficient and cost effective. Of the best buy plans, XXX is the least costly to build at $4,194,101 but also produces the least amount of AAFCUs (402) at $10,433 per AAFCU. HHM will cost an additional $2,602,982 on an average annual basis and produce 117 additional AAFCUs for an incremental cost of $22,247 on an average annual basis per additional AAFCU. This means HHM can be implemented for only 117 more units but the incremental cost per additional incremental AAFCU will be 100% greater than XXX at $10,433.

XXX has the least average cost, is the ICA best buy and is cost effective. It produces 402 AAFCUs and is ranked 8th place in the HGM. XXX's rates 5th overall in total average annual cost. On the other hand, HHM is the largest plan at 14th place overall in total average annual cost. It is 7th place in average cost and 5th place in cost effective analysis. It is the second best buy plan and the biggest most expensive plan. It will always end up on the final ICA list of best buy plans. It is not necessarily a good buy but is simply an end point. HHM provides 117 extra AAFCUs but at double the incremental cost of XXX and a first cost of more than 20 million more than XXX.

Upon further evaluation, a quantified water constraint was applied. This would eliminate all the Hyrdoriparian alternatives from consideration and thereby remove one of the best buy alternatives from the 1st run. The reason the initial evaluation included all the alternatives is: an array of possibilities needed to be fully developed and established to better know what important elements should remain and what elements should be excluded from further analysis.

Final Array of Alternatives (2nd Run):

The results of the 2nd ICA run are displayed in the Table below along with rankings of average cost (annual costs per AAFCU) and HGM: The top average cost alternative and incrementally effective and efficient solution evaluated was XXX. The second ranked average cost and cost effective plan was MMM; it also came out as a best buy. The third ranked average cost plan was not cost efficient and effective as shown in the CEA ranking and did not rank as a best buy plan.

Table 49: Average Cost, ICA and HGM Rankings

Total Average Annual Cost	Average Cost	Cost Effectiveness Analysis (CEA) Ranked by Average Cost	ICA Ranking	HGM Ranking	Alternative	Average Net AAFCUs	Average Annual Cost	Average Cost (Cost Per AAFCU)
1	8	5		8	MXN	62	$1,326,375	$21,393
2	7	4		7	MMN	115	$1,666,659	$14,492
3	1	1	1	5	XXX	402	$4,194,101	$10,433
4	6			6	MXX	375	$4,922,724	$13,127
5	4	3		3	MMX	409	$5,203,844	$12,723
6	5			4	NMX	406	$5,287,973	$13,024
7	2	2	2	1	MMM	454	$5,719,304	$12,597
8	3			2	NMM	451	$5,724,641	$12,693

A detailed breakdown of the ICA results is listed below in Table 50.

Table 50: Final Incremental Cost Analysis Results

Alt.	AAFCUs	Annual Cost	Average Cost	Incremental Cost	Incremental Output	Incremental Avg. Cost
XXX	402	$4,194,101	$10,433	$4,194,101	402	10,433
MMM	454	$5,719,304	$12,597	$1,525,203	52	29,330

Figure 2: Final Incremental Cost Results For Paseo de Las Iglesias
(Incremental Average Cost by Incremental Output)

