US Army Corps
of Engineers®

Manhattan, Kansas
Local Protection Project
Section 216 Feasibility Study

FINAL FEASIBILITY REPORT

August 2014

Kansas City District
Northwestern Division

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Manhattan, Kansas
Local Protection Project
Final Feasibility Report

August 2014
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Executive Summary

The existing Manhattan, Kansas, Local Protection Project provides local flood risk management for highly developed areas within the City of Manhattan, Kansas. The project was authorized by the Flood Control Act of 1954 and constructed in the early 1960's.

The City of Manhattan is located in central Kansas, and lies at the confluence of the Big Blue River and the Kansas River. The Big Blue River is east of the downtown area and connects to the Kansas River which lies just south and southeast of the City. Both rivers have a history of repeated and sometimes catastrophic flooding. Upstream Corps lake projects provided some regulation of these rivers starting in the mid-twentieth century, resulting in moderation of the flooding risks for some events. The City is situated along U.S. Highway 24, which links the area to Kansas City (about 125 miles to the east). The City is also served by State Routes (SR) 18 and 177 which link the area to Interstate 70.

The Corps of Engineers Tuttle Creek Lake is situated just 6 miles to the north of Manhattan with the Big Blue River flowing into and out of Tuttle Creek Lake. Tuttle Creek is a major lake in the Kansas River basin system of lakes. This lake system is critical to the Corps' flood risk management mission for both the Kansas and Missouri Rivers. Discharge and level of performance is a complex issue for the levee unit due to the presence of Tuttle Creek Lake, the confluence of the Kansas River with the Big Blue River occurring within the study area, and given that each river has an independent contributory basin. These complexities were resolved in the study through the use of current Community of Practice preferred hydrologic and hydraulic modeling applications which produced the first full modern hydraulic modeling of this combined floodplain area in over 50 years.

This report focuses on identifying, describing, and offering recommendations to improve the identified performance weaknesses in the Manhattan local protection project (levee unit) by reducing the risk of flooding due to overtopping, geotechnical, or structural failure. This study recommends raising the height of the unit to reduce flooding risks in a manner consistent with the intent of the original authorization. The increased reliability is achieved by constructing a new top of levee elevation averaging 1.5 ft above the existing, with a maximum raise of 3.3 ft depending on location and existing ground contours.

The increase in levee unit height is achieved by adding earthen embankment material to the interior side and top of the existing levee with the exact configuration of the raise depending on the existing features, adjacent real estate, and avoidance of environmental impacts. The additional levee height increases the need for associated improvements and modifications to the geotechnical underseepage control features and appurtenant structural components. No existing pump station modifications or pump station additions are needed for the Recommended Plan.

This report categorizes the identified levee unit weaknesses and the related solutions as "reconstruction" (a subcategory of new work), which requires new congressional authorization.

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The Recommended Plan has few direct or cumulative environmental impacts largely because it sustains the existing project rather than encumbering additional resources for a “new” flood risk management project. Furthermore, because the authorized project footprint is essentially unchanged, there are relatively no other long-term adverse social effects. There are no takings of threatened or endangered species in the Recommended Plan. Hazardous waste and CERCLA do not affect the recommended solution. There are no real estate takings.

An Environmental Assessment has been prepared and is included with this report. This assessment reviewed the existing environmental conditions of the study area and discusses the potential impacts of the various project alternatives considered and the Recommended Plan. No significant impacts have been identified and environmental mitigation has been determined not necessary.

The Recommended Plan for the Manhattan levee unit is economically justified and is the National Economic Development (NED) Plan.

The estimated total implementation cost of these measures is $23,754,000 (October 2014 prices) shared with the non-federal levee sponsor. The total annual benefits are $4,074,440; annual costs are $1,177,660 and the net benefits are $2,896,780. The resultant Benefit-Cost Ratio (BCR) is 3.5 to 1. The sponsor will receive credit for the cost of any necessary lands, easements, rights-of-way, relocations or disposal area (LERRD). The estimated aggregate federal share of the plan is $15,440,100 or 65% of the total cost and the estimated sponsor share is $8,313,900, or 35%. The sponsor will take ownership of project improvements and assume all future operation, maintenance, repair, and replacement costs of the completed works.

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Manhattan, Kansas, Local Protection Project
Feasibility Study
Final Feasibility Report

I. Introduction and Study Background

A. Introduction

The existing Manhattan, Kansas, Local Protection Project was authorized by the Flood Control Act approved 3 September 1954 (Public Law 83-780), and constructed in the early 1960's. The Corps of Engineers designed and constructed the existing levee Project in coordination with the design and construction of Tuttle Creek Lake to help reduce flooding in the City of Manhattan. Tuttle Creek Lake, located six miles north of Manhattan, was originally authorized in the Flood Control Act of 1938 and is operated for multiple purposes including Flood Risk Management. Although these two separate Federal projects work together as a system, under extreme flood situations the City of Manhattan remains vulnerable to potentially large, though rare, Tuttle Creek Lake surcharge releases into the Big Blue River, and also from major flood flows on the Kansas River. The Manhattan, Kansas, Local Protection Project is primarily comprised of one levee unit that is located generally west and north of the confluence of the Big Blue River and the Kansas Rivers. The levee is slightly over 5 miles long.

Figure 1: Manhattan, Kansas, Levee Unit

B. Reason for Study

The Manhattan levee withstood the Flood of 1993, but levee performance during the flood did not meet expectations. Floodwater encroached dangerously close to top of the levee along the Big Blue River and triggered the City to begin the evacuation of persons within certain levee-

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protected areas. Additionally, some sand boils were observed indicating potential underseepage concerns and pump stations were operating near maximum capacity. The 1993 situation indicated that the levee may provide much less than the original authorized and intended level of performance – thus warranting further evaluation. In response to the performance observed in 1993, the City of Manhattan engaged the Kansas City District Corps of Engineers to evaluate the adequacy of the levee unit.

Natural environmental changes and expanded industrial and commercial development in the vicinity of the Kansas and Big Blue Rivers have taken place since the original project authorization. The Manhattan population and economy have grown significantly since the construction of the original local protection project in the early 1960's. Much of the City's economy and governmental infrastructure, including the downtown area, waste water, and water treatment facilities is dependent on the areas protected by the levee. Most of the levee unit is now over 50 years old. Project failure would endanger lives and create massive physical flood damages.

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.

C. Feasibility Study Authority and Cost Sharing Agreement

This Feasibility Study has been conducted under Section 216 of the 1970 Flood Control Act which provides continuing authority to reexamine completed civil works and determine whether the projects are providing benefits as intended. Section 216 reads as follows:

> *The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects, the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to the significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying structures or their operation, and for improving the quality of the environment in the overall public interest.*

The Feasibility Study began December 12, 2005, with the execution of a Feasibility Cost Sharing Agreement between the Corps of Engineers and the City of Manhattan, Kansas, (local non-federal levee sponsor). The study is cost-shared 50% federal and 50% non-federal.

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D. Purpose and Scope of the Study

The purpose of the feasibility study effort is to review the existing conditions of the Manhattan, Kansas, local protection project, identify potential weaknesses (areas of concern), and analyze alternatives for potential improvements to increase the project performance and reduce the risk of flooding to local communities.

This Feasibility Report documents the existing conditions, evaluation of alternatives, and improvement recommendations for Manhattan, Kansas, local protection project. These recommendations are intended for authorization and implementation following the approval of this report. Historical and reference information is provided in this report where needed for context and continuity.

E. General Geographic Area and Study Area Descriptions

The City of Manhattan is located in central Kansas and lies at the confluence of the Big Blue River and the Kansas River. The Big Blue River is east of the downtown area and connects to the Kansas River which lies just south and southeast of the City. Both rivers have a history of repeated and sometimes catastrophic flooding. Upstream Corps lake projects have provided some regulation of these rivers starting in the mid-twentieth century, resulting in moderation of flooding risks for some events. The City is situated along U.S. Highway 24, which links the area to Kansas City (about 125 miles to the east), and is also served by State Routes (SR) 18 and 177 which link the area to Interstate 70.

