BLACKSNAKE CREEK FLOOD-RISK MANAGEMENT PROJECT
MISSOURI RIVER BASIN
ST. JOSEPH, MISSOURI

APPENDIX I
SOCIOECONOMICS

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1.0 INTRODUCTION

1.1 PURPOSE

This feasibility-level economic analysis provides a benefit-cost analysis of the proposed Blacksnake Creek flood-risk management project. Demographic data and economic development background pertaining to the community are discussed, and the development of a complete structure inventory is discussed. The inventory serves as the basis for a risk-based analysis which evaluates flood damages in the study area on an annualized equivalent basis and calculates damage reduction project performance by simulating a large number of possible flood events, taking into account all pertinent economic and engineering data including uncertainty factors. This analysis results in several outputs:

- Description and quantification of economic and social flood damage impacts to properties within the study area in the existing condition;
- Statistical estimates of project engineering performance or reliability under existing conditions in the context of a range of possible flood events;
- Estimated economic performance of alternatives formulated to improve project performance, in terms of residual damages, damages prevented, annualized benefits and costs;
- Statistical estimates of enhanced project engineering performance provided by each alternative;
- Economic optimization of alternatives and identification of the most economically efficient alternative;
- Characterization of the selected plan in terms of economic performance (annual damages, benefits, costs and residual damages) and engineering performance (or assurance).

1.2 STUDY GUIDANCE

Pertinent guidance governing economic analysis procedures includes:

- Economic and Environmental Principles and Guidelines for Water and Related Resources Implementation Studies (P&G), dated March 1983.
- Engineering Regulation (ER) 1105-2-100, “Planning Guidance Notebook,” dated 22 April 2000 (partially updated subsequently).

- Engineering Regulation (ER) 1105-2-101, Risk-Based Analysis for Flood Damage Reduction Studies, dated 3 January 2006

- Engineer Manual (EM) 1110-2-1619, Risk-Based Analysis for Flood Damage Reduction Studies, dated 1 August 1996.

- Economic Guidance Memorandum (EGM) 04-01, Generic Depth-Damage Relationships for Residential Structures with Basements, dated 10 October 2003.

- EGM 09-04, Generic Depth-Damage Relationships for Vehicles, dated 22 Jun 2009.

- Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios in Support of the Lower Atchafalaya Reevaluation and Morganza to the Gulf, Louisiana Feasibility Studies, New Orleans District, U.S. Army Corps of Engineers (Corps), May 1997.

- Institute for Water Resources (IWR) Report 96-R-12, Analysis of Nonresidential Content Value and Depth-Damage Data for Flood Damage Reduction Studies, Jack C. Kiefer and J. Scott Willett (Planning & Management Consultants Ltd., Carbondale IL), May 1996.

- Water Resources Development Act (WRDA) of 1990, Section 308.

2.0 STUDY AREA SETTING

2.1 LOCATION

St. Joseph is located in Buchanan County in northwestern Missouri, about 55 miles north of Kansas City, Missouri. The city is situated on the main stem of the Missouri River between river miles 452 and 445. Downtown St. Joseph is at mile 449.5.

Within this broad area, this analysis is specifically concerned with Blacksnake Creek, a tributary to the Missouri River. Blacksnake Creek originates in rural areas just north of the city limits in Andrew County and subsequently flows through the northwestern portion of St. Joseph to its mouth at the Missouri River (mile 449.1). The stream is an open channel above Karnes Road and runs initially through agricultural areas in Andrew County and then through mainly residential areas near the northern edge of St. Joseph. At Karnes Road the stream enters a combined sewer and continues downstream as a covered channel.

Along the 4.3-mile length of the portion of the creek located within the city limits of St. Joseph, Blacksnake generally parallels U.S. Highway 59 (known locally as St. Joseph Avenue) and is located just east of the busy commercial strip lining that street. The covered channel extends all the way to the mouth of the creek, which is located at the foot of Jules Street on the southern edge of downtown St. Joseph.

2.2 SOCIOECONOMIC CONTEXT

2.2.1 Demographic Data - St. Joseph had a population of 76,780 as of the 2010 Census, making it the eighth-largest city in Missouri. Demographic data for the city are displayed in Table I-1, which indicates that the 2010 population total represented an increase of 3.8 percent over the 2000 Census total of 73,990. Although population increased from 2000 to 2010, the increase was smaller than increases for the same period for Missouri (7.0 percent) and the United States (U.S.) (9.7 percent). Similarly, for the 20-year period from 1990 to 2010, the population of St. Joseph increased 6.9 percent; an increase, but well below the increases experienced for Missouri (17.0 percent) and the U.S. (24.1 percent) for this time period. The 2013 population estimate for the city had risen to 77,147 (American Community Survey).

The growth of population for Buchanan County overall and for the St. Joseph Metropolitan Statistical Area (MSA) was similar to that of the city. The county's population increased 3.7 percent from 2000 to 2010 and 7.4 percent from 1990 to 2010. The MSA, which covers four counties in Missouri and Kansas, had a 2010 population of 127,927, which represented an increase of 4.1 percent since 2000 and 9.9 percent since 1990.

In addition to the population data in Table I-1, a number of other points can be gleaned from that table as well as Tables I-2 (social data), which are based on 5-year averages from the American Community Survey. (Note that demographic data in other sections of this report, including the main report, are based on the 2010 Census figures rather than these 5-year averages through 2012.) These tables indicate that the residents of St. Joseph city, in comparison to Missouri and the nation, are

- Somewhat younger, with a median age of 35.6 vs. 37.9 for Missouri and 37.2 for the U.S.;
- Significantly more likely to be white (88.3 percent vs. 83.1 percent for the state and 74.2 percent for the U.S.);
- Less likely to be Hispanic than the nation (5.7 percent vs. 16.4 percent) but more than the state (3.5 percent);
- Slightly less educated in terms of the number of high school graduates (84.4 percent vs. 87.2 percent for Missouri and 85.7 percent for the U.S.), and significantly less educated in terms of those with bachelor degree or higher (20.4 percent vs. 25.8 percent and 28.5 percent);
- Somewhat more likely to be disabled (4.5 percent of under 18 and 42.7 percent of over 65, vs. 4.7 percent and 38.5 percent for the state and 4.0 percent and 36.8 percent for the nation);
- Much more likely to be natives of the U.S. (96.4 percent) and to speak English at home (94.1 percent) than the nation (87.1 percent and 79.5 percent), but about the same as the state.

Additional data on housing and economics in St. Joseph are provided in Tables I-3 and I-4. Some points worth noting from these tables:

- Per capita income for St. Joseph ($21,440) is slightly lower than for Buchanan County ($22,184) and the St. Joseph MSA ($22,139), and significantly lower than for the state ($25,546) and the nation ($28,051). The same pattern holds true for median and mean household income and median and mean family income.
- A larger proportion of St. Joseph's residents (18.4 percent) were below the poverty line than in the state (15.0 percent) and the U.S. (14.9 percent).
- St. Joseph has a higher percentage of residents receiving food stamp benefits (16.1 percent) and cash public assistance (3.1 percent) than the MSA (13.1 percent and 2.6 percent), Missouri (13.1 percent and 2.4 percent), and the nation (11.4 percent and 2.7 percent).
- The city's unemployment rate of 8.6 percent was higher than the county's (8.0 percent) and slightly higher than the state's (8.5 percent), but lower than the U.S. rate of 9.3 percent.
- Housing stock in St. Joseph, of which 53.8 percent was built prior to 1960, is much older than for the state (31.5 percent) and the nation (30.3 percent).
- The average St. Joseph home value of $121,234 was significantly lower than the comparable values for the county ($135,418), the MSA ($138,872), and the state ($169,314), and was less than half the national value of $254,710. Median home values in the city also are similarly well behind those for the state and nation.

Table 1-Demographic Data

TABLE I-1 -- DEMOGRAPHIC DATA	St. Joseph, MO (city)	Buchanan County MO	St. Joseph, MO-KS Metro Area	Missouri	U.S.
POPULATION					
Total population (July 1, 2012 Census estimate)	77,176	89,706	127,927	6,024,552	313,873,685
Total population (2008-12 ACS)	76,729	89,162	127,176	5,982,413	309,138,720
Total population (2010 Census)	76,780	89,201	127,329	5,988,927	308,745,538
Total population (2000 Census)	73,990	85,998	122,336	5,595,211	281,421,906
% increase, 2000-2010	3.8%	3.7%	4.1%	7.0%	9.7%
Total population (1990 Census)	71,852	83,083	115,816	5,117,073	248,709,873
% increase, 1990-2010	6.9%	7.4%	9.9%	17.0%	24.1%
AGE (Universe: Total population)					
Median age in years	35.6	36.6	37.8	37.9	37.2
Under 18 years (%)	23.6	23.5	22.8	23.7	23.9
62 years and over (%)	16.7	16.9	17.4	17.3	16.3
SEX (In percent; universe: Total population)					
Male	49.9	49.9	51.2	49.0	49.2
Female	50.1	50.1	48.8	51.0	50.8
RACE (In percent; universe: Total population)					
One race	96.3	96.7	97.1	97.8	97.3
White alone	88.3	89.7	90.6	83.1	74.2
Black or African American	5.2	4.5	4.3	11.5	12.6
American Indian and Alaska Native	0.4	0.4	0.4	0.4	0.8
Asian	0.9	0.8	0.7	1.6	4.8
Native Hawaiian and Other Pacific Islander	0.2	0.2	0.1	0.1	0.2
Some other race	1.3	1.2	0.9	1.0	4.8
Two or more races	3.7	3.3	2.9	2.2	2.7
White (alone or in combination)	91.8	92.8	93.3	85.1	76.5
Black (alone or in combination)	7.5	6.5	5.9	12.5	13.6
American Indian (alone or in combination)	1.6	1.5	1.7	1.3	1.6
Asian (alone or in combination)	1.3	1.2	1.0	2.0	5.6
Native Hawaiian (alone or in combination)	0.3	0.3	0.2	0.2	0.4
Some other race (alone or in combination)	1.6	1.4	1.2	1.2	5.3
HISPANIC OR LATINO (ANY RACE) (Percent of total population)					
Hispanic or Latino of any race	5.7	5.3	4.2	3.5	16.4

Source: U.S. Census Bureau, American Community Survey (ACS), 5-year estimates 2008-2012, unless otherwise indicated

Table 2– Social Data

TABLE I-2 -- SOCIAL DATA	St. Joseph, MO (city)	Buchanan County MO	St. Joseph, MO-KS Metro Area	Missouri	U.S.
HOUSEHOLDS					
Total households	33,307	38,416	53,593	2,710,506	131,642,456
HOUSEHOLDS BY TYPE					
Family households (%)	60.9	63.2	64.9	65.5	66.5
Nonfamily households (%)	39.1	36.8	35.1	34.5	33.5
HHs with one or more people under 18 years	30.2	30.6	30.8	31.7	33.3
HHs with one or more people 65 years and over	25.0	25.3	26.3	25.1	24.9
Average household size	2.5	2.5	2.5	2.5	2.6
Average family size	3.2	3.2	3.1	3.0	3.2
PERSONS BY HOUSEHOLD TYPE / GROUP QUARTERS (Percent of total population)					
Living in family households	80.3	81.8	82.8	82.7	83.7
Living in nonfamily households	19.7	18.2	17.2	17.3	16.3
Living alone	32.7	30.9	29.7	28.7	27.5
Living in group quarters	5.3	4.5	6.5	2.9	2.6
EDUCATIONAL ATTAINMENT (Percent of population 25 years and older)					
High school graduate or higher	84.4	85.4	86.1	87.2	85.7
Bachelor degree or higher	20.4	20.3	19.1	25.8	28.5
Graduate degree or higher	7.2	6.9	6.6	9.6	10.6
DISABLED BY AGE (Percent of civilian noninstitutionalized population)					
Persons under 18 with a disability	4.5	4.2	4.7	4.7	4.0
Persons 65 and over with a disability	42.7	41.7	40.6	38.5	36.8
RESIDENCE 1 YEAR AGO (Percent of population 1 year and over)					
In same house 1 year ago	77.3	79.2	81.1	83.6	84.8
PLACE OF BIRTH AND CITIZENSHIP STATUS (Percent of total population)					
U.S. native	96.4	96.9	97.5	96.1	87.1
Foreign born	3.6	3.1	2.5	3.9	12.9
FOREIGN BORN - WORLD REGION OF BIRTH (Percent of foreign-born population)					
Europe	10.8	11.3	13.6	21.8	12.1
Asia	20.7	21.0	21.6	36.0	28.5
Africa	20.0	19.7	17.3	7.9	4.0
Oceania	1.1	1.1	2.0	1.5	0.6
Latin and Central America (includes Mexico)	44.8	44.2	43.1	30.3	52.8
Northern America	2.5	2.7	2.5	2.6	2.1
LANGUAGE SPOKEN AT HOME (Percent of population 5 years and over)					
English only	94.1	94.7	95.6	93.9	79.5

Source: U.S. Census Bureau, American Community Survey (ACS), 5-year estimates 2008-2012

Table 3- Economic Data

TABLE I-3 -- ECONOMIC DATA	St. Joseph, MO (city)	Buchanan County MO	St. Joseph, MO-KS Metro Area	Missouri	U.S.
INCOME					
Median household income	$42,248	$44,181	$45,717	$47,333	$53,046
Mean household income	$53,829	$56,325	$57,286	$63,405	$73,034
Median family income	$53,416	$55,952	$57,576	$59,395	$64,585
Mean family income	$65,212	$67,614	$68,331	$75,484	$85,065
Per-capita income	$21,440	$22,184	$22,139	$25,546	$28,051
Households with food stamp benefits (%)	16.1	15.1	13.1	13.1	11.4
Households with cash public assistance (%)	3.1	2.9	2.6	2.4	2.7
Households with income =/> $200,000 (%)	1.2	1.4	1.4	2.8	4.6
Family HHs with income =/> $200,000 (%)	1.8	2.0	1.9	3.8	6.0
POVERTY STATUS OVER THE LAST 12 MONTHS (Percent of persons for whom poverty status is determined)					
Persons below poverty level	18.4	16.5	14.3	15.0	14.9
Persons under 18 in poverty	25.8	22.7	19.4	20.9	20.8
Persons over 65 in poverty	9.2	8.7	8.7	8.9	9.4
EMPLOYMENT STATUS (Percent of population 16 years and over)					
Civilians employed	91.4	92.0	92.6	91.5	90.7
Civilians unemployed	8.6	8.0	7.4	8.5	9.3
In military	0.2	0.2	0.2	0.4	0.5
COMMUTING TO WORK (Workers 16 years and over)					
Mean travel time to work (minutes)	16.4	17.5	19.1	23.2	25.4
WORKERS BY OCCUPATION (Percent of civilian employed population 16 years and over)					
Management, professional & related	27.3	28.0	28.2	34.3	35.9
Service occupations	20.0	19.4	19.1	17.7	17.8
Sales and office occupations	24.6	24.3	24.0	25.3	24.9
Farming, fishing & forestry	0.3	0.4	0.6	0.6	0.7
Construction, extraction, maintenance & repair	8.0	8.3	9.1	8.7	8.6
Production, transportation & material moving	19.8	19.7	18.9	13.5	12.1
WORKERS BY INDUSTRY (Percent of civilian employed population 16 years and over)					
Agriculture, forestry, fishing, hunting, mining	0.4	1.0	2.0	1.8	1.9
Construction	5.5	5.9	6.7	6.4	6.5
Manufacturing	17.9	18.2	17.0	11.7	10.6
Wholesale trade	2.7	2.6	2.7	2.8	2.8
Retail trade	11.9	11.5	11.3	11.9	11.6
Transportation, warehousing & utilities	5.0	5.0	5.1	5.1	5.0
Information	1.3	1.4	1.3	2.2	2.2
Finance, insurance, real estate, rental, leasing	6.0	5.9	5.6	6.9	6.7
Professional, scientific, management & admin.	6.3	6.2	5.6	9.0	10.7
Educational services, health care, & social assistance	23.9	23.5	24.2	23.8	22.9
Arts, entertainment & recreation, and accommodation & food services	9.5	9.0	8.4	8.9	9.2
Other services, except public administration	5.2	5.4	5.1	4.8	4.9
Public administration	4.3	4.4	5.1	4.7	4.9
CLASS OF WORKER (Percent of civilian employed population 16 years and over)					
Private wage and salary workers	83.5	82.7	79.9	80.4	78.7
Government workers	12.5	12.6	14.3	13.4	14.9
Self-empl. in own unincorporated business	3.9	4.5	5.5	6.0	6.3
Unpaid family workers	0.1	0.2	0.2	0.2	0.1

Source: U.S. Census Bureau, American Community Survey (ACS), 5-year estimates 2008-2012

Table 4- Housing Data

TABLE I-4 -- HOUSING DATA	St. Joseph, MO (city)	Buchanan County MO	St. Joseph, MO-KS Metro Area	Missouri	U.S.
HOUSING UNITS					
Total housing units	33,307	38,416	53,593	2,710,506	131,642,456
Single-family units (% of total)	75.5	77.0	76.9	73.6	67.5
Duplexes (% of total)	4.5	4.0	3.8	3.6	3.8
Mobile homes per 1,000 housing units	32	43	64	67	65
HOUSING OCCUPANCY					
Owner-occupied housing units - %	62.6	65.7	68.1	69.0	65.5
Renter-occupied housing units - %	37.4	34.3	31.9	31.0	34.5
Homeowner vacancy rate (%)	2.7	2.4	2.3	2.5	2.3
Rental vacancy rate (%)	6.6	6.5	5.5	8.0	7.7
YEAR STRUCTURE BUILT (Percent of total housing units)					
Built 2005 or later	0.1	0.1	0.1	0.3	0.3
Built before 1960	53.8	50.3	45.5	31.5	30.3
YEAR HOUSEHOLDER MOVED INTO UNIT (Percent of occupied housing units)					
Moved in 2005 or later	14.0	13.1	11.7	10.9	10.8
Moved in 1969 or earlier	5.9	6.0	5.9	4.4	4.7
VEHICLES AVAILABLE (Percent of occupied housing units)					
No vehicles available	9.5	8.5	7.7	7.3	9.0
1 vehicle available	38.1	35.6	32.6	33.2	33.7
2 vehicles available	37.2	37.4	37.8	38.8	37.6
3 or more vehicles available	15.2	18.4	21.8	20.7	19.7
HOME VALUES (Universe: owner-occupied housing units)					
Median home value	$99,800	$108,300	$110,600	$138,400	$181,400
Average home value	$121,234	$135,418	$138,872	$169,314	$254,710
Value of less than $50,000 (%)	14.6	13.5	14.0	11.5	8.6
Value of $500,000 or more (%)	1.0	1.3	1.9	3.4	10.9

Source: U.S. Census Bureau, American Community Survey (ACS), 5-year estimates 2008-2012

2.2.2 Local Economy - The Blacksnake Creek basin, especially the urbanized portion, is one of the oldest parts of the city, if not the oldest. A fur-trading post was established at the mouth of Blacksnake Creek in 1827. The community that developed around this post was known as Blacksnake Hills and was later renamed St. Joseph. Much of the city's notable history as a "jumping-off" point for the Western frontier occurred in the immediate area of the community at the mouth of Blacksnake Creek, including the establishment and operation of the Pony Express in 1860.

After the Civil War, St. Joseph recovered and became a leading wholesaler for westward-bound supplies. This rapidly growing commerce enabled the city to enjoy its most prosperous period in the 1870s and 1880s, and it also began to develop during this period into a meat-packing center.

The city's population grew rapidly from nearly 9,000 in 1860 to a peak of 102,979 in 1900. However, after nearby Leavenworth, Kansas, lost to Kansas City the intense competition to build the first Missouri River bridge in northwestern Missouri, rail traffic gradually shifted away from St. Joseph and Leavenworth to Kansas City, and the economy of St. Joseph began to decline. Population fell rapidly from 1900 to 1910 and then stabilized somewhat, and for the last century, the city's population has remained relatively stable at between 71,000 and 81,000.

Today, St. Joseph's economy is dominated by the health care industry and manufacturing. As can be seen in Table 3, the percentage of workers employed in the educational services, health care, and social assistance industry is 23.9 percent, the largest industry by employment in St. Joseph, although the percentage is very comparable to the county, MSA, state, and nation. Heartland Health employs more than 3,000 people in St. Joseph. The second largest industry is manufacturing, and the 17.9 percent of workers in the city employed in manufacturing concerns is significantly more than the comparable percentage in manufacturing statewide (11.7 percent) and nationwide (10.6 percent). Leading manufacturers in St. Joseph include Triumph Foods, Johnson Controls, Sara Lee, and Altec Industries. Other items of note in Table 3 are the relatively small share of city residents who work in agriculture and forestry – only 0.4 percent in St. Joseph, compared to from 1 percent to two percent in the county, MSA, state, and nation – and the percentage of government workers (12.5 percent), which is somewhat less than for Missouri (13.4 percent) and the U.S. (14.9 percent).

A key presence in the city and the region is the animal health and life sciences industry, which accounts for a large share of manufacturing in St. Joseph. The city is one component of the KC Animal Health Corridor, which includes a critical mass of leaders in the business, academic, scientific and government firms located along the east/west axis from Columbia, Missouri through Kansas City to Manhattan, Kansas and also on a second axis from Kansas City to Maryville via St. Joseph. Nearly one-third of the $19 billion global animal health industry is concentrated in this region. In St. Joseph, about 6,200 workers are employed in the veterinary pharmaceutical preparation industry, agricultural chemicals, and blood derivatives. Certain companies that are represented locally in this sector also have a global presence. Nestle Purina's global headquarters for research and development for Friskies dog and cat foods is located in St. Joseph, as is the global headquarters of Boehringer Ingelheim Vetmedica. The city also hosts the headquarters for the U.S. Animal Health Association.

Narrowing the focus to the Blacksnake Creek study area, there are 42 businesses located along the stream from Karnes Road to the mouth. Table I-5 summarizes the breakdown by industry of companies in this area. Of the 42 businesses, 20 are in either the "other services" category or in retail.

Table 5- Study Area Industrial Structure

TABLE I-5 STUDY AREA INDUSTRIAL STRUCTURE		
NAICS code	**Industry**	**Number of businesses**
22	Utilities	1
23	Construction	2
31-33	Manufacturing	4
42	Wholesale	3
44-45	Retail	8
48-49	Transportation & Warehousing	1
52	Financial	2
53	Rental & Leasing	1
62	Health Care & Social Assistance	1
71	Arts, Entertainment & Recreation	1
72	Accommodation & Food Services	0
811	Other Services - Repair & Maint.	8
812	Other Services - Personal & Laundry Services	1
813	Other Services - Religious, Civic & Professional	3
92	Public administration	2
unidentified	unidentified	4
Total	Total	42
NAICS = North American Industrial Classification System		

2.3 HISTORICAL FLOODING ON BLACKSNAKE CREEK

None of the historical floods in the Blacksnake Creek basin has been adequately documented in terms of economic damages. Generally, only anecdotal information is available. Even if more comprehensive and detailed estimates of economic damage were available, use of such estimates to check or calibrate the synthetic estimates presented in the economic analysis for this project would be complicated by the absence of gage data for the stream, which limits the ability to apply estimated frequencies or probabilities to the individual events.

In any case, available information indicates that flooding was seen as an issue in the Blacksnake basin as early as a major flash flood in 1849 and has remained one to the present day. Other flash floods are known to have occurred over the following century, including a major one in 1943, but details are not available. In 1959, the Blacksnake basin experienced two significant flash flooding events. The most severe of these events occurred in May and sent a high-velocity wave of water six to eight-feet deep down St. Joseph Avenue and the railroad right-of-way. Newspaper accounts indicated significant damage to about 130 homes and 23 businesses. One death also was reported in the flood, at a location central to this study: Karnes Road, where the open stream enters the covered channel. Later flash flood events culminated in a June 1984 event believed to have been a 0.5 to 0.33-chance storm event. One post-flood estimate put the damage at $3.6 million, or about $8.8 million in 2016 dollars. A Corps reconnaissance study followed the 1984

event, culminating in the 1987 report which identified an interest in federal action. No other major Blacksnake Creek floods have occurred in the interim since 1984, although there have been smaller events for which there is very little documentation.

3.0 DATABASE DEVELOPMENT

3.1 ECONOMIC ANALYSIS PARAMETERS

3.1.1 Index Years, Price Level and Interest Rates

- The existing conditions analysis is indexed to conditions of 2016. The base year for the analysis - i.e., the year when the project would be completed and operational - is FY 2020. A nominal future condition is also included in the analysis, indexed to 2038. However, note that all three of these conditions are identically characterized in the risk and uncertainty analysis. That is to say, engineering data, including water surface profiles, and economic development assumptions are considered constant in all respects from 2016 through 2067. No firm plans for future economic development in the Blacksnake flood plain were discovered. Consequently, both the economic and the hydrologic/hydraulic engineering data are identical for all three conditions.

The economic analysis in this report is based on a FY 2016 price level (index: 1 October 2015). The current FY 2016 federal interest rate for water resource projects of 3.125 percent is used in annual costs calculations. (Benefits in this analysis are not sensitive to interest rate changes.) The economic period of analysis is 50 years, the maximum allowed by guidance and also the maximum time period that would be reasonable for attempting to project either economic or hydrologic and hydraulic conditions in the basin.

3.1.2 Economic Reaches

- For the economic analysis, the study area was originally divided into three reaches. One of these was not carried over into the final stages of the study, and the economic analysis results will be reported in relation to two reaches. The reaches are illustrated on Figure 1 and are discussed below:

Reach 1 – Reach 1 is the most downstream reach, extending from the mouth of Blacksnake Creek upstream to Fillmore/Grand Street just north of downtown St. Joseph. The stream in this area is a covered channel flowing through a primarily industrial portion of the city. This reach has a small amount of residential land use, but is mostly industrial and commercial. As of 2016, Reach 1 included seven homes and 28 businesses spread between 46 non-residential structures. Wireco World Group and Lawhon Construction are major business presences in this reach, but most of the businesses are small and medium-sized enterprises. Most structures in this reach are older structures in fair condition.

Reach 2 – Like Reach 1, Reach 2 is a covered channel. Reach 2 runs from Fillmore/Grand Street upstream to Karnes Road, where the open stream enters the covered channel. Reach 2 contains much more residential land use than Reach 1 but also has a commercial/retail strip along St. Joseph Avenue/Highway 59. There are 94 homes and 18 non-residential structures housing 14 businesses in Reach 2.

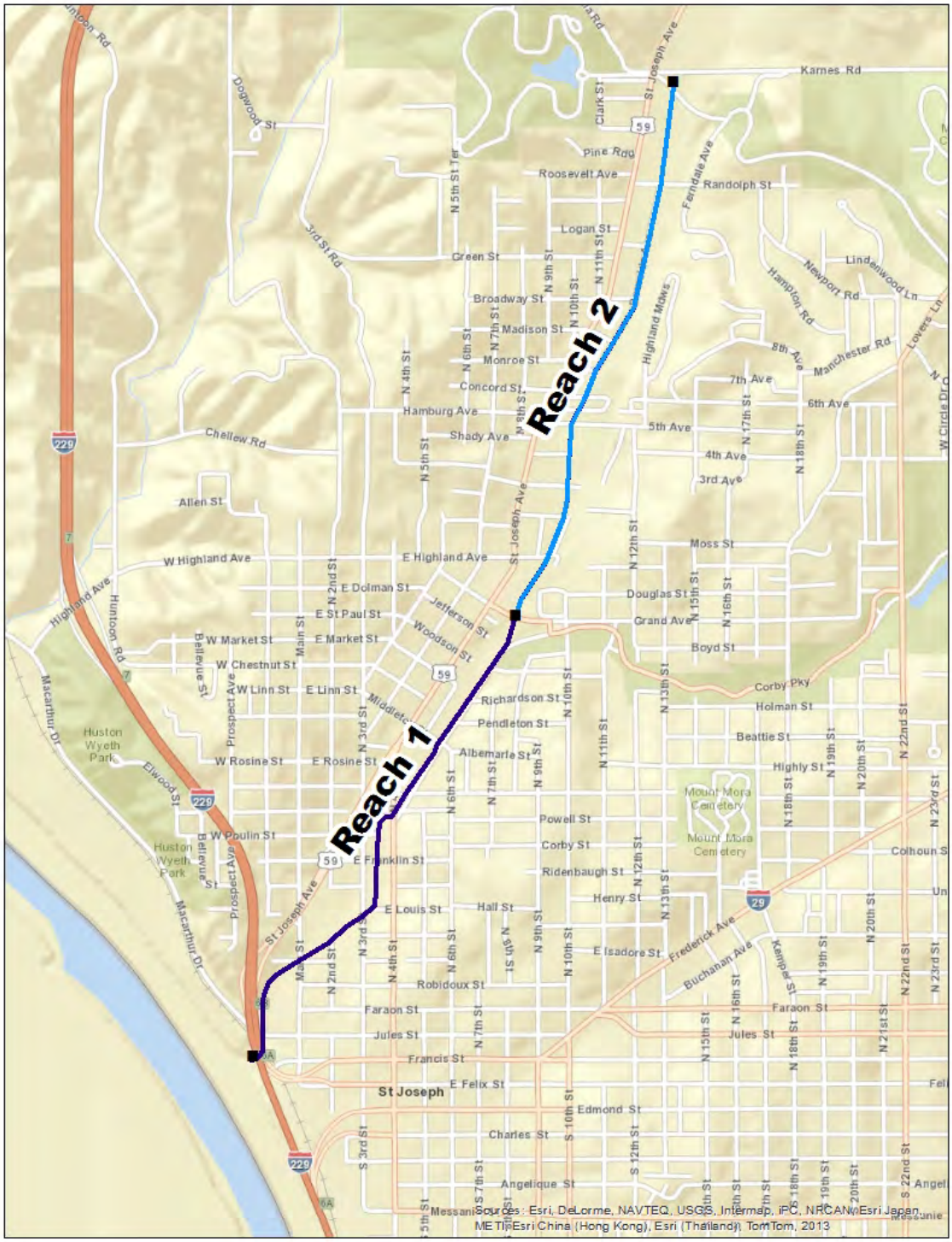

Figure 1- Economic Study Reaches

The other original reach, which was removed from the later stages of the economic analysis, was Reach 3. This reach is the upstream portion of Blacksnake Creek, from Karnes Road upstream to the headwaters in southernmost Andrew County. This segment is an open channel, running through rural areas and residential neighborhoods of northern St. Joseph. Homes in this area are generally newer and larger than further downstream, and the great majority of these homes are near Blacksnake Creek but are on high ground above the floodplain with a few exceptions where homes could be affected by the largest potential flood events. Since the proposed project would be constructed just north of Karnes Road, benefits from less frequent/severe flooding would affect only Reaches 1 and 2. Reach 3 was included in the study to ensure that any adverse induced impacts from the project are fully considered. As the study developed, it became clear that impacts from the project in this area would be negligible and it was dropped from further economic analysis.

3.2 DATA DEVELOPMENT

3.2.1 Initial Database Development

- The economic database for the Blacksnake Creek analysis was based initially on data from Buchanan County tax records which included appraised values for structures in the study area along with supporting data in the form of structure characteristics for each property. The Kansas City District (NWK) economics staff subsequently carried out a complete, structure-by-structure field survey of all buildings in the 0.2 percent annual chance of exceedance (ACE) floodplain within the study area. The purpose of the survey was to build on the initial data from the county tax records in three areas. First, current occupancy as shown in the tax records was confirmed or updated for each building. Second, where businesses and public facilities were concerned, the nature of the activity was not always obvious from the tax data or the business name, so properties were inspected for additional clues, as well as for the presence of significant outside inventory or equipment. Third, first-floor elevations relative to the ground were estimated by visual inspection and ground elevations were checked for reasonableness, and the presence of basements also was noted. Notes from the completed field survey were subsequently integrated with the tax data to form an adjusted initial structure inventory for the study area.

Note that Section 308 of the Water Resources Development Act (WRDA) of 1990 has been observed in this analysis, and structures built since 1991 in the 1 percent ACE floodplain with a first-floor elevation lower than the 1 percent ACE flood elevation are not included in the structure inventory. That said, Section 308 issues are virtually nonexistent in the Blacksnake Creek area since the floodplain has been urbanized and fully developed for many years and there is little opportunity to build new structures in the floodplain. The structures in the Blacksnake structure inventory were built before 1991, and long before 1991 in the vast majority of cases.

3.2.2 Elevations and Stationing

– Each property in a flood-risk management economic analysis is assigned a ground elevation at mean sea level, as well as a first-floor elevation and a lowest opening elevation if it is different from the first-floor elevation. Properties also are assigned stations positioning them relative to the stream. The elevations and stations are used in the flood damage analysis model to help determine depths of flooding for each flood event evaluated. Ultimately, the first-floor elevations for each type of structure are assigned an

uncertainty factor, usually expressed as a standard deviation around a normally distributed variable.

For the Blacksnake analysis, ground elevations were estimated using 2008 GIS mapping with 2-foot contours. During the field survey, these ground elevations were checked for reasonableness and consistency. Foundation heights were also observed during the field survey and were applied to the ground elevations to obtain first floor elevations. To account for uncertainty, all structures were assigned a standard deviation of 0.3 feet in first-floor elevation. This value is based on Table 6-5 of EM 1110-2-1619, which indicates that the uncertainty associated with mapping based on an aerial survey with 2-foot contours is characterized by a standard deviation of 0.3 feet.

3.2.3 Structure Valuation: Residential

– Corps planning guidance requires property to be valued in terms of depreciated replacement value. Also called current cash value, depreciated replacement value is the cost today to replace an asset (a building, a piece of equipment, etc.) with another object of the same type, function, and condition. Although appraised values of all structures were obtained from Buchanan County, these were not intended to be used in the economic analysis, as these values are not necessarily depreciated replacement values. The appraisal database was useful primarily for the structure characteristics, which are the basis of property tax appraisals and which included exterior wall type, number of stories, area in square feet, construction class/quality, age, and conditions. These characteristics were also utilized by the Corps Kansas City District (KCD) economic staff to estimate depreciated replacement values using a modified Marshall and Swift methodology based on costs per square foot. No information was available for some factors typically used in Marshall and Swift valuation, particularly interior characteristics such as walls, heating and cooling, floor type and other attributes requiring internal inspections of each home. But a valuation process was developed to adapt the detailed Marshall and Swift process to the more limited data generally available for Corps economic analyses. For residential properties, the valuation method enumerated below was used to determine structure depreciated replacement values:

1. Determine type of home: site-built or manufactured, single family or multiple (apartments).

2. Determine quality of construction: low, fair, average, good, very good, or excellent. These standard Marshall and Swift categories were applied to each structure during the field survey using sample photographs of each type provided in the Marshall and Swift reference guides.

3. Identify exterior walls type. Although the basic exterior wall composition types are in turn divided into multiple sub-categories in the Marshall and Swift data, with each category characterized by a separate set of values per square foot, the valuation for this analysis was based on only the basic material (wood, metal, masonry).

4. Determine basic replacement cost per square foot based on type, construction quality, size, and exterior wall type. Since it was not possible to identify exterior wall types in optimal detail in the field survey, we instead computed an average of the square foot values for all

categories listed within each construction type, quality type, and size.

5. Calculate a basic total replacement cost by multiplying the square foot cost by the area in square feet.

6. For homes with basements, add a value to account for the basement. Basement sizes for individual structures were not available, so it was assumed that basement size was equal to 75 percent of the structure footprint area. Values for unfinished basements were used in an effort to be conservative in assigning values.

7. Add garage value based on map measurement of outbuildings by GIS staff.

8. Calculate total replacement value using the basic cost per square foot plus the additions for basement and garage.

9. Determine typical physical life for each type of home using Marshall/Swift tables.

10. Determine effective age. The field survey evaluated the relative condition of each home using a rating of 1 to 5 (low to very good). These ratings were converted to an average aging factor for each level, from 10 percent of physical life used for homes in very good condition to 80 percent of physical life used for homes in poor condition. These age factors based on observed conditions were applied to the typical physical life to obtain an effective age.

11. Select depreciation factor using the effective age and typical physical life. These percentages are available in Marshall and Swift tables.

12. Calculate depreciated replacement value for the structure by applying the depreciation factor to the total replacement value.

Uncertainty factors for residential structure values were developed by assuming that the true rating of construction quality for any given home could be one category higher or lower than our estimate. For example, if a home's construction quality was rated as fair in the field survey, for the uncertainty calculations we assumed that the true rating could instead be low (one category below fair) if we were too optimistic, or average (one category above fair) if we were too pessimistic. Basic square foot values were identified for each condition for one and two story homes with either wood or masonry walls. Three typical home sizes were evaluated: 1600, 2400, and 3000 square feet. Within each home type and typical size, the percentage change in square foot value from one construction quality rating to the next was calculated. We then accounted for uncertainty by finding the maximum incremental change between quality ratings in any category or size. The maximum incremental change was approximately 35 percent. The 35 percent maximum change was divided by two to obtain an estimated standard deviation of 17.5 percent. This standard deviation was applied to each residential occupancy type used in the damage analysis.

3.2.4 Structure Valuation: Nonresidential and Infrastructure

- As with residential valuation, the appraised county tax values for nonresidential structures were

considered but not ultimately used since these depreciated values are not always consistent with depreciated replacement values. An additional shortcoming was that most public facilities do not have values in the tax records. A modified Marshall and Swift method was used to estimate values for nonresidential structures. The process, very similar to the one used for residential structure values, is summarized below:

1. Determine occupancy type, such as garage, church, office building, retail store, motel, etc.

2. Determine construction class. The classes are A, B, C, D, or S as defined in the Marshall and Swift Valuation Service.

3. Determine construction quality: low, fair, average, good, very good, or excellent.

4. Calculate replacement value per square foot based on occupancy type, construction class and quality.

5. Compute total replacement value by multiplying area in square feet by the square foot replacement value selected.

6. Determine typical physical life for the relevant structure type by using Marshall and Swift tables.

7. Determine effective age. As with residences, the field survey evaluated the condition of each business or facility using a relative rating of 1 to 5 (low to very good). These ratings were converted to an average aging factor for each level, from 10 percent of physical life used for structures in very good condition to 80 percent of physical life for structures in poor condition. These age factors based on observed conditions were applied to the typical physical life to obtain an effective age.

8. Select depreciation factor from the Marshall and Swift tables using the effective age and typical physical life.

9. Calculate depreciated replacement value for the structure by applying the depreciation factor to the total replacement value.