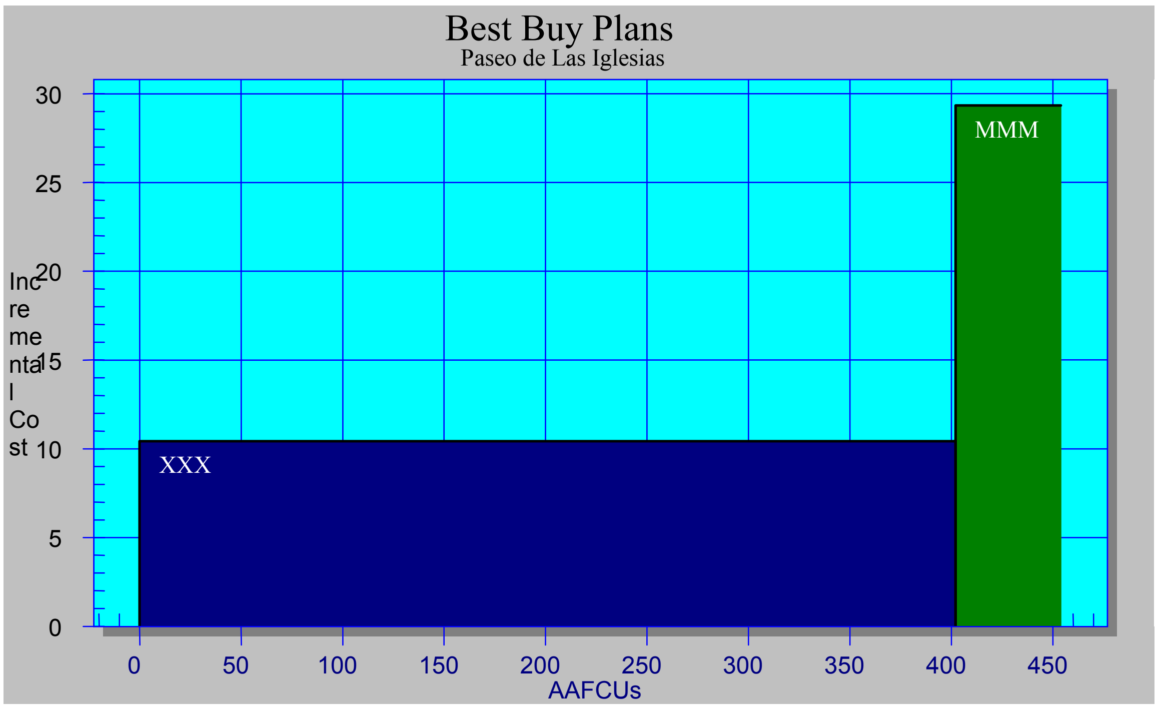
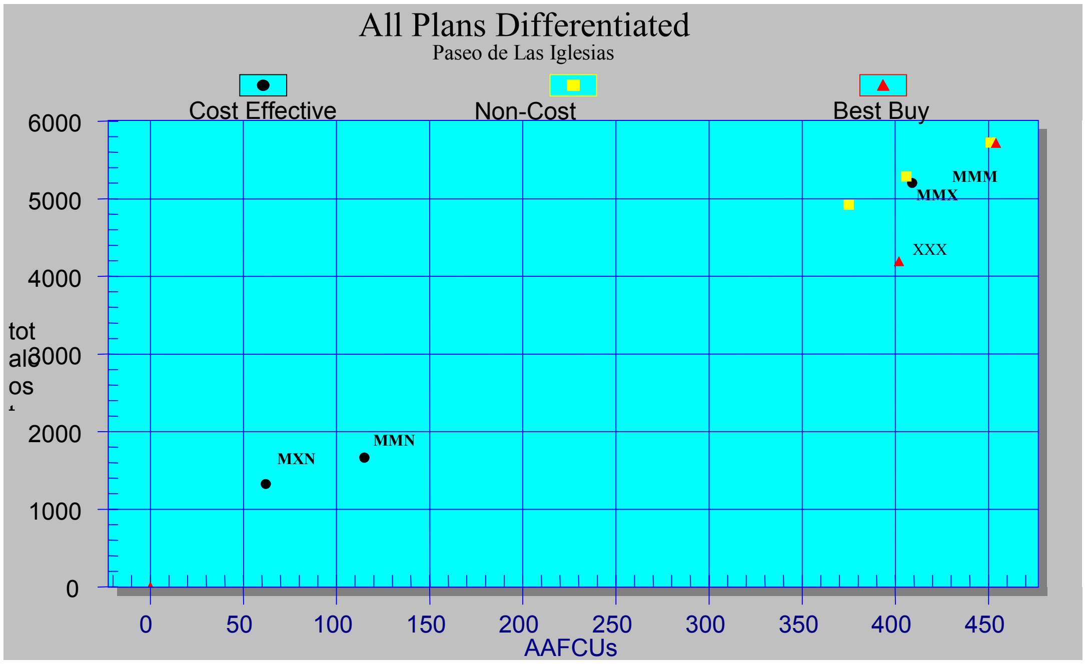


Figure 3: All Plans Differentiated
(CEA Plans and Best Buy Plans Labeled)



The incremental cost analysis indicates that alternatives listed in Table 50 are cost efficient and cost effective. Of the best buy plans, XXX is the least costly to build at $4,194,101 but also produces the least amount of AAFCUs (402) at $10,433 per AAFCU. MMM will cost an additional $1,525,203 on an average annual basis and produce 52 additional AAFCUs for an incremental cost of $29,330 on an average annual basis per additional AAFCU. This means MMM can be implemented for an additional 52 more units but the incremental cost per additional incremental AAFCU will be 300% greater than XXX at $10,433.