The Corps of Engineers Tuttle Creek Lake is situated just 6 miles to the north of Manhattan with the Big Blue River flowing into and out of Tuttle Creek Lake. Tuttle Creek is a major lake in the Kansas River basin system of lakes. This lake system is critical to the Corps' flood risk management mission for both the Kansas and Missouri Rivers.

The specific geographical components of the primary study area include the following:

- The entire 0.2% annual chance event (1/500) floodplain area which includes roughly the eastern 1/2 of the Manhattan city limits to include downtown Manhattan and some small unincorporated acreage in Riley and Pottawatomie Counties (outside the Manhattan city limits) which is also protected by the levee.
- The existing Manhattan, Kansas, Local Flood Protection Project and associated features and appurtenances.
- As required for the hydraulic modeling and floodplain evaluations, a length of Big Blue River channel and bank-side area which lies on both sides and continuously along the Big Blue River starting from the Kansas and Big Blue confluence to Tuttle Creek Dam (generally east and north of the downtown area).
- As required for the hydraulic modeling and floodplain evaluations, a limited length of Kansas River channel and bank-side area which lies just south of the City on both sides and continuously along the Kansas River.

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F. Non-Federal Sponsor

The City of Manhattan, Kansas, owns and operates the Manhattan, Kansas, levee unit and is the local sponsor for this feasibility study. The City serves as the primary local point of contact for all community-related matters regarding this study. City staff work with the Kansas City District Corps of Engineers on a routine basis and ensure that City and local considerations are taken into account as the study progresses.

Construction of the existing local protection project began on 4 May 1961, and local interests accepted the completed project for operation and maintenance in July 1963. Compliance with Corps of Engineers standards for federal levee maintenance and repair is an ongoing sponsor responsibility.

G. Relevant Prior Studies and Reports

The original Manhattan local protection project was authorized by specific legislation, as documented in reports of Congress, and was implemented through a series of design memorandums, and operations and maintenance (O&M) manuals. Following original project implementation, various reports and studies associated with the project or the adjacent rivers have been published; these include Kansas Reservoir system regulations, river hydrology updates, and floodplain mapping evaluations. From these, a select listing of documents follows which are considered important to the current feasibility study.

- Report on Kansas River, Kans., Colo., and Nebr., 21 August 1931 (published as House Document No. 195, 73d Congress, 2d Session, 1934). This is the initial report on flooding problems within the Kansas River Basin.
- Review Report on the Kansas River, Colo., Nebr., and Kans., 15 March 1947 (published as House Document 642, 81st Congress, 2d Session, 1950). This report provides the overall planning basis for constructing Milford and Tuttle Creek Lakes and the local protection project for Manhattan, Kansas.
- Flood Control Act approved 3 September 1954 (Title II, Public Law 780, 83d Cong., 2d Sess., H.R. 9859) authorized the original Manhattan, Kansas, Local Flood Protection Project.
- Design Memorandum (DM) No. 1, Flood-Protection Project, Manhattan, Kansas, Kansas River, Kansas, August 1959. This DM presents engineering details for the Manhattan, Kansas, levee.
- US Army Corps of Engineers. Construction Plans for Levees and Appurtenances: Flood Protection Project, Kansas River, Manhattan, Kansas, February 1961.
- US Army Corps of Engineers. Operation and Maintenance Manual: Flood Protection Project, Kansas River Basin, Manhattan, Kansas, revised June 1980 (latest edition of the Manhattan levee O&M Manual).
- Upper Mississippi River System Flow Frequency Study (UMRFFS), January 2004. The UMRFFS study established methods and data related to river flows.

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- Lower Kansas River Basin Lake Regulation Manual, Volume 2, Tuttle Creek Lake Kansas, Department of the Army, Kansas City District, Corps of Engineers, August 1973 (Revised 1995). This manual provides specific direction concerning releases under both routine and surcharge conditions which can directly affect the Manhattan, Kansas, Levee.

II. Existing Project Conditions and Flood History

A. Existing Project Description

The existing Manhattan protective works consist principally of an earthen levee, one minor floodwall, several gatewells and appurtenances, two pump stations and some minor channel improvements made at the time of levee construction. The Manhattan levee unit is located generally west and north of the confluence of the Big Blue River and the Kansas Rivers, and is approximately 28,841 feet long. The project extends over the final 4.6 miles of the lower Big Blue River, and over 2.1 miles on the Kansas River from Kansas River Mile #147.7 to Mile #149.8; and includes the confluence area of these two rivers. The Manhattan Local Protection Project works in conjunction with the reservoir system in the upper Kansas River, and with Tuttle Creek Lake on the lower Big Blue River to provide a limited level of flood risk management for the City of Manhattan. Storage and releases from Tuttle Creek Lake play a major role in the flows along the levee.

The levee was typically constructed with a 10-foot crown width and three horizontal to one vertical (3H:1V) embankment slopes. The levee is essentially an earthen unit with a limited number of concrete and steel structural components. The land area within the levee unit is nearly fully developed and exhibits intense commercial, governmental and light industrial uses accompanied by a significant residential population residing generally along the fringe of the southwestern portions of the protected area. Roughly 1,600 acres and just over $1B in private and local governmental investments are protected by the levee.

B. Review of Existing Levee Features, Operations, Construction and Modifications

Construction of the existing project began on 4 May 1961, and local interests accepted the completed project for operation and maintenance in July 1963. The City constructed a linear recreation (walking/running) trail on top of the existing levee using loose aggregate material during the late 1980's and early 1990's with no effects on flood risk management. The records examined during the course of this study indicate the significant levee features have remained essentially unchanged since construction with no major levee modifications until the 2000's as described below.

The Manhattan levee was designed and constructed with two pump stations; the Manhattan Avenue Pump Plant and the Poyntz Avenue Pump Plant, both of which were originally constructed as part of the federal project. The Poyntz Avenue plant was demolished and a new plant constructed at the same location in 2003 by local interests. A third pumping facility known as the Bypass Pump Plant is also used on occasion, but was not designed as part of the original levee project and is not part of the Federal project. The Bypass Pump Plant was originally

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constructed as part of a municipal wastewater treatment plant which has since been demolished. The Bypass Pump Plant is not needed to manage interior drainage as the Poyntz Avenue plant was designed to provide sufficient capacity without consideration of this old plant, however, the Sponsors kept the station in place for their own use for backup capacity. The Bypass Pump Plant was analyzed in this study for failure potential in the same manner as other existing private utilities but this facility is not proposed to be made a part of the Federal project. Operation and maintenance of the plant will remain a fully non-Federal responsibility.

A significant 2012 levee modification was undertaken (locally funded) by the City of Manhattan which involved construction of a small levee raise along the Big Blue River levee segment – this resulted in an average raise of 0.5 ft. over a 4,600 ft section. This small raise addressed a critical low area in levee height and enabled the City to receive a FEMA 1% event accreditation letter early in 2013 (ref. 44 CFR 65.10). The Kansas City District Corps of Engineers worked closely with the City to ensure that the hydrology and hydraulic modeling used for the design of that raise and the associated FEMA accreditation process was the same as the new modeling generated during this study. The District also reviewed and approved the plans for the actual levee modification. This small raise is included in the existing baseline levee conditions for this study.

The Kansas River portion of the project was designed using a balanced overtopping discharge of 335,000 cubic feet per second (cfs). This provided a freeboard of two feet above the design discharge (220,000 cfs) at the mouth of the Big Blue River. The Big Blue River levee segment (also known as the tieback segment) was designed using a 110,000 cfs release from Tuttle Creek Lake with two feet of freeboard. (USACE 1980).

Table 1 provides a summary of the design discharge conveyance target for the Manhattan local protection project.