Uncertainty in the valuation of nonresidential structures is assumed to be normally distributed and is characterized in this analysis by a standard deviation of 15 percent for all properties. Like the structure value uncertainty for residential properties, this standard deviation assumes that assessment of construction types and qualities is a key source of value uncertainty and reflects the typical differences (an estimated 30 percent) between successive categories of construction types in Marshall and Swift commercial data.

Streets were valued using typical replacement costs per mile based on an average of available estimates from the transportation departments of Missouri and several other states. The depreciated replacement values used in this analysis are $1,699,000 for major city streets and $1,019,000 for secondary streets (FY 2016 prices). A standard deviation of 15 percent was

applied to the street values for uncertainty. Note that streets in the Blacksnake flood plain are generally older side streets that slope down from St. Joseph Avenue into the flood plain, and only small portions of most of these streets are within the flood plain. Therefore, flood damage potential for streets is minimal.

3.2.5 Contents Valuation: Residential

- Residential contents are not valued separately in the damage analysis, since users of standard residential depth-damage functions issued by IWR in 2000 and 2003 are directed to enter 100 percent as the residential content-to-structure value ratio (CSVR). For purposes of estimating investment only, the residential CSVR used is 50 percent. For mobile homes, which are not included in the IWR functions, a CSVR of 63.6 percent is used (see EM 1110-2-1619, 1 Aug. 1996, Table 6-4). There are only two mobile homes in the study area.

An additional component of residential contents that is not accounted for in the IWR depth-damage functions is vehicles and other items external to the home, such as outbuildings and landscaping. Values for outbuildings were estimated directly in this analysis, using the Marshall and Swift data and procedures. It is primarily vehicles and landscaping that remain to be accounted for in this study and vehicles are the main item in terms of value. Based on 2010 Census data for the block groups in the study area, the analysis assumes an average of 1.6 cars per residence. It is also assumed that 50 percent of residents will evacuate their cars in cases of flooding with less than six hours warning time (which would be the case with flash-flooding on Blacksnake Creek). This assumption comes from Table 5 in EGM 09-04 (although it may overstate the efficacy of evacuation since it appears to be based only on data for residents who have an opportunity to move their vehicles, and some residents might not have enough warning time in a flash flood to even have an opportunity to evacuate property). The combined effect of these two assumptions is that 1.6 cars would be present in the floodplain during flash flooding at 50 percent of the homes in the study area – or, what is the same thing, each home is assumed to have 0.8 cars left behind after evacuation is accounted for. The average 2015 sale value for used vehicles, according to the automotive data site Edmund's Used Vehicle Market Report, was $18,800. Multiplying this value by 0.8, a value of $15,000 is assumed for cars left behind at each of the 48 residences.

3.2.6 Contents Valuation: Nonresidential

- One large business in Reach 1, Wireco World Group (formerly Wire Rope), was interviewed for the analysis to obtain detailed, site-specific economic data. In most cases, however, contents for non-residential properties, including uncertainty factors, were estimated using generic CSVRs. These were taken from a report issued by the Corps New Orleans District (MVN). The report, and its applicability to this study, are discussed below in section 3.2.8 dealing with nonresidential depth-damage functions. The CSVRs included in the MVN dataset include uncertainty factors in the form of standard deviations and minimum/maximum values.

3.2.7 Damage Functions: Residential

- Residential damages for most homes in this analysis, shown in Table I-6, are based on depth-damage functions released in Economic Guidance Memorandum (EGM) 04-01, "Generic Depth-Damage Relationships for Residential Structures With Basements," dated 10 October 2003. This EGM summarized data developed by

the Institute for Water Resources (IWR) using post-flood residential damage claim records provided by the Federal Emergency Management Agency (FEMA). The functions account for both structural and content damage to homes with and without basements. Based as they are on post-flood damage claims data, the functions should also account for any emergency flood avoidance actions taken by residents such as evacuation or flood proofing. Of the eight residential occupancy types selected for this analysis, four use the IWR functions: one-story with and without basement and two-story with and without basement.

Two other functions for one and a half-story homes with and without basement were created by averaging the IWR functions for one and two story homes. Although the IWR functions begin as low as eight feet below the first floor for homes with basements, all homes in this analysis have been assigned beginning damage stages of minus two feet. This prevents the software from beginning to read the functions until a depth of minus two feet is attained, and then only for homes with basements.

The remaining two functions are for mobile homes and vehicles. For the three mobile homes in the structure inventory, a depth-damage relationship from the MVN dataset discussed just below in section 3.2.8 was used. For vehicles, the depth-damage function follows the official Corps Institute of Water Resources (IWR) data released in EGM 09-04.

3.2.8 Damage Functions: Nonresidential and Infrastructure

– The depth-damage function used for the largest business in the study area, Wire Rope, was developed based on an interview with representatives of that business. For other businesses, depth-damage relationships for both structures and contents (as well as CSVRs) used in this analysis are taken from data developed by MVN, as published in “Depth-Damage Relationships for Structures, Contents, and Vehicles and CSVRs in Support of the Lower Atchafalaya Re-evaluation and Morganza to the Gulf, Louisiana Feasibility Studies,” May 1997, and other studies. The depth-damage functions are shown in Table I-6. The MVN dataset remains one of the best published sources for commercial and public valuation and flood damage estimates and has been recommended by Corps subject experts for use in NWK flood-risk management economic analyses. The functions are based on a wide range of expertise, including panels made up of experienced subject experts on construction and post-flood cleanup, owner/operators of businesses, and FEMA post-flood depth-damage functions for the same region. One additional function for churches was taken from IWR Report 96-R-12, "Analysis of Nonresidential Content Value and Depth-Damage Data for Flood Damage Reduction Studies” (1996), a report based on flooding in the Wyoming Valley of the Susquehanna River basin in Pennsylvania.

The Planning Guidance Notebook (ER 1105-2-100, Appendix E, para. E-19q(2)) requires that when “comparable floodplain data” (i.e., generic data) are used, the study must justify the applicability of the data to local conditions. The particular MVN dataset used in this analysis (there are several such datasets for different types of conditions, published in at least three reports) is actually quite appropriate for the Blacksnake study area. The data for both depth-damages and content values were based on post-flood surveys with business operators conducted in the aftermath of an urban, freshwater (not saltwater, it should be emphasized), inland flood event in Louisiana. These characteristics transfer well to the St. Joseph context of flooding. Moreover, the owner/operators interviewed represented the same types of businesses and

facilities as are found in the St. Joseph structure inventory, including restaurants, grocers, retail and services, professional offices, repairs and home use businesses, warehouses and contractors, and public facilities. The structure damage functions are for masonry, wood, or metal walls and should be applicable to most areas with these types of nonresidential structures (with the possible exception of regions with extreme climate factors that require entirely different building codes). The Wyoming Valley data used for churches are also appropriate for use in this study area. Though they are based on a flood event associated with a tropical storm system, the flood-risk circumstances are not very different: an inland area (Wilkes-Barre is more than 100 miles inland), characterized by mixed-use urbanized land uses affected by freshwater flooding.

Two other points should be added to this discussion. First, it will be noted that some of the functions assume that damage occurs at an elevation of zero. One reason for this is that surface flows do, in fact, damage some items. Examples include finished goods inventories stored on the floor (particularly items such as food or drugs), inventories that are very sensitive to humidity even if not directly touching the water, or equipment with electrical wiring in the floor. Another reason is that depth-damage functions typically are structured in depth increments of a half-foot, if not a foot. If damage occurs with depths of only two or three inches (as it usually would), these depths would more readily round to zero than to one foot or one half foot. Damage percentages paired with an elevation of zero, therefore, might in actuality be accounting for very shallow flows of greater than zero depth. Second, in this flash-flooding context, there is very little opportunity for businesses to evacuate equipment and inventory (particularly if the flood occurs overnight). Therefore, the nonresidential depth-damage functions have not been further modified to reflect flood damage avoidance measures like evacuation.

Uncertainty factors are included in the MVN dataset. The depth-damage functions include median, maximum, and minimum values that serve as the basis for triangular damage uncertainty distributions in the risk analysis. The Wyoming Valley data, on the other hand, included only median values and had to be augmented by assumed uncertainty bounds that were assigned using professional judgment.

For city streets, the depth-damage function used in this analysis was formulated by obtaining typical costs per mile for minor maintenance such as regrading and resurfacing as well as for more major reconstruction to compare against the costs of new construction. In general, it is assumed that lower levels of inundation will result in relatively minor damage requiring repairs amounting to regrading and/or resurfacing, while more severe inundation levels will require much more expensive repairs that would be comparable to reconstruction. The resurfacing and reconstruction costs per mile obtained were divided by the new construction costs per mile to produce the generalized depth-damage percentages.

Table 6- Depth-Damage Functions

TABLE I-6 - DEPTH-DAMAGE FUNCTIONS											
Depth in feet>>	0	1	2	3	4	5	6	8	10	12	16
Residential 1NB struc	13	23	32	40	47	53	59	67	73	77	81
Residential 1NB cont	8	13	18	22	26	29	32	36	38	40	40
Residential 2NB struc	9	15	21	26	31	36	41	49	56	61	69
Residential 2NB cont	5	9	12	16	19	21	24	28	32	35	37
Residential 1WB struc	26	32	39	46	52	59	65	74	80	81	81
Residential 1WB cont	16	19	22	25	27	30	32	36	39	39	39
Residential 2WB struc	18	22	27	32	37	42	47	56	65	71	76
Residential 2WB cont	12	14	16	18	20	22	24	29	34	40	53
Residential 1.5NB struc	11	19	27	33	39	45	50	58	65	69	75
Residential 1.5NB cont	7	11	15	19	22	25	28	32	35	37	39
Residential 1.5WB struc	22	27	33	39	45	50	56	65	73	76	79
Residential 1.5WB cont	14	16	19	21	24	26	28	33	37	40	46
Residential mob home struc	10	45	46	97	97	97	97	97	97	97	97
Residential mob home cont	0	85	95	99	99	99	99	99	99	99	99
Residential - vehicles	0	25	43	59	72	84	93	100	100	100	100
Commercial struc masonry	0	14	26	33	41	48	53	65	72	76	78
Commercial struc metal	0	10	19	21	27	38	47	53	59	60	62
Commercial struc wood	0	18	31	38	43	51	57	69	76	84	91
Commercial cont - warehouse	0	28	45	55	62	72	78	87	93	96	96
Commercial cont retail	0	30	55	65	77	88	96	97	97	97	100
Commercial cont repair	0	30	41	52	65	75	91	93	99	100	100
Commercial cont grocer	0	39	54	66	79	92	97	100	100	100	100
Commercial cont professional	0	31	52	65	73	79	82	86	89	92	98
Commercial cont public	0	25	55	69	79	84	85	85	90	90	94
Commercial cont restaurant	0	26	54	68	83	88	95	98	99	100	100
Commercial cont service station	0	14	26	34	41	46	50	56	59	61	63
Commercial cont salvage yard	0	3	8	15	25	35	45	60	70	70	70
Commercial cont manufacturer	1	10	20	30	40	50	60	80	100	100	100
Streets & roads	1	2	4	6	8	11	15	23	33	43	63
Disaster relief	0	0	0	10	30	50	70	90	100	100	100
Emergency costs	0	0	0.5	1	3	5	7	9	9	9	9

3.2.9 Non-Physical Costs of Flooding - In addition to the tangible damages to businesses, homes, and other physical property items caused by flood inundation or exposure, the costs of flooding include emergency costs and disaster relief costs. Emergency cost savings can encompass savings related to a wide range of flooding impacts, including emergency personnel costs, flood fighting costs (sandbagging, for example), avoidance costs (raising or evacuation of property), temporary food and housing, debris cleanup, and damage to infrastructure items not otherwise included in the damage analysis such as sewer lines. The city of St. Joseph was contacted to obtain available historical data on emergency costs incurred during previous flood events. However, local governments rarely have this type of data on file, particularly when no serious flood events have occurred recently, with the result that there is a dearth of empirical data. For this reason, we were unable to obtain enough reliable data to estimate this category of

impacts based on direct or first-hand data. Yet emergency flood fighting costs are a recognized and significant category of economic impacts from flooding, and accuracy is not served by their absence from the economic analysis.

As an alternative, we consulted several reports published by the Corps pertaining to the 1993 Missouri River basin flood in order to estimate typical emergency costs for a large flood in an urban setting. The 1993 event was rated as equal to or approximating a 0.2 percent ACE event in most locations along the Missouri. These reports included the 1993 Interagency Floodplain Management Review Committee Report (Galloway Report); Impacts of the Great Flood of 1993 (CELMV, May 1996); and the Flood Plain Management Assessment of the Upper Mississippi River and Lower Missouri Rivers and Tributaries (USACE, June 1995). We compared 1993 flood damage estimates for damage centers detailed in these reports with 1993 agency emergency costs as reported in these documents. Based on these data, emergency costs as a percentage of total physical flood damages ranged from a low of 12.4 percent to a high of 15 percent, with an average of 13.4 percent for all states impacted by the 1993 flood. In addition, we also consulted a white paper by a former Corps Head Quarters (HQUSACE) reviewer who surveyed planning reports submitted to HQUSACE by Corps districts across the nation in recent years. This analysis found that emergency costs claimed in approved Corps reports averaged about nine percent of total equivalent annual damages (EAD) reduced. Based on the information contained in these sources, we assumed that emergency costs are equivalent to a maximum of nine percent of physical flood damages in the largest events and to smaller percentages in lesser events. Preliminary HEC-FDA runs were executed to obtain estimates of total physical damages for the 0.2 percent-chance event in each study reach, and emergency costs were then entered into the structure inventory as a structure in each reach with a value equivalent to the 500-year damages from the preliminary HEC-FDA runs. The depth-damage function developed starts at two feet of flooding with 0.5 percent damage and rises to the maximum of nine percent at eight feet of flooding. Uncertainty in the damage function was represented very conservatively by a triangular function in which the maximum or upper uncertainty bound rises to a maximum of 11 percent at nine feet.

Also included in the data we reviewed from prior studies were estimates of disaster relief costs. However, these costs appeared to overlap with the emergency cost estimates in the same studies, presenting a potential for double-counting damages, and we instead elected to obtain data from the Region VII FEMA office. Their data included typical costs for disaster housing assistance and grant assistance to individuals and families following recent Missouri floods, including the 1993 Missouri River flood. Relocation and reoccupation costs for non-residential occupants were not estimated and were not included in the analysis. The data indicated that residential emergency assistance averaged about $11,600 per home (FY 2016 prices). We multiplied this average household amount by the estimated number of homes damaged in a 0.2 percent-chance flood, again using preliminary HEC-FDA runs. This total was entered into the HEC-FDA study file for each levee unit area as the maximum emergency costs that could be incurred, with a standard deviation of 10 percent. A depth-damage function was developed based on the idea that disaster relief would mainly be an issue in the larger flood events. The function therefore begins with 10 percent damage at three feet of flooding and rises to 100 percent at 10 feet.

(Note that this category of damages is included only in the final FY 16 benefit calculations for the National Economic Development (NED) plan and is not included in the 2012 economic screening.)

3.3 FINAL DATABASE – INVESTMENT AND POPULATION AT RISK

Completion of the tasks discussed above ultimately results in an economic structure inventory. The structure inventory is subsequently used for several purposes, but initially it is the basis for estimates of investment in the study area. A determination of population within the study area completes the economic database used in the damage analysis.

3.3.1 Investment – Investment for the Blacksnake Creek study area is summarized in Table I-7. The estimated total investment in the study area, in FY 2016 prices, is $71,750,000. There are 101 homes, 42 businesses, and 64 nonresidential structures. Reach 1, the downstream reach, contains seven homes and 28 businesses in 46 nonresidential structures. Total investment in Reach 1 is $49,496,000, which is 69 percent of the total for the study area. Total investment in Reach 2 is estimated at $22,454,000, which is 31 percent of the total for the study area. Reach 2 contains 94 homes and 14 businesses in 18 nonresidential structures.

Residential value accounts for 16 percent of total investment, while 79 percent is nonresidential investment and five percent is streets. Structure value represents 53 percent of the combined value of residential and nonresidential properties (streets excluded), while contents, including residential vehicles, makes up the other 47 percent.

These investment totals are assumed to remain constant under existing, base year and future conditions. Therefore, Table I-7 represents investment for the future without-project condition as well as for existing conditions.

Table 7- Total Investment

TABLE I-7 TOTAL INVESTMENT				
FY 16 prices; $000s				
	Reach 1 (mouth to Fillmore St.)	**Reach 2** (Fillmore St. to Karnes Rd.)	**Total**	
RESIDENTIAL				
Quantity	7	94	101	
Value - Structures	$352.4	$5,285.1	$5,637.5	
Value - Contents	$281.2	$5,280.4	$5,561.6	
Value - Total	$633.6	$10,565.4	$11,199.0	15.6%
NON-RESIDENTIAL				
# Businesses	28	14	42	
# Structures	46	18	64	
Value - Structures	$23,170.7	$5,474.4	$28,645.1	
Value - Contents	$22,467.8	$5,819.2	$28,287.0	
Value - Total	$45,638.5	$11,293.6	$56,932.1	79.3%
ROADS & STREETS				
Value	$3,024.4	$594.6	$3,619.0	5.0%
TOTALS				
Total Value	$49,296.5	$22,453.6	$71,750.0	
Percentage of Overall	68.7%	31.3%		
Total # Structures	53	112	165	
Structures vs. Contents				
Total Value - Structures*	$26,547.5	$11,354.1	$37,901.6	52.8%
Total Value - Contents	$22,749.0	$11,099.6	$33,848.5	47.2%
	68.7%	31.3%		
*includes value of streets				

3.3.2 Population at Risk – Population at risk (PAR) is the portion of the population living, working, or otherwise temporarily in the study area flood plain. These persons are potentially at risk in the event of flooding.

The resident portion of PAR was estimated using 2010 Census block data for blocks adjoining Blacksnake Creek. The study area includes portions of the following Census tracts and block groups: Andrew County tract 101, block groups 1, 2 and 3; Buchanan County tract 2, block groups 2 and 3; Buchanan County tract 3, block groups 1 and 2; Buchanan County tract 5, block groups 1 and 3; Buchanan County tract 12, block group 1; and Buchanan County tract 30, block group 1. It is estimated that there are 2,525 people residing in the flood plain or adjacent to it and, therefore likely to be in the flood plain frequently.

The second group included in PAR is workers. Data on the number of employees per business are not easily available and were not collected for the study, but based on the number of businesses and their scales of operations, there are believed to be at least 500 workers at the 42 businesses in the study area, bringing the total above 3,000. The third group is comprised of those temporarily in the area, such as customers of area businesses or simply drivers passing through the area. Producing a sensible estimate of this sub-group of PAR is very difficult, but the count here will be based on traffic along Highway 59/St. Joseph Avenue. Data from the Missouri Department of Transportation indicates that the average daily traffic count on Highway 59 near Karnes Road is 10,790. This works out to about 450 vehicles per hour. All together, it appears that a reasonable estimate of PAR in the Blacksnake study area would be about 3,500.

4.0 DAMAGE ANALYSIS MODELING

4.1 THE HEC-FDA RISK ANALYSIS PROGRAM

The basic assumption underlying use of a risk analysis program is that data in flood-risk studies are based on imperfect knowledge and unpredictable future developments, so that key variables for which median or most likely values are specified could, in reality, take on a range of values above and below the specified values. A program with advanced mathematical capabilities is needed to perform an analysis that reflects risk and uncertainty, and the Blacksnake Creek economic analysis uses the HEC-FDA program to compute damages and benefits. HEC-FDA is the acronym for the Flood Damage Analysis program produced by the Hydrologic Engineering Center. This program is standard in Corps economic risk analyses for flood-risk studies. The newest certified version of FDA, 1.4, is used in this analysis.

In HEC-FDA, key economic input data are first loaded into the program. There are two economic input files for HEC-FDA: a structure inventory file compiling data for all damageable property in the study area, including structure values, ground and first-floor elevations, and stream stationing, and an occupancies file that compiles information for each major occupancy type (one-story homes, retail businesses, government offices, etc.), including CSVRs, depth-damage functions, and uncertainty factors for all economic variables. Together, these data files shape the three main economic variables critical to estimating flood damages at each location: elevation, value, and damage susceptibility. Along with the economic data, the hydrologic/hydraulic data for the stream are also entered into the program in the form of water surface profiles for eight selected flood events. All engineering and economic data are entered into the program in terms of median or most likely values and are accompanied by appropriate uncertainty parameters specifying the range of possible values for each variable.

The first phase of the risk analysis produces an economic stage-damage function. The program performs numerous iterations, each combining various possible values for each economic input (elevation, value, and depth-damage) by sampling the uncertainty distributions provided for those variables. Flood damages for each foot of flooding are computed based on the level of investment subject to flooding, the beginning damage elevation, and the estimated damage to that investment with various depths of flooding. The HEC-FDA program references each

structure's first floor elevation or beginning damage elevation to the corresponding frequency event elevation at the reach index point. Individual stage-damage relationships at each structure for each investment category are then computed with risk and aggregated to the reach index location specified for integration with the engineering data.

But the ultimate goal is to express damages in an annualized equivalent form, and this is the purpose of the second phase of the risk analysis, which integrates the economic stage-damage function with the engineering data. The HEC-FDA program utilizes a Monte Carlo process to randomly sample multiple probability distribution functions to produce tens of thousands of possible flood events instead of a few discrete scenarios. For each event, the program samples the range of possible values for each variable and determines (a) whether the flood event results in damage, and (b) how much damage occurs. The result is to effectively extend the period of record synthetically to thousands of flood events in a manner that reflects uncertainty in assumptions and the dynamic interaction of variables over long periods of time.

The calculation of annual damages conceptually involves a weighted average in which damages computed for each event are multiplied by the incremental probability of that event and the product is summed. This total, referred to as EAD, represents an estimate of the average damages that would be expected in any given year over the long term. The outcome of the Monte Carlo simulations is a single expected value for annual damages that represents an average of the thousands of synthetic events. Even though it is a single value, the expected value integrates many variables, including their uncertainty distributions. The average annual damage total can then be compared on an equivalent basis to an annualized cost for the planned project to obtain a benefit-cost ratio. Computations are made for expected annual damages under each condition, existing (or base, since both conditions are equivalent in this analysis) and future. The goal of the economic screening of alternatives is to identify the National Economic Development (NED) plan. The NED plan is the plan with the highest net benefits. This is considered the most economically efficient alternative. EAD is assumed constant in those years of the period of analysis beyond the most likely future condition. An equivalent annual damage also is computed, representing essentially a summation of base and future year conditions with the future year damages expressed as a discounted present worth value which is added to the base year damages.

An additional result of the risk analysis is a set of statistics characterizing project performance or assurance – the probability that a project will successfully contain flood events of varying magnitudes. There are three main assurance outputs. Annual exceedance probability (AEP) is the probability of a damaging flood occurring in any given year. The AEP is calculated with reference not to a single event, but to the entire range of possible events. A second output is long-term risk; the probability that a damaging flood will occur over periods of 10, 30, and 50 years. The third output is conditional non-exceedance probability (CNEP). CNEP is an estimate of the probability that a levee unit will successfully contain certain specified flood events of interest such as the 1 percent ACE event (i.e., the flood magnitude with a 1 percent chance of occurring in any year).

4.2 MODELING FOR BLACKSNAKE CREEK

4.2.1 Basic Modeling - The comprehensive structure inventory for the study area discussed above in section 3, including elevations, values, and depth-damage functions for each property, accompanied by uncertainty factors, and the set of water surface profiles were entered into the HEC-FDA risk analysis program for damage computations. Damages in this analysis consist of physical inundation damages to commercial, industrial, residential and public/non-profit structures and their contents, and roads. Without-project and with-project water surface profiles were prepared for eight flood events: 50 percent, 20 percent, 10 percent, four percent, two percent, 1 percent, 0.4 percent, and 0.2 percent, plus invert stages. This analysis uses one set of profiles for all without-project conditions: existing, base year, and future. The sets of profiles were prepared for each of the eight structural alternatives. A standard operating procedure for the effective use of HEC-FDA is the extension of the exceedance frequency and stage-discharge functions with uncertainty to the 0.9999 event, and this procedure was followed in the Blacksnake model, with the exceedance frequency functions modified to include the estimated stage for the 0.9999 event. The same procedures were followed for the with-project water surface profiles prepared for each of the structural alternatives.

4.2.2 Special Issues - While the Blacksnake analysis is a typical HEC-FDA analysis in most respects, two aspects merit additional mention. The first concerns integration of the stage-probability-discharge functional relationship within FDA. Early runs of the model resulted in stage-damage functions showing unrealistically high damages at minimal levels of flooding. Exceedance probability functions with uncertainty also showed extreme values at +/- two standard deviations, which undoubtedly contributed to the distorted stage-damage functions. These anomalies probably were due to the small size of the basin, the lack of availability of stream gauge data, and the relatively small increments between water surface profiles – all of which sometimes combine, when risk and uncertainty factors are added, to produce extreme and unrealistic results. These shortcomings in the model proved intractable, and ultimately it was decided to attempt to deal with the problem by completely removing discharge data from the calculations. HEC-FDA includes two alternatives for forming the exceedance probability functions: in addition to the commonly-used discharge-frequency relationship, there is a second option to base these functions on water surface profiles formed by stage-frequency relationships. Use of this approach provided much more reasonable and realistic results. This version of the model, along with earlier versions for comparison, was subsequently presented informally to an advanced HEC-FDA training class for critique. Instructors and students at the course did not identify any significant shortcomings with the stage-frequency form of the model.

The second issue concerns the extent of flood-risk reduction provided under existing conditions by the combined sewer. The sewer does provide some protection against smaller floods. The threshold at which flows begin to exceed the sewer's capacity and escape the underground pipe to flood overbank areas occurs in the range of a nominal 20 percent to 10 percent ACE event. The water surface profiles formulated for the modeling reflect this zero damage threshold. In the risk-based context of the HEC-FDA model, the zero damage frequency is higher (i.e., more frequent) than suggested above, with an expected value of about 26 percent. In other words, the combined sewer, in a risk-based context, does not perform as well in reducing flood risk as

would be expected given the nominal rating. In any case, the actual effect of the existing combined sewer in reducing flood risk is reflected in the economic damage model.

4.2.3 Atlas 14 – Very late in the feasibility study (subsequent to the Alternative Formulation Briefing), the National Oceanic and Atmospheric Administration (NOAA) published a new precipitation-frequency atlas for the U.S., known as Atlas 14. The new precipitation-frequency data potentially affects and alters the hydrology and hydraulics prepared for many Corps flood-risk management studies, in many cases indicating significantly higher stages than previously estimated. Although the Atlas 14 data was released very late in the Blacksnake Creek study, NWK undertook a sensitivity analysis using the new data to investigate whether either economic justification or identification of the NED plan could be affected by the new data. A new set of water surface profiles reflecting the Atlas 14 estimates for the events considered in the economic analysis was prepared by NWK engineering staff. These profiles were entered into the HEC-FDA model and a sensitivity analysis was executed. The results of this sensitivity analysis will be discussed below in section 6.4.

5.0 EXISTING AND FUTURE WITHOUT-PROJECT CONDITIONS

As discussed above, there is no distinction in this analysis between existing, base year, and future conditions. Water surface profiles and other hydrologic/hydraulic data are considered stable over the period of analysis, as is the economic structure inventory. The results summarized in this section therefore will represent existing conditions as well as future without-project conditions.

5.1 EXPECTED ANNUAL DAMAGES (EAD)

The without-project conditions EAD calculated by the HEC-FDA model are summarized in Table I-8. Total EAD is estimated at $3,483,000. Of this total, 78 percent is in Reach 1 and 22 percent is in Reach 2. Nonresidential accounts for 82 percent of total EAD, while residential accounts for 11 percent, emergency costs for six percent, and streets for about 1 percent.

Table 8- Future Without-Project Condition Equivalent Annual Damages

TABLE I-8 - FUTURE WITHOUT--PROJECT CONDITION EQUIVALENT ANNUAL DAMAGES				
FY 16 prices; 3.125% interest rate; $000s				
	Reach 1	Reach 2	Total	
Residential	$ 38.6	$ 363.6	$ 402.3	11.5%
Commercial/Public	$ 2,525.9	$ 330.1	$ 2,855.9	82.0%
Streets & Roads	$ 27.5	$ 0.0	$ 27.6	0.8%
Emergency Costs	$ 127.4	$ 69.8	$ 197.2	5.7%
TOTAL	**$ 2,719.4**	**$ 763.5**	**$ 3,483.0**	100.0%
	78.1%	21.9%	100.0%	

The HEC-FDA program also produces estimates of damages in selected events, and two common reference events are the 1 percent and 0.2 percent flood events. In a 1 percent ACE flood event, an estimated $36.6 million in damage would be expected according to the model. Of the 165 structures in the study area, 134 would be inundated by the 1 percent event. In a 0.2 percent ACE event, 157 of the 165 structures would be inundated, and estimated damages would total $44.3 million. Damages in these two events and others, as calculated within the HEC-FDA program, are presented by reach in Table I-9.

Table 9- Exceedance Probability vs. Damage (without condition)

TABLE I-9 EXCEEDANCE PROBABILITY VS. DAMAGE (WITHOUT CONDITION)					
FY 16 prices; $000s					
REACH 1	Residential	Non-Residential	Streets	Emergency Costs	Total
50.00%	$0.2	$16.0	$0.2	$0.8	$17.2
20.00%	$44.2	$2,891.0	$30.1	$145.9	$3,111.1
10.00%	$153.9	$10,063.6	$110.2	$507.7	$10,835.3
4.00%	$208.8	$18,529.9	$202.7	$934.8	$19,876.2
2.00%	$283.3	$22,606.3	$251.4	$1,140.5	$24,281.5
1.00%	$393.5	$25,739.8	$292.8	$1,298.6	$27,724.7
0.50%	$431.7	$28,236.0	$326.5	$1,424.5	$30,418.6
0.20%	$458.6	$30,754.4	$359.8	$1,551.6	$33,124.3
REACH 2	Residential	Non-Residential	Streets	Emergency Costs	Total
50.00%	$0.8	$0.7	$0.0	$0.2	$1.7
20.00%	$455.6	$413.6	$0.0	$87.4	$956.6
10.00%	$1,239.1	$1,124.7	$0.1	$237.8	$2,601.7
4.00%	$2,510.4	$2,278.7	$0.2	$481.7	$5,271.0
2.00%	$3,370.5	$3,059.4	$0.3	$646.8	$7,076.9
1.00%	$4,230.7	$3,840.2	$0.4	$811.8	$8,883.2
0.50%	$5,040.5	$4,575.2	$0.5	$967.2	$10,583.4
0.20%	$4,752.3	$5,284.5	$0.6	$1,117.2	$11,154.5
TOTAL	Residential	Non-Residential	Streets	Emergency Costs	Total
50.00%	$1.0	$16.7	$0.2	$1.0	$18.9
20.00%	$499.8	$3,304.5	$30.1	$233.3	$4,067.7
10.00%	$1,392.9	$11,188.3	$110.3	$745.5	$13,437.0
4.00%	$2,719.2	$20,808.5	$202.9	$1,416.6	$25,147.2
2.00%	$3,653.8	$25,665.7	$251.8	$1,787.3	$31,358.4
1.00%	$4,624.2	$29,580.0	$293.2	$2,110.4	$36,607.8
0.50%	$5,472.1	$32,811.2	$327.0	$2,391.7	$41,002.0
0.20%	$5,210.9	$36,038.9	$360.3	$2,668.7	$44,278.8

5.2 EXCEEDANCE PROBABILITY RATINGS

The probability of the occurrence of damaging flooding in the without-project condition is summarized in Table I-10. The HEC-FDA model's risk-based assessment of without-project conditions in the basin results in an estimated AEP of approximately 26 percent. Since the combined sewer has been estimated to contain peak flows for at least a 20 percent flood event or slightly larger, the risk-based estimate indicates that the sewer's actual performance is lower than previous (non-risk based) estimates. The HEC-FDA results also indicate that there is essentially no chance of containing even a 10 percent ACE event, much less larger events, under conditions

Table 10- Without-Project Exceedance Probability. HEC-FDA Estimates

TABLE I-10 -- WITHOUT-PROJECT EXCEEDANCE PROBABILITY HEC-FDA ESTIMATES			
	REACH 1 (DOWNSTREAM)	**REACH 2 (UPSTREAM)**	**TOTAL PROJECT AREA**
ANNUAL EXCEEDANCE PROBABILITY*			
Median	26.0%	26.6%	26.0%
Expected	25.8%	26.6%	25.8%
LONG-TERM RISK ** (chance of flooding during period)			
over 10 years	94.9%	95.4%	95.4%
over 30 years	100.0%	100.0%	100.0%
over 50 years	100.0%	100.0%	100.0%
CONDITIONAL EXCEEDANCE PROBABILITY PER EVENT (in %)			
10.0%	100.0%	100.0%	100.0%
4.0%	100.0%	100.0%	100.0%
2.0%	100.0%	100.0%	100.0%
1.0%	100.0%	100.0%	100.0%
0.4%	100.0%	100.0%	100.0%
0.2%	100.0%	100.0%	100.0%
CONDITIONAL NON-EXCEEDANCE PROBABILITY PER EVENT (in %)			
10.0%	0.0%	0.0%	0.0%
4.0%	0.0%	0.0%	0.0%
2.0%	0.0%	0.0%	0.0%
1.0%	0.0%	0.0%	0.0%
0.4%	0.0%	0.0%	0.0%
0.2%	0.0%	0.0%	0.0%
* Annual exceedance probability (AEP) is the chance of a damaging flood in any year. The statistic implies nothing about the magnitude of the flood except that it would be large enough to exceed the system's capacity. The same is true of the long-term risk of flooding.			

of risk and uncertainty, and that the occurrence of a damaging flood over any long-term period, even 10 years, is almost certain. This does not mean that a damaging flood would occur in every 10-year time period. The statistic is to be understood as predicting the occurrence of damaging floods about every 10 years, on average, over the long term.

6.0 ALTERNATIVES SCREENING

6.1 ALTERNATIVES DEVELOPED FOR ANALYSIS

Eight structural alternatives and one nonstructural alternative were quantitatively evaluated for economic efficiency (net benefits) and economic justification (benefit-cost ratios) for this study in 2012. The alternatives and how they were treated in the economic analysis are discussed below.

6.1.1 Structural Alternatives – Of the eight structural alternatives, Alternatives 1-4 formed one discrete group of similar, although separate, alternatives. The four alternatives in this group were variants of the same basic plan, which involved raising Karnes Road to act as a dry detention dam with an overflow spillway. Alternative 1 involved no excavation for the detention area upstream of Karnes Road, while 2, 3 and 4 involved increasing amounts of excavation. Due to the risk that these alternatives would cause drainage issues on residential properties just upstream of the project, all four alternatives would have included a levee/floodwall combination upstream of Karnes Road. This feature was meant to protect homes in that area from any adverse or induced effects of the detention basin and would not have reduced flood risk relative to the without-project condition. Alternative 4 extended the detention basin downstream of Karnes Road, removing a short portion of Karnes and adding a second levee.

A second group of structural alternatives was comprised of Alternatives 5-8, which were also variants of the same plan. Like Alternatives 1-4, these plans involved dry detention upstream of Karnes Road. Unlike Alternatives 1-4, they used the natural topography and a lower pool height to avoid the need for the Karnes Road dam and levee/floodwall combination upstream. The dry detention area in Alternative 5 was upstream of Karnes Road. Alternatives 6 and 8 extended it a short distance downstream to Northwest Parkway, as in Alternative 4. Alternative 7 expanded the detention area upstream of Karnes to the west. Thus, project scale increased in moving from alternative 5 to 6 to 7, as it did in moving from 1 to 2, 3 and 4. Alternative 7, unlike the other three alternatives in this group, would have required 21 residential property relocations.

Benefits for these structural alternatives were calculated using the HEC-FDA program. EAD was estimated for the without-project condition for homes, businesses and streets, and residual EAD was then computed based on the modified water surface profiles for each alternative, resulting in an EAD reduction that was used as benefits for the alternative. Emergency and disaster relief costs were not included in the screening cost estimates but would not have affected the alternative rankings.

The structural alternatives were initially costed in 2009 at an equivalent screening level of detail. First costs for the eight alternatives (subsequently updated to FY 2012 prices) ranged from $14.7 million to $25 million, as shown in Table I-11. The first costs were annualized based on the then-current interest rate of 3.75 percent, a period of analysis of 50 years, and an installation period of six years from PED to project completion (used in calculating interest during construction). The first costs accounted for design, real estate, and construction costs. OMRR&R costs also were estimated at the screening level and added to the annualized first costs. OMRR&R costs were estimated at $130,000 for alternatives 1-4 and $24,000 for alternatives 5-8 (FY 2012 prices). Alternatives 5-8 would be expected to have much lower OMRR&R costs because they do not include the Karnes Road detention dam and the levee/floodwall and are designed to work with rather than against the natural topography of the area.

6.1.2 Nonstructural Alternatives – In addition to the eight structural alternatives, several non-structural alternatives were considered in the early stages of plan formulation, including flood proofing, acquisition, relocations and elevation. Current Corps and FEMA guidance on the screening process for nonstructural measures advises against several types of such measures in this area since they would be hampered by constraints such as the typical age and condition of structures, the types of construction, and the flash-flooding nature of the flood risk. One nonstructural alternative that would at least be technically feasible, acquisition, was included in the benefit-cost analysis prepared for the screening.

Alternative 9 is an acquisition plan that would have bought out all 146 structures (residential and commercial/industrial) in the 1 percent ACE flood plain. (The 19 remaining structures in the structure inventory are in the 0.2 percent ACE flood plain but not the 1 percent and were not considered for the buyouts.) The economic analysis for this alternative involved modifying the HEC-FDA structure inventory used in analyzing the structural alternatives, zeroing out the value of each structure to be bought out along with the value of any associated vehicles. HEC-FDA was then executed using the revised structure inventory to calculate the EAD for a cleared flood plain. The resulting estimated EAD reduction constitutes the benefits of the alternative. Costs for the acquisition alternative (Alternative 9) included costs for purchase of both the 146 structures and their lots. Real estate tax records for structures in the flood plains were not readily available, so the structure acquisition costs were based on the depreciated replacement values of the structures as estimated in the economic analysis, while land acquisition costs were estimated by NWK real estate staff based on recent land sales in or near the Blacksnake Creek study area. A two-year period was assumed for implementation and was used in the interest during construction calculations. No annual OMRR&R costs were assumed for the acquisitions alternative.

6.2 SCREENING RESULTS

Table I-11 summarizes the main results of the benefit-cost analysis of the nine screening alternatives, while Table I-12 shows the project performance for each screening alternative (i.e., the likelihood that the project's capacity would be exceeded.) The main points emerging from the economic screening analysis were as follows:

- The HEC-FDA analysis estimated EAD of $2,890,000 (FY 2012 prices) for the without-project condition. (Note that the total EAD of $3,483,000 cited above in section 5.1 is a later post-screening estimate reflecting a later price level and additional damage categories.) All structural alternatives reduced these damages by approximately 73 percent to 87 percent. All alternatives had benefit-cost ratios exceeding unity, ranging from 1.8 to 3.3.
- Alternative 9, the buyouts alternative, reduced EAD by 99 percent and was economically feasible with a benefit-cost ratio of 1.5. But the high cost of the project resulted in a net benefits total of just over $1 million, making it the lowest ranking alternative.
- Alternatives 5, 6, and 8 were the economically optimal alternatives. Alternative 5 had a small but insignificant margin of superiority in net benefits over alternative 6, but 5 and 6 came in second in the rankings to Alternative 8.
- All alternatives dramatically alleviated long-term flood risk, but by no means would they eliminate it. Not only the largest flood events, but also those of more modest scale would continue to result in damaging floods; see the annual exceedance probabilities in Table I-12, which show that approximately a 10 percent annual exceedance probability is the best that any of the alternatives can achieve in Reach 1.
- The structural alternatives generally had a much more pronounced effect on preventing damaging floods in Reach 2, which is the location of the entrance to the sewer.
- Alternative 8 was identified as the NED plan, to be discussed further in section 7.

Table 11- Screening Benefits & Costs by Alternative

TABLE I-11 -- SCREENING BENEFITS & COSTS BY ALTERNATIVE

FY12 prices; 3.75% interest rate; $000s

Alternative	Total project costs ($1,000s)	Annual OMRR&R costs	Annual costs ($1,000s)	Annual damages ($1,000s)	Annual benefits ($1,000s)	Benefit-cost ratio	Net benefits ($1,000s)
Existing	n.a.		n.a.	$2,890.0	n.a.	n.a.	n.a.
1	$16,093.0	$130.0	$906.4	$657.8	$2,232.2	**2.5**	$1,325.8
2	$22,372.0	$130.0	$1,210.5	$524.0	$2,366.0	**2.0**	$1,155.5
3	$25,032.0	$130.0	$1,337.4	$447.0	$2,443.0	**1.8**	$1,105.5
4	$24,838.0	$130.0	$1,328.2	$480.6	$2,409.4	**1.8**	$1,081.3
5	$14,732.0	$24.0	$739.9	$477.7	$2,412.3	**3.3**	$1,672.3
6	$16,298.0	$24.0	$813.9	$410.2	$2,479.8	**3.0**	$1,665.8
7	$22,950.0	$24.0	$1,134.0	$371.3	$2,518.7	**2.2**	$1,384.7
8	$15,105.1	$24.0	$753.6	$410.2	$2,479.8	**3.3**	$1,726.2
9	$40,184.4	$0.0	$1,858.7	$26.7	$2,863.3	**1.5**	$1,004.6

These screening results were calculated during FY 2012. They have not been updated to current price level and interest rate since doing so would not affect the screening results, but costs and benefits pertaining to the selected plan are presented in Tables I-13 through I-17 in the current FY16 price level and interest rate.

Table 12- Screening Project Performance by Alternative

TABLE I-12 -- SCREENING PROJECT PERFORMANCE BY ALTERNATIVE						
Alternative	Annual exceedance probability *		Non-exceedance probability in 1% event **		Chances of flooding over 10 years	
	Reach 1	Reach 2	Reach 1	Reach 2	Reach 1	Reach 2
Existing	0.3893 < 5 year	0.3288 < 5 year	0.0000	0.0000	99.3%	98.1%
1	0.1244 < 10 year	0.0384 ~ 25 year	0.0000	0.0428	73.5%	33.8%
2	0.1128 ~ 10 year	0.0174 > 50 year	0.0000	0.1783	69.8%	16.1%
3	0.1007 ~ 10 year	0.0081 ~ 125 year	0.0000	0.9998	65.4%	7.9%
4	0.1052 ~ 10 year	0.0038 > 250 year	0.0000	0.9998	67.1%	3.7%
5	0.0966 ~ 10 year	0.0213 ~ 50 year	0.0000	0.1816	63.8%	18.8%
6	0.0922 ~ 10 year	0.0118 > 75 year	0.0000	0.0072	62.0%	11.2%
7	0.0841 > 10 year	0.0038 > 250 year	0.0000	0.9998	58.5%	3.8%
8	0.0922 ~ 10 year	0.0118 > 75 year	0.0000	0.0072	62.0%	11.2%

* Annual exceedance probability is the probability that a damaging flood (of whatever magnitude) would occur during any given year.

** Nonexceedance probability in the 1% event is the probability that the project would contain the 1%-chance flood event without significant damage from overtopping or project failure.

6.3 ATLAS 14 SENSITIVITY ANALYSIS

As discussed above in section 4.2.3, a new set of water surface profiles for the eight alternatives was computed based on the new Atlas 14 precipitation-frequency data. The profiles were entered into HEC-FDA along with the economic data used in the 2012 screening analysis, and the screening analysis was redone to determine whether the new data had any material effect on the study's previous conclusions.

The effects of the Atlas 14 profiles were very minimal in the Blacksnake Creek study area. Without-project EAD increased by less than 2 percent, and residual damages with the alternatives in place increased by less than 3 percent in most cases. In terms of economic justification, none of the benefit-cost ratios for the alternatives changed more than marginally,

and the benefit-cost ratio for Alternative 8, the NED plan, did not change at all. The other issue that required investigation was the screening rankings. Although the margin of superiority that Alternative 8 held in net benefits over the other alternatives narrowed somewhat, the screening rankings did not change in any way and Alternative 8 continued to be the NED plan.

Since the effect of the Atlas 14 data on the economic analysis was essentially nonexistent in the sensitivity test, it was decided that no further action was required in response to the new data; i.e., damage and benefit computations previously completed for the study did not need to be revised to reflect the Atlas 14 data. Thus, no change was made in the damages and benefits previously computed for use in the study. All damages and benefits reported in the tables in this appendix are based on the pre-Atlas 14 hydrologic/hydraulic data.

7.0 PLAN SELECTION

7.1 THE NED PLAN

The NED plan emerging from the screening analysis was Alternative 8, which excavates the Blacksnake Creek floodplain both north and south of Karnes Road to create detention capacity during peak flows. The NED plan requires no control structures such as levees, floodwalls, or detention dams and works more in harmony with the natural topography of the area than several of the earlier alternatives. The abandonment of Karnes Road in the area of the creek – a decision made by the city late in the study - is assumed, and this action reduces construction costs that would have been necessitated by raising, reconstructing, and strengthening the road, as well as installing culverts, in order to maintain the operability of Karnes Road. It also eliminates the need to relocate three power poles. The NED plan has a margin of superiority of about 3 percent in net benefits over the second-ranking alternatives (Alternatives 5 and 6, which were essentially tied in net benefits).

7.2 NED PLAN COSTS

A new and more detailed cost estimate for the NED plan was developed in 2016. The current estimated total project cost in FY 2016 dollars, summarized in Table I-13, is $14,761,000. This total includes preconstruction engineering and design, real estate requirements, construction, and construction management and contingencies.

Annual cost calculations for the NED plan, totaling $641,700, are summarized in Table I-14. Annual costs were calculated at the current FY 2016 federal water resources interest rate of 3.125 percent. A 50-year period of analysis is assumed. Interest during construction computations assume project completion in FY 2020.

A new estimate of OMRR&R costs also was prepared for the NED plan in early 2014. The OMRR&R tasks assumed in the new estimate include routine annual costs of $28,300 as well as replacement costs at longer intervals, particularly the replacement of riprap every 20 years at

$19,400. These costs were updated to FY 2016 dollars subsequently. The discounted present worth of the OMRR&R costs is $29,300 at the interest rate of 3.125 percent, slightly more than, but comparable to, the 2012 screening-level estimate of $23,000, particularly when the four year difference in price levels is taken into account.

Table 13- Total Project Costs

TABLE I-13 -- TOTAL PROJECT COSTS	
FY 16 prices; $000s	
Planning, Engineering & Design (PED)	$1,829.0
Lands & Damages	$1,290.0
Construction Management (S&A)	$467.0
Construction	
Relocations	
Compensable	*$411.0*
Non-compensable	*$1,008.0*
Total	$1,419.0
Fish & Wildlife Facilities	$381.0
Floodway Control & Diversion Structures	$9,375.0
TOTAL PROJECT COST	**$14,761.0**
Fully-Funded Cost	$14,985.0

Table 14- Annual Costs

TABLE I-14 -- ANNUAL COSTS	
FY 16 prices; 3.125% interest rate; $000s	
First Costs	$14,761.0
IDC	$628.2
Total Investment Cost	$15,389.2
I&A factor (3.125%, 50 years)	0.03979
Annual Cost subtotal	$612.4
Annual OMRR&R Cost	$29.3
TOTAL ANNUAL COST	**$641.7**

7.3 NED PLAN BENEFITS

Benefits for the NED plan were recalculated most recently in early 2016 to account for price level changes in structure inventory values and other adjustments. The 2016 update had three components: (1) Price levels were updated, using a factor of 1.1745 (Construction Cost Index, Engineering News Record, October 2008 to October 2015) to adjust structure replacement values to current prices. Depreciation percentages applied to the structure replacement values to produce depreciated replacement values were also updated to reflect the passage of additional time; (2) The method of calculating residential vehicle damages was revised. Previous benefit computations for the project, including the 2012 screening benefits, accounted for vehicle and landscaping values by assuming that the total vehicle and landscaping value for each residence was equal to 5 percent of the residential structure value. The revised method used in the 2016 calculations is summarized above in section 3.2.5. This change in methodology was expected to produce, and did produce, only very minimal changes in EAD and EAD reduced; (3) Emergency costs and disaster relief costs avoided, which were not included in EAD and benefit calculations prior to 2016, were added to the analysis. The procedures used for emergency costs are summarized above in section 3.2.9.

Summarized in Table I-15, annual benefits total $3,051,800 in FY 2016 dollars. This total is not affected by interest rate changes. The without-project EAD of $3,482,900 is reduced by about 86 percent with the NED plan in place. Reach 1 accounts for 77 percent of the benefits, while Reach 2 contributes the remaining 23 percent. Nonresidential benefits account for 81 percent of total benefits, while residential accounts for 12 percent, emergency costs for 6 percent, and streets for about 1 percent.

Table I-15 also shows probabilistic estimates of the benefits. For example, there is a 25 percent chance that benefits under conditions of uncertainty would exceed $3,659,900 and a 50 percent chance that benefits would exceed $3,022,400. The latter total is close to the expected value of the benefits ($3,051,800).

Finally, the HEC-FDA model estimates that in a 1 percent flood event, the number of structures inundated would be reduced from 134 without the project to 57 with the project in place. In a 0.2 percent event, the project would reduce the number of inundated structures from 157 to 117.

Table 15- Annual Benefits

TABLE I-15 -- ANNUAL BENEFITS				
FY16 prices; 3.125% interest rate; $000s				
BENEFITS	Reach 1	Reach 2	Total	
Future without-project EAD	$2,719.4	$763.5	$3,482.9	
Residual with-project EAD	$368.9	$62.2	$431.2	
Damage reduction EAD	$2,350.5	$701.3	$3,051.8	
	77.0%	23.0%	100.0%	
BENEFITS BY CATEGORY				
Residential	$30.9	$338.4	$369.3	12.1%
Non-Residential	$2,182.4	$299.7	$2,482.1	81.3%
Streets	$23.2	$0.0	$23.2	0.8%
Non-Physical Costs	$114.0	$63.2	$177.2	5.8%
Total	$2,350.5	$701.3	$3,051.8	94.2%
PROBABILISTIC BENEFITS *			Total	
75% probability that benefits exceed:	$1,841.6	$569.4	$2,411.0	
50% probability that benefits exceed:	$2,321.2	$701.2	$3,022.4	
25% probability that benefits exceed:	$2,832.7	$827.2	$3,659.9	
Mean benefits	$2,350.5	$701.3	$3,051.8	

7.4 BENEFIT-COST DATA FOR NED PLAN

As seen in Table I-16, at the 3.125 percent interest rate and the FY 2016 price level, the NED plan for Blacksnake Creek has a very strong benefit-cost ratio of 4.8. Annual benefits total $3,052,000, annual costs are estimated at $642,000, and annual net benefits total $2,410,000.

Table 16- Benefit-Cost Data

TABLE I-16 -- BENEFIT-COST DATA	
FY 16 prices; 3.125% interest rate; $000s	
Annual Benefits	$3,051.8
Annual Costs	$641.7
Benefit-Cost Ratio	4.8
Net Benefits	$2,410.1

7.5 INDUCED DAMAGES AND REGIONAL ECONOMIC IMPACTS

7.5.1 Induced Damages - The feasibility study tasks included investigation of the potential for the NED plan to raise stages upstream or downstream of the project area. The investigation concluded that the project would not raise stages for the 1 percent flood event over future without-project conditions

7.5.2 Relocations – Although relocations would have been necessary with some alternatives considered during the screening process, the NED plan would necessitate no relocations of businesses or residences either inside or outside of the project area.

7.5.3 Regional Economic Development (RED) Impacts - The benefit evaluation process involves analysis of the economic losses to the subject study area from flooding as well as the potential gains to the study area from the successful prevention of flooding. Some impacts with and without a flood-control project may be of major significance to a metropolitan area or community, but may not have any net impact on the national economy. For example, if a flood interrupts production at a given business in one community, that community suffers a loss. However, if the lost production is replaced by production at another plant elsewhere in the country, the loss to the local community does not represent a net loss to the national economy. Regional economic development (RED) impacts of this nature are not included in determining the NED benefits and costs, but do receive consideration in the decision-making process.

In the short term, during construction of the project, temporary increases in employment would be expected. The temporary presence of construction workers in the area for the project could bring a temporary increase in demand for some services in the local area and also in business volume, profits and sales tax receipts at the local retail and service establishments. In the longer term, implementation of the selected plan would contribute to the long-term stability of a large section of central St. Joseph traversed by Blacksnake Creek. Area businesses and residents with flood-risk concerns would be expected to continue their existing occupancy, and new businesses and investment would be more easily attracted to the study area in the future if vacancies occur, resulting in a stronger tax base. The continued deterioration of flood-prone buildings would be prevented, as would any subsequent effects on the resale market. With continued industrial and commercial stability enhanced by the increased reliability against flooding, existing neighborhoods and populations would also be expected to remain relatively stable, barring impacts from other sources. Other undesirable impacts of flooding, such as detours resulting in time costs and extra operating expenses, would also be alleviated.

7.6 PROJECT PERFORMANCE

The estimated performance of a flood-risk management project in reducing the chances of occurrence of damaging floods is known as assurance. Assurance can be expressed as a range of statistics, and HEC-FDA, in addition to estimating economic damage and damage reduced, also provides a range of assurance estimates as an output. Table I-16 summarizes assurance statistics for the Blacksnake Creek project. The table displays statistics for both reaches of the project area

as well as for the project area as a whole. For example, in Reach 2, the upstream reach, the project has essentially a 100 percent chance of containing the 4 percent ACE flood event, but in Reach 1, the downstream reach, the CNEP is 38.8 percent. Given these results, the CNEP for the entire project area is considered to be 38.8 percent because the rating for the entire project area is based on whichever reach has the lowest performance rating. For the Blacksnake project, performance in the upstream reach, near the project, is lower than in the downstream reach. This can be seen dramatically in the CNEP results for a 1 percent ACE flood event, where the HEC-FDA model calculates a 48.1 percent chance that Reach 2 would avoid significant damage, but only a 3.2 percent chance that Reach 1 would also avoid damage. Because the assurance ratings for the downstream reach are lower than for the upstream reach, the ratings for the project area as a whole are conservatively based on the downstream ratings.

The annual exceedance probability in the project area is rated at 25.8 percent under without-project conditions. This means that without the project, there is approximately a 26 percent chance of a damaging flood in any given year. The statistic accounts for the entire range of possible floods that would be large enough to result in economic damage and thus encompasses a broad range of smaller, moderate, and larger events. With implementation of the project, the annual exceedance probability drops from 26 percent to approximately 5 percent

The long-term risk calculations displayed in the table indicate the estimated chances of a damaging flood over specified time periods. Like the ACE, these statistics account for floods with a broad range of possible magnitudes. For example, on average over the long-run under without-project conditions, there is a 95.4 percent chance that a damaging flood would occur over a 10-year period, and for longer time periods such as the 30 and 50-year periods, it is essentially 100 percent. This is a long-term average and does not necessarily mean that a damaging flood will occur in the next 10 years. Under with-project conditions, the chances of flooding over the 10-year period drop to 38.5 percent, and over the 30-year period, the chances are reduced to 76.8 percent.

7.7 RESIDUAL RISK

Although it might be desirable if a flood-risk management project could totally eliminate the consequences of flooding to property and people, the simple fact is that no project that conceivably could be constructed would successfully contain every possible flood. Significant flood risk will continue after the Blacksnake project is implemented. Indeed, another way of looking at the results in Table I-17 is that the chances that a damaging flood will occur in the project area even with the project in place are not reduced significantly except in the smaller, more frequent floods. Exceedance probability (the chances of flood damage) in a 4 percent or a 2 percent ACE event is 100 percent for without-project conditions, and the project reduces it to 61.2 percent for the 4 percent event and 88.4 percent for the 2 percent event. But for events larger than the 2 percent event, even with the project in place, the exceedance probability approaches 100 percent. A total of $431,000 in residual EAD - about 14 percent of total without-project EAD – would be expected after project implementation.

The high continuing probability that damaging flood events will occur in the project area does not mean that the project is ineffective. As can be seen in the discussion of benefits above, the project very substantially reduces potential economic damage over the long term. But it accomplishes this not by completely preventing floods from occurring, but by alleviating depths of flooding to much less dangerous and harmful levels when floods do occur. There will be a continuing need, even after project implementation, to monitor potential flood events diligently and take appropriate precautions.

Table 17- Project Performance (Assurance) HEC-FDA Estimates

TABLE I-17 -- PROJECT PERFORMANCE (ASSURANCE) HEC-FDA ESTIMATES						
	REACH 1 (DOWNSTREAM)		REACH 2 (UPSTREAM)		TOTAL PROJECT AREA	
	WITHOUT PROJECT	WITH PROJECT	WITHOUT PROJECT	WITH PROJECT	WITHOUT PROJECT	WITH PROJECT
ANNUAL CHANCE OF EXCEEDANCE (ACE)*						
Median	26.0%	4.6%	26.6%	1.0%	26.0%	4.6%
Expected	25.8%	4.8%	26.6%	1.1%	25.8%	4.8%
LONG-TERM RISK** (chance of flooding during period)						
over 10 years	94.9%	38.5%	95.4%	10.0%	94.9%	38.5%
over 30 years	100.0%	76.8%	100.0%	27.1%	100.0%	76.8%
over 50 years	100.0%	91.2%	100.0%	40.9%	100.0%	91.2%
CONDITIONAL EXCEEDANCE PROBABILITY PER EVENT (in %)						
10.0%	100.0%	1.6%	100.0%	0.0%	100.0%	61.2%
4.0%	100.0%	61.2%	100.0%	0.0%	100.0%	61.2%
2.0%	100.0%	88.4%	100.0%	5.7%	100.0%	88.4%
1.0%	100.0%	96.8%	100.0%	51.9%	100.0%	96.8%
0.4%	100.0%	99.8%	100.0%	77.2%	100.0%	99.8%
0.2%	100.0%	100.0%	100.0%	86.9%	100.0%	100.0%
CONDITIONAL NON-EXCEEDANCE PROBABILITY PER EVENT (in %)						
10.0%	0.0%	98.4%	0.0%	100.0%	0.0%	98.4%
4.0%	0.0%	38.8%	0.0%	100.0%	0.0%	38.8%
2.0%	0.0%	11.6%	0.0%	94.3%	0.0%	11.6%
1.0%	0.0%	3.2%	0.0%	48.1%	0.0%	3.2%
0.4%	0.0%	0.2%	0.0%	22.9%	0.0%	0.2%
0.2%	0.0%	0.0%	0.0%	13.1%	0.0%	0.0%

* Annual chance of exceedance (ACE) is the chance of a damaging flood in any year. The statistic implies nothing about the magnitude of the flood except that it would be large enough to exceed the system's capacity.

** The same is true of the long-term risk of flooding; it is based on the probability of a damaging flood of any magnitude.

8.0 CONCLUSION

The feasibility-level socioeconomics analysis of the Blacksnake Creek federal flood- risk management project in St. Joseph, Missouri, has found that a strong federal interest exists in the NED plan. The plan, estimated to cost $14,761,000, exhibits very strong economic justification with a benefit-cost ratio of 4.8 at the current federal interest rate of 3.125 percent. With net annual benefits of $2,410,000, the project represents a strong contribution to national economic outputs.

Annual benefits	$ 3,052,000
First costs	$ 14,761,000
Annual costs	$ 642,000
Benefit-cost ratio	4.8
Net benefits	$ 2,410,000

Supplement to Appendix I: PLAN FOR ECONOMIC UPDATES

ER 1105-2-100, para. D-4, requires a plan for conducting updates of the project economic justification. Economic updates, revisiting estimated damages, benefits, costs, affected population, and residual risk will be required every three years until the project gains a new construction start, after which the required interval will be five years. Updates are not intended to involve major economic analyses or extensive reworking of the feasibility study analysis. They are intended to verify the continuing validity of important assumptions on which the economic justification is founded as well as to update data to current price levels.

Under the guidance, several different approaches are available for carrying out an economic update, depending on the nature of the economic base. Total investment and economic damage potential in some study areas are dominated by a few larger companies, and updates can be readily prepared in these cases by reevaluating the benefits of just a few companies that account for a high percentage of project benefits. This approach is not possible for the Blacksnake Creek project because the economic base is distributed among primarily smaller and medium-sized service and retail businesses spread along an approximately 2.3 mile stretch of St. Joseph Avenue. Sampling is another option which can be an acceptable approach in generally residential areas but tends to be far less satisfactory for dealing with commercial and industrial areas with a heterogeneous mix of businesses. Although most of the structures in the Blacksnake Creek study area are residential, 79 percent of total investment is accounted for by nonresidential structures, so sampling would not be an advisable methodology for an economic update in this area.

The planned approach for updating the Blacksnake Creek study area economic data would be to carry out a 100 percent field survey to identify land use and occupancy changes, re-calculate structure values in current dollars, and adjust equipment and inventory values for changes in activity and price levels. Local city and Chamber of Commerce staff would be consulted to further help identify major changes of the previous three years pertaining to the economic structure inventory and particularly to major nonresidential properties. Discussions would encompass verification of continuing operations at major properties, identification of significant changes in operational scale at major businesses and facilities, and identification of significant new development including major new businesses, public facilities, residential developments, and roads and streets.

Upon completion of the field survey and discussions (or other research), a decision would be made regarding whether the changes observed since the last report would constitute a significant change in previous economic assumptions and modeling results. If not, the update would be considered a Level 1 economic update and would simply reaffirm the previously reported benefits, which would continue to be the economic data of record for another three years.

Level 1 update labor estimate:
Data gathering and survey – 24 hours
Report preparation – 16 hours
Total – 40 hours

If the changes observed in economic conditions in the study area are more significant, a higher level of economic update would be prepared. Tasks to be completed would depend upon the degree of economic change observed, with more substantial changes requiring higher update levels, but might include the following for a Level 2 update:

1. Economic structure inventory revisions for nonresidential properties -- For the first update, these revisions might be a price level adjustment of replacement costs; for subsequent updates, there would be new replacement cost estimates using RS Means data or the equivalent. Depreciation of the structures also would be revisited and recalculated based upon field observations of the conditions of individual structures. Nonresidential contents in this analysis are computed as percentages of structure value and will update automatically when structure values are updated. (16 hours)

2. Economic structure inventory revisions for residential properties -- The updating of residential structure values would be based on an update factor determined based on changes in the average and median housing values for the city, count and MSA (or down to the block group level if data are available at that level). The factor would be applied to all residential structure values. Vehicle values would be updated with an up-to-date estimate of the average used vehicle cost in the U.S. (or smaller area if available). (4 hours)

3. Transportation network -- For roads, streets and railroads, updated average replacement costs per mile, as well as average depreciation factors, will be used to bring depreciated replacement values up to date for each type of road. (1 hour)

4. New development -- For significant new additions to the property base, including large businesses and facilities built above the 1 percent flood elevation, significant new residential projects built above the 1 percent flood elevation, or major new roads and streets, new depreciated replacement values would be estimated in the same manner in which they have been prepared for the present report. However, major new development in the Blacksnake study area is not really anticipated at this time. (8 hours)

5. Other benefits -- For disaster relief costs, up-to-date data will be obtained from FEMA. For emergency costs, updated values would be driven by new HEC-FDA calculations of residential and nonresidential EAD; the emergency costs are estimated as a percentage of these costs. (2 hours)

6. Damages and benefits analysis -- The HEC-FDA program will be loaded with the updated property database and new damage and benefit estimates will be produced. (8 hours)

7. Benefit-cost ratio -- An updated cost estimate will be prepared by engineering staff and annualized. Benefit-cost ratios and net benefits will be calculated based on the updated benefits from HEC-FDA and the annual costs. (2 hours)

8. Population -- Estimates of population at risk will be updated if block-level Census data are available for current conditions. (4 hours)

9. Documentation -- An update report will be prepared documenting the tasks completed and the results of the updated analysis. (32 hours)

Total estimated labor: 77 hours. This estimate is based on a Level 2 economic update; if higher levels are required, the labor could greatly increase.