XXX has the least average cost, is the ICA best buy and is cost effective. It produces 402 AAFCUs and is ranked 8th place in the HGM. XXX's rates 5th overall in total average annual cost. On the other hand, MMM is one of the largest plans at 7th place overall in total average annual cost. It is 2nd place in average cost and 2nd place in cost effective analysis. It is the second best buy plan and the biggest most expensive plan. It will always end up on the final ICA list of best buy plans. It is not necessarily a good buy but is simply an end point. MMM provides 52 extra AAFCUs but at triple the incremental cost of XXX and a first cost of more than 17 million more than XXX.

The following presents summary results from MCACES level cost estimates for the Recommended Plan. These costs are not directly comparable to the preliminary cost estimates included in the Incremental Cost Analysis, since they have been refined and include additional items not included in the preliminary estimates.

Table 51: MCACES for Alternative MMM

Benefits	
First Cost	
Construction & Real Estate	$72,828,371
Construction Costs	$46,586,265
Real Estate Costs	$26,242,106
Contingency	$6,987,940
PED	$4,658,627
Eng. During Construction	$465,863
Construction Mgmt	$3,482,323
Adaptive Mgmt	$1,870,205
Monitoring	$623,304
Total First Costs	$90,916,632
IDC	$4,941,039
Gross Investment	$95,857,671
Average Annual Costs	$5,765,687
OMRRR	$1,869,961
Total Average Annual	$7,414,600

Recreation Analysis:

As mentioned earlier in the Santa Cruz River Park subsection of the Recreation Analysis section under without project conditions in this report, the Santa Cruz River Park already exists. It runs along the Santa Cruz River in two segments. One segment is from Silverlake to Grant Road while the second segment runs from Irvington road to Ajo Way. The park facilities include: pedestrian and bicycle trails, a Frisbee golf course, exercise courses, restrooms, drinking fountains, ramadas, picnic sites, BBQ grills, playgrounds, parking and art projects.

Any proposed plan to promote recreation within the already established park area would be minimal when compared to the larger environmental restoration project because there will undoubtedly be impacts upon the environment. Whenever the encroachment of humans is involved in the form of recreation adverse impact may result especially to a newly developed environment. However, these impacts can be minimized in ways that promote environmental ecosystems and still promote human interaction with nature. Special care must be taken to insure that the nature habitat and character of the restored area is preserved while still allowing appropriate recreational activities to occur.

These are considerations that have to be met when formulating recreation opportunities. They have been considered greatly and at this juncture in the study process a recreation plan has been developed around the restoration features of the tentatively selected NER plan.

Recreation Improvements:

Even though the Santa Cruz River Park already exists along the Santa Cruz River, some changes can be made to the park to increase recreation value and perhaps visitation along the River. Decomposed granite (DG) and parking serve a recreation purpose by providing opportunities to a variety of recreational users. Signs interpret the environment thereby enhancing recreation experience of the user. Comfort stations, rest stops, and benches serve the basic needs of the recreational user. Other changes to the park can serve the ecosystem restoration purpose by reducing safety and maintenance concerns stemming from the project. All road segments and ramps designated as maintenance provide access to areas in case of emergencies such as flooding and fire. Access will also provide a means to maintain vegetation in the newly restored area and park facilities. Warning signs are also added to direct pedestrians off the newly restored area and basically guide pedestrians away from any potential danger.

Table 27 below shows how changes made to the park have been separated by purpose. The changes separated into the recreation purpose will be discussed in detail in this section while changes separated into the ecosystem purpose will be added to the restoration cost of the project and no longer discussed within this section.