Table 1: Summary of Levee Unit Construction History and Design Discharge

Levee Segment	Initial Federal Project Completed (yr)	Last Major Modification (yr)	River	Original Design Discharge (cfs)
Manhattan – Big Blue Levee Segment	1963	2012 (small levee raise)	Big Blue	110,000 + 2 ft of freeboard
Manhattan – Kansas River Levee Segment	1963	2003 (new Poyntz pump station)	Kansas	220,000 + 2 ft of freeboard

B1.0 Existing Levee Features

Drawings of all existing levee features can be found in the US Army Corps of Engineers. Operation and Maintenance Manual: Flood Protection Project, Kansas River Basin, Manhattan, Kansas, revised June 1980. This manual is considered a reliable and authoritative source of information concerning the existing levee. The Corps' National Levee Database was also used for feature location and elevation reference in this study.

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B2.0 Project Operations, Maintenance and Inspections

The Manhattan Local Protection Project was turned over to the levee unit sponsor following the completion of construction in 1963. The Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R) of the unit and is accomplished by the sponsor and annually inspected by the Kansas City District. The primary sponsor responsibilities for a federal flood risk management project are detailed in the Code of Federal Regulations (CFR) Title 33 - Navigation and Navigable Waters, Chapter II - Corps of Engineers, Department of the Army, Part 208 - Flood Control Regulations, Maintenance and Operation of Flood Control Works. Additional guidelines regarding operations and maintenance requirements are contained in Engineering Regulation (ER) 1130-2-530 (Project Operation).

The Operation and Maintenance Manual for this unit addresses project specific sponsor responsibilities and contains the full text of Title 33. The sponsor has operating staff that are familiar with the details of effective levee maintenance practices. The sponsor maintains their own office and legal records, and operation and maintenance records to the extent they determine useful. The Corps of Engineers does not normally inspect nor duplicate these records.

B3.0 Maintenance & Repair History

Maintenance and repair is conducted by the sponsor on an as needed basis. The specific projects undertaken by the sponsor over the long history of the unit are too numerous to list here. Generally, the more intensive repairs can include, but are not limited to:

- Repair of erosion and replacement of stone-fill levee slope protection.
- Repair of outlet structures and outlet channels.
- Gatewell and pump station rehabilitations and repairs and pump station outfall repairs.

The Manhattan levee meets the requirements for eligibility for the Public Law 84-99 emergency assistance program. The project is inspected annually and a more in-depth Periodic Inspection is conducted every five years. Corps of Engineers inspections indicate that the levee has been maintained to an overall adequate standard. Any deficiencies or encroachments in the project identified in inspection reports have generally been minor in nature, not significantly impacting project operations or readiness, and have been addressed by the sponsor in a timely manner. Sponsor operations and maintenance is an important and indispensible component of ensuring the existing system provides the intended risk management.

B4.0 Foundation and Underseepage Conditions

In recent studies and investigations of other Civil Works projects, foundation conditions have been identified as a significant factor in the performance of aging levee systems. The state of the art of foundation investigation and analysis has improved greatly since many of these projects were implemented and proper levels of underseepage control and risk reduction is now identified as a greater concern than it may have been in the past. This has also increased emphasis on the proper maintenance of existing and proposed underseepage control systems.

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The Manhattan levee unit has a limited number of existing underseepage features – earthen underseepage berms and one minor relief well system.

The Manhattan unit's only relief well system is located near the Poyntz Avenue pump plant on the Kansas River segment of the levee. This relief well system serves to lower underseepage pressures around a small drainage ditch carrying storm-water runoff from higher elevation areas within the City to the river. The feasibility study undertook a review of the results from three recent relief well inspections (Corps annual and periodic inspections). The relief well system maintenance and the general condition was found to be "unacceptable" during these three inspections. This relief well system was originally constructed with six wells. Two of the original relief wells were inadvertently lost or covered from nearby construction activities at some point since the original levee construction. The remaining wells were tested in 2009 and do not meet minimum performance requirements.

However, as this well system deficiency was established and made known, the sponsor did undertake investigation of potential remedies. The sponsor has scheduled a locally funded project to eliminate the need for this relief well system. This involves installing a box culvert extension with suitable earthen fill – with completion of this modification scheduled in 2016. The sponsor is coordinating the design of the remedy with Kansas City District engineering staff for review and approval. Note that any new underseepage work items recommended in this report do not address this existing well system as this particular deficiency remains the responsibility of the sponsor. The future without project condition analysis assumes that this local sponsor project is successfully implemented, thus no future risk from this area of concern was included.

C. Review of River Basin Characteristics and Flood History for the Manhattan Area

C1.0 Kansas River Basin

The Kansas River Basin is located in the northern half of Kansas, southern Nebraska, and eastern Colorado, shown in Figure 2. Major tributaries include the Big Blue, Republican, Solomon, Saline, and Smoky Hill Rivers. The Kansas River is formed by the convergence of the Republican and Smoky Hill Rivers at Junction City, Kansas, about 20 miles upstream from Manhattan. The river receives discharge from the Big Blue River just downstream from Manhattan. Much of the river's watershed is regulated for flood risk management and other purposes, but the river itself is generally free-flowing.

Kansas River discharge is related to climate, season, and location in the drainage basin. The highest discharge generally occurs in the summer months with the maximum monthly discharge in July. Major floods on the Kansas River are usually caused by the combination of a prolonged period of general widespread precipitation which results in antecedent saturated or near-saturated soil conditions followed by a series of short duration, high intensity storms. Floodwaters in the Kansas River Basin are of comparatively low velocity and of several days duration.

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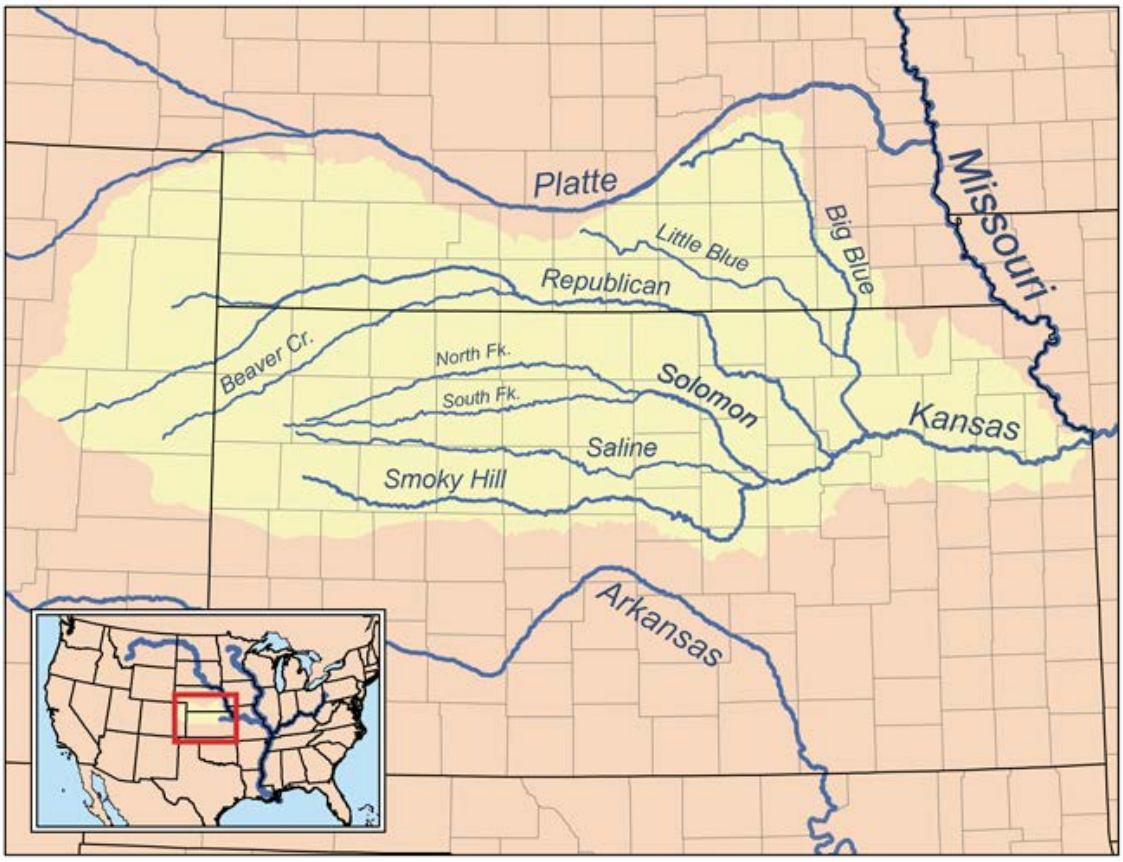
Figure 2: The Kansas River Basin



C2.0 Big Blue River Basin

The Big Blue River basin comprises a total area of 9,628 square miles. Three-fourths of the basin is situated in Nebraska, and the remainder in Kansas. The source of the Big Blue River is near Grand Island, Nebraska. From there, the river flows generally eastward about 50 miles to Ulysses, Nebraska, and then southward over 300 miles to Tuttle Creek Lake.

The portion of the Big Blue River within the study area (lower Big Blue) extends approximately 12.3 winding river miles downstream of Tuttle Creek Lake to its confluence with the Kansas River. Significant channel migration on the lower Big Blue has occurred in response to flood events. Since completion of the Tuttle Creek Dam the Big Blue channel has not experienced significant lateral migration.

C3.0 Historical Flood Events and Damages

Table 2 lists the three largest confirmed peak discharges (in cubic feet per second) at the United States Geological Survey (USGS) gages on the Kansas and Big Blue Rivers near Manhattan,

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Kansas. These gages were selected based on their proximity to Manhattan and the capability of the instrumentation to record peak discharge data.

Table 2: Major Floods at or near Manhattan

USGS Sta.	Station Name	1903	1951	1993
6879500	Kansas River at Ogden (Upstream of Manhattan)[1]	236,000	298,000	85,000
6887500	Kansas River at Wamego (Downstream of Manhattan) [2]	280,000	400,000	199,000
6887000	Big Blue River near Manhattan[2]	93,800	93,400	58,800

[1] From Juracek and others (2001).
[2] From Combs and Perry (2003).

Based on historical accounts and observations, it is believed that the largest flood on both the Kansas and Big Blue Rivers occurred in 1844; however no measurements exist for this event.

C3a. The 1903 Flood

The second largest flood for which reliable stage records are available occurred during the latter part of May and the first part of June 1903. This flood resulted from extraordinarily heavy rainfall the last five days in May preceded by above-normal rainfall throughout May. The rainfall at Abilene was estimated at 15 inches on May 28. Kansas River flood stage was exceeded approximately 16 days at Manhattan *(USACE 1959)*. The information available on 1903 Flood damages around the City of Manhattan is limited. This flood apparently affected the area between the Kansas River and 5th St. the hardest with some damages extending westward toward 8th St. Approximately $25,000 in damages was incurred in 1903 dollars -- which would account for about $2.5 million in 2013 dollars. This flood was large enough to cause the Kansas River to permanently change course at Manhattan.

C3b. The 1951 Flood

The maximum flood of record occurred in July 1951 and resulted from the combined effects of well above average rainfall in May and June and a major event spanning four days (July 9 through 12) of extremely heavy precipitation over the lower portion of the Kansas River Basin. The Kansas River at Manhattan was above flood stage on June 4, June 7 through 19, and June 22 through July 24, 1951 for a total of 47 days. The maximum gage height of 33.40 feet occurred at 3:00 a.m., July 13, with an estimated discharge of 300,000 cfs in the Kansas River and about 98,000 cfs in the Big Blue River *(USACE, Manhattan, Kansas Flood Protection Project Design Memorandum No. 1 - 1959)*. Fort Riley and Manhattan were the first urban areas to be flooded by the Kansas River. Some of the barracks at Fort Riley were smashed or carried away by the flood. The Kansas River at Manhattan began overflowing on July 11 and was soon spread out from bluff to bluff along the entire valley. The main Manhattan business district, including approximately 300 businesses, and about 1,600 homes in Manhattan were flooded. Depths of flooding in the main business section ranged from six to eight feet. River currents through areas located nearest the Kansas River demolished or swept away thirty homes and two large

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industrial buildings. Approximately 5800 people were evacuated and there was two deaths reported. Total damages from the flood event are estimated at $13.4 million in 1951 dollars, or approximately $239 million in 2013 dollars.

C3c. The 1993 Flood

The third largest flood for which reliable stage records are available occurred in July 1993. Moderate to major flooding occurred on the Kansas, Big Blue, Black Vermillion, Smoky Hill, Solomon, Saline, and Republican Rivers and their tributaries *(Combs and Perry 2003).* As with the flood of 1951, heavy rainstorms in July were preceded by several months of above average rainfall. Manhattan received more than 100 percent of the normal annual precipitation (1961 to 1990 average) for January through June 1993. May through July precipitation at Manhattan was 35.38 inches and was the second wettest period in 104 years of record. July rainfall was 535 percent of the normal (Wahl et al. 1993).

Based on levee freeboard gage readings during the flood and surveyed high water marks, the water surface elevation in the Big Blue came within 3 to 4 feet of the top of the Big Blue River section of the Manhattan levee. High stages on the Big Blue River were most noticeable upstream and near the U.S. Hwy 24 and Union Pacific bridge crossings. The existing Manhattan levee prevented an estimated $18.9 million damages from the 1993 flood (2014 dollars).

The presence of Tuttle Creek Lake in 1993 contributed greatly to lessening flood impacts and potential flood damages. A comparison of the observed controlled and a simulated uncontrolled daily mean discharge in the Big Blue River near Manhattan for July 1993 *(Perry 1993)* indicated that the storage of floodwaters in Tuttle Creek Lake reduced a potentially devastating Big Blue flood of more than 95,000 cfs on July 5 to a much less destructive flood of 60,000 cfs on July 25. Without the Tuttle Creek reservoir storage, the Big Blue would have likely overtopped the current Manhattan levee, and flooding downstream from Manhattan along the Kansas River would have been much more severe (towards Wamego and Topeka, Kansas). Although the Manhattan levee did not fail this event prompted great concern within the local community about levee performance.

D. River Discharge Evaluations and Existing Project Hydraulic Characteristics

For this study, it was necessary to undertake improved modeling of the existing hydrologic and hydraulic conditions along the Big Blue and Kansas Rivers to adequately understand the current overtopping threat for the Manhattan levee. An updated hydrologic analysis for Manhattan was performed. The updated analysis included over 40 years of additional hydrologic record as compared to the 1960's-era original design and the limited update done during a 1981 FEMA flood insurance study. The study:

- examined Tuttle Creek Lake releases during period of operation (1963 onwards);
- evaluated both regulated and unregulated discharges so as to extend period of record prior to when flood control projects were built in the basin;
- performed detailed coincident frequency analysis at the confluence;

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- developed updated frequency flows. These are significantly higher than older estimates in the previous 1981 FEMA flood insurance study. These updated flows coincide with 1993 flood observations.

A new hydraulic model was developed for the feasibility study area which uses the new feasibility hydrology. New inundation mapping was produced for a series of flood events and back-checked and calibrated against 1993 Flood high water records. This extensive effort has produced a hydraulic model which closely aligns with 1993 observations.

D1.0 Comparison of Designed and Observed Project Performance

An important aspect of assessing the existing condition was identifying the cause, or causes, of the project to not perform as originally intended during the 1993 flood event. Review of available original project design and construction information indicates that the existing levee was originally analyzed, designed, and constructed to the best available knowledge, criteria, and methods of the time. Further, there has been no significant change to the levee itself in the intervening years and the project is well maintained by the project sponsor. A number of possible factors have been identified that could have led to the project not performing to its original hydraulic design. The specific attributable impacts have not been determined for all factors.

The 1993 flood identified hydraulic performance issues that, when compared to the original project design, can be attributed to 1) a general loss of flow conveyance / higher channel roughness (e.g. more vegetation in the channel and floodplain), 2) availability of high water mark data post-dam and levee which shows how the river has responded to these features, and 3) the hydraulic methods /model capabilities utilized to model the confluence and bridges along the Big Blue River levee segment.

It is possible that even the best knowledge and methods at the time were insufficient to accurately predict future project performance, which does not imply that the design was deficient or contained any omissions. The original project design was based on high water marks of the 1951 flood; however there was no flow measurement recorded near the peak of the 1951 flood forcing the original designers to estimate the peak flow. The confidence of that original peak flow estimate is much lower than peak flow estimates of the 1993 flood, as flow measurements were made within 1-foot of the peak stage during the 1993 event. The current analysis of flood performance is calibrated to actual performance data, current high-water works, and advanced analysis methods not available to the original designers.

The original design n-values (channel roughness) are lower than what was used during 1993 flood calibration in the feasibility study existing conditions hydraulic model (described in Eng Appendix Vol. 1, H&H section 2.4.7). When evaluating the study model with original design n-values and no levee, the model reasonably matched the 1951 flood high water marks on the Kansas River (see Eng Appendix Vol. 1, H&H section 2.4.8). The model also matched the high water mark at the Manhattan, KS, Big Blue River gage within 1-ft. For comparison, the original design hydraulic profile slopes on the Big Blue River are less than what was observed during the

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1993 flood, even though the 1993 flood flows were less than the design discharges. Between the confluence and the three bridges that span the Big Blue River along the levee (UPRR railroad, eastbound Highway 24, and westbound Highway 24), the design profile slope is 0.00007 ft/ft, essentially a flat line from the Kansas River design elevation at the confluence; the 1993-modeled profile is 0.00024 ft/ft when calibrated to 1993 high water marks. Upstream of the bridges, the design profile slope increases to 0.00038 ft/ft and the 1993 high water profile slope is about 0.00058 ft/ft.
There have been noted changes within the watershed of the Big Blue River upstream of the City of Manhattan, including the increase of vegetation along the channel affecting roughness coefficients. This has been modeled and accounts for approximately one foot of impact to river stages. The original design analysis of the levee appears to have assumed that the entire floodway would remain cleared of trees and woody vegetation. Considering the environmental and maintenance impacts, this assumption is unsustainable. There has been additional urban development in the Big Blue watershed as well, likely increasing runoff. The relationship between urban development and hydraulic impacts has not been thoroughly understood or considered in the past. It is likely these changed watershed conditions have led to increases in Big Blue River hydrographs and flood frequencies. The understanding of watershed scale impacts is much better understood and acknowledged now, as evidenced by the number of local partners involved in current on-going efforts to study and implement regional flood risk management.

Lastly, the feasibility study existing conditions feasibility hydraulic model uses a more sophisticated method to account for hydraulic losses at the bridges than what was used in the 1950's-era design, which shows slightly higher losses than the original design profiles.

In summary, the identified hydraulic performance issues are most likely attributable to 1.) The limitations of available original design knowledge and analysis methods compared to actual performance data and improved methods today, and 2.) The impacts associated with increased vegetation and urban development in the Big Blue River watershed since original project construction.

D2.0 Operation of Kansas River Basin Reservoir System

Construction of reservoirs in the Kansas River basin was first authorized by Congress in 1938. An expanded and coordinated multi-purpose system of reservoirs and levees throughout the Kansas River basin was authorized in the Flood Control Act of 1944. Eighteen (18) federal lakes/reservoirs now exist in the Kansas River basin; seven managed by the Corps of Engineers and eleven by the Bureau of Reclamation. All of the Reclamation lakes and five of the Corps lakes (Tuttle Creek, Milford, Kanopolis, Wilson, and Harlan County) are located upstream of the City of Manhattan levee, shown in Figure 3. Tuttle Creek and Milford are the only lakes close enough to have effects on flows passing along the Manhattan levee.

This reservoir system was authorized in part for flood risk management, and to act in concert with various systems of federal levees in Topeka, Kansas City, and other downstream areas. Modifications to this original 1944 lakes authorization have appeared in subsequent Flood

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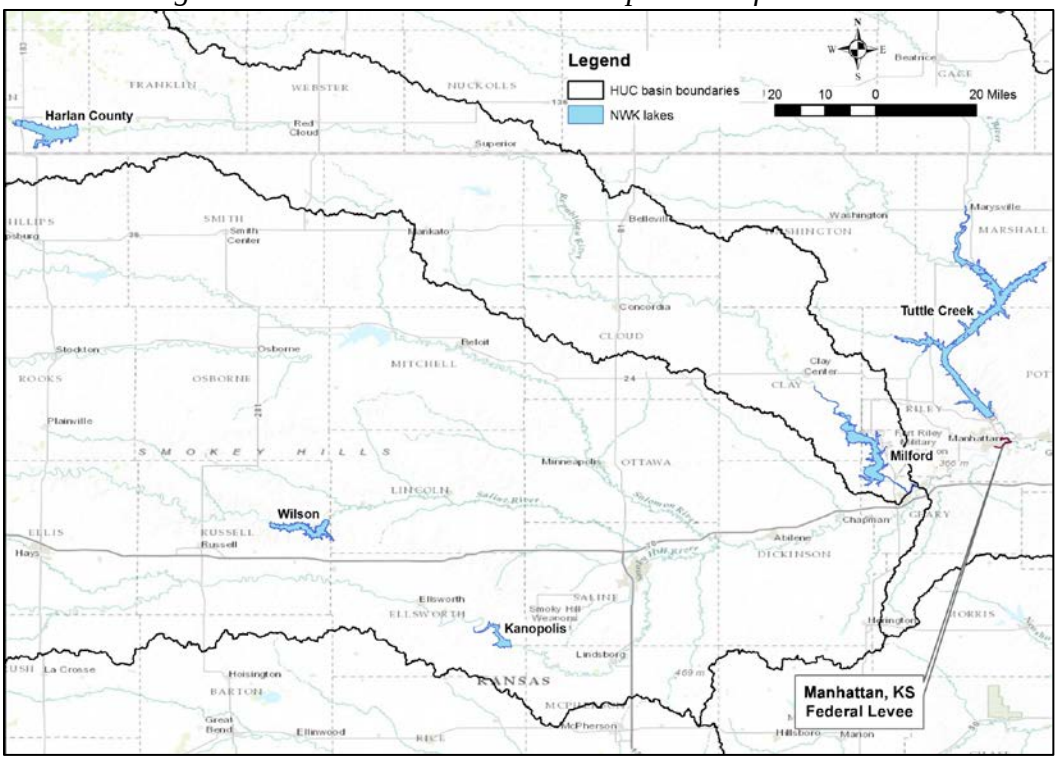
Control Acts, including the addition of the Manhattan levee in 1954, but the basic objective of providing a coordinated flood risk management system in the Kansas River, as outlined in the 1944 Act, has been preserved.

Figure 3: Kansas Basin Reservoirs Upstream of Manhattan



The Kansas Basin lakes are operated with consideration of flows at specific gage locations on the Kansas and Missouri River. The nearest upstream and downstream control points to Manhattan are at Ft. Riley and Topeka, respectively. Depending on the amount of water stored in their flood control zones, each reservoir restricts releases based on river conditions. Reservoir releases from the system will not increase downstream flow more than the limits presented in Table 3 at the Desoto gage on the Kansas River, the Kansas City gage on the Missouri River, or the Waverly gage on the Missouri River.

Table 3: Kansas River Basin Reservoirs Releases: Downstream Flow Limits

	Desoto Gage Kansas River	Kansas City Gage Missouri River	Waverly Gage Missouri River
Phase 1: Lower zone of flood control pool	66,000 cfs	176,000 cfs	90,000 cfs
Phase 2: Middle zone of flood control pool	110,000 cfs	220,000 cfs	130,000 cfs
Phase 3: Upper zone of flood control pool	130,000 cfs	240,000 cfs	180,000 cfs

Cfs = cubic feet per second

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D3.0 Description of Upstream Reservoirs

Tuttle Creek Reservoir

Tuttle Creek Lake is located on the Big Blue River about 6 miles (direct measurement) north of Manhattan. The lake's drainage area is 9,628 square miles. The lake provides flood control, recreation, fish and wildlife conservation, water quality control, and navigation supplementation. When at its multipurpose pool, elevation 1075.0 feet mean sea level (msl), the lake covers about 12,350 acres, extends some 16 miles upstream from the dam, and spreads a mile wide, on average, over that length. At full flood control pool, elevation 1136.0 msl, the lake swells to cover about 53,700 acres and extends upstream 35 valley miles (USACE 2004).

Discharges from Tuttle Creek Lake are controlled by the outlet works under normal operating conditions and convert to emergency spillway release under surcharge conditions. The outlet works include a low flow outlet and a primary outlet works. The low flow outlet is two 24-inch pipes that have a discharge of approximately 100 cfs per pipe at pool elevation 1061 feet msl. The primary outlet works consist of four 10 ft by 20 ft gates with one additional emergency gate. These gates control discharges to two 20 ft diameter horseshoe conduits that discharge to a stilling basin and outlet channel. The primary outlet works have a discharge capacity of 31,300 cfs at pool elevation 1075 feet msl and 45,900 cfs at pool elevation 1136 feet msl. The emergency spillway is at a crest elevation of 1116 feet msl and is controlled with eighteen 40 ft by 20 ft tainter gates. The spillway has a maximum discharge of approximately 579,000 cfs at maximum water surface elevation of 1151.4 feet msl.

Other Upstream Reservoirs

Milford, Kanopolis, Wilson, and Harlan County Lakes are owned and operated by the Corps of Engineers for multiple purposes including flood control, recreation, fish and wildlife conservation, water quality control, and navigation supplementation. Ten Bureau of Reclamation lakes in the basin are primarily operated for municipal and agricultural water supply, but some include a flood risk management purpose which is operated by the Corps of Engineers. Because of the location of these lakes within the basin, their operation is expected to have only minor and generally indirect effects on the Manhattan levee. Furthermore, recent flood observations have not indicated performance concerns of the Manhattan Levee on the Kansas River.

D4.0 Recent River Discharge Evaluations

River flow rates for both the Kansas and Big Blue Rivers were based on output from the Kansas River UNET model. The Kansas River UNET model was developed by the Kansas City District for unsteady flood routing of the daily flows over the period of record from 1929 to 2002. The daily flows were evaluated in two scenarios. The "Unregulated" scenario evaluated a synthetic period of record flows along the Kansas and Big Blue Rivers assuming that no reservoirs were in place within the Kansas River Basin for the entire period of record. The "Regulated" scenario developed a synthetic record assuming current Kansas River Basin reservoir operations were in

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place for the entirety of the period of record. This approach was developed using actual USGS daily gage records over the period of record. This is an approach similar to the methods used for the USACE Kansas River Hydrology Report (2002) and the USACE Upper Mississippi River System Flow Frequency Study Appendix E (2004).

The flow frequency analyses completed for both the Big Blue and Kansas Rivers were conducted using a combined analysis of regulated and unregulated flow data. The presence of reservoirs upstream of the study reach for both rivers precludes a flow frequency analysis as defined in Bulletin 17B, as the presence of significant regulation will not produce valid analytical flow frequency results. The final method employed for flow frequency analysis used a hybrid analysis.

Discharges developed from these recent studies have been used to establish the existing conditions flow frequency data used in this study. Since flood events above the 0.2% annual chance of exceedance (1/500) event need to be considered in this study, the discharge-frequency curves were extended up to the 0.133% annual chance of exceedance (1/750) flood event. The hydrological studies included a coincident flow frequency analysis to account for most likely coincident flows on both the Kansas and the Big Blue Rivers. To develop these relationships between each basin and the Kansas River below the confluence, the peak annual flow from each basin was extracted from the UNET regulated record and plotted with the corresponding flow below the confluence on the same day as the tributary peak flow. At each location along the levee, the hydraulic analysis for each annual chance event (i.e. 1% or 1/100) was based on the higher of two water surface profiles - one profile based on flows from a Kansas River flood (with corresponding coincident discharges on the Big Blue River), and the other profile based on flows from a Big Blue River flood (with corresponding coincident discharges on the Kansas River). Table 4 and Table 5 summarize the discharges developed for use in this study.

Table 4: Big Blue River Flood Discharges

Annual Chance Exceedance		Big Blue River Flow (cfs)	Most Likely Kansas River Below Confluence (cfs)	Coincident Kansas River Above Confluence (cfs)
0.133%	1/750	179,400	397,200	217,800
0.2%	1/500	167,000	361,200	194,200
0.333%	1/300	151,700	319,000	167,300
0.5%	1/200	115,800	258,600	142,800
1%	1/100	71,600	177,300	105,700
2%	1/50	46,200	120,500	74,300
4%	1/25	33,000	70,000	37,000
10%	1/10	27,000	46,800	19,800

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Table 5: Kansas River Flood Discharges

Annual Chance Exceedance		Kansas River Above Confluence (cfs)	Most Likely Kansas River Below Confluence (cfs)	Coincident Big Blue River Flow (cfs)
0.133%	1/750	277,400	387,700	110,300
0.2%	1/500	229,700	345,100	115,400
0.333%	1/300	182,200	283,200	101,000
0.5%	1/200	150,800	235,200	84,400
1%	1/100	109,500	167,200	57,700
2%	1/50	79,000	115,900	36,900
4%	1/25	56,400	70,000	13,600
10%	1/10	32,000	39,800	7,800

Expressing discharge probability in percent chance exceedance (occurrence) is currently used by the Corps of Engineers in lieu of a flood return interval expressed in years. Percent chance exceedance expresses the probability of the discharge occurring each year. Corps of Engineers risk and uncertainty (R&U) analytical tools and procedures were used in this feasibility analysis per ER 1105-2-101. The risk analysis and evaluations resulting from this type of analysis are not directly comparable to the discharge-plus-freeboard performance criteria used for the original levee design.

The basis for the hydraulic analysis was development of an existing conditions HEC-RAS model for this study. This model was calibrated to the flood event of 1993 from measured high-water marks and corresponding instantaneous discharge estimates and included all applicable geometric data including recent cross-section data and bridge data. Once the model was calibrated, a series of steady flow water surface profiles was created based on the flood discharges previously discussed.

Once the HEC-RAS model was calibrated using the 1993 Flood, the existing conditions water surface profiles were generated for the 10%, 1%, 0.5%, 0.2%, and 0.13% annual chance exceedance flood events. The results of the final model calibration closely reflect the actual 1993 Flood observations and records. The analysis shows that the 1993 Flood at Manhattan was roughly a 1.4% annual chance (1/70) flood event on the lower Big Blue River.

During the completion of this Feasibility Report it was recognized that the hydrology on which the study was based is now twelve years old. The hydrology modeling completed and published in 2002 has since been adopted as the basis for updated Flood Insurance Studies by FEMA, so there is a desire to keep the flows on this basis and not incorporate the additional years of available data. A brief review and sensitivity analysis of the additional data shows no major flood events have occurred in the intervening years that would be expected to increase nominal river flows or stages. Actually, it is expected that incorporation of the additional data to the hydrology model would slightly decrease nominal flows. Associated river stages would also decrease, but likely no more than 0.4 ft. This potential difference in river stages is not considered significant enough to affect the analysis or recommendations of this study. Future project design will be based on updated hydrology at the time of construction.

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Further details of the existing conditions hydrologic and hydraulic modeling are found in the Hydrology and Hydraulics Chapter of the Engineering Appendix Volume 1.

E. Review of Economic Conditions

The economic analysis was prepared according to the procedures outlined in the following: Economic and Environmental Principles and Guidelines for Water and Related Resources Implementation Studies (P&G); Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook, dated 22 April 2000; ER 1105-2-101, Risk-Based Analysis for Evaluation of Hydrology/Hydraulics, Geotechnical Stability, and Economics in Flood Damage Reduction Studies, dated 1 March 1996; EM 1110-2-1619, Risk-Based Analysis for Flood Damage Reduction Studies.

The existing Manhattan local protection project protects highly developed urban portions of the Manhattan metropolitan area. The protected area encompasses a major segment of the Manhattan economy. Flood disruptions to this area would strongly impact the local and regional economy. The existing conditions economic analysis quantifies and characterizes the economic impact from flooding using risk-based principles. Economic investment surveys support the economic modeling used for the determination of potential flood damages.

E1.0 Manhattan Economic Overview

The City of Manhattan serves as a regional economic hub and retail market for surrounding rural counties. It greatly benefits from the presence of Kansas State University and Fort Riley. Federal, state, and local governmental functions, retail, and agribusiness form a substantial portion of the growing economic base. Manhattan is the county seat of Riley County and the City extends into adjacent Pottawatomie County. The 2010 U.S. Census shows Manhattan's population (within the city limits) to be 52,281, which is a 16.6% increase from the 2000 Census count of 44,831. These figures include both the student population from Kansas State University as well as Fort Riley soldiers and their families residing in Manhattan. Manhattan is also the principal City of the Manhattan metropolitan area which has a population of over 125,000 (2010 Census).

E2.0 Major Transportation Characteristics

Major transportation routes near Manhattan are shown in Figure 4. Manhattan is served by US Highway 24 which runs through the City and project area. K-177 is a four lane state highway that connects the City to Interstate 70, located 6 miles to the south. K-18 and K-113 are major state highway connectors through the City into outlying areas. A Union-Pacific RR mainline, and spurs, route through the City and the project area. Manhattan Regional Airport is located 4 miles west on K-18 and provides connections to major hub airports (Chicago and Dallas are typical).

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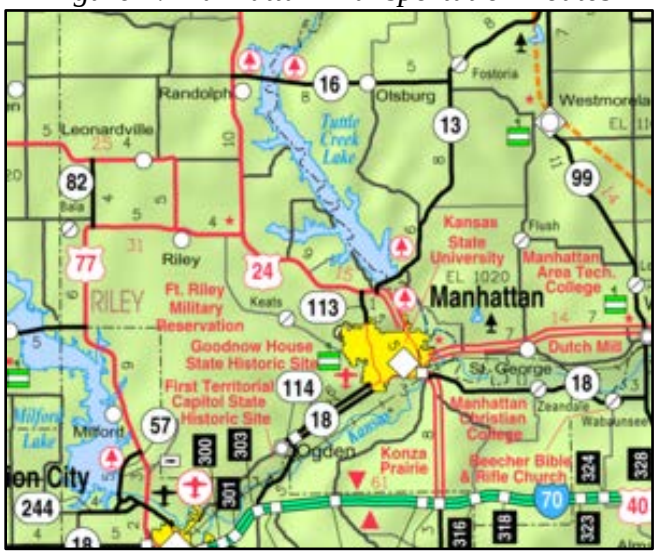
Figure 4: Manhattan Transportation Routes



E3.0 Economic Investment Surveys for Flood Damage Modeling

Economic investment surveys of the study area were undertaken using recent floodplain mapping and field survey data collection techniques. Initial survey area structure information was obtained from Riley and Pottawatomie Counties appraiser's database. A potential inundation area was defined using the 0.2% chance flood inundation mapping to create an inventory of structures for the existing conditions damage analysis (economic analysis area – EAA). A search of the online tax databases for Pottawatomie and Riley County was conducted to gather individual structure information. These searches were followed up with meetings with the appraisers of both counties. A new replacement cost was determined by the county appraisers for each structure using the dimensions of the building, the square footage, and other factors. This replacement value was used in conjunction with the age, condition, and functionality of the structure to estimate appropriate depreciated replacement values for each structure.

After the structure inventory was compiled, a 100% structure-by-structure visual survey of all buildings in the study area was conducted over several weeks in July 2011 with a follow-up survey in November 2012, so as to confirm the county tax record data and estimate the first floor elevations for each structure. Notes from the completed field survey were subsequently integrated with the tax data to form a complete structure inventory for the area. Any planned developments within the protected area that have reliable near-term development schedules were included in the survey and resulting characterizations.

For this analysis, three study reaches were defined. Each river has one unique reach along with the confluence reach which overlaps the floodplain between the two rivers. The locations and index points for each reach can be seen in the Table 6. The reach index point is used to aggregate the stage damage relationships for the different categories of investment located in the vicinity of the reach.

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Table 6: Study Reaches Used in HEC-FDA Analysis

Stream	Beginning River Mile	Ending River Mile	Index Point River Mile
Kansas River	145.59	149.79	
Confluence Reach	145.59	146.91	146.84
KR - Reach 2	146.92	149.79	147.67
Big Blue	0.4	1.51	
Confluence Reach	0.4	0.83	0.82
BB - Reach 2	0.84	1.51	0.95

E4.0 Detailed Socioeconomic Characteristics

E4a. Economic Analysis Area (EAA) Population and Housing Units

The portion of Manhattan subject to flood inundation in a 0.2% annual chance event has a total of 2,295 structures including 1,703 residential structures, 390 commercial structures, 108 industrial structures, and 94 public/municipal structures. This EAA is characterized by industrial and commercial facilities nearer to the levee, and residential areas further north and west. Census information was examined at the block level to estimate residential population within this area. The 2010 census reveals that 6,892 people currently live within this area and occupy 3,454 housing units; this figure represents the population at risk estimate for the study. Note that the residential structures and housing units have different values because multiple housing units can be located within one residential structure (apartments, duplex, etc). This population at risk estimate does not include the workforce that works within the area but lives outside the area. Table 7 displays population and housing information for this flood-prone area as well as the adjacent counties and the state. The ten-year growth in residential population and housing units within the flood-prone area has been low at 2.62% and 1.35% respectively; the potential for additional residential development within this flood-prone area is low.

Table 7: Population and Housing

Population and Housing Trends, 2000 to 2010						
	POPULATION			HOUSING UNITS		
	YEARS		*% CHANGE*	YEARS		*% CHANGE*
	2000	2010	*2000-2010*	2000	2010	*2000-2010*
State of Kansas	2,688,418	2,853,118	*6.10%*	1,131,200	1,233,215	*9.00%*
City of Manhattan	**44,831**	**52,281**	***16.60%***	**17,690**	**21,619**	***22.21%***
Riley County	62,843	71,115	*13.20%*	23,397	28,212	*20.58%*
Pottawatomie County	18,209	21,604	*18.60%*	7,311	8,626	*17.99%*
For surveyed 0.2% floodplain (EAA)	6,716	6,892	***2.62%***	3,408	3,454	***1.35%***

E4b. Economic Analysis Area Investment

Using the EAA surveys described above, the study determined that total investment within the flood-prone area is estimated at $1.18 Billion dollars (FY14 price level) and includes investment in structures, contents and equipment for commercial, industrial, residential, transportation, and public categories of investment. Depreciated replacement value for buildings and infrastructure

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in the study area is estimated at $536 Million. Businesses and residences have roughly a $641 Million investment in contents. Business contents include inventory, office equipment, computers, production equipment and machinery, and other miscellaneous contents. Table 8 and Table 9 show investment values for the surveyed area.

Table 8: Economic Analysis Area Investment Summary in Dollars

Investment (x $1000) FY14 Price Level						
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**

Table 9: Economic Analysis Area Investment Category Percentages

Investment by Category 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%	18.8%	100.0%

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F. Review of Existing Environmental and Cultural Resources

An Environmental Assessment was undertaken in this study in accordance with 40 CFR 1500 Parts 1500-1508, 1 July1986. Details of the existing and future environmental conditions and appropriate considerations thereof are found in the Environmental Assessment accompanying this Feasibility Report. The following material summarizes some of the key environmental and cultural characteristics of the study area.

The study area contains a broad range of environmental conditions from the highly developed urbanized residential, commercial, and industrial areas in the City of Manhattan, to the undeveloped areas that are primarily used for agricultural row crop production, to the areas riverward of the levee unit that consist of remnants of the wooded riparian corridor of the Big Blue and Kansas Rivers. Past disturbances and densely developed areas have affected the variety of fish and wildlife. However, many species commonly found within a Midwest U.S. urban setting are present. Wildlife in the project area is typical of that found in a fairly urbanized setting. Wildlife populations are lowest in the central urban core of the study area and increase on the outer edge. Many species of mammals, birds, reptiles, and amphibians utilize the undeveloped areas inside within the protected area and the remaining reverie habitat areas riverward of the levee. The riparian corridor, although severely reduced in much of the study area, continues to represent a substantial amount of important wildlife habitat that is directly connected to these major rivers.

Kansas River and Big Blue River fisheries are characterized by species typical of large turbid rivers. Most indigenous fish species still remain and fishing is an important recreational activity in vicinity of the existing project area.

Within the protected area, the undeveloped ground primarily consists of maintained grassland and agricultural row crop production. Riverward of the levee unit, vegetation consists of maintained grassland, areas in agricultural row crop production, and remnants of the wooded riparian corridor along the Big Blue and Kansas Rivers. Large cottonwoods, suitable as bald eagle roosts and hunting perches, are found along both rivers in the vicinity of the existing project area.

F1.0 Threatened or Endangered Species

No threatened or endangered species are located within the immediate project footprint. Two federally-listed threatened or endangered species are associated with segments of the nearby Kansas River. The piping plover (*Charadius melodus*), federally-listed as threatened, is a seasonal migrant along portions of the Kansas and Missouri Rivers, and has nested occasionally on the Kansas River, since 1998. Piping plovers are associated with unvegetated shorelines, sandbars, and mudflats. The federally-endangered interior least tern (*Sterna antillarum*) utilizes similar unvegetated habitat, and also has occasionally nested on the Kansas River since 1998. Neither species has been found nesting on the Kansas River since 2009. Past nesting was concentrated downstream from the study area, but occasionally birds were observed near the confluence of the Big Blue and Kansas Rivers. A separate study of the birds on the Kansas

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River completed in 2006 concluded that the habitat conditions to support these species were unsustainable and unlikely to support future populations.

F2.0 Wetlands

Few wetlands remain within the interior of the Manhattan levee unit. Most wetlands were observed adjacent to a small tributary to the Big Blue River. Wetland locations, classifications, and acreages were determined by overlaying study area maps with National Wetlands Inventory (NWI) maps. NWI maps are typically used as a reference for locating existing wetlands. Field delineation was conducted to verify the presence or absence of NWI wetlands and any additional wetlands that might be present.

F3.0 Cumulative Effects

Although this study involves the evaluation of the existing Manhattan levee, any federal activity that may affect the overall aquatic ecosystem of the Kansas River has typically been an item of concern for the resource agencies in this region. The Kansas River system and adjacent floodplains were significantly altered by human activities in the past. These same types of activities continue now and are expected well into the future. As a result, resource agencies have expressed concerns about cumulative and secondary impacts on the Kansas River. Major impacts to the riverine environment on these rivers began with modification of the Kansas River channel and stabilization of the river bank in the 1800's. As industrial and residential development continued along the river, upstream reservoir and local levee systems were developed to provide flood risk management and allow continued economic development.

Previous modifications to the Kansas River and associated floodplains have been spurred by several federal and private initiatives. This resulted in a changed environment within and along the river and specifically within urban areas bordering the river. The cumulative impact of these activities (navigation, flood risk management, industrialization, and residential development) has resulted in an intermittently developed floodplain protected by urban and agricultural levee systems. Development is expected to continue within these urban areas into the foreseeable future as demand for products, services, and flood risk management continues. Longer-term external initiatives to preserve remaining wild and scenic areas on the Kansas River to include tributaries and side channels and floodplain environments remain viable. Cumulative impacts related to these past activities were evaluated to determine the level of significance of any proposed project. Additional discussion of Cumulative Impacts is provided in Section 5.0 of the Environmental Assessment.

F4.0 Cultural Resources

The Kansas City District Archeologist conducted a literature and background review of the Manhattan local protection project area. The review consisted of an examination of the National Register of Historic Places (NRHP), pertinent archeological documents in the Corps office, and the Kansas State Historical Society's Archeological Inventory (an on-line resource).

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The background review found that the majority of the Manhattan Levee project area has not been previously surveyed for cultural resource sites. Three archeological sites 14RY380, 382, and 384, are mapped within a previously surveyed area near the existing levee. All three are late nineteenth century sites associated with demolished buildings. The NRHP eligibility status of these sites is not reported in site files. Two other archeological sites, 14PO24 and 14PO25, are recorded 0.6 and 0.8 miles east of the northern half of the project area. Site 14PO24 is a Historic Kansa Indian village site and 14PO24 is an earlier prehistoric village site. Both sites are considered eligible for listing in the NRHP.

In conclusion, any work within or close to the existing levee footprint (an area that has seen heavy prior disturbance) is unlikely to impact any sites listed on or eligible for listing on the NRHP. An archaeological survey of the proposed borrow area will be conducted during project design. Any and all project activities recommended in this study will be coordinated with the State Historic Preservation Officer and affiliated Native American tribes.

F5.0 Hazardous, Toxic and Radioactive Waste (HTRW) Assessment

An HTRW assessment of the study area adjacent to the levees and potential work areas was conducted in accordance with ER 1165-2-132. The assessment included an initial review of database search reports, followed by site visits suitable for feasibility phase determinations.

A Phase I Environmental Site Assessment (ESA) was performed for the Manhattan Levee in February, 2004, and identified five prospective HTRW sites in areas near the existing Manhattan levee unit. Subsequent updates during latter stages of the feasibility study (2013) were performed to determine if any additional HTRW sites may have been added to records, or discovered within the existing project area, that might potentially affect any recommendations for additional flood risk management measures by this study. One additional site was found during this update. All six sites require consideration in the plan formulation process as described later in this report. Details of these findings and conclusions appear in Section 3.3 of the accompanying Environmental Assessment and are summarized in Table 10.

Table 10: Summary of Known HTRW Sites in the Study Area

Name	Description
Manhattan Public Water Supply Wells #14 and #15 – Stations 211+00 and 213+00	Wells have intermittently detected VOC's in the past. Investigation found a plume of TCE extending underneath the levee between Stations 215+00 and 218+00. Remediation underway by private owner.
Manhattan Public Water Supply Wells #12 and #13	Wells located 1000 ft. landward of the levee have intermittently detected VOC's in the past
Private Property near Wildcat Creek	Active leaking underground storage tank.
Private Disposal Area near Station 63+00	Vehicles, trailers, tires, appliances that may potentially cause soil and groundwater contamination.
Railroad Tracks – Stations 89+00 to 120+00	Potential for contamination from creosote in railroad ties and petroleum products from rail cars.
Manhattan Avenue Battery Site	Former dumpsite for battery casings near Wildcat Creek levee. Lead contaminated soil removed in 2005.

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F6.0 Recreation Resources

Recreational use associated with the natural areas along the Big Blue and Kansas Rivers is an important resource in the study area. The Manhattan levee unit has a recreational bike/hike/running trail on the crest of the levee along its length and is known as the "Linear Trail". The Linear Trail is very popular and heavily used. Any construction related disruption of this trail would be weighed by the local community. The City has stated that past local levee projects were able to find publicly-acceptable solutions to trail use disruptions. In addition to the trail, both rivers provide important boating and fishing opportunities.

G. Review of Levee Elevations, Model Elevation Inputs, and Survey Information

During early portions of the existing conditions assessment, the O&M Manual and Record Drawings were reviewed and used for general information. This was followed by numerous field visits to the project site, and discussions and levee examinations with sponsor representatives. In 2006, Kansas City District completed a levee and topographic field survey that included adjacent ground surfaces, