**US Army Corps**
**of Engineers**
Kansas City District

***MANHATTAN LOCAL PROTECTION PROJECT***
***FEASIBILITY STUDY***

***MANHATTAN, KANSAS***
***(Manhattan Levee)***

***(Section 216 Review of Completed Civil Works)***

# Economics Appendix

August 2014 Final Feasibility Report

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## 1.1 INTRODUCTION

### 1.1.1 Purpose

The purpose of this economic analysis is to assist in updating and verifying performance data for the Manhattan Kansas Local Flood Protection Project and the extent of the economic impacts from flooding with the existing project, as well as to evaluate the benefits from various plans to increase project performance. This appendix presents a risk-based analysis of the flooding problem under the existing condition and levee unit, using a comprehensive structure inventory developed for the project area. The future without project condition is then characterized, and finally a risk-based evaluation in terms of benefits, costs, and performance of various alternatives under the with-project condition is provided. Section 2.1 describes the EAA demographics, investment, economic development and business patterns. Sections 3.1 and 4.1 summarize data preparation and model development used for economic damage analysis. Section 5 describes the existing condition analysis results. The future without project condition is examined in Section 6.1. Section 7.1 contains the alternatives description along with a screening level costs and benefits comparison. The NED plan is identified in detail in Section 8.1. The engineering performance, potential for induced damages, benefits breakdown by category, final costs, benefit cost ratio, and net benefits are discussed in that section as well. Section 9.1 describes the future with project condition in terms of each of the three socioeconomic accounts: National Economic Development (NED), Regional Economic Development (RED), and Other Social Effects (OSE). The remaining sections,10.1, 11.1, and 12.1 describe the residual risk post-project implementation, the plan for conducting economic updates, and the conclusion for the Economic Appendix.

### 1.1.2 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;

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

-ER 1105-2-101, Risk-Based Analysis for Evaluation of Hydrology/Hydraulics, Geotechnical Stability, and Economics in Flood Damage Reduction Studies, dated 3 January 2006.

-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, Corps of Engineers, dated May 1997.

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

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

-HEC-FDA Flood Damage Reduction Analysis User's Manual (Version 1.2.4), dated November 2008.

-EM 1110-2-1304. Civil Works Construction Cost Index System (CWCCIS), dated September 2013.

-Director of Civil Works' Policy Memorandum (CWPM 12-001) Methodology for Updating Benefit-to-Cost Ratios (BCR) for Budget Development, dated March 8 2012.

### 1.1.3 Location

Manhattan, Kansas is located in Riley and Pottawatomie Counties in east central Kansas about 120 miles west of Kansas City, MO. Manhattan encompasses a nearly 16 square-mile area, adjacent to the confluence of the Big Blue and Kansas Rivers. The Corps of Engineers operates and maintains Tuttle Creek Lake on the Big Blue River, which is about 5 miles north of downtown Manhattan. Tuttle Creek is a major reservoir in the Kansas River basin system of reservoirs that provide flood risk reduction to cities downstream including Topeka, Lawrence, and Kansas City as well as Manhattan.

This analysis is primarily concerned with the leveed portion of the floodplain in Manhattan along the Big Blue and Kansas Rivers. The term "economic analysis area" (EAA) as used in this report, will refer to those areas of Manhattan protected by the Federal levee. This term is used in the economic analysis in preference to "study area," which in this study refers to a much larger area than the economic survey area.

### 1.1.4 Federal Project Description

The original Manhattan, Kansas local flood protection project was authorized in the Flood Control Act of 1954 (Title II, Public Law 780, 83d Cong., 2d Sess., H.R. 9859). Construction of the project began on 4 May 1961, and the local sponsor accepted the completed project for operation and maintenance in July 1963. The project, located at the confluence of the Big Blue and Kansas rivers, consists of 28,841 feet of levee, 4,100 feet of channel improvement

for the Kansas River, modification of the Rock Island (now Union Pacific) railroad bridge, six pressure relief wells, and two pumping plants.

### 1.1.5 Historical Flooding

In 1844, the Manhattan area experienced what is believed to be the largest flood within recorded history on the Kansas River. Unfortunately, there is only anecdotal information about this flood. The City of Manhattan did not exist at the time, but the flood reached from the river to what is today the Kansas State University campus, approximately a mile and a half away from the closest point on the Kansas River. The crest for this flood in the area where Manhattan currently stands was estimated to be 40 feet, according to the National Weather Service.

In May of 1903, a flood crest of 30 feet, the third highest flood crest on record for Manhattan, was recorded. This flood hit the area between the Kansas river and 5th Street the hardest but also extended west to 8th Street. Damages of $25,000 were reported, which would be equivalent to more than $600,000 in 2014 dollars. This flood was large enough to cause the Kansas River to change course at Manhattan.

In mid-July of 1951, the second highest recorded flood crest of 33.4 feet occurred in Manhattan. The inundation covered a 220-block area, approximately 60% of the entire city. Downtown was covered in 8 feet of water and 30 homes were completely swept away. Two people were killed in the flooding, and approximately 5,800 people were evacuated. According to a post-flood report, total damages were estimated at $13,394,100 in 1951 ($239 million in 2014 dollars). The damages affected more than 300 businesses and public structures and 1,600 homes.

In 1993, the fourth highest crest in history of 29.9 feet was recorded at Manhattan. Actual and threatened flooding occurred in several neighborhoods outside the levee, including Dix Addition, Fairmont, Knoxberry, Countryside Estates and Hunter's Island. These areas include several hundred homes. The Big Blue River section of the levee had approximately three to four feet of freeboard remaining at the peak of the flood.

This study was triggered by the flood event of July 1993. The design documentation for the Manhattan levee describes a system designed for a significantly higher coincident flow regime than was experienced in 1993. But with approximately 60,000 cfs released from Tuttle Creek reservoir, and approximately 100,000 cfs flowing in the Kansas River, a threat of potential overtopping was indicated along the Big Blue River section of the Manhattan levee system. Corps hydrologic engineering staff involved in conducting surveillance in Manhattan verified the need for review of the system performance.

A Reconnaissance Study conducted by the Kansas City District in 2003 and 2004 under Section 905(b) of the Water Resources Development Act (WRDA) of 1986 established a preliminary determination of federal interest.. The 905(b) evaluation demonstrated that a federal interest existed for proceeding with a Feasibility Study. The 23 Nov 2004 CENWD-PDD-B Memorandum, "Subject: Manhattan, Kansas, Local protection Project, Flood Damage Reduction Reconnaissance Study (Section 216), PWI No. 013394; Submission of Final 905(b) Analysis for

Approval." provided the Kansas City District with approval to proceed with the Feasibility Cost Sharing Agreement (FCSA) and the Section 216 feasibility study.

## 2.1 SOCIOECONOMIC DESCRIPTION

### 2.1.1 Population and Social Characteristics

Manhattan, Kansas, with a 2010 population of 52,281, is the eighth largest city in Kansas. Manhattan's population increased by 16.6% between the 2000 Census and the 2010 Census, compared to only 6.1% growth for the rest of Kansas and 9.7% growth nationally during this same decade. Manhattan's population has grown substantially in this period, especially relative to the remainder of the state.

Riley and Pottawatomie Counties have experienced substantial population growth as well. The 2010 populations of Riley and Pottawatomie Counties are 71,115 and 21,604, respectively. Riley County population grew 13.2% from the 2000 to the 2010 census. Though the EAA includes only commercial areas of Pottawatomie County, it is worth noting that the county experienced 18.6% population growth from the 2000 to the 2010 census.

The specific EAA was defined using inundation mapping for Riley and Pottawatomie Counties for the City of Manhattan. This approximately 1,300-acre flood plain area accounts for about 11% of Manhattan's total area and has a total of 2,294 structures including 1,704 residential structures and 590 non-residential structures. The area is characterized by a large industrial and commercial area close to the levee and a larger residential area north and west of that commercial area. Census information was examined at the block level to estimate residential population for the EAA. The 2010 census reveals that 6,892 people currently live in the EAA in 3,454 housing units; this figure will be used as the nighttime population at risk estimate for the study. The daytime population at risk is 7,650, according to a recent Kansas City District analysis using the Levee Screening Tool. These figures are conservative as they do not include those in the area temporarily, including customers of area businesses and those traveling through the EAA on city highways and streets. Table 1 displays population and housing information for the EAA. The population and housing in the EAA overall has been largely steady between 2000 and 2010 with a growth rate of 2.6% and 1.4% respectively. Riley County Census Tract 5, block groups 1 and 2, located in the mid to northern part of the EAA along 4th street, experienced the highest rate of population growth in the EAA. This is likely explained by a number of newer multifamily residences that have recently been built there.

**Table 1: Population and Housing Trends, 2000 to 2010**

| ANALYSIS AREA | POPULATION | | | HOUSING UNITS | | |
|---|---|---|---|---|---|---|
| | YEARS | | % CHANGE | YEARS | | % CHANGE |
| | 2000 | 2010 | 2000-2010 | 2000 | 2010 | 2000-2010 |
| State of Kansas | 2,688,418 | 2,853,118 | 6.1% | 1,131,200 | 1,233,215 | 9.0% |
| City of Manhattan | 44,831 | 52,281 | 16.6% | 17,690 | 21,619 | 22.2% |
| Riley County | 62,843 | 71,115 | 13.2% | 23,397 | 28,212 | 20.6% |
| Pottawatomie County | 18,209 | 21,604 | 18.6% | 7,311 | 8,626 | 18.0% |
| EAA | | | | | | |
| Riley County | | | | | | |
| Tract 8.02, BG* 1-2 | 2,093 | 2,172 | 3.8% | 1,081 | 1,106 | 2.3% |
| Tract 8.01, BG* 1 - 5 | 2,860 | 2,882 | 0.8% | 1,503 | 1,528 | 1.7% |
| Tract 5, BG* 1 | 1,411 | 1,516 | 7.4% | 686 | 677 | -1.3% |
| Tract 9, BG* 3052-3055, 3057, 3067, 3073, 3075, 3087, 3088, 3092 | 352 | 322 | -8.5% | 138 | 143 | 3.6% |
| Pottawatomie County | 0 | 0 | 0 | 0 | 0 | 0 |
| Total for EAA | 6,716 | 6,892 | 2.6% | 3,408 | 3,454 | 1.4% |

*2000 and 2010 Census*
*Block and block group boundary mapping was changed between the 2000 and 2010 Census. Blocks and block groups used in this table are based on 2010 mapping. 2000 mapping was used to determine the correct areas for comparison, i.e., not necessarily the same block or block group in both years.*
* BG (block group) – A geographical unit used by the Census

Table 2 contains age and racial demographic information for the State of Kansas, City of Manhattan, and Riley and Pottawatomie Counties. The population in the EAA is 83.5% white, with small black (5.5%), Asian (5.1%), and Hispanic (5.8%) populations. Compared to Kansas as a whole, where 13.3% of the population are seniors, the City of Manhattan has a relatively small senior population (7.5%). This difference can likely be explained by the city's large university and the younger population that typically is associated with a university.

Manhattan's population is well educated with nearly 50% of the city's population holding a bachelor's degree or higher. Manhattan also maintains a low unemployment rate of 4.3% as compared to the state's rate of 6.3%. However, despite the well-educated population and the low unemployment rate, nearly one-third (29%) of Manhattan's population lives beneath the poverty level, compared to 12.4% in the state. Manhattan also has a much lower median household income ($36,630 vs. $49,424) than Kansas.

**Table 2: Age, Race, Income, and Education Demographics, 2010**

| | State of Kansas | City of Manhattan | Riley County | Pottawatomie County |
|---|---|---|---|---|
| Total Population | 2,583,118 | 52,281 | 71,115 | 21,604 |
| Persons under 5 | 7.1% | 5.6% | 6.6% | 8.5% |
| Persons under 18 | 25.2% | 15.3% | 18.1% | 29.2% |
| Persons over 65 | 13.3% | 7.5% | 7.3% | 12.2% |
| Male | 49.7% | 50.9% | 52.3% | 49.6% |
| Female | 50.3% | 49.1% | 47.7% | 50.4% |
| White | 87.4% | 83.5% | 85.0% | 94.6% |
| Black | 6.1% | 5.5% | 6.6% | 1.3% |
| American Indian or Alaska Native | 1.2% | 0.5% | 0.7% | 0.9% |
| Asian | 2.5% | 5.1% | 4.2% | 0.8% |
| Native Hawaiian and Other Pacific Islander | 0.1% | 0.2% | 0.2% | 0.1% |
| Two or more races | 2.7% | 3.5% | 3.2% | 2.3% |
| Person of Hispanic or Latino Origin | 10.8% | 5.8% | 7.0% | 4.7% |
| White persons, not Hispanic | 77.8% | 80.2% | 79.1% | 90.7% |
| People living below the poverty level | 12.4% | 28.8% | 24.7% | 7.1% |
| Unemployed | 6.0% | 4.3% | 4.5% | 2.4% |
| Bachelor's degree or higher | 29.3% | 49.4% | 42.3% | 28.4% |
| Median household income | $49,424 | $36,630 | $39,257 | $53,430 |

*2010 Census and 2010 American Community Survey*

There are two public institutions that heavily influence these demographics: Kansas State University, with a fall 2012 enrollment of 24,378 students (a record high) and approximately 3,000 employees, and the U.S Army's Fort Riley (just west of Manhattan) with a normal post population of more than 8,000. Manhattan is also the primary service and retail center for the tri-county area, which has a population of more than 100,000 people.

Though Manhattan is located in both Riley and Pottawatomie Counties, the section of Pottawatomie County within the EAA is a heavily industrial area with essentially no residential population. The section of the EAA within Riley County contains substantial non-residential properties as well, including county and city administration buildings, a large regional shopping mall, and the city's main downtown retail and service area, along with nearly 1,700 residential structures.

### 2.1.2 Investment

The Manhattan levee protects 1,703 residential, 390 commercial, and 108 industrial properties, along with 94 public and municipal buildings and more than 30 miles of streets and roads. The estimated total value of investment in the leveed area, including properties and contents, is approximately $1.18 billion (FY 14 prices). Commercial property value in the EAA, including structures and contents, totals $585.5 million. Industrial value in the EAA, including structures and contents, totals $129.8 million. Public and municipal buildings are valued at $114.5 million, and residential property value in the EAA is more than $305.7 million. Streets and roads in the leveed area total almost $41.5 million. Investment details are summarized in Table 3 by structure and contents values.

**Table 3: Investment (in $000) FY14 Price Level by Reach and Category**

| Confluence Reach | Commercial | Industrial | Public/Municipal | Residential | Streets and Roads | Total |
|---|---|---|---|---|---|---|
| Structures | 212 | 21 | 42 | 984 | - | **1,259** |
| Structure Value | $156,213.8 | $11,752.0 | $26,240.3 | $104,940.4 | $17,462.6 | **$316,609.1** |
| Content and Other Value | $230,274.9 | $12,301.4 | $19,127.3 | $88,717.0 | $0.0 | **$350,420.6** |
| Total | $386,488.7 | $24,053.4 | $45,367.6 | $193,657.4 | $17,462.6 | **$667,029.7** |
| **Kansas River Reach** | | | | | | |
| Structures | 125 | 54 | 39 | 719 | - | **937** |
| Structure Value | $32,284.4 | $6,692.1 | $26,808.1 | $54,191.1 | $17,640.5 | **$137,616.1** |
| Content and Other Value | $46,502.0 | $22,448.4 | $24,386.0 | $57,809.2 | $0.0 | **$151,145.5** |
| Total | $78,786.3 | $29,140.5 | $51,194.0 | $112,000.3 | $17,640.5 | **$288,761.6** |
| **Big Blue River Reach** | | | | | | |
| Structures | 53 | 33 | 13 | 0 | - | **99** |
| Structure Value | $35,721.9 | $33,724.7 | $5,844.9 | $0.0 | $6,435.2 | **$81,726.8** |
| Content and Other Value | $84,486.4 | $42,893.9 | $12,048.7 | $0.0 | $0.0 | **$139,429.0** |
| Total | $120,208.3 | $76,618.6 | $17,893.6 | $0.0 | $6,435.2 | **$221,155.8** |
| **Total Number of Structures** | **390** | **108** | **94** | **1,703** | **-** | **2,295** |
| **Total Value** | **$585,483.3** | **$129,812.5** | **$114,455.2** | **$305,657.7** | **$41,538.4** | **$1,176,947.1** |

*The Confluence, Kansas River, and Big Blue River reaches shown in this table refer to the study reach breakdown used for the economic analysis of the study area. The reach delineation is explained further in section 3.1.4.*

Table 4 further breaks down the investment value in the study and displays the percentages of each category in relation to total structural and content value. Structures in the EAA are predominantly non-residential, with commercial structures and content making up 49.7%, industrial structures making up 11%, and public and municipal structures making up 9.7% of total investment in the EAA. Overall, non-residential structures account for almost 71% of total for the EAA. The bulk of the investment for the EAA is also concentrated in the Confluence Reach with more than half (56.7%) of the overall investment contained in that reach.