Table 52: Allocation of Features

Recreation	Ecosystem Restoration
DG Trail North Bank	Compacted Earth Road (Infrequent Use)
Comfort Stations	Gravel Road (Frequent Use)
Rest Stops	Paved Road (Maintenance Road)
Concrete Benches	Bridges
Signage	
Parking	

Unit Day Value Method:

With the recreation improvements identified and described above, the unit day value (method described in the recreation component of this report under the without project condition) can be derived by selecting point values for recreation criteria and with the input of the US Army Corps of Engineers, LA District and local government agencies. These values are then applied to projected visitation. Because visitation figures have already been adjusted for double counting and projected over fifty years using a relationship to projected population growth, they will be used as a basis. But, further adjustments will be made to account for changes in visitation due to the construction of the project. These adjusted visitation figures will again be compared to capacity limits established by the National Recreation Parks Association.

The recreation criteria described in the Recreation Demand Section of this report remain the same for the with project condition. The only changes will include impacts of the proposed recreation improvements along the Santa Cruz River. They include:

1. ***Recreation Experience***--*S*ame as Without Project Condition
2. ***Availability of Opportunity***--*S*ame as Without Project Condition
3. ***Carrying Capacity***--As previously discussed, Pima County will experience rapid population growth. To accommodate this increase in population additional parking lots, along with areas three comfort stations and twenty benches are being proposed for the Rillito River Park. DG multipurpose trail segments will also enhance carrying capacity along the Santa Cruz River. These proposed facilities would allow for future population growth.
4. ***Accessibility***--Same as without project
5. ***Environmental***--*S*ince there is no significant thriving riparian areas located in the study area, the restoration of the Santa Cruz River would prove to be a highly valued recreational area. Visitors could recreate near a thriving habitat for plants and animals. Restoration of this area could mean some of the significant unmet recreational demand for riparian areas could be met. Restoration features would also create more passive opportunities for wildlife viewing, aesthetic experience, and education. Recreational trails, signs, and access will be located so as to allow for recreation activities in such a way as to discourage interference and recreation in habitat areas.

Point values for the five recreation criteria listed above are estimated for the proposed Rillito River Park features.

Table 53: Point Values for Without Project Conditions
Paseo de las Iglesias

Recreation Criteria	Value Range	Point Values Without Project	Point Values With Project
Recreation Experience	0-30	8	8
Availability of Opportunity	0-18	3	3
Carrying Capacity	0-14	6	10
Accessibility	0-18	8	8
Environmental	0-21	2	12
Total		27	41

The point values described above are totaled and converted into an equivalent UDV amount. The total point value for Santa Cruz River Park is 41 for the five recreational criteria. The equivalent UDV amount for 41 points is $5.71. This UDV amount represents how much a visit to the park is worth in dollar amount for the with project condition.

Projected Visitation:

To calculate the recreational value for with project conditions, the UDV is multiplied by projected annual visitation. Projected annual visitation includes anticipated increases in visitation due to the addition increases to carrying capacity and the changes in the environmental experience. Projected visitation also includes additional visits due to the improvements, population growth, and the Paseo de las Iglesias restoration.

Table 54: Projected Visitation
Santa Cruz River Park Extension

Location	Original 2001	Half + Adjustment 2001	2012	2020	2030	2040	2050	2060	2062
Visitors (OneBank)	18,312	24,812	28,697	29,681	35,131	40,371	45,039	49,260	52,921
Annual Growth Rate			1.021	1.017	1.017	1.014	1.011	1.009	1.009

Recreation Value:

To calculate the recreational value for with project conditions, the UDV is multiplied by annual visitation. The product of the UDV and average annual visitations over 50 years can be seen in the below table.

Table 55: Projected Recreation Value
Santa Cruz River Park Extension

Location	2008	2010	2020	2030	2040	2050	2058
Recreation Value (One Bank)	$163,718	$169,332	$200,424	$230,318	$256,945	$281,029	$301,913

The stream of recreation values over 50 years was discounted (NPV = $3,199,450) for Santa Cruz River Park Extension. Annualized recreation value is $182,193 for one bank of the Santa Cruz River Park. The other bank is approximately $163,973 for a total of $346,166. Benefits equal $135,484 for the Santa Cruz River Park.

Costs:

The US Army Corps of Engineers, Los Angeles District prepared cost estimates for the recreation project improvements.

Table 56: Recreation Plan
Santa Cruz River Park Extension

Improvements	Quantity	Description	Cost
DG Trail	255,249 Sq. Ft.	Decomposed Granite Path	$135,281.78
Comfort Stations	2 Stations	One rest room every two miles	$110,000.00
Rest Stops	5 Stops	Rest areas at 1 per mile	$99,700.00
Concrete Benches	20 Benches	Benches at 1 per quarter mile	$2,400.00
Signage	10 Signs	Signs at 1 per half mile	$777.50
Parking	5 Parking Lots	5 lots along the Santa Cruz	$67,072.20
Total			$415,231.00

The following presents summary results from cost estimates for the Recreation Plan. These costs are based on MCACES cost estimates. When are refined cost estimates and may have additional costs included within the estimate. MCACES are not directly comparable to the preliminary cost estimates.

Table 57: Summary of Benefits and MCACES

Recreation Value	
Recreation Value W/O	$210,682
Recreation Value W	$314,648
Total Benefits	$135,484
First Cost	
Construction & Real Estate	$854,566
Construction Costs	$854566
Real Estate Costs	$0
Contingency	$128,185
PED	$85,457
Eng. During Construction	$9,828
Construction Mgmt	$63,879
Total First Costs	$1,141,914
Interest During Construction	$13,123
Gross Investment	$1,155,037
Average Annual Costs	$69,474
OMRRR	$36,260
Total Average Annual Costs	$105,074
B/C	1.29
Net Benefits	$30,410

US Army Corps of Engineers Guidance (PGL 36) specifies that the level of financial participation in recreation development by the Corps may not increase the Federal cost of the project by more than ten percent. The total first cost for the recommended restoration project is $90,916,632. This cost would be cost shared on a 65%/35% basis between the Corps and the local sponsor. Hence, the Corps share of the restoration project cost totals about $59,095,810. Recreation costs are cost shared on a 50%/50% basis between the Corps and the local sponsor. Fifty percent of the first cost of the recreation plan is $570,957 that would only increase the level of Federal financial participation by less than 1%.

A D D E N D U M

Existing Recreational Resources:

The following presents the primary recreation facilities within Pima County/Tucson metropolitan area.

National Parks (Tucson Metropolitan Area):

- Coronado National Forest
- Saguro National Park
  - Rincon Mountain District
  - Tucson Mountain District
- Santa Catalina Ranger District
  - Pusch Ridge Wilderness
  - Ricon Mountain Wilderness

State Parks (Tucson Metropolitan Area):

- Catalina State Park

BLM Lands (Tucson Metropolitan Area):

- Empire-Cienega Conservation Area

County Parks:

- Augie Acuna Los Ninos Neighborhood Park
- Cienega Creek Natural Preserve
- John A Valenzuela Community Center
- Southeast Regional Park
- Coronado Middle School Park
- Emily Gray Jr. High School
- George Mehl Foothills District Park
- McDonald District Park
- Lew Sorensen Tanque Verde Center
- Kino Veterans Memorial
  Community Center and Sports Complex
- Kino Teen Center
- Old Spanish Trail Bicycle and Hiking Trail
- Thomas Jay Regional Park
- Murphey Multi-Use Field
- Rillito River Park
- Roy P. Drachman- Agua Caliente Regional Park
- Arthur Pack Regional Park
- Casas Adobes Neighborhood Park
- Catalina Neighborhood Park and Recreation Center
- Children's Memorial Neighborhood Park
- Denny Dunn Neighborhood Park
- Feliz Paseos
- Flowing Wells Jr. High School
- Linda Vista Neighborhood Park
- Meadowbrook Neighborhood Park
- Overton Arts Center
- Pegler Recreation Area
- Picture Rocks
  Community Center and District Park
- Richardson Neighborhood Park
- Rillito Vista
  Neighborhood Park and Recreation Center
- Sunset Point Neighborhood Park
- Ted Walker District Park
- Wildwood Neighborhood Park
- Branding Iron Neighborhood Park
- Cardinal Neighborhood Park
- Centro Del Sur Community Center
- Lawrence District Park
- Mission Ridge Neighborhood Park
- Paseo De Los Arboles Commemorative Park
- Paseo De Lupe Eckstrom
  (Tucson Diversion Channel)
- Santa Cruz River Park
- Southwest Community Center
- Three Points Veterans
  Memorial Neighborhood Park
- Vesey Neighborhood Park
- Winston Reynolds-Manzanita
  District Park
- Ajo Regional Park
- E.S. "Bud" Walker Neighborhood Park
- Gibson Neighborhood Park
- Palo Verde Neighborhood Park
- Anamax Neighborhood Park and Recreation Center
- Continental Community Center
- Kay Stupy-Sopori Neighborhood Park
- Tucson Mountain Park
- Sahuarita District Park and
- Cienega Creek Natural Preserve
- Tortolita Mountain Park
- Colossal Cave Mountain Park
  Joan M. Swetland Community Center

City Parks:

- Christopher Columbus Park
- Sentinel Peak Park
- Case Park
- Fort Lowell Park
- Golf Links Sports Complex
- Greasewood Park
- Houghton Park
- Jacobs Park
- John F. Kennedy Park
- Kino& 36th St. Park
- Lakeside (Charles Ford) Park
- Lincoln Park
- Gene C. Reid Park
- Rodeo Park
- Santa Cruz River Park
- Morris K Udall Park
- Valle Allegre Park
- Freedom Park
- Himmel Park
- Juhan Park
- Mansfield Park
- McCormick Park
- Mission Manor Park
- Joaquin Murrieta Park
- North Central Park
- Jesse Owens Park
- Palo Verde Park
- Michael Perry Park
- Purple Heart Park
- Rodeo Grounds
- San Juan Park
- Santa Rita Park
- Sunnyside Park
- 20/30 Park
- Alvernon Park
- Balboa Heights Park
- Bravo Park
- Catalina Park
- Cherry Avenue Park
- Connor Park
- Country Club Annex Park
- De Anza Park
- Desert Aire Park
- Desert Shadows Park
- Eastmoor Park
- El Presidio Plaza Park
- El Pueblo Park
- Escalante Park
- Francisco E. Esquer Park
- Estevan Park
- Fiesta Park
- Stefan Gollob Park
- Groves Park
- Hoffman Park
- Don Hummel Park
- Iron Horse Park
- Jacinto Park
- Harriet Johnson Park
- La Madera Park
- La Mar Park
- Linden Park
- Menlo Park
- Mesa Village Park
- Military Plaza Park
- Miracle Mile Manor Park
- Mirasol Park
- Mitchell Park
- Oaktree Park
- Ormsby Park
- Oury Park
- Parkview Park
- Pinecrest Park
- Pueblo Gardens Park
- Rodeo Wash Park
- Rolling Hills Park
- Santa Rosa Park
- Sears Park
- Swan Park
- Swanway Park
- Tahoe Park
- Terra Del Sol Park
- James Thomas Park
- Toumey Park
- Veinte De Agosto Park
- Villa Serena Park
- Vista Del Prado Park
- Vista Del Pueblo Park
- Vista Del Rio Park
- Wilshire Heights Park
- Harold Bell Wright Park
- Amphitheater High School
- Amphitheater Middle School
- E.C. Nash Elementary School
- Flowing Wells High School
- Pima Community College
- Sunnyside High School
- Booth-Fickett Middle School
- Catalina High School
- Cholla High School
- Doolen Middle School
- Jefferson Park Elementary School
- John B. Wright Elementary School
- Magee Middle School
- Manzo Elementary School
- Palo Verde High School
- Richey Elementary School
- Rincon High School
- Rollin Gridley Middle School
- Sahuaro High School
- Santa Rita High School
- Townsend Middle School
- Tucson Magnet High School
- Utterback Middle School
- Vail Middle School
- Manuel Valenzuela Alvarez Park
- Cherokee Avenue Park
- El Tiradito Wishing Shrine
- Garden of Gethsemane
- Jardin Cesar Chavez Park
- Mariposa Park
- Riverview Park
- San Augustine Park
- Seminole Park
- Street Scene Park
- Sunset Park
- Verdugo Park