**Table 4: Investment by Reach and Percentage**

| Structure, Content, and Other Value | | | | |
|---|---|---|---|---|
| | **Confluence Reach** | **Kansas River Reach** | **Big Blue River Reach** | **Total** |
| **Commercial** | 57.9% | 27.3% | 54.4% | 49.7% |
| **Industrial** | 3.6% | 10.1% | 34.6% | 11.0% |
| **Public/Municipal** | 6.8% | 17.7% | 8.1% | 9.7% |
| **Residential** | 29.0% | 38.8% | 0.0% | 26.0% |
| **Streets and Roads** | 2.6% | 6.1% | 2.9% | 3.5% |
| **Total** | 56.7% | 24.5% | 24.5% | 100.0% |

### 2.1.3 Economic Development

According to the Manhattan Economic Development website, the largest individual employers in the City of Manhattan are Kansas State University (6,028), Fort Riley Civilian Personnel (3,543), USD #383 (1,350), GTM Sportswear (900), Mercy Regional Health Center (795), Super Wal-Mart (480), City of Manhattan (374), Meadowlark Hills Retirement Center (349), Hy-Vee (300), and Manko Window Systems (240). Several of the largest employers are located within the EAA including GTM Sportswear, Super-Wal-Mart, and Manko Window Systems, along with several city buildings including City Hall.

Table 5 summarizes Manhattan's industrial structure according to the percentage employed in each industry from the 2012 Economic Census. In general, educational services and health care represent the largest percentage of employment in the city, with 40.3% of the work force, compared to the state total of 23.7% and the national total of 22.1%. The second largest share of employment in the city is in the arts, entertainment, recreation, and accommodation and food services industries. For the city as a whole, manufacturing accounts for 4.5% of employment.

**Table 5: Manhattan, KS Employment by Industry**

| Industry | Manhattan % | Kansas % | U.S. % |
|---|---|---|---|
| Agriculture, forestry, fishing and hunting, and mining | 0.7% | 3.6% | 1.9% |
| Construction | 5.8% | 6.4% | 7.1% |
| Manufacturing | 4.5% | 13.4% | 11.0% |
| Wholesale trade | 1.3% | 3.0% | 3.1% |
| Retail trade | 12.4% | 11.1% | 11.5% |
| Transportation and warehousing, and utilities | 1.5% | 4.9% | 5.1% |
| Information | 2.1% | 2.6% | 2.4% |
| Finance and insurance, and real estate and rental and leasing | 4.5% | 6.3% | 7.0% |
| Professional, scientific, and management, and administrative and waste management services | 6.3% | 8.3% | 10.4% |
| Educational services, and health care and social assistance | 40.3% | 23.7% | 22.1% |
| Arts, entertainment, and recreation, and accommodation and food services | 12.5% | 7.7% | 8.9% |
| Other services, except public administration | 2.7% | 4.4% | 4.9% |
| Public administration | 5.4% | 4.7% | 4.8% |

*2010 Economic Census*

A further breakdown of industrial activity is provided by the 2010 County Business Patterns (U.S. Census Bureau) in Table 6. There were 2,709 businesses in the Manhattan, Kansas Micropolitan Statistical Area, a Census Bureau designation defined as an urban area based around an urban cluster with a population of 10,000 – 49,999 in 2010. These businesses were distributed among the following major industries: retail trade, 16.9%; other services (except public administration), 11.6%; construction, 11.1%; health care and social assistance, 10.2%; professional, scientific, and technical services, 9.0%; finance and insurance, 7.0%; real estate and rental/leasing, 5.6%; administration and support and waste management and remediation services, 4.6%; transportation and warehousing, 2.9%; wholesale trade, 2.6%; manufacturing, 2.5%. Other industries comprised less than 2% of businesses in the micropolitan area. (Technically, Manhattan has been upgraded to metropolitan area status, containing Geary, Pottawatomie, and Riley Counties, as well as a number of other towns besides Manhattan, but the County Business Patterns statistics were still being reported in terms of the micropolitan statistical area of Manhattan as of 2010.)

**Table 6: Manhattan, KS Micropolitan Statistical Area General Business Patterns, 2010**

| | Number of establishments | Paid employees | Annual payroll |
|---|---|---|---|
| Agriculture, forestry, fishing and hunting | 3 | 20 to 99 | N/A |
| Mining, quarrying, and oil and gas extraction | 2 | 0 to 19 | N/A |
| Utilities | 6 | 250 to 499 | $34,468 |
| Construction | 302 | 2,356 | $91,223 |
| Manufacturing | 67 | 2,694 | $104,880 |
| Wholesale trade | 70 | 976 | $32,678 |
| Retail trade | 457 | 7,268 | $147,177 |
| Transportation and warehousing | 79 | 842 | $23,459 |
| Information | 52 | 1,035 | $30,465 |
| Finance and insurance | 189 | 1,379 | $49,370 |
| Real estate and rental and leasing | 152 | 831 | $22,523 |
| Professional, scientific, and technical services | 243 | 1,677 | $56,939 |
| Management of companies and enterprise | 23 | 250 to 499 | N/A |
| Administrative and support and waste management and remediation services | 124 | 1,613 | $47,460 |
| Educational services | 31 | 506 | $9,950 |
| Health care and social assistance | 275 | 6,300 | $204,758 |
| Arts, entertainment, and recreation | 39 | 377 | $4,523 |
| Accommodation and food services | 275 | 5,659 | $64,303 |
| Other services (except public administration) | 313 | 2,326 | $60,689 |
| Industries not classified | 7 | 4 | $70 |
| Total for all sectors | 2,709 | 36,731 | $1,001,842 |

*2010 County Business Patterns (U.S. Census Bureau)*

Manhattan has generally experienced positive economic growth in recent years, in spite of the recent economic environment nationally. The city has recently been ranked first by Forbes in 2011 as one of the best small communities for business and careers; Manhattan also ranked sixth on Forbes' list of best small cities for jobs. Business Facilities magazine ranked Manhattan second on their 2010 list of top ten metros for economic growth potential (under 200,000 population). In 2008, Manhattan was selected by the Department of Homeland Security as the site for the National Bio and Agro-Defense Facility, an estimated $720 million dollar project to open in 2018. The Kansas Department of Agriculture has also recently announced that they are moving from the state capital, Topeka, to Manhattan to be closer to Kansas State University, the National Bio and Agro-Defense Facility, and other agriculture related entities. This involves the relocation of about 160 employees and construction of a 50,000 square-foot office building. Neither of these facilities will actually be located within the current EAA, but they indicate that Manhattan is a growing community that is attracting a lot of development.

The section of the city just west of the confluence of the Kansas and Big Blue River has experienced a significant amount of commercial and residential development in recent years, in both Pottawatomie and Riley Counties. For example, of the 191 non-residential structures located in the section of the EAA in Pottawatomie County alone, approximately 34% have been built within the past 15 years. Development under construction in the EAA includes a Dick's Sporting Goods, multiple fast food restaurants, a Hilton Hotel, a conference center, multi-family apartment buildings, and the recently opened Flint Hills Discovery Center.

## 3.1 DAMAGE ANALYSIS DATABASE PREPARATION

### 3.1.1 Analysis Years and Period of Analysis

The existing conditions economic analysis was completed in 2012. The base year used for the analysis is 2023, the year the project is expected to be completed. The existing conditions and base year have the same assumptions and condition. A 50-year period of analysis was used as the beneficial effects of the levee could not be confidently forecasted beyond this time interval. 50 years is also the maximum period of analysis allowed per regulation. The future condition was defined as 2073. However, the future condition uses the same assumptions as the base year, so there are no differences between these years in the without project condition.

### 3.1.2 Future Development

Almost all properties included in the database for the existing condition analysis are existing properties as of 2012, including some recently completed redevelopment. Discussions with county and city economic development staff have identified one planned development that is appropriate for use in the database and will be completed by the base year. This structure is a redevelopment of an existing structure. The city has approved an economic development agreement with CivicPlus, a company that currently has office space in Manhattan outside the current EAA, to build a five-story 50,000 square-foot office building at the intersection of 4th Street and Pierre. This will be replacing an existing structure both in reality and within the HEC-FDA model. (The first floor of the new building will be built above the 1% flood elevation and therefore will not be subject to restrictions under Section 308 of WRDA 1990.)

Otherwise, investment in the area for the purposes of this study is considered stable from the existing to the future without-project condition. Stream flows and stages affecting the EAA are also not forecasted to change during the period of analysis. For further information concerning the future without-project condition, see section 6.1 below.

### 3.1.3 Interest Rate and Price Level

For purposes of annualizing costs and damages in the investment and screening level of the analysis, the FY14 Federal water resources interest rate of 3.5% and a project life of 50 years are assumed. All these investment and damage values are expressed in 1 October 2013 prices (FY14 ). For the final NED plan in section 8.1, the costs and benefits were updated to a FY15 price level and used the FY15 interest rate of 3.375%.

### 3.1.4 Study Reaches

For this analysis, three study reaches were defined. See Figure 1 below for map of the reach delineation. Each river has one reach unique to it along with the confluence reach which overlaps the floodplain between the two rivers. The confluence reach is included in both the Kansas and the Big Blue model, as the floodplain overlaps in that area. (The models for both streams include the confluence reach in order to determine which river is controlling and should be used as the basis for damage estimation; see section 4.1.5.) The confluence reach is located

between Kansas River RM 145.59 and 146.91 with an index point of 146.84 and between Big Blue River RM 0.4 and 0.83 with an index point of 0.82. The Kansas River-specific reach is located between the RM of 146.92 and 149.79 with an index point at 147.67. The Big Blue River specific reach is located between the RM 0.84 and 1.51 with an index point of 0.95.

**Table 7: HEC-FDA Study Reaches**

| Stream | Beg. River Mile | End River Mile | Index Station |
|---|---|---|---|
| Kansas River | 145.59 | 149.79 | |
| Confluence Reach | 145.59 | 146.91 | 146.84 |
| Kansas River Reach | 146.92 | 149.79 | 147.67 |
| Big Blue | 0.40 | 1.51 | |
| Confluence Reach | 0.40 | 0.83 | 0.82 |
| Big Blue Reach | 0.84 | 1.51 | 0.95 |

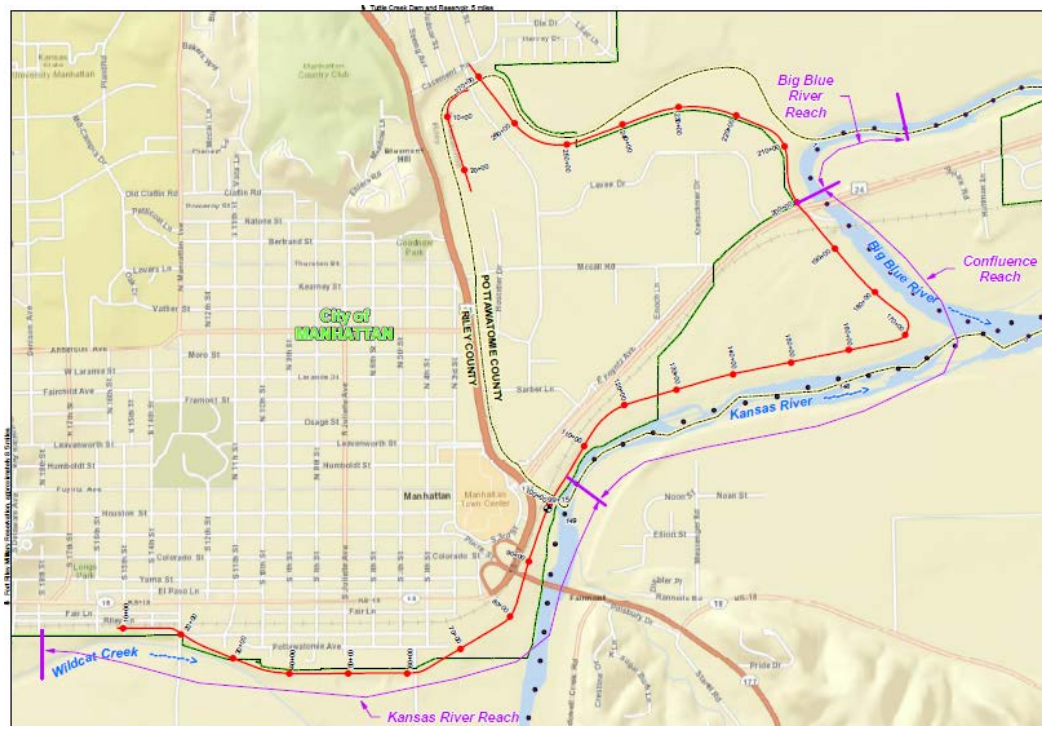


**Figure 1: Manhattan Levee Reach Delineation**

### 3.1.5 <u>Economic Categories for Structure Occupancies</u>

The economic structure inventory in this study is categorized in terms of three basic categories: residential, commercial, industrial, and public structures, and streets and roads. Each structure under the first two of these categories was assigned a specific occupancy from a list of 57 occupancy types based on the structure and contents characteristics. These characteristics include the type of business (such as retail or industrial) or residence (such as 1 story or 2 stories) that occupies the structure and the construction class. Occupancies also specify damage percentages for structures and contents, content-to-structure value ratios, beginning damage elevation, and uncertainty in those variables. The occupancy assignment affects how the damages for each structure are calculated.

### 3.1.6 Data Collection Methodology

Data collection, the first phase of the economic database development, involved three steps: (1) obtaining county tax records and appraisal information for structures within the EAA; (2) execution of a structure-by-structure field survey; and (3) combining the existing tax record data with the structure-by-structure field survey data.

### 3.1.7 Data Collection

In order to create an inventory of structures for the damage analysis, a potential inundation area was defined, starting with the 0.2% chance flood inundation mapping and extending it by about a block at the western edge of the inundation to account for uncertainty. Parcel identifiers were then obtained for this area based on GIS mapping data. A search of the online tax databases for Pottawatomie and Riley County was conducted, to gather specific structure information on type, age, value, condition, square footage, and occupancy, among other factors. These searches were followed up with meetings with the appraisers of both counties to go over some of the aspects of the databases and discuss how best to use them to obtain appropriate depreciated replacement values on each of the structures. Depreciated replacement value is defined as the cost of replacing an item today with an item of equivalent condition and functionality. Corps of Engineers planning guidance requires the use of depreciated replacement value when valuing properties for economic analysis. In order to determine depreciated replacement value, the replacement cost of the item is identified or calculated, and that value is depreciated according to the item's age, condition, and functionality.

Each county provided estimated replacement costs (Replacement Cost New) from their appraisals of each structure. The Replacement Cost New was determined by the county appraisers using the dimensions of the building and the square footage, the interior and exterior materials used to build the structure, the function of the building, and the HVAC and plumbing makeup for the structure. The county also does a field survey of each property every two years to confirm their existing information and update anything as necessary. This value, and the method by which it was calculated, was considered satisfactory as a basis for the calculation of depreciated replacement value. Depreciation was calculated by Kansas City District economic staff based on the age, condition, and functionality of the structure, as given by the appraiser's database and confirmed by the field survey, and applied to the replacement costs to estimate depreciated replacement values for each structure.

After the structure inventory was compiled, Kansas City District economics staff carried out a 100% structure-by-structure windshield survey of all buildings in the EAA over several weeks in July 2011 and a follow-up survey in November 2012. The purpose of the survey was to confirm the county tax record data, especially occupancy information, and estimate first floor elevations for each structure. In cases where building use or occupancy had changed, the structure inventory was updated accordingly. Notes from the completed field survey were subsequently integrated with the tax data to form a complete structure inventory for the area for use in HEC-FDA.

### 3.1.8 Mapping

Kansas City District GIS staff processed flood plain mapping and elevation information for Manhattan provided by the city. Real estate parcels and structure footprints were included in the GIS layers. A map based on the 0.2% chance flood plain (and extending slightly beyond that event, as discussed above) was produced; this guided the structure inventory and field survey tasks. Ground elevations were assigned to all floodplain structures based on the contours and elevations from the mapping. Figure 2 below gives an overview of the EAA inventoried for economic damages and Figure 3 shows the inventory area with the parcels highlighted. Figure 4 shows the overall City of Manhattan and the relationship between the floodplain EAA and the city. For more detailed GIS information about the study, please refer to the mapbook.

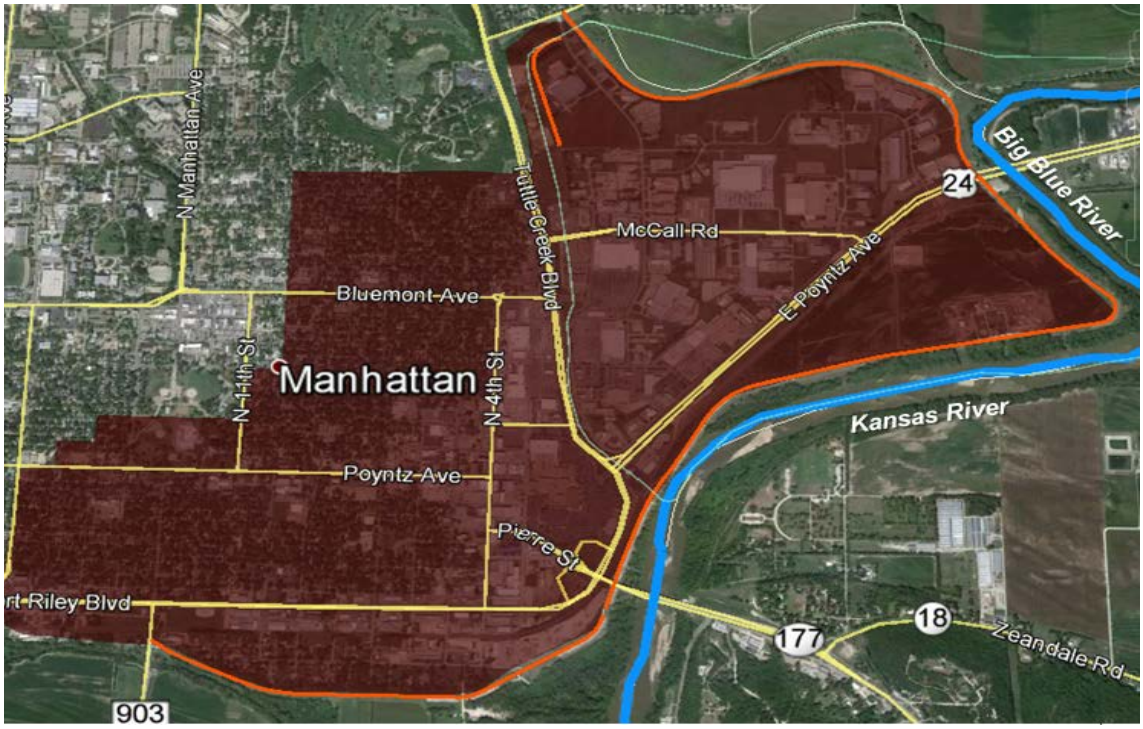


**Figure 2: City of Manhattan Economic Analysis Area**

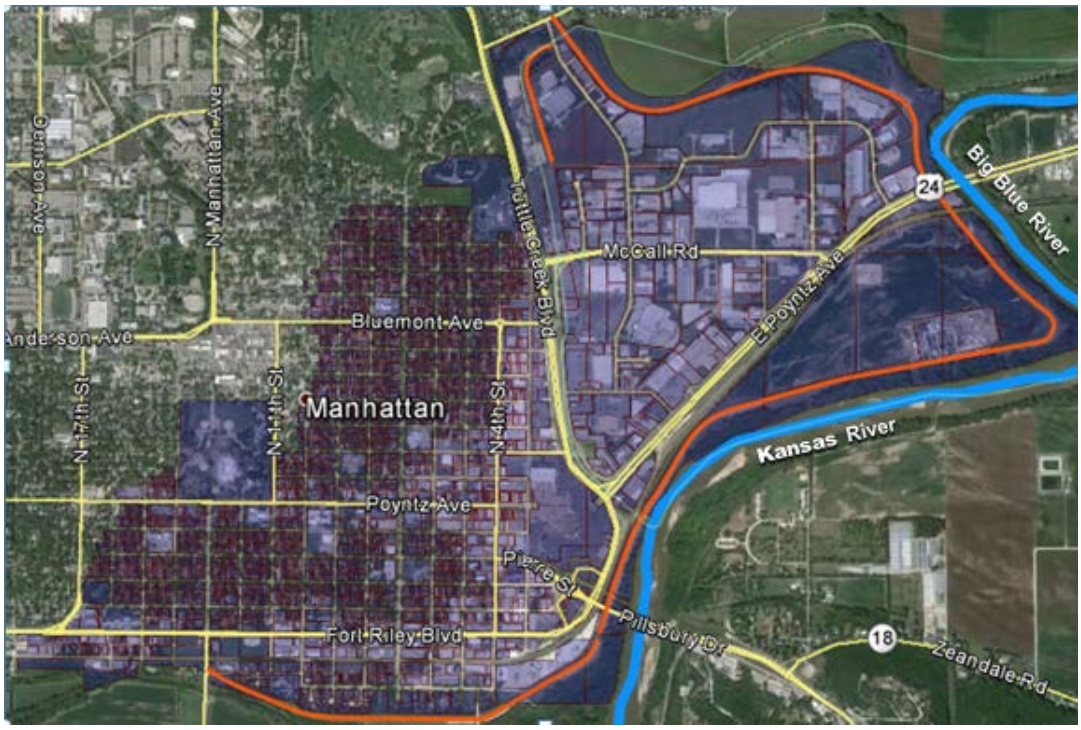


**Figure 3: City of Manhattan Economic Analysis Area Parcel Outline**

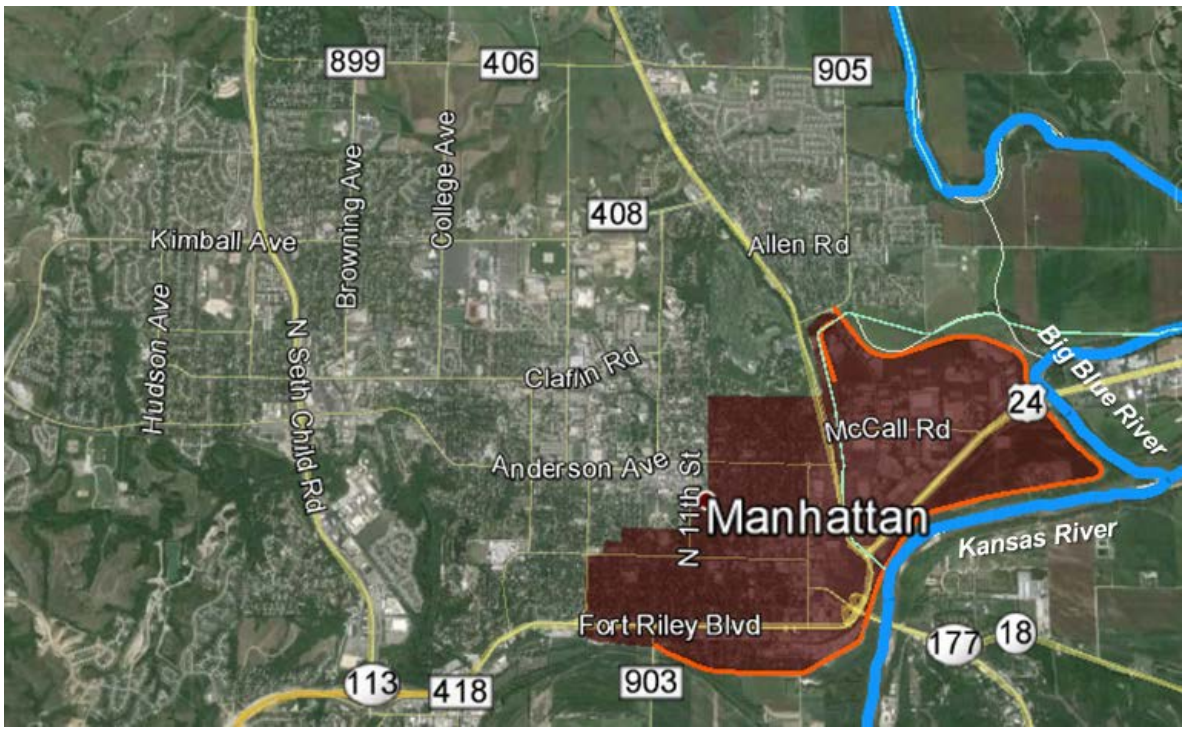


**Figure 4: City of Manhattan**

## 4.1 DATA AND MODEL DEVELOPMENT

### 4.1.1 Property Inventory

In the second phase of the database preparation for the economic analysis, the raw data obtained from the county and city tax and GIS data and from the field survey were further developed, refined, and organized to produce the three key variables for each property to be used in the damage analysis: beginning damage elevations, property values, and depth-damage relationships. The HEC-FDA program used for the damage analysis also requires specification of uncertainty factors. These variables are discussed individually below.

All economic damage data in this analysis are based on physical inundation damage to properties – businesses, public facilities, residences, and streets.

### 4.1.2 Elevations

Each structure in a flood damage reduction analysis is assigned a ground elevation. Buildings additionally are assigned a first-floor elevation expressed as a foundation height above the ground elevation. Damage to the building is generally assumed to begin at the ground elevation, while contents damage begins at the first-floor elevation. However, this can vary based on the occupancy assigned to the structure. For example, whether a residential structure has a basement or not determines at what stage damage due to flooding begins. Property elevations help determine depths of flooding for each flood event evaluated.

Most structures were assigned a ground elevation based on the centroid point in each real estate parcel using GIS data from the USGS 2011 National Elevation Dataset (NED). The NED data uses raster elevation data referenced to North American Vertical Datum of 1988 (NAVD 88). The location of some structures required that the ground elevation be assigned based on 1-foot contour maps, also based on USGS information. Each structure also was assigned a station or stream mile for the purpose of allowing the stage-damage relationship for the structure to be transferred to the index point of the reach in the damage analysis.

In addition to the ground elevations and stations, each structure was assigned a foundation height relative to the ground elevation. The foundation heights were estimated in half-foot intervals by visual observation during the field survey. The first-floor elevation (or beginning damage elevation) in the economic analysis model was determined by adding the foundation height to the ground elevation.

The first-floor elevation for each type of structure is characterized by an uncertainty factor, usually expressed as a standard deviation around a normally distributed variable. According to EM 1110-2-1619, Table 6-5, the uncertainty associated with mapping based on an aerial survey with 2-foot contours would be characterized by a standard deviation of 0.3 feet. The table does not give the error associated with 1-foot contour maps, which by inference might have a standard deviation of something less than 0.3 feet. However, at least three factors increased the uncertainty beyond this rule of thumb: (1) the generalized block-by-block method that was necessary for assigning ground elevations in some areas in this analysis due to time

constraints; (2) the difficulty of estimating the correct ground elevation for properties where the structure footprint is traversed by multiple elevation contours; and (3) the uncertainty inherent in brief and somewhat distant visual observation and estimation of foundation heights in the field during windshield surveys. These factors are bigger issues with some properties and areas than others, and the exact uncertainty associated with each limitation is unknown. But in order to accommodate the known uncertainty factors involved in estimating elevations for this study, all structures in the database were assigned a standard deviation of 0.6 feet. This could potentially impact the damages for the existing condition due to the greater uncertainty assumed, but it would increase damages under each alternative in a similar way. Therefore, using this standard deviation should not impact alternatives screening or plan selection, as it would impact damages under each alternative and existing condition in the same way.

### 4.1.3 Valuation

For this analysis, the replacement cost value for both residential and non-residential structures was taken directly from the Riley County and Pottawatomie County appraisal tax databases. After meeting with both counties' appraisers and discussing their processes in detail, it was determined that the replacement cost from the counties databases was appropriate for this study and would provide a good starting point to determine the depreciated replacement value for each structure. The appraisers for each county use the dimensions of the building and the square footage, the interior and exterior materials used to build the structure, the function of the building, and the HVAC and plumbing makeup for the structure, to determine a new replacement cost for each structure. From this replacement cost, a depreciation scheme for both residential and non-residential structures, based on age and condition of the structure and generally taken from RS Means, was applied by Kansas City District economics staff to each structure in the inventory in order to obtain a depreciated replacement value for each structure in the EAA. A summary of the depreciation scheme for residential properties is shown in Table 8, while Table 9 summarizes the depreciation rates for non-residential properties.

**Table 8: Residential Depreciation Scheme by Age and Condition**

| Age of Structure | Depreciation Range |
|---|---|
| 1 - 10 years | 0% - 5% |
| 11 - 20 years | 6% - 13% |
| 21 - 30 years | 13% - 22% |
| 31 - 40 years | 23% - 35% |
| 41 - 50 years | 36% - 49% |
| 51 - 60 years | 51% - 64% |
| 61 - 70 years | 65% - 76% |
| 71 - 80 years | 77% - 80% |
| Over 80 years | 80% |
| **Condition** | **Depreciation** |
| Excellent | No more than 5% |
| Good | Subtract 20% of the age depreciation |
| Average | Assume age deprecation |
| Fair | Add an additional 20% of the age depreciation percentage |
| Poor | Add an additional 40% of the age depreciation percentage |
| Unacceptable | Depreciated 95% |

**Table 9: Non-Residential Depreciation Scheme by Age and Condition**

| Age of Structure | Depreciation Range |
|---|---|
| 1 - 10 years | 0% - 2% |
| 11 - 20 years | 2% - 5% |
| 21 - 30 years | 5% - 11% |
| 31 - 40 years | 12% - 21% |
| 41 - 50 years | 23% - 38% |
| 51 - 60 years | 40% - 57% |
| 61 - 70 years | 59% - 71% |
| 71 - 80 years | 71% - 80% |
| Over 80 years | 80% |
| **Condition** | **Depreciation** |
| Excellent | No more than 5% |
| Good | Subtract 20% of the age depreciation |
| Average | Assume age deprecation |
| Fair | Add an additional 20% of the age depreciation percentage |
| Poor | Add an additional 40% of the age depreciation percentage |
| Unacceptable | Depreciated 95% |

Uncertainties in structure values for residential and non-residential structures are characterized by standard deviations. The standard deviation for residential structure value in this analysis is assumed to be normally distributed and is characterized by a standard deviation of 0.19. This standard deviation is based on the typical differences in value between successive categories of construction quality (based especially on exterior wall type). Uncertainty in the valuation of non-residential structures is assumed to be normally distributed and is characterized in this analysis by a standard deviation of 0.21 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 between successive categories of construction types.

A nominal residential contents-to-structure value ratio (CSVR) of 1.0 was used for residential structures in the area in accordance with IWR guidance in EGM 04-01. (As discussed in the EGM, use of this CSVR does not mean that residential damages are calculated based on a contents value equal to 100% of structure value Additionally, an “other” value was assigned to each structure, based on car values, landscaping values, and any other detached small structures not accounted for in the overall structure value. Using the ADESA analytical services monthly analysis of Wholesale Used Vehicle Prices by Vehicle Model Class, an average used car price was determined for both cars and trucks (defined as trucks, vans, and SUVs) as $9,097 and $10,152 respectively. Then to determine the distribution of cars and trucks to each residence, the motor vehicle registration summary records for the State of Kansas were obtained from the US Census. 36% of the vehicles in Kansas were registered as cars and 64% were registered as trucks, vans or SUVs, so a “representative” vehicle value of $9,772 was used. From there an average value for each residential category was obtained and an additional 2% of that value was added to account for landscaping and other structures on residential properties. The additional 2% assumption was based on looking at a combination of average home prices for the area and average outside structure costs (including average shed costs of $700, average detached garage

price per square foot of $72, and average cost for a two car detached garage of $48,740, according to data obtained from remodeling.net for the Wichita, KS area, the closest area for which data was available). These "other" values for each residential category can be seen in the Table 10.

**Table 10: Residential Other Value Assignment Summary**

| Housing Type | Category Code | Average Value | Car Value | Other Value (rounded) |
|---|---|---|---|---|
| 1 Story No Basement | R01 | $67.30 | $9.77 | $11.1 |
| 1.5 Story No Basement | R02 | $48.21 | $9.77 | $10.7 |
| 2 Story No Basement | R03 | $149.00 | $9.77 | $12.8 |
| 1 Story W/ Basement | R04 | $49.15 | $9.77 | $10.8 |
| 1.5 Story W/ Basement | R05 | $57.16 | $9.77 | $11.0 |
| 2 Story W/ Basement | R06 | $129.08 | $9.77 | $12.4 |

The residential category R08, apartments, was developed differently. These structures were generally coded as commercial in the county databases and were depreciated according to the non-residential depreciation scheme. Additionally, the "other" value was developed differently than with the other residential properties, as more than one vehicle would presumably be at the property and the values of these properties are so varied that an average is not appropriate. The number of units in each apartment property was obtained from the appraiser's database and 50% of these apartments were assumed to have a car. It was assumed that not every apartment would have a car with it, especially in a college town, and that in the event of a flood, at least half of the cars would be moved out of the floodplain. From there, 2% of each structure's depreciated replacement value was added to account for landscaping and outbuildings. So a structure categorized as an apartment was given an individual "other" value based on the actual value of individual structures and the number of units.

The CSVRs for non-residential structures relied on data developed by the New Orleans District Corps of Engineers as published in the "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," dated May 1997. This dataset was based on a mid-1990s canal flooding event in the Baton Rouge area. Given that the characteristics of flooding in the New Orleans study (inland, freshwater, long duration flooding, similar business types) matched the characteristics of the Manhattan Levee analysis, these data were deemed appropriate for use in this analysis. These CSVRs were based on interviews with business owners or operators in the Baton Rouge area. Seven broad business categories are included: restaurants, grocers, retail and services, professional offices, repairs and home use businesses, warehouses and contractors, and public facilities. In addition to the similarity in flooding characteristics between the two studies, these types of businesses in the New Orleans study are very similar to those in Manhattan. The development of the owner/operator data for each of these categories included interviews with 10 businesses or facilities, usually representing several specific types of business within each broad category. Additional CSVRs for churches and service stations were taken from IWR Report 96-R-12, "Analysis of Non-residential Content Value and Depth-Damage Data for Flood Damage Reduction Studies," May 1996. This report evaluated post-flood data from the Wyoming Valley area of the Susquehanna River basin in northeastern Pennsylvania. The context of the data is long-term, freshwater, mainstem river flooding in an urbanized area, which is similar to the

flooding context of the Manhattan analysis. Finally, the 12 non-residential properties for which available information was insufficient to determine an occupancy type were assigned a CSVR of 1.0.

Uncertainties in residential contents valuation are not specified in this analysis for those homes affected by the IWR functions, following the EGM guidance for the functions warning against the use of any uncertainty factors because of how the functions are constructed and used in the risk analysis. That approach has been followed in the Manhattan analysis. Uncertainties in contents valuation for non-residential structures are assumed to be subject to a normal distribution and are characterized by standard deviations accompanying the CSVRs in the New Orleans and Wyoming Valley data.

Lengths and types of road potentially adversely impacted within the 0.2% chance flood plain were estimated using GIS data provided by the city. The valuation of road and streets is based on typical construction costs per mile, which are applied to the length in miles for each type of road. Data on typical construction costs for highways, city streets and county roads were collected by Kansas City District primarily during FY 2003-04 (but also including some later data). A broad range of estimates for each type of road resulted from this research, and rather than averaging the data, we selected figures from the lower end of these ranges. These figures have been updated for price levels subsequently. The main sources used in the research included information obtained from HNTB for Kansas City District studies; data from state transportation departments in Missouri, Arkansas, South Dakota, Florida, Virginia and Washington; long-term regional planning data from the cities of Columbia, Missouri, and Topeka, Kansas; and additional data from other sources including the Minnesota state auditor and the University of Virginia. The totals used in this report for typical construction costs per mile are $1.5 million for highways and $1.2 million for city streets. A total of 30.3 miles of roads and highways were valued at $39.7 million for the EAA. Uncertainty in valuation of roads and streets was computed as a triangular distribution. Low and high values around the median were computed by changing assumptions for replacement cost per mile. For roads and highways, the allowable range in values is from 34.6% to 182.7%.

Clean-up costs were estimated at 2% of total investment in structures and contents. This assumption was based on data obtained from previous studies and approved reports from other Corps districts as well as Kansas City District reports. Estimated cleanup costs for each levee unit were entered into HEC-FDA, along with an appropriate depth-damage relationship, for integration with the hydrologic data and to determine annual cleanup costs incurred in each unit over the period of analysis.

Other costs of flooding such as emergency costs are much more difficult to determine and estimate than physical flood damages. In the Manhattan study area, actual study area historical data about these types of emergency costs are neither readily available nor easily estimated because the last damaging flood event for the area behind the levee was in 1951. As an alternative, several reports were consulted that were 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%-chance 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*, U.S. Army Corps of Engineers Lower Mississippi Valley Division, May 1996; and the *Flood Plain Management Assessment of the Upper Mississippi River and Lower Missouri Rivers and Tributaries*, U. S. Army Corps of Engineers June 1995.

1993 flood damages were compared with 1993 agency emergency costs as reported in these documents. The 1993 emergency cost category data included the following: Federal Emergency Management Agency disaster administrative costs (costs of temporary disaster field offices and temporary hires, but not including costs for permanent administrative staff or permanent office and equipment costs), Department of Health and Human Services 1993 flood disaster costs, Corps flood emergency and emergency operations costs, and Environmental Protection Agency 1993 flood costs relative to underground storage tanks, oil spill response, and Abatement, Control, Compliance program operations. Based on the data provided in the reports, emergency costs, as a percent of total physical flood damages, ranged from a low of 12.4% to a high of 15%, with an average of 13.4% for all states impacted by the 1993 flood. The average of 13.4% of total flood damages was used for determining emergency costs in this analysis. Preliminary HEC-FDA runs were executed to obtain estimates of total physical damages for the 0.2%-chance event in each study reach, and these totals were used as the basis for determining emergency costs.

Traffic disruption costs were not analyzed for this study. While there is a potential for traffic disruption costs, due to the compact nature of the study area and the rarity of the floods necessary to inundate the existing study area, it was determined that benefits for this category would be minimal.

### 4.1.4 Depth-Damage Functions

The goal of this portion of the analysis is the production of depth-damage relationships or functions for each type of item susceptible to inundation. An item that has experienced prolonged submersion might be a total loss, or badly damaged but salvageable, or even relatively unaffected in some cases. Depth-damage functions give estimated percentages of value affected by each foot of flooding; e.g., 2 feet of inundation might be associated with damage amounting to 20% of total property value. The relationships are developed for each type of occupancy within each economic category and are usually broken down by structure and contents. Uncertainty in the depth-damage percentages must also be specified in terms of either a standard deviation or minimum and maximum values for each foot of flooding.

As discussed in section 4.1.3 Valuation**,** residential damages for most homes in this analysis are based on depth-damage percentages released in Economic Guidance Memorandum 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. Of the seven residential occupancy types selected for this analysis, the IWR functions pertain to six: 1-story with and without basement, 1 1/2-story with and without basement, and 2-story with and without basement. (Note that the 1 1/2 story functions are not included in the

EGM but were developed based on the EGM data by averaging the 1- and 2- story functions.) The "other" damages for residences in this analysis were based upon the "Generic Depth-Damage Relationships for Vehicles" from Economic Guidance Memorandum 09-04 which has depth-damage percentages for vehicles obtained from several post-flood damage surveys.

For the non-residential structures, the treatment of depth-damage relationships is similar to the contents valuation process for the same businesses described above in section 4.1.3. The New Orleans District report discussed there is also the source for many of the depth-damage functions used in this analysis and is considered relevant to the EAA for the same reasons. 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. The New Orleans owner/operator estimates used for Manhattan were based on post-flood surveys conducted in the aftermath of an urban, freshwater, main stem (long duration) flooding event in Louisiana. The owner/operators interviewed represented many of the same types of businesses and facilities as those included in the Manhattan structure inventory. These are the factors making the data relevant for Manhattan. Depth-damage functions are included in the New Orleans District report for each of three types of non-residential structure (masonry, steel, and wood) and seven types of non-residential contents (restaurants, grocers, retail and services, professional offices, warehouses and contractors, repair and home use establishments, and public facilities). The New Orleans functions include median, maximum, and minimum values that serve as the basis for triangular damage uncertainty distributions in the risk analysis. Additional depth-damage functions for churches and service stations came from a published IWR report evaluating data from the Wyoming Valley in Pennsylvania. These depth-damage curves included only median values and had to be augmented by assumed uncertainty bounds. The Wyoming Valley depth damage functions are deemed appropriate for use in this analysis because the context of the data is again long-term, freshwater, main stem river flooding in an urbanized area with similar non-residential occupancy types, which is similar to the flooding context of the present analysis.

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.

Depth-damage functions used for roads and streets in this analysis were 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 depth-damage percentages.

The depth-damage functions constructed for the costs of cleanup and emergency costs were determined in two ways. Estimated cleanup costs for each levee unit were entered into HEC-FDA, along with an appropriate depth-damage relationship based on professional judgment, for integration with the hydrologic data and to determine annual cleanup costs incurred in each unit over the period of analysis. Emergency cost depth-damage functions were developed in conjunction with preliminary runs of the HEC-FDA program that estimated single-event damages for the 0.2%-chance event and other large events. The emergency costs function was structured so that a 0.2%-chance flood would result in damages for this category equal to about 13.4% of total physical damages. Percentages for smaller events were estimated as proportions of the 13.4% damage based on comparing typical flood depths in each event.

### 4.1.5 HEC-FDA Model Development

Much of the Manhattan floodplain is subject to flooding from either the Kansas River or the Big Blue River. In order to deal with these dual sources of flooding in the economic analysis, two HEC-FDA models were developed; one using Kansas River water surface profiles and stream stations and one using Big Blue River water surface profiles and stream stations. In order to be able to obtain one result that would accurately reflect damages from both river systems, three different reaches were delineated. At the confluence, due to the dual floodplain area between the two rivers, a confluence reach was developed for use in each of the two models. This reach uses the same structure inventory in each model, but uses Kansas River water surface profiles and stationing in one model and corresponding data for the Big Blue River in the second model. The model that returned the highest damages for the confluence reach is determined to be the governing river for the confluence reach. The results from that river's model are used to determine which river would ultimately be assigned to those structures for the purposes of alternatives analysis. Then a separate upstream reach was developed on each of the two rivers, with structures uniquely assigned to each one according to their proximity to either river. The results from the two models are discussed further in section 5.

The comprehensive structure inventory for the EAA – including elevations, property values, and depth-damage functions for each property - was entered into HEC-FDA for damage computations. HEC-FDA refers to the Flood Damage Analysis software developed by the Hydrologic Engineering Center for use in Corps of Engineers flood risk economic analyses. HEC-FDA is the standard program used for this purpose within USACE, and the certified version 1.2.5a was used for this analysis. The basic assumption underlying use of a risk analysis program is that the data in flood damage analyses are based on imperfect knowledge and those 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. The economic structure inventory is loaded into HEC-FDA and integrated with hydraulic and hydrologic data characterizing flood potential as well as geotechnical and structural data characterizing the levee segments. All engineering and economic data are entered into the program in terms of median or most likely values and accompanied by appropriate uncertainty parameters specifying the range of possible values for each variable. The conceptualization of the subsequent risk analysis simulates tens of

thousands of theoretical flood events, synthetically extending the period of record to thousands of years and thereby producing results that embody uncertainties in assumptions and the dynamic interaction of variables over time. 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. See Appendix H.2.3. of the HEC-FDA Users Manual for further description.

Damages are initially expressed as a stage-damage relationship; i.e., each foot of potential flooding at an index point is associated with an estimated amount of damage. But the ultimate goal is expression of damages in a probabilistic, annualized equivalent form. The calculation of average annual damages conceptually involves a weighted average in which the primary damages for each event are multiplied by the incremental probability of that event. The product is summed and then divided by 100 to obtain a total that represents an estimate of the average damages that could be expected in any given year over the long term. (Again, this is a conceptual rather than a literal description of the process of determining annualized damages.) The expected 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.

An additional result of the risk analysis is a set of statistics characterizing project performance in terms of assurance, annual exceedance probability, and long-term exceedance probability. The program estimates the probability that a levee unit will successfully contain certain specified flood events of interest such as the 1% event. These statistics account for both the possibility of overtopping (hydraulics) and the possibility of geotechnical or structural failure.

### 4.1.6 Hydrologic and Hydraulic Data

Study reaches serve the basic purpose of allowing the aggregation of stage-damage data for all properties located in a particular portion of the stream's floodplain. Each reach is assigned an index point, and all property elevations in that reach are adjusted to the elevations at the index point. These adjustments in elevation compensate for variations in the lay of the land along the stream and particularly the gradual drop in ground elevations typically encountered when going downstream a river or creek.

As described in Section 3.1.4, the Kansas River has a unique reach between RM 146.92 and 149.79 with an index point at 147.67. The confluence reach for the Kansas River is located between RM 145.59 and 146.91 with an index point at RM 146.84. The Big Blue River was separated into its unique reach between RM 0.84 and 1.51 with an index point at RM 0.95, and its confluence reach between RM 0.40 and 0.83 with its index point at 0.82.

A review of the records indicated that both the Kansas and Big Blue Rivers sometimes respond to a rainfall event that produces a pronounced peak in one hydrograph and only a weak response in the other tributary. At other times, both tributaries respond to the same event, but rarely do both hydrographs peak on the same day. For this reason, the rivers are being classified as semi-independent. Since each basin has shown the capacity to influence the presence of flooding below the confluence, individual relationships between the flow coincidence from each basin and the Kansas

River below the confluence were developed. To develop the water surface profiles used in the HEC-FDA model, the hydraulic analysis identified the most likely coincident flow given a flood event on the Big Blue or Kansas River. See the Engineering Appendix section 2.3.12 for additional information on the coincident frequency analysis.

Water surface profiles relating Kansas River and Big Blue River stages to frequencies or probabilities of occurrence throughout the EAA were provided for each of eight events, including the 10-, 4-, 2-, 1-, 0.5-, 0.3-, 0.2- and 0.13% flood events. The exceedance-probability relationship for both the Kansas River and the Big Blue River was evaluated using the graphical method, which involves specifying a discharge-probability relationship (including a discharge for the 0.999, 0.99, 0.95, 0.9, 0.8, 0.7, 0.5, 0.3, and 0.2 probability events) for each index point along with the equivalent record length (50 years) for the stream. A stage-discharge relationship also was entered for each reach, with the addition of a standard deviation of 1.0 foot for Kansas River stages and 1.5 feet for Big Blue River stages.

District H&H staff also produced the levee overtopping elevations, adjusted to the index points, which were calculated using the National Levee Database elevation data. The lowest point along the length of the levee is in the northern section of the Big Blue Reach. The city independently completed a raise of the levee in 2012 along the Big Blue River segment in order to qualify for FEMA levee certification. The National Levee Database data was then supplemented with data concerning this raise. The city's levee raise along the Big Blue segment of this levee was between 0 and 1.2 feet, with an average of about .5 feet. This post-raise levee height is considered the existing and future without-project condition for the Big Blue segment of the levee for evaluation in the HEC-FDA models.

### 4.1.7 Geotechnical and Structural Data

Geotechnical and structural deficiencies in the existing levee also were evaluated and incorporated into the HEC-FDA model. Seven areas of geotechnical or structural deficiency were identified along the Kansas River segment of the levee and two areas of deficiency were identified along the Big Blue River segment. According to the PDT engineering staff, each of these deficiencies is independent of any of the other geotechnical or structural deficiencies in the levee. Additional deficiencies were identified in the levee but were determined to stem from inadequate maintenance and thus were not considered in calculations that would ultimately help determine the feasibility of a Federal project. The City of Manhattan has designed a project to address the identified deficiency of two buried relief wells. This design is currently under review by District staff prior to implementation by the city. There are no features included in the alternatives for the purposed of addressing known O&M deficiencies. The Recommended Plan specifically includes only those features necessary to support the future levee height according to current design criteria."

A probability of failure curve for each levee section with an identified deficiency was developed by Kansas City District geotechnical and structural engineers. These curves defined the relationship between the water surface elevation and probability of failure at each levee section. H&H engineers then used the percent difference between hydraulic profiles and the top of levee elevation at the location of each fragility curve to translate these curves to the index

points for each river. Each reach has a single probability of failure function accounting for the multiple locations of concern within the reach by combining them at the index point using the Unimodal Bounds Theorem equation so that they could be incorporated into the HEC-FDA models. The probability of failure curves for each index point are shown in Tables 11, 12, 13, 14. The combined probability function at each index point was truncated at the adjusted top of levee elevation.

**Table 11: Probability of Failure Curves for Big Blue River Confluence Reach**

| Exterior Stage (ft) | Probability of Failure |
|---|---|
| 1007.39 | 0.00 |
| 1007.87 | 0.07 |
| 1008.90 | 0.22 |
| 1009.31 | 0.28 |
| 1009.93 | 0.29 |
| 1010.99 | 0.31 |
| 1012.15 | 0.33 |
| 1013.30 | 0.37 |
| 1014.64 | 0.41 |
| 1014.73 | 0.43 |
| 1016.30 | 0.76 |

**Table 12: Probability of Failure Curves for Big Blue River Reach 2**

| Exterior Stage (ft) | Probability of Failure |
|---|---|
| 1008.10 | 0.00 |
| 1008.14 | 0.01 |
| 1009.20 | 0.20 |
| 1009.62 | 0.28 |
| 1010.25 | 0.29 |
| 1011.06 | 0.30 |
| 1011.41 | 0.31 |
| 1012.73 | 0.33 |
| 1014.04 | 0.37 |
| 1014.38 | 0.38 |
| 1015.39 | 0.41 |
| 1015.47 | 0.43 |
| 1015.54 | 0.44 |
| 1016.35 | 0.62 |
| 1016.85 | 0.72 |
| 1017.05 | 0.76 |
| 1017.12 | 0.77 |
| 1017.34 | 0.81 |

**Table 13: Probability of Failure Curves for Kansas River Reach 1**

| Exterior Stage (ft) | Probability of Failure | Exterior Stage (ft) | Probability of Failure |
|---|---|---|---|
| 1008.91 | 0.00 | 1017.13 | 0.35 |
| 1010.08 | 0.01 | 1017.18 | 0.36 |
| 1010.99 | 0.02 | 1017.34 | 0.37 |
| 1011.08 | 0.03 | 1017.42 | 0.39 |
| 1011.93 | 0.04 | 1017.66 | 0.45 |
| 1012.08 | 0.05 | 1018.12 | 0.56 |
| 1012.80 | 0.07 | 1018.15 | 0.57 |
| 1012.93 | 0.08 | 1018.19 | 0.58 |
| 1013.08 | 0.09 | 1018.31 | 0.60 |
| 1013.65 | 0.11 | 1018.33 | 0.61 |
| 1013.81 | 0.12 | 1018.65 | 0.67 |
| 1014.03 | 0.13 | 1018.72 | 0.69 |
| 1014.09 | 0.14 | 1018.83 | 0.71 |
| 1014.56 | 0.16 | 1018.99 | 0.74 |
| 1014.62 | 0.17 | 1019.12 | 0.76 |
| 1014.94 | 0.18 | 1019.19 | 0.77 |
| 1015.06 | 0.19 | 1019.20 | 0.78 |
| 1015.11 | 0.20 | 1019.50 | 0.83 |
| 1015.58 | 0.23 | 1019.68 | 0.85 |
| 1016.07 | 0.26 | 1019.87 | 0.88 |
| 1016.16 | 0.27 | 1019.97 | 0.89 |
| 1016.54 | 0.30 | 1020.05 | 0.90 |
| 1016.68 | 0.31 | 1020.13 | 0.91 |
| 1016.99 | 0.34 | 1020.18 | 0.92 |

**Table 14: Probability of Failure Curves for Kansas River Reach 2**

| Exterior Stage (ft) | Probability of Failure | Exterior Stage (ft) | Probability of Failure |
|---|---|---|---|
| 1010.85 | 0.00 | 1019.97 | 0.31 |
| 1011.82 | 0.01 | 1020.37 | 0.34 |
| 1012.95 | 0.02 | 1020.54 | 0.35 |
| 1013.95 | 0.03 | 1020.60 | 0.36 |
| 1014.60 | 0.04 | 1020.80 | 0.37 |
| 1014.97 | 0.05 | 1020.91 | 0.39 |
| 1015.58 | 0.07 | 1021.22 | 0.45 |
| 1015.83 | 0.08 | 1021.83 | 0.56 |
| 1015.98 | 0.09 | 1021.89 | 0.57 |
| 1016.57 | 0.11 | 1022.07 | 0.60 |
| 1016.75 | 0.12 | 1022.48 | 0.67 |
| 1016.99 | 0.13 | 1022.57 | 0.68 |
| 1017.06 | 0.14 | 1022.71 | 0.70 |
| 1017.58 | 0.16 | 1022.91 | 0.73 |
| 1017.64 | 0.17 | 1023.12 | 0.76 |
| 1017.98 | 0.18 | 1023.18 | 0.77 |
| 1018.14 | 0.19 | 1023.58 | 0.82 |
| 1018.19 | 0.20 | 1023.82 | 0.85 |

| | | | |
|---|---|---|---|
| 1018.71 | 0.23 | 1024.08 | 0.88 |
| 1019.26 | 0.26 | 1024.21 | 0.89 |
| 1019.35 | 0.27 | 1024.31 | 0.90 |
| 1019.71 | 0.29 | 1024.43 | 0.91 |
| 1019.79 | 0.30 | 1024.49 | 0.92 |

## 5.1 EXISTING CONDITIONS DAMAGE ANALYSIS RESULTS

### 5.1.1 Manhattan Levee Expected Annual Damages

Table 15 shows existing condition expected annual damage (EAD) results for each reach in each model. Expected annual damages are the average economic flood damages on an annualized basis and accounting for uncertainty in the stage-discharge-frequency-damage parameters. As discussed in section 4.1.5, the confluence reach was evaluated in both HEC-FDA models in order to determine which river's profiles were more appropriate for flood damage analysis for the reach. The EAD results from the model indicate that the Kansas is the governing stream for the confluence reach, meaning that area will experience a higher elevation of flooding from the Kansas River than the Big Blue River in the same flood event. Therefore, the Kansas River profiles were used for the confluence reach for existing conditions, future without project condition, and alternatives analysis. The results for the area referred to as the confluence reach in subsequent sections will be the results for the confluence area as calculated using Kansas River profiles.

Using the Kansas River model totals for summing total expected annual damages, EAD for the leveed area was found to be $6,745,000 (FY14 prices). This reflects the FY14 Federal interest rate of 3.5%, but these benefits are not sensitive to changes in interest rate.

**Table 15: Kansas and Big Blue River HEC-FDA Expected Annual Damages – Existing Condition ($000's) – FY14 Price Level**

| Stream and Reach | Total Expected Annual Damage |
|---|---|
| **Kansas River - Reach 1 (confluence)** | $3,436.0 |
| **Kansas River - Reach 2** | $833.6 |
| ***Big Blue River - Reach 1 (confluence)*** | *$2,032.3* |
| **Big Blue River - Reach 2** | $2,475.7 |
| **Total Damages** | $6,745.3 |

*Note that the Confluence Reach as analyzed in the Big Blue model does not figure into the totals for the table, as the Big Blue was determined to not be the governing stream for this reach.*

Table 16 displays the expected annual damage results broken down by occupancy category and reach. Non-residential (including commercial, industrial, and public properties) damages total $5,343,000, while damages to residential structures total $715,000 for the EAA. The bulk of the damages are experienced in the Big Blue Reach 2 and the confluence reach due to the concentration of large commercial and industrial structures in those areas.

**Table 16: Expected Annual Damages by Category and Reach ($000's)**

| Category | Confluence Reach | Kansas River Reach | Big Blue River Reach | Total |
|---|---|---|---|---|
| **Commercial** | $2,350.6 | $283.4 | $1,265.7 | $3,899.6 |
| **Industrial** | $191.3 | $136.2 | $699.9 | $1,027.4 |
| **Public/Municipal** | $148.7 | $97.4 | $170.1 | $416.2 |
| **Residential** | $530.0 | $185.4 | $0.0 | $715.4 |
| **Streets and Roads** | $44.6 | $27.0 | $21.0 | $92.6 |
| **Emergency** | $134.0 | $73.9 | $274.6 | $482.5 |
| **Cleanup** | $36.9 | $30.4 | $44.4 | $111.6 |
| **Total** | **$3,436.0** | **$833.6** | **$2,475.7** | **$6,745.3** |

FY14 Price Level

The percentages of total damages occurring in each of the categories and reaches are explored further in Table 17, which displays the distribution of damages in terms of percentages by reach and damage category. Non-residential properties account for nearly 80% of total EAD in the Manhattan levee area. Just over half of the damage (50.9%) occurs in the Confluence reach, again where the bulk of the commercial and industrial buildings in the area are located.

**Table 17: Percentage of Total Expected Annual Damages by Category and Reach**

| Category | Confluence Reach | Kansas River Reach | Big Blue River Reach | Total |
|---|---|---|---|---|
| **Commercial** | 68.4% | 34.0% | 51.1% | 57.8% |
| **Industrial** | 5.6% | 16.3% | 28.3% | 15.2% |
| **Public/Municipal** | 4.3% | 11.7% | 6.9% | 6.2% |
| **Residential** | 15.4% | 22.2% | 0.0% | 10.6% |
| **Streets and Roads** | 1.3% | 3.2% | 0.8% | 1.4% |
| **Emergency** | 3.9% | 8.9% | 11.1% | 7.2% |
| **Cleanup** | 1.1% | 3.6% | 1.8% | 1.7% |
| **Total** | **50.9%** | **12.4%** | **36.7%** | **100.0%** |

Table 18 displays the type and cumulative number of structures, value of the structures impacted, and total damages for the Confluence Reach for each of the floods used in the HEC-FDA model - the 10%, 4%, 2%, 1%, 0.5%, 0.33%, 0.2% and 0.13% events. The HEC-FDA output files used to develop these tables do not recognize the existing levee, which accounts for the damages beginning at a more frequent flood event than would be expected when taking the levee into account, but this table is intended to display the nature of flooding in each of the reaches for the EAA.

**Table 18: Distribution of Damages in the Confluence Reach ($000's)**

| Confluence Reach Damages Distribution | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 10% | 4% | 2% | 1% | 0.5% | 0.33% | 0.2% | 0.1% |
| **Commercial** | | | | | | | | |
| Number of Structures Impacted | 0 | 88 | 133 | 176 | 203 | 209 | 210 | 212 |
| Total Value of Structures + Contents Impacted | $0.0 | $194,926.0 | $226,346.8 | $253,431.6 | $315,235.2 | $385,257.6 | $386,029.1 | $386,488.7 |
| Total Damages | $0.0 | $57,981.2 | $137,871.1 | $182,094.7 | $213,787.5 | $262,237.9 | $288,828.3 | $306,283.9 |
| **Industrial** | | | | | | | | |
| Number of Structures Impacted | 0 | 19 | 21 | 21 | 21 | 21 | 21 | 21 |
| Total Value of Structures + Contents Impacted | $0.0 | $23,159.2 | $24,053.4 | $24,053.4 | $24,053.4 | $24,053.4 | $24,053.4 | $24,053.4 |
| Total Damages | $0.0 | $4,864.6 | $15,149.8 | $18,051.8 | $19,096.4 | $19,372.1 | $19,516.5 | $19,594.9 |
| **Public/Municipal** | | | | | | | | |
| Number of Structures Impacted | 0 | 1 | 3 | 17 | 32 | 38 | 40 | 41 |
| Total Value of Structures + Contents Impacted | $0.0 | $130.9 | $887.6 | $9,841.5 | $40,567.0 | $43,971.9 | $44,600.4 | $45,274.0 |
| Total Damages | $0.0 | $11.0 | $123.5 | $2,623.7 | $12,792.7 | $21,811.2 | $27,160.5 | $30,014.3 |
| **Residential** | | | | | | | | |
| Number of Structures Impacted | 140 | 418 | 707 | 841 | 896 | 927 | 944 | 958 |
| Total Value of Structures + Contents Impacted | $16,178.2 | $65,923.2 | $113,019.6 | $142,827.9 | $163,378.8 | $180,683.3 | $185,158.8 | $188,591.9 |
| Total Damages | $231.2 | $4,204.7 | $15,280.2 | $29,836.1 | $46,513.0 | $58,500.9 | $72,376.6 | $82,726.4 |
| **Streets and Roads** | | | | | | | | |
| Number of Structures Impacted | 0 | 10 | 24 | 28 | 28 | 29 | 29 | 29 |
| Total Value of Structures + Contents Impacted | $0.0 | $6,381.2 | $14,183.0 | $16,064.3 | $16,064.3 | $16,903.3 | $16,903.3 | $16,903.3 |
| Total Damages | $0.0 | $180.9 | $765.6 | $1,825.4 | $3,395.4 | $4,613.5 | $5,934.0 | $7,038.1 |

FY14 Price Level

Like the table above, Tables 19 and 20 display the type and cumulative number of structures, the value of the structures impacted, and total damages but for the Kansas Reach and Big Blue Reach respectively for each of the floods used in the HEC-FDA model - the 10%, 4%, 2%, 1%, 0.5%, 0.33%, 0.2% and 0.13% events. Again, the HEC-FDA output files used to develop these tables do not recognize the existing levee, which accounts for the damages beginning at a more frequent flood event than would be expected when taking the levee into account, but this table is intended to display the nature of flooding in each of the reaches for the EAA.

## Table 19: Distribution of Damages in the Kansas River Reach ($000's)

| Kansas Reach Damages Distribution | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 10% | 4% | 2% | 1% | 0.5% | 0.33% | 0.2% | 0.1% |
| **Commercial** | | | | | | | | |
| Number of Structures Impacted | 0 | 0 | 8 | 32 | 83 | 83 | 93 | 108 |
| Total Value of Structures + Contents Impacted | $0.0 | $0.0 | $7,006.7 | $33,420.6 | $58,037.0 | $58,037.0 | $61,338.6 | $67,167.5 |
| Total Damages | $0.0 | $0.0 | $2,494.3 | $10,471.0 | $27,843.2 | $36,316.5 | $43,048.8 | $47,516.2 |
| **Industrial** | | | | | | | | |
| Number of Structures Impacted | 0 | 0 | 6 | 22 | 43 | 46 | 50 | 53 |
| Total Value of Structures + Contents Impacted | $0.0 | $0.0 | $2,274.6 | $5,935.2 | $24,786.5 | $26,547.8 | $28,192.4 | $28,647.5 |
| Total Damages | $0.0 | $0.0 | $335.2 | $1,411.4 | $11,498.1 | $16,264.7 | $20,509.2 | $23,155.8 |
| **Public/Municipal** | | | | | | | | |
| Number of Structures Impacted | 0 | 0 | 0 | 5 | 18 | 26 | 34 | 34 |
| Total Value of Structures + Contents Impacted | $0.0 | $0.0 | $0.0 | $12,830.7 | $18,493.6 | $19,792.6 | $39,242.1 | $39,242.1 |
| Total Damages | $0.0 | $0.0 | $0.0 | $3,071.5 | $8,393.9 | $11,274.8 | $14,220.7 | $19,711.5 |
| **Residential** | | | | | | | | |
| Number of Structures Impacted | 3 | 36 | 196 | 413 | 540 | 596 | 643 | 669 |
| Total Value of Structures + Contents Impacted | $165.6 | $6,072.7 | $34,145.5 | $68,351.5 | $87,954.5 | $96,601.0 | $101,710.0 | $105,061.0 |
| Total Damages | $50.4 | $125.9 | $711.4 | $4,971.8 | $14,457.9 | $22,149.7 | $30,464.9 | $37,582.3 |
| **Streets and Roads** | | | | | | | | |
| Number of Structures Impacted | 1 | 1 | 6 | 15 | 23 | 25 | 25 | 25 |
| Total Value of Structures + Contents Impacted | $368.6 | $368.6 | $5,008.4 | $12,911.8 | $17,081.2 | $17,640.5 | $17,640.5 | $17,640.5 |
| Total Damages | $27.7 | $86.1 | $203.0 | $620.0 | $1,619.1 | $2,609.1 | $3,980.6 | $5,458.5 |

FY14 Price Level

**Table 20: Distribution of Damages in the Big Blue River Reach ($000's)**

| Big Blue Reach Damages Distribution | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 10% | 4% | 2% | 1% | 0.5% | 0.33% | 0.2% | 0.1% |
| **Commercial** | | | | | | | | |
| Number of Structures Impacted | 5 | 13 | 46 | 53 | 53 | 53 | 53 | 53 |
| Total Value of Structures + Contents Impacted | $1,847.8 | $36,396.6 | $115,836.4 | $122,208.3 | $122,208.3 | $122,208.3 | $122,208.3 | $122,208.3 |
| Total Damages | $219.9 | $7,956.8 | $53,565.4 | $88,599.3 | $102,273.6 | $104,078.5 | $104,338.0 | $104,613.2 |
| **Industrial** | | | | | | | | |
| Number of Structures Impacted | 3 | 4 | 32 | 33 | 33 | 33 | 33 | 33 |
| Total Value of Structures + Contents Impacted | $12,092.9 | $12,329.2 | $76,328.8 | $76,618.6 | $76,618.6 | $76,618.6 | $76,618.6 | $76,618.6 |
| Total Damages | $492.1 | $6,522.9 | $24,183.1 | $52,160.5 | $62,549.3 | $64,304.3 | $64,697.9 | $65,032.4 |
| **Public/Municipal** | | | | | | | | |
| Number of Structures Impacted | 0 | 6 | 10 | 13 | 13 | 13 | 13 | 13 |
| Total Value of Structures + Contents Impacted | $0.0 | $9,176.2 | $16,993.5 | $17,893.6 | $17,893.6 | $17,893.6 | $17,893.6 | $17,893.6 |
| Total Damages | $0.0 | $460.3 | $6,762.2 | $11,431.6 | $13,868.0 | $14,232.8 | $14,313.4 | $14,390.1 |
| **Residential** | | | | | | | | |
| Number of Structures Impacted | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Value of Structures + Contents Impacted | $0.0 | $0.0 | $0.0 | $0.0 | $0.0 | $0.0 | $0.0 | $0.0 |
| Total Damages | $0.0 | $0.0 | $0.0 | $0.0 | $0.0 | $0.0 | $0.0 | $0.0 |
| **Streets and Roads** | | | | | | | | |
| Number of Structures Impacted | 0 | 2 | 5 | 6 | 6 | 6 | 6 | 6 |
| Total Value of Structures + Contents Impacted | $0.0 | $1,487.3 | $4,576.2 | $6,235.2 | $6,235.2 | $6,235.2 | $6,235.2 | $6,235.2 |
| Total Damages | $0.0 | $27.4 | $252.5 | $767.7 | $1,847.4 | $2,303.7 | $2,459.1 | $2,638.5 |

FY14 Price Level

### 5.1.2 Manhattan Levee Project Performance

The Manhattan Levee project performance by reach for existing conditions is shown in Table 21. The Big Blue River reach of the levee has the weakest performance of the reaches in the existing condition, making it the governing reach for overall levee performance. On that basis, the existing levee has an estimated 52.6% chance of passing a 1% event without significant damage, a 9.4% chance of safely passing a 0.4% event, and a 3.5% chance of passing a 0.2% event. The long-term exceedance probability is defined as the chance that the target stage, in this case the height of the levee, will be exceeded within the specified time frame. Under these assumptions, there is about a 53.4% chance that the levee will be overtopped in the next 50 years and a 14.2% chance that it will overtopped in the next 10 years. The annual exceedance probability, the chance that a flood event will cause damage within the levee in any given year, is 1.5%.

**Table 21: HEC-FDA Manhattan Levee Assurance - Existing Condition Overtopping and Levee Failure**

| Manhattan Levee | Confluence Reach | Kansas Reach | Big Blue Reach |
|---|---|---|---|
| **Assurance (Conditional Non-Exceedance Probability)** | | | |
| 10% event | 100.0% | 99.9% | 99.7% |
| 4% event | 97.0% | 96.6% | 94.1% |
| 2% event | 86.2% | 86.2% | 76.9% |
| 1% event | 62.4% | 62.8% | 52.6% |
| 0.4% event | 22.5% | 22.4% | 9.4% |
| 0.2% event | 6.4% | 6.2% | 3.5% |
| **Long-Term Exceedance Probability** | | | |
| 10 years | 10.6% | 10.8% | 14.2% |
| 30 years | 28.5% | 29.0% | 36.8% |
| 50 years | 42.9% | 43.5% | 53.4% |
| **Expected Annual Exceedance Probability** | 1.1% | 1.1% | 1.5% |
| **Height Above the Expected 1% Stage to Top of Levee (ft)** | 3.7 | 4.8 | 3.7 |

Table 22 contains information on the levee performance based on overtopping only, without considering any geotechnical or structural deficiencies in the levee. As would be expected, the levee performance is much better when not considering the structural and geotechnical deficiencies in the levee. Assurance (formerly referred to as conditional non-exceedance probability) increases by about 35% for the 1% chance flood (52.6% vs. 88.9%). Assurance in the 0.2% chance flood is 3.5% for overtopping plus deficiencies versus 9.1% for overtopping alone.

**Table 22: HEC-FDA Manhattan Levee Assurance – Existing Condition Overtopping Only**

| Manhattan Levee | Confluence Reach | Kansas Reach | Big Blue Reach |
|---|---|---|---|
| **Assurance (Conditional Non-Exceedance Probability)** | | | |
| 1% (100 year) | 93.4% | 94.0% | 88.9% |
| 0.4% (250 year) | 51.1% | 51.2% | 21.8% |
| 0.2% (500 year) | 18.5% | 17.9% | 9.1% |
| **Long-Term Exceedance Probability** | | | |
| 10 years | 4.6% | 4.5% | 6.1% |
| 30 years | 13.1% | 13.0% | 17.3% |
| 50 years | 20.8% | 20.6% | 27.1% |
| **Expected Annual Exceedance Probability** | 0.5% | 0.5% | 0.6% |

## 6.1 FUTURE WITHOUT-PROJECT CONDITION

The future without-project condition structure inventory is assumed to be the same as for base conditions as there are no confirmed new developments to be included within the leveed area, beyond the CivicPlus building discussed in Section 3.1.2. That building will be completed by the base year for analysis, so there is no change to the inventory. There are expected to be few opportunities for new development within the leveed area since the city is essentially

landlocked between Fort Riley, Kansas State University, Tuttle Creek Reservoir, and hilly topography to the north. Therefore, the central portion of the city, the focus of the EAA, is extremely urbanized and only redevelopment is possible in the majority of the EAA. Land use patterns present little opportunity for development into the future within the EAA, especially as much of the land in the EAA has been redeveloped very recently. The future National Bio and Agro-Defense Facility and Kansas Department of Agriculture office buildings are planned in the region, but not within the EAA.

Based on projections prepared by the Kansas Water Office (KWO), it is estimated that the Manhattan's population will increase to 56,084 by 2020, 62,513 by 2030, and 68,942 by 2040. This would represent increases of 7.3%, 19.6%, and 31.9% from Manhattan's 2010 population of 52,281. While these projections do estimate significant population increases in the coming decades, it is expected that no more than a small portion of the increase will translate into additional development within the protected area itself for reasons discussed above.

Additionally, we are assuming no changes in hydraulic/hydrologic or geotechnical/structural conditions from the existing condition to the future without-project condition.

Table 23 displays future without-project conditions for the EAA. These numbers are the basis for comparison of the early array alternatives analysis discussed further on in this section. In the future without-project condition, the Manhattan levee has expected annual damages totaling $6,745,000. No interest rate is specified because this total is not sensitive to interest rates.

**Table 23: Manhattan Levee Future without Project Condition Damages and Assurance FY14 Price Level ($000s)**

| Manhattan Levee | Confluence Reach | Kansas Reach | Big Blue Reach | Totals |
|---|---|---|---|---|
| **Conditional Non-Exceedance Probability** | | | | |
| 1% (1/100) | 62.4% | 62.8% | 52.6% | 52.60% |
| 0.4% (1/250) | 22.5% | 22.4% | 9.4% | 9.43% |
| 0.2% (1/500) | 6.4% | 6.2% | 3.5% | 6.19% |
| **Long Term Exceedance Probability** | | | | |
| 10 years | 10.6% | 10.8% | 14.2% | 14.18% |
| 30 years | 28.5% | 29.0% | 36.8% | 36.79% |
| 50 years | 42.9% | 43.5% | 53.4% | 53.44% |
| **Height Above the Expected 1% Stage to Top of Levee (ft)** | 3.7 | 4.8 | 3.7 | |
| **Expected Annual Damages** | | | | |
| Commercial | $2,350.6 | $283.4 | $1,265.7 | $3,899.6 |
| Industrial | $191.3 | $136.2 | $699.9 | $1,027.4 |
| Public/Municipal | $148.7 | $97.4 | $170.1 | $416.2 |
| Residential | $530.0 | $185.4 | $0.0 | $715.4 |
| Streets and Roads | $44.6 | $27.0 | $21.0 | $92.6 |
| Emergency | $134.0 | $73.9 | $274.6 | $482.5 |
| Cleanup | $36.9 | $30.4 | $44.4 | $111.6 |
| **Total** | $3,436.0 | $833.6 | $2,475.7 | $6,745.3 |

Under the future without-project condition, damages for the 1% flood could total $315.5 million, and 0.2% flood event damages could total $840.6 million. The number of structures affected in a 1% chance flood in without-project conditions is approximately 1,700. The number of structures affected in a 0.2% chance flood in without-project conditions is approximately 2,200.

## 7.1 ALTERNATIVES SCREENING

### 7.1.1 Overview of Evaluation Procedures

Economic costs and benefits resulting from a project are evaluated in terms of their impacts on national wealth, without regard to where in the United States the impacts may occur. National Economic Development (NED) benefits must result directly from a project and must represent net increases in the economic value of goods and services to the national economy, not simply to a locality. For example, if a flood interrupts auto production at a plant in one community, that community suffers a loss. But if the affected company replaces the interrupted production at another plant in another city, the community's loss does not represent a net loss to the national economy, and the prevention of such a loss cannot be claimed as a NED benefit.

NED costs represent the costs of diverting resources from other uses in implementing the project, as well as the costs of uncompensated economic losses resulting from detrimental effects of the project. NED benefits, the benefit-cost ratio, and the net NED benefits are calculated during the evaluation process. Net benefits represent the amount by which the NED benefits exceed NED costs, thereby defining the plan's contribution to the nation's economic output. The plan with the highest net benefits is considered the recommended plan, assuming technical feasibility, environmental soundness, and public acceptability. Note that the plan with highest net benefits is not necessarily the plan with the highest benefit-cost ratio. The benefit-cost ratio helps identify which plans have likely economic feasibility and can be carried forward for further analysis, but the NED plan is selected from among those plans that are economically feasible based on net annual benefits.

### 7.1.2 General Description of Alternatives

The existing top of levee elevation (at the low overtopping point, which is located at the upper end of the Big Blue River section) is about 1 foot below the 0.5% event elevation. Five preliminary alternatives were analyzed for the project area and are summarized below. In the analysis of each of these alternatives, it was assumed that all geotechnical and structural issues would be addressed along with the levee raise, and no probability of failure curves are assigned to the alternatives.

- Plan 1 - No action alternative.
- Plan 2 - A levee raise of 7,200 feet in length from station 200+0 to 273+0, with an average levee raise of 0.75 feet and a maximum raise of 1.5 feet. Five gatewell replacements and 29 relief wells are also included in this alternative.

- Plan 3 - A levee raise of approximately 14,100 feet in length from stations 131+0 to 273+0 with an average raise of 1.5 feet and a maximum raise of 3.3 feet. Five gatewell replacements and 29 relief wells are also included in this alternative.
- Plan 4 - A levee raise of approximately 23,500 feet in length from station 0+00 to 72+0 and 101+0 to 273+0 with an average raise of 2.1 feet. Other measures include 13 gatewell replacements, 1 gatewell raise, pump station strengthening, and 45 relief wells.
- Plan 5 – A levee raise of approximately 14,100 feet of levee from stations 131+0 to 273+0 with an average levee raise of 1.3 feet and a maximum raise of 2.6 feet. Other measures included are 5 gatewell replacements and 29 relief wells. The alternative also includes expansions of the Highway 24 and Union Pacific Railroad (UPRR) bridges, which would entail extensive rehabilitation of the existing Highway 24 bridge by extending the eastbound and westbound lanes by approximately 160 feet. (The Union Pacific Railroad Bridge, is estimated to be approximately 80+ years-old, and assumed to be a total replacement for cost estimating purposes.)

### 7.1.3 Screening Benefits Determination

To determine the economic justification of the array of alternatives, each alternative was entered into the HEC-FDA risk analysis model. The Monte Carlo analysis in HEC-FDA was then employed to determine residual damages – i.e., damages that would continue to occur in the with-project condition even with implementation of that alternative. The residual damages that would continue to occur in the with-project condition were expressed as equivalent annual damages that account for both the base year condition and the discounted present-worth of the future year condition. The difference between the without-project condition EAD and the residual EAD for each alternative represents the damages reduced or benefits for the alternative. The alternatives analysis involved no modifications to the existing condition economic structure inventory and occupancy type data. Screening benefits in this analysis were based on physical inundation reduction to homes, businesses, public facilities, and roads. A separate set of with-project water surface profiles was used for the alternatives analysis.

A preliminary induced damages analysis was completed for the area north of the existing levee and is discussed in later sections.

### 7.1.4 Engineering Data Considerations

Top of levee elevations and hydraulic and hydrologic data for the screening analysis also were unchanged from the existing conditions analysis. Given the structural and geotechnical character of all identified deficiencies in the Manhattan levee system, the probability of failure function is important in determining the performance of alternatives. Each reach, in the existing condition, has a single probability of failure function accounting for the multiple locations of concern within the reach by combining them at the index point. The alternatives did not have a probability of failure due to geotechnical and structural issues associated with them because it was assumed those concerns would be remedied when the alternative was implemented. While it is acknowledged that there would be a very small degree of remaining risk with a repaired

levee, this risk would be similar under each of the alternatives and would not affect the overall ranking of alternatives or significantly affect the results.

### 7.1.5 Screening Cost Estimates

Screening level costs were prepared by NWK cost engineering staff for each of the alternatives and are summarized in Table 24. (For more detailed information on cost estimates, see the Cost Appendix.) Interest during construction was added to the first costs, assuming a project initiation of 2015 with a design and construction period of 8 years The screening costs were prepared in FY13, but have been updated with a CWCCIS composite factor of 1.0132 (30 September 2013 version of EM 1110-2-1304, annual numbers) to a FY14 price level. The annualized costs assumed a 50 year period of analysis using the FY14 Federal interest rate of 3.5%.

Costs for operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) were estimated for each alternative and are based on life cycle cost analysis. The analysis only includes the new (net) additional OMRR&R costs the sponsor would be expected to incur based on the proposed unit modifications. The analyses considered and accounted for the new additional OMRR&R in each year of occurrence, and then computed a present worth value of the future OMRR&R costs. The present worth value was then annualized using the FY14 Federal interest rate of 3.5% and a 50 year period of analysis.

The assumptions used in determining the new additional OMRR&R costs for each alternative are as follows:

- Each new relief well is assumed to be maintained every 4 years at an estimated cost of $5,000 per well.

- New wells are assumed to be replaced after 40 years at replacement cost of either $55,000 or $65,000 depending on the type and size of the well placed at the site.

- The sponsor would continue to incur costs for any existing relief wells but these costs are ongoing for the existing project and are not included in the analysis of the proposed project.

- Plan 5 would require mitigation. Given this reality, an annual estimate of $5,000 in additional maintenance costs was added to this alternative based on the suggestion of district environmental staff.

**Table 24: Screening Costs Summary ($000's)**

| Category | Plan 1 (no action) | Plan 2 | Plan 3 | Plan 4 | Plan 5 |
|---|---|---|---|---|---|
| PED | $0.00 | $2,426.0 | $2,466.0 | $5,093.0 | $6,015.0 |
| LERRD | $0.00 | $4,526.0 | $4,801.0 | $8,524.0 | $5,311.0 |
| Construction | $0.00 | $13,206.0 | $13,538.0 | $30,186.0 | $38,658.0 |
| Construction Management | $0.00 | $1,217.0 | $1,237.0 | $2,470.0 | $3,019.0 |
| Total First Costs | $0.00 | $21,376.0 | $22,042.0 | $46,273.0 | $53,003.0 |
| IDC | $0.00 | $2,993.0 | $3,086.0 | $6,478.0 | $7,420.0 |
| Total Economic Costs | $0.00 | $24,369.0 | $25,128.0 | $52,751.0 | $60,423.0 |
| Annual Costs | $0.00 | $1,038.9 | $1,071.3 | $2,249.0 | $2,576.1 |
| O&M | $0.00 | $52.1 | $52.1 | $52.3 | $80.9 |
| Total Annual Costs | $0.00 | $1,091.0 | $1,123.4 | $2,301.3 | $2,657.0 |

FY14 Price Level, 3.5% interest rate, 50 year period of analysis

### 7.1.6 Alternatives Screening Results

Table 25 illustrates equivalent annual damages and damage reduction under each of the alternatives in the early alternatives array. Under future without-project conditions, the EAA would be expected to experience equivalent annual damages of $6,745,000. Under Plan 2, annual damages are reduced by $3,174,000 with residual damages of $3,572,000 million. Annual damages are reduced by $3,975,000 for the EAA, with residual damages of $2,770,000, under Plan 3. Plan 5 adds an additional $75,000 in annual damages reduced. As expected, Plan 4 would provide the greatest damage reduction, reducing annual damages by $5,064,000, a reduction of 75%.

**Table 25: Alternatives Analysis, Equivalent Annual Damages and Damages Reduced, FY Price Level ($000's)**

| Alternative | Equivalent Annual Damages | | | |
|---|---|---|---|---|
| | Total Without Project | Total with Project | Damage Reduced | Percent Damage Reduced |
| **Plan 1 (no action)** | | | | |
| Confluence Reach | $3,436.0 | - | - | - |
| Kansas River Reach | $833.6 | - | - | - |
| Big Blue River Reach | $2,475.7 | - | - | - |
| **Total** | **$6,745.3** | **-** | **-** | **-** |
| **Plan 2** | | | | |
| Confluence Reach | $3,436.0 | $1,968.2 | $1,467.9 | 42.7% |
| Kansas River Reach | $833.6 | $597.0 | $236.6 | 28.4% |
| Big Blue River Reach | $2,475.7 | $1,006.4 | $1,469.3 | 59.3% |
| **Total** | **$6,745.3** | **$3,571.6** | **$3,173.8** | **47.1%** |
| **Plan 3** | | | | |
| Confluence Reach | $3,436.0 | $1,700.4 | $1,735.6 | 50.5% |
| Kansas River Reach | $833.6 | $519.8 | $313.9 | 37.7% |
| Big Blue River Reach | $2,475.7 | $549.7 | $1,926.1 | 77.8% |
| **Total** | **$6,745.3** | **$2,769.8** | **$3,975.5** | **58.9%** |
| **Plan 4** | | | | |

| | | | | |
|---|---|---|---|---|
| Confluence Reach | $3,436.0 | $949.6 | $2,486.4 | 72.4% |
| Kansas River Reach | $833.6 | $280.4 | $553.2 | 66.4% |
| Big Blue River Reach | $2,475.7 | $451.3 | $2,024.4 | 81.8% |
| **Total** | **$6,745.3** | **$1,681.4** | **$5,064.0** | **75.1%** |
| **Plan 5** | | | | |
| Confluence Reach | $3,436.0 | $1,700.4 | $1,735.6 | 50.5% |
| Kansas River Reach | $833.6 | $514.8 | $318.9 | 38.3% |
| Big Blue River Reach | $2,475.7 | $479.5 | $1,996.2 | 80.6% |
| **Total** | **$6,745.3** | **$2,694.7** | **$4,050.7** | **60.1%** |

Estimated increases in reliability associated with these early alternatives for the Manhattan Levee are shown in Table 26. The total column uses the statistics from the least reliable reach as that is the most relevant number for determining reliability for the entire levee. Note that the assurance or conditional non-exceedance probability for the 1% chance flood increases substantially under each of the preliminary alternatives. Under the without-project condition, the most at-risk reach is the Big Blue reach, but this changes from alternative to alternative. For example, under Plan 3, the chance of safely passing a 1% flood increases from about 52.6% to 99.2% in the Big Blue River reach, while the confluence reach is at 96.3%. The conditional non-exceedance probability for a 0.2% event increases from 3.5% to 50.4% in the Big Blue segment. The channel widening in Plan 5 adds an additional 4% in assurance in the 0.2% chance flood scenario for that reach. For the alternatives, the least-reliable reaches shift to the confluence reach. However, the levee's overall reliability is substantially increased under each of the alternative scenarios.

**Table 26: Alternatives Reliability Analysis**

| | **Long Term Risk** | | | **Assurance (Conditional Non-exceedance Probability) (% event)** | | | **Height Above the Nominal 1% Stage to Top of Levee (ft)** |
|---|---|---|---|---|---|---|---|
| **Alternative** | **10** | **30** | **50** | **1.0%** | **0.4%** | **0.2%** | |
| **Plan 1 (no action)** | | | | | | | |
| Confluence Reach | 10.6% | 28.5% | 42.9% | 62.4% | 22.5% | 6.4% | 3.7 |
| Kansas River Reach | 10.8% | 29.0% | 43.5% | 62.8% | 22.4% | 6.2% | 4.8 |
| Big Blue River Reach | 14.2% | 36.8% | 53.4% | 52.6% | 9.4% | 3.5% | 3.7 |
| **Total** | 14.2% | 36.8% | 53.4% | 52.6% | 9.4% | 3.5% | |
| **Plan 2** | | | | | | | |
| Confluence Reach | 4.6% | 13.1% | 20.8% | 93.4% | 51.1% | 18.5% | 3.7* |
| Kansas River Reach | 4.5% | 13.0% | 20.6% | 94.0% | 51.2% | 17.9% | 4.8* |
| Big Blue River Reach | 4.7% | 13.5% | 21.4% | 95.6% | 37.7% | 19.7% | 4.9 |
| **Total** | 4.7% | 13.5% | 21.4% | 93.4% | 37.7% | 17.9% | |
| **Plan** | | | | | | | |
| Confluence Reach | 3.8% | 11.1% | 17.8% | 96.3% | 61.6% | 25.6% | 4.4 |
| Kansas River Reach | 3.7% | 10.8% | 17.3% | 96.9% | 63.2% | 26.7% | 5.8 |
| Big Blue River Reach | 2.5% | 7.4% | 12.0% | 99.2% | 67.9% | 50.4% | 6.7 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Total** | 3.8% | 11.1% | 17.8% | 96.3% | 61.6% | 25.6% | |
| **Plan 4** | | | | | | | |
| Confluence Reach | 2.0% | 5.9% | 9.7% | 99.7% | 87.9% | 58.7% | 6.6 |
| Kansas River Reach | 1.8% | 5.3% | 8.7% | 99.8% | 88.8% | 61.4% | 8.9 |
| Big Blue River Reach | 2.1% | 6.0% | 9.8% | 99.6% | 74.8% | 57.8% | 7.3 |
| **Total** | 2.1% | 6.0% | 9.8% | 99.6% | 74.8% | 57.8% | |
| **Plan 5** | | | | | | | |
| Confluence Reach | 3.8% | 11.1% | 17.8% | 96.3% | 61.6% | 25.6% | 4.4 |
| Kansas River Reach | 3.7% | 10.8% | 17.3% | 96.9% | 63.2% | 26.7% | 5.8 |
| Big Blue River Reach | 2.2% | 6.4% | 10.5% | 99.6% | 73.7% | 54.9% | 6.7 |
| **Total** | 3.8% | 11.1% | 17.8% | 96.3% | 61.6% | 25.6% | |

**The existing Kansas River segment of the levee is currently higher than the nominal 200 year raise at the index points so there is no actual rise under that alternative for that segment, explaining why the freeboard above the 1% event is equivalent to the existing condition.*

### 7.1.7 Costs, Net Benefits, and Benefit-Cost Ratios

Table 27 contains net benefits and benefit-cost ratios for each of the early array alternatives. Costs were annualized using the FY14 project interest rate of 3.5% and a 8-year design and construction period. OMRR&R costs were developed as discussed in the Screening Cost Estimates section. Plan 3, with annual costs of $1,123,000 and estimated annual benefits of $3,976,000, has estimated net annual benefits of $2,852,000 and a benefit-cost ratio of 3.5, making it the presumptive NED plan. Plan 3 has a $90,000 (about 3.2% of the overall benefits) margin in annual net benefits over the second ranking alternative, Plan 4, as well as a much larger BCR. Based on these results, the Plan 3 has both the highest net benefits and largest BCR, making it the NED plan.

**Table 27: Manhattan Levee Alternatives Analysis, Screening Alternatives - Benefits and Costs Summary ($000's)**

| Alternative | Plan 2 | Plan 3 | Plan 4 | Plan 5 |
|---|---|---|---|---|
| **Damages and Benefits** | | | | |
| EAD W/O Project | $6,745.3 | $6,745.3 | $6,745.3 | $6,745.3 |
| EAD Residual | $3,571.6 | $2,769.8 | $1,681.4 | $2,694.7 |
| Residual as a % of without project | 52.9% | 41.1% | 24.9% | 39.9% |
| Probabilistic Estimates | | | | |
| 0.75 | $1,973.6 | $2,644.8 | $3,318.9 | $2,651.4 |
| 0.50 | $2,735.8 | $3,595.6 | $4,642.7 | $3,716.9 |
| 0.25 | $3,916.7 | $4,798.4 | $5,111.5 | $4,901.4 |
| Annual Benefits - Screening Level | $3,173.8 | $3,975.5 | $5,064.0 | $4,050.7 |
| **Costs** | | | | |
| First Costs | $21,376.0 | $22,042.0 | $46,273.0 | $53,003.0 |
| Annual Costs - Screening Level | $1,038.9 | $1,071.3 | $2,249.0 | $2,576.1 |
| O&M Costs | $52.1 | $52.1 | $52.3 | $80.9 |
| Total Annual Costs | $1,091.0 | $1,123.4 | $2,301.3 | $2,657.0 |
| Net Benefits | $2,082.8 | $2,852.1 | $2,762.7 | $1,393.8 |
| Benefit-Cost Ratio | 2.9 | 3.5 | 2.2 | 1.5 |

FY14 Price Level, 50 year period of analysis, 3.5% interest rate

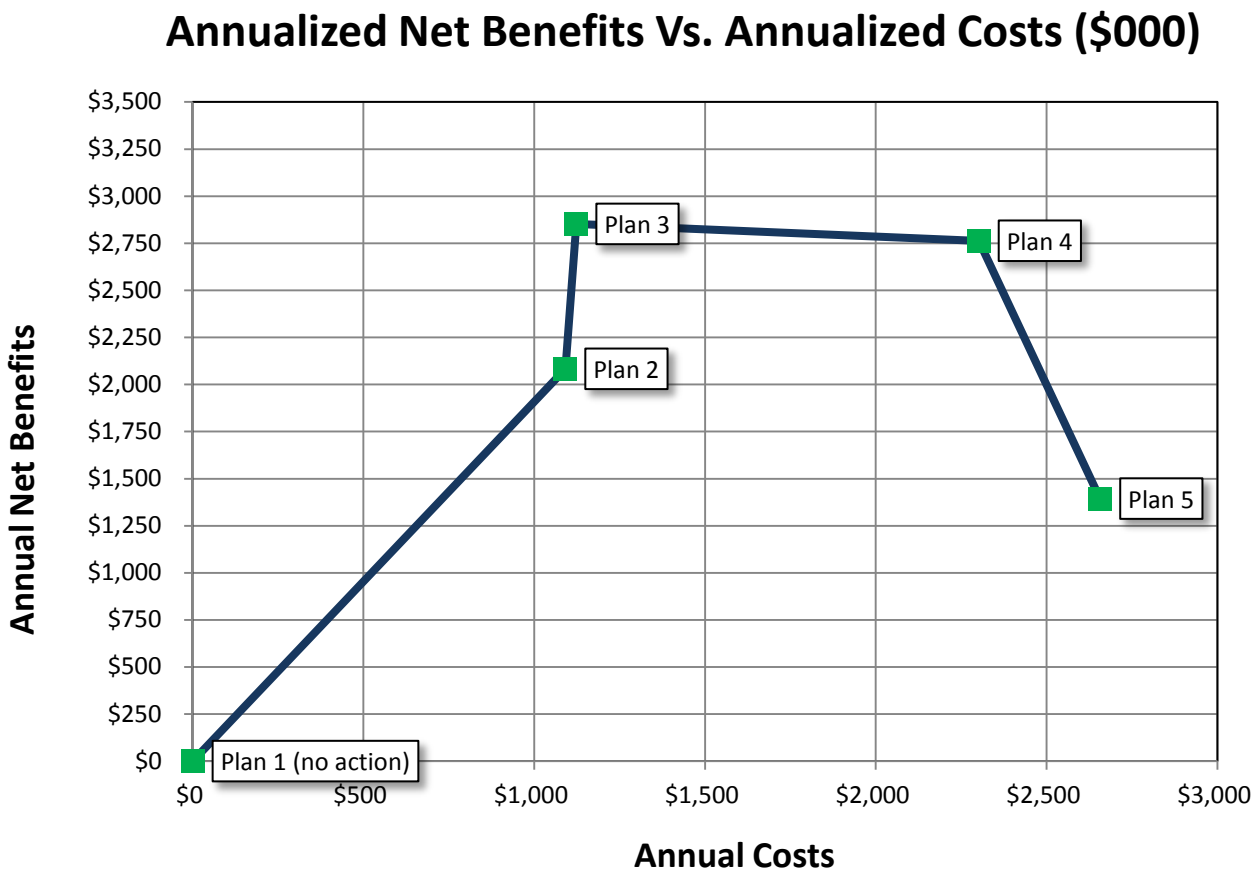


**Figure 5: Manhattan Levee Alternatives Array Analysis Cost Optimization Curve**

Figure 5 is a graph of annualized net benefits versus annualized costs. This graph illustrates that Plan 3, with about $90,000 in greater annual net benefits than the next closest alternative (Plan 4) and less than half of the annual costs, is the optimal plan as well as the NED plan. It also shows the large gap in net benefits between Plan 3 and Plan 5. This is due to the large increase in costs necessary for channel widening without a commensurate increase in benefits.

Subsequent to the early alternatives array screening, the PDT considered additional raise alternatives in the range between Plan 3 and Plan 4 in order to ensure that the correct NED plan had been selected. This analysis determined that raising the levee more than a few inches beyond the Plan 3 top of levee elevation would increase costs exponentially by expanding the footprint of the raise much farther along the Kansas River section. For example, an alternative levee raise in between the two plans would have a similar footprint to Plan 4, requiring an estimated 90% of the structural costs of the Plan 4 and 70% of the levee raise costs (earthwork, etc) for the difference between the Plan 3 and Plan 4. The estimated annual costs would be $1.78 million. A sensitivity run in HEC-FDA using an interpolated levee raise between Plan 3 and Plan 4 revealed that this additional alternative raise would increase benefits by only about 35% of the difference between Plan 3 and Plan 4, an increase of about 10% in overall benefits. The estimated annual benefits of this plan would be $4 million. With a BCR of 2.2 and net benefits

of $2.3 million, this plan is economically justified but is less cost-effective than either Plan 3 or Plan 4.

Overall, raises between Plan 3and  Plan 4 would appear to require increases in cost similar to the larger Plan 4 while providing damage reduction closer to the smaller Plan 3. Thus, it was determined that the appropriate alternatives were analyzed and the NED plan had been identified correctly.

## 8.1 THE NED PLAN

### 8.1.1 Description of the NED Plan

The plan emerging from the screening analysis as the NED plan is the Plan 3 levee raise.  Details of this alternative are as follows:

- This raise requires about 14,100 feet of levee between stations 131+00 and 273+00 with an average raise of about 1.5 feet and a maximum raise of 3.3 feet, as well as a 500-foot extension up Casement Road (via a road raise) on the Big Blue River segment that is needed to meet high ground.
- The raise will be constructed primarily on the landside, except between stations 149+00 and 163+00 where the levee will be raised on the riverward due to the existing water treatment plant.
- Between stations 200+00 and 272+00, the levee raise will require relocating City of Manhattan water wells and power poles located landward of the levee.
- Stations 40+00 to 64+00: This section has a landside ditch which does not meet levee safety criteria when it is empty.  Private property lines are adjacent to the ditch and modification will require costly real estate purchases.  It is recommended that a minimum ponding elevation of 1015 feet be maintained during flood events to maintain criteria.
- Stations 64+00 to 97+00: This section is characterized by a generally thin blanket. Private properties are located near the landside toe which excludes underseepage berm as a solution.  Installation of 13 fully penetrating relief wells with 12-inch diameters spaced between 200 and 300 feet is required.
- Stations 110+00 to 120+00:  This segment has a generally thin blanket.  Railroad tracks constrain real estate inside the levee. Relief well design requires installation of 12 fully penetrating relief wells spaced 100 feet apart.
- Stations 120+00 to 137+00:  This section has a generally thin blanket.  A 100-foot wide underseepage berm with a minimum thickness of 3 feet at the berm toe is recommended to meet levee safety criteria.
- Stations 165+12 to 173+50:  This segment, along the Big Blue and Kansas River confluence, has a generally thin blanket.  A farm is located on the protected side which allows for construction of a 300-foot wide underseepage berm with a minimum thickness of 3 feet at the berm toe as required to meet safety criteria.
- Stations 265+70 to 272+00: This section has a generally thin blanket.  The landside contains business buildings adjacent to the levee toe which excludes the construction of

underseepage berms. Relief well design requires the installation of 4 fully penetrating relief wells with 12 inch diameters spaced 200 feet apart.

- Stations 94+00 to 97+00: This is the tallest segment of the levee. It does not have landside constraints, making it ideal for berm construction.
- Stations 170+00 to 272+00: This levee segment has an average height, but is constrained on the landside with power poles, water wells, and buildings, making it ideal for filter drain construction.
- Replacement of five gatewell structures.
- Installation of an emergency closure structure (ECS) of fill and plastic sheathing that would be available if flooding occurs during construction.
- A sandbag gap at Hays Drive at the Casement Road tie-in.
- 11 utility relocations.
- 13 relief wells of 50-inch depth and 16 relief wells of 16-inch depth.

### 8.1.2 Engineering Performance of NED Plan

Table 28 compares the without and with project condition reliability statistics for the NED plan. Under the without project condition, the leveed area has a 1.5% chance of a damaging flood in any given year. This decreases to 0.4% under Plan 3. Currently, the Manhattan levee has a 52.6% chance of containing a 1% chance (100-year) flood. Under Plan 3, this would increase to a 96.3% chance. Under without-project conditions, the chances of Manhattan experiencing a damaging flood within a 50 year period are 53.4%. Were Plan 3 to be implemented, this would decrease to 17.8%.

**Table 28: Engineering Performance Future Without Project Conditions vs. NED Alternative (Plan 3)**

| Manhattan Levee | | |
|---|---|---|
| **Annual Exceedance Probability** | **FWOP** | **Plan 3** |
| **Median** | 1.3% | 0.3% |
| **Expected** | 1.5% | 0.4% |
| **Long Term Exceedance Probability** | | |
| **10 years** | 14.2% | 3.8% |
| **30 years** | 36.8% | 11.1% |
| **50 years** | 53.4% | 17.8% |
| **Conditional Non-Exceedance Probability** | | |
| **10% event** | 99.7% | 100.0% |
| **4% event** | 94.1% | 100.0% |
| **2% event** | 76.9% | 99.9% |
| **1% event** | 52.6% | 96.3% |
| **0.4% event** | 9.4% | 61.6% |
| **0.2% event** | 3.5% | 25.6% |

### 8.1.3 Costs of NED Plan

Screening-level costs for the NED plan were updated to a more detailed MCACES 90% cost estimate and updated to an FY15 price level. The updated costs for the Plan 3 are shown in Table 29 below.

**Table 29: NED Plan Cost Breakdown ($000's)**

| NED Cost Plan Summary | |
|---|---|
| **Item** | |
| **Construction** | **$16,387.0** |
| **LERRD** | **$2,489.0** |
| **PED** | **$3,531.0** |
| **Construction Management** | **$1,347.0** |
| **Total First Costs** | **$23,754.0** |
| **IDC** | **$3,207.0** |
| **Annual Costs** | **$1,123.7** |
| **O&M** | **$54.0** |
| **Total Annual Costs** | **$1,177.7** |

FY15 Price Level, 50 year period of analysis, 3.5% interest rate

### 8.1.4 Economic Performance and Justification of NED Plan

#### 8.1.4.1 Benefit Cost Ratio and Net Benefits.

**The NED plan has total annual benefits of $4,077,000 and annual costs of $1,178,000, as indicated in Table 30. The plan exhibits strong economic justification with a benefit-cost ratio of 3.5. With net benefits of $2,899,000 the project would contribute strongly to national economic development. Benefits and costs for the NED plan were updated to reflect a price level of FY15 and the FY 15 Federal interest rate of 3.375%.**

**Table 30: Total NED Project Benefits and Costs ($000's)**

| Manhattan Levee | |
|---|---|
| **Annual Benefit** | **$4,076.6** |
| **First Costs** | **$23,754.0** |
| **Annual Costs** | **$1,177.7** |
| **BCR** | **3.5** |
| **Net Benefits** | **$2,898.9** |

FY15 Price Level, 50 year period of analysis, 3.375% interest rate

#### 8.1.4.2 Benefits Breakdown

The total project benefits of $4,077,000 and the category breakdowns are shown in Table 31. Approximately 83.4% of total benefits come from reduction of damages to non-residential buildings, while 7.5% are from reduction in damages to residential buildings, 1% from roads and streets, and 8.2% in reductions in emergency and cleanup costs. Note that damages to vehicles are included in residential damages.

The probabilistic assessment of damage reduction is also shown in Table 31. The mean value of damages reduced as produced by the risk analysis is $4,077,000. There is a 75% probability that the actual benefits exceed $2,710,000, a 50% chance they exceed $3,687,000, and a 25% chance that they exceed $4,923,000.

**Table 31: NED Plan Benefits Summary ($000's)**

| **Manhattan Levee** | |
|---|---|
| **Total EAD (equivalent annual damages)** | |
| Without Project Damages | $6,929.4 |
| Residual Damages (with project) | $2,852.8 |
| Damages reduced (benefits) | $4,076.6 |
| **Benefits By Category** | |
| Commercial | $2,453.4 |
| Industrial | $724.5 |
| Public/Municipal | $221.1 |
| Residential | $306.1 |
| Streets and Roads | $40.0 |
| Emergency | $275.5 |
| Cleanup | $55.9 |
| **Probabilistic benefit estimates** | |
| 0.75 | $2,709.6 |
| 0.50 | $3,686.5 |
| 0.25 | $4,923.0 |
| Mean | $4,076.6 |

*Probabilistic benefits refer to the probability that the benefits exceed a certain amount. In this case, there is a 75% probability that the actual benefits exceed $2,710,0000, a 50% chance they exceed $3,687,000, and a 25% chance that they exceed $4,077,000.*
FY15 Price Level, 50 year period of analysis, 3.375% interest rate

### 8.1.5 Induced Damages

According to ER 1105-2-100 Chapter 3, Section 3-3 b (5), "When a project results in induced damages, mitigation should be investigated and recommended if appropriate. Mitigation is appropriate when economically justified or there are overriding reasons of safety, economic or social concerns, or a determination of a real estate taking (flowage easement, etc.) has been made. Remaining induced damages are to be accounted for in the economic analysis and the impacts should be displayed and discussed in the report."

Immediately north of the Big Blue River segment of the existing levee in Manhattan, there is a large area of residential development within the 0.2% floodplain, approximately 1,300 structures, currently unprotected by any structural flood risk management project, some of which was damaged during the 1993 flood. H&H analysis determined that this area would likely experience slightly raised water surface profiles if the current levee is raised. With Plan 3, the greatest change in water surface elevation in this area would be less than 5 inches. This increase of 4.8 inches also occurs in an area that is largely undeveloped land. The bulk of the developed

residential area would experience an estimated increase of only 1-2 inches under Plan 3. There are no induced damages in the northern area for a 1% event.

Plan 3 is the NED plan with annual net benefits of approximately $2,898,900 and a benefit-cost ratio of 3.5. In order to estimate induced damages that could result from the levee raise, a preliminary structure inventory for the northern area, based primarily on GIS data, was imported into HEC-FDA. An outline of the area used for this inventory is shown in Figure 4. Then, existing condition and with-project water surface profiles for Plan 3 in the northern area were run in the FDA model.

Table 32 displays the results from this abbreviated analysis of induced damages. Under without-project conditions, the area experiences $689,100 in EAD, while under Plan 3, the area experiences $691,200 in EAD. Therefore, Plan 3 induces about $2,100 in annual damages in the area north of the levee. Considering this alternative has estimated annual benefits of $4,077,000, the damages induced are minimal.

Abbreviated examination of the feasibility of an additional structural feature (a new 5 to 6 mile long levee segment of consistent height) for this northern area revealed incremental negative net benefits that would not normally support a Federal interest decision under current Corps policies. Non-structural measures to mitigate these increases (as well as the existing flood risk that exists in the unprotected area) are being investigated under the Silver Jackets program.

Given the minimal nature of the induced damages found in this abbreviated analysis, no further damage investigations are planned, nor are mitigation measures considered necessary. Minimal damages of this nature do not constitute a taking. However, these minor induced damages will be subtracted from the overall benefits of the project. This will result in a $2,100 reduction in total project benefits to $4,074,000.

**Table 32: Estimated Induced Damages, Expected Annual Damages ($000's)**

| | W/O Project Damages | Damages Reduced | Residual Damages | Induced Damages |
|---|---|---|---|---|
| **Area North of Levee** | | | | |
| W/O Project Condition | $689.1 | $0.0 | $689.1 | - |
| Plan 3 Alternative | $689.1 | $0.0 | $691.2 | $2.1 |
| **Leveed Area** | | | | |
| W/O Project Condition | $6,929.4 | $0.0 | $6,929.4 | $0.0 |
| Plan 3 Alternative | $6,929.4 | $4,076.6 | $2,852.8 | $0.0 |
| **Total Area** | | | | |
| W/O Project Condition | $7,618.5 | $0.0 | $7,618.5 | $0.0 |
| Plan 3 Alternative | $7,618.5 | $4,076.6 | $3,544.0 | $2.1 |

Note: This table summarizes the recommended alternative impacts on two separate and discreet areas; the leveed area and the area north of the levee. These two separate areas, for the purposes of the overall study, should not be summarized. This comparison should only be used for consideration within the induced damages discussion.
FY15 Price Level, 50 year period of analysis, 3.375% interest rate

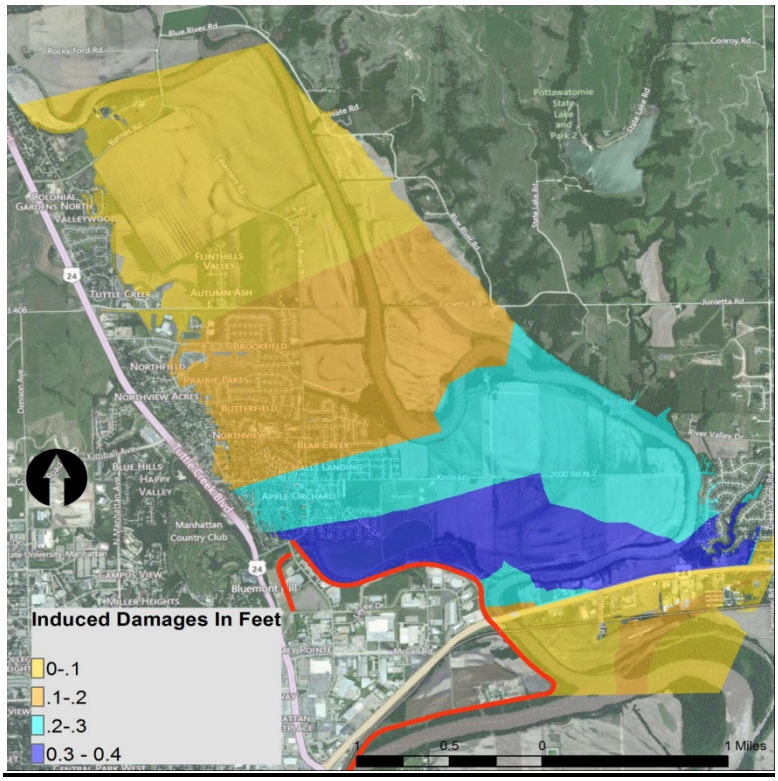


**Figure 6: Manhattan Potential for Induced Damages, North of the Existing Levee**

## 9.1 FUTURE WITH-PROJECT CONDITION SUMMARY

A recently reinvigorated emphasis on collaborative planning within the Corps of Engineers has set the stage for greater consideration of the full range of Federal interest in water resources projects. This includes not only tangible NED effects of the project, but also non-NED economic impacts, social impacts, and environmental impacts on the city and region. Environmental aspects are discussed in a separate appendix, while this section discusses some of the major economic and social considerations.

### 9.1.1 NED Effects of NED Plan

The overall annual NED contribution to the national economy is about $2,897,000, the total net benefits of the project. The project would reduce the existing condition EAD of $6,929,000 by nearly two-thirds to $2,853,000 in residual EAD. Many of the adverse impacts described in the previous sections would be headed off, including the following:

**Residential** - Residents would be spared most of the heavy personal losses they would face from flood damage if no action was taken.

**Businesses** - Business owners likewise would be spared most of their potential flood losses in buildings, equipment and inventories. This includes physical flood damages as well as income losses from shutdowns.

**Public sector** - Public sector repair costs would be greatly reduced at public facilities

such as parks, community centers, City Hall, and Riley County government buildings. Costly repairs to city streets and roads would be reduced. Expenditures on flood-fighting by emergency personnel, as well as relocation and reoccupation assistance, would also be reduced.

### 9.1.2 RED Effects of NED Plan

Regional economic development factors associated with project implementation - mostly positive - include the following:

**Existing local jobs, income and tax base** *(probable positive impacts on income and jobs)* - The planning horizon for existing companies in and around the EAA would include a reduced degree of flood risk. Discouraging factors in the business climate such as the potential of ruinous flood damage and income losses from shutdowns would be reduced, while the potential for flood insurance requirements and stiffer building codes would be removed. The risk of relocation from the city and region by large local employers such as GTM Sportswear, McCall's, Quaker Oats, and Parker Hannifin and others would be reduced. Population losses, likely to occur in the context of a serious and ongoing flood risk, would be less likely. The threat of large-scale job losses from relocations as well as reductions of the city's tax base would be reduced.

**Economic growth** *(probable positive impacts on income and jobs)* - The project would greatly alleviate flood risk obstacles to attracting new businesses with new jobs. This would potentially improve the regulatory climate for those businesses wishing to expand, build, or move into the market from the outside, helping the local economy by providing jobs and income. The downtown area, within the EAA, has undergone an extensive redevelopment over the past several years, reinforcing the need for greater protection from large flood events.

**Project construction impacts** *(miscellaneous possible minor impacts, both positive and adverse, to jobs and income)* - Some temporary and permanent easements will be required, but they are not significant. The region would temporarily gain jobs during construction of the project. The temporary presence of construction workers may bring a temporary increase in demand for some local services, but also a temporary increase in volume, profits, and sales tax receipts at local retail and service businesses. Minor temporary population increases could occur in the EAA in connection with project construction. Minor traffic disruption near the levees could occur during construction, although based on the best available information at this time, no roads are anticipated to be blocked or closed for extended periods. Most of the project area would be accessed from the levee road and should not interfere with the normal flow of traffic.

### 9.1.3 Other Social Effects of NED Plan

**Public safety** (p*robable positive impacts to human life)* - Public safety concerns, particularly within the leveed area of Manhattan, would be minimized by a large reduction in flood risk. The Manhattan Levee was evaluated for the levee safety program using the Levee Screening Tool in 2013 to determine an LSAC rating. Daytime population at risk for the area was estimated to be 7,650 and the nighttime population at risk was estimated to be 6,892, meaning that several thousand people would benefit at any given time from reduced flood risk.

The chances of levee overtopping or failure within a 10-year period would decrease from 15.1% to 3.8% under the NED plan. The chances over a 50-year period would decrease from 55.9% to 17.8%. In any given year, the levee has an almost 1.6% chance of overtopping or failing under existing conditions. This would be reduced to less than a half percent if Plan 3 alternative is implemented.

**Effects on minority and low-income residents** *(probable positive socioeconomic impacts)* Near the landward edge of the levee on the Kansas River segment, there are a number of lower-income housing units that could be severely impacted by any flood event. These residents would particularly benefit from the reduced flood risk afforded by the project.

**Threats to center city redevelopment** *(probable positive cultural impacts)* **–** A large portion of the existing leveed area has recently been redeveloped including a number of retail stores, office buildings, and a museum. A reduction in flooding threat would only add to the desirability of relocating to or redeveloping this area.

**City hall and other government buildings (probable positive impacts)** – Several city and Riley County buildings are located within the flood plain, including City Hall and a fire station. Reducing threats to some of the main governmental and emergency buildings in Manhattan would reinforce public safety

## 10.1 RESIDUAL RISK

Although floodplain occupants and users would desire total protection from flooding, this is not an achievable goal. There is always the potential for a flood that would exceed project capacity. No flood risk management project can guarantee total elimination of flood risk. Given a particular stated degree of levee performance and flood risk reduction, floodplain tenants often feel they are almost completely protected from flooding. However, it is important for floodplain users and occupants to be aware of the level of flood risk that remains even after implementation of a recommended project.

The NED plan has substantial economic benefits and reduces EAD by two-thirds relative to the existing condition. The probability of flooding will be greatly diminished. But the estimated residual annual damages total approximately $2,853,000. There will still be a 17.8% chance of a damaging flood occurring over a 50-year period. And there is a 0.4% chance that there will be a damaging flood in any given year.

In general, if a flood occurs that overtops or breaches the levees and the volume of water is sufficient to produce severe flooding depths, damages in the EAA could reach $1 billion. Large-scale evacuations of urban neighborhoods would be necessary in advance, followed by relocation assistance. Most highly-traveled highways and streets in the city as well as railroad track would be closed and in some cases inundated. See Table 33 for inundation depths at a few specific structures in Manhattan based on the structure detail files from the HEC-FDA model.

**Table 33: Expected Depths for Infrequent, Large Flood Events at Selected Locations**

| | Depth in Feet | |
|---|---|---|
| Structure | 0.2% Event | 0.13% Event |
| Manhattan Town Center | 2.9 | 4.0 |
| Manhattan City Hall | 0.2 | 1.3 |
| Flint Hills Discovery Center | 7.6 | 8.9 |
| Manko Window Manufacturing | 13.9 | 15.4 |

Local leadership and emergency operations staff will need to design plans for these extreme flood events, which might be infrequent but would hold the potential for catastrophe if they occurred. Effective emergency planning in advance is the best way to protect communities and minimize the damage from these rare flood events. Meanwhile, those who currently hold flood insurance policies might very well find it advantageous to keep their policies, which usually are fairly inexpensive in areas with certified levees.

## 11.1 PLAN FOR ECONOMIC UPDATES

ER 1105-2-100, para. D-4, requires that feasibility reports include a plan for conducting periodic updates of the project economic justification. Director of Civil Works' Policy Memorandum 12-001 "Methodology for Updating Benefit-to-Cost Ratios (BCR) for Budget Development" dated March 8, 2012 will be used to guide the update process for Manhattan. Economic updates, revisiting estimated damages, benefits, costs, affected population, and residual risk, will be required when the last approved data are more than three years old. (The three-year interval becomes five years once the project receives a construction start.) 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 convert data to current price levels. It is currently expected that the first economic update would be required in FY 2018. Project economic justification updates will include the following tasks and estimated labor:

1. Data gathering -- Information supporting the floodplain inventory will be updated as follows:

a. Windshield survey of EAA -- The update will begin with a windshield survey including all major portions of the EAA. The purpose will be to initially identify major changes in the scale or condition of residential and non-residential properties and transportation networks. (8 hours)

b. Discussions with local leaders and research -- City and/or Chamber of Commerce staff will be consulted to further help identify major changes since approval of the last decision document pertaining to the economic structure inventory and particularly to major non-residential properties. Discussions will 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. Business operators may also be consulted briefly for general information on operational scale. (12 hours)

c. Additional research -- Available information on the internet will be consulted, including totals for new construction permits. (8 hours)

2. Economic structure inventory revisions -- The economic database will be revised, based on the first task, as follows:

a. Non-residential properties -- Structure values of the remaining businesses and public facilities will be updated using CCI (Construction Cost Index, Engineering News Record) or RS Means factors to bring replacement costs up to current price levels. Average depreciation factors for the intervening period based on RS Means data will then be applied to produce updated depreciated replacement structure values. Non-residential contents in this analysis are computed as percentages of structure value and will update automatically when structure values are updated. (4 hours)

b. Residential values -- Residential updating will be based on the same sample of properties used to determine depreciated replacement structure values in the feasibility analysis. The depreciated replacement structure values of the sample properties will be updated individually using RS Means cost per square foot values and appropriate individual depreciation rates. The average sample change in replacement value versus the feasibility study or previous update will be computed and applied to replacement values in the remainder of the residential database. Average depreciation factors will be applied to produce updated depreciated replacement values. (24 hours)

c. 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. (2 hours)

d. New development -- For significant new additions to the property base, including large businesses and facilities, major new roads and streets, and significant new residential projects, appropriate adjustments will be made to the property inventory when properties could account for a disproportionately large share of benefits in view of their structure and content values as well as their damage susceptibility. (12 hours)

e. Other categories of benefits -- For disaster relief costs, the average percentage change in value will be computed for the residential category and applied to the relief costs. Emergency costs will be updated using an average encompassing both the residential and non-residential percentage changes. (4 hours)

3. Computation of damages and benefits -- The HEC-FDA program will be loaded with the updated property database and new damage and benefit estimates will be produced. (4 hours)

4. Costs -- An updated cost estimate will be prepared by engineering staff (labor not included here) and developed for use in the benefit-cost update. (2 hours)

5. Population -- Estimates of affected population and population at risk will be updated if significant new block or block-level Census data are available. (4 hours)

7. Documentation -- A brief report will be prepared documenting the tasks completed and the results of the updated analysis. (8 hours)

**Total labor: 92 hours.**

This estimate is subject to change if conditions in the EAA change significantly.

## 12.1 CONCLUSION

The feasibility-level socioeconomic analysis of the Manhattan Levee has found that a strong Federal interest exists in the NED plan, a levee raise with necessary structural and geotechnical fixes. Annual benefits of the plan are $4,074,000 (when induced damages are subtracted from the benefits) while annual costs are $1,178,000 (FY15 prices). Total first costs for the NED plan are $23,754,000. The plan exhibits very strong economic justification with a benefit-cost ratio of 3.5. With annual net benefits of $2,897,000, the project presents an opportunity for a strong contribution to national economic outputs. The plan would also make important contributions to public safety and regional economic considerations.

**Table 34: NED Plan Breakdown ($000's)**

| Manhattan Levee | |
|---|---|
| **Annual Benefits** | **$4,076.6** |
| **Induced Damages** | **$2.1** |
| **Annual Benefits less Induced Damages** | **$4,074.4** |
| **First Costs** | **$23,754.0** |
| **Annual Costs** | **$1,177.7** |
| **Benefit Cost Ratio** | **3.5** |
| **Net Benefits** | **$2,896.8** |

FY15 Price Level, 50 year period of analysis, 3.375% interest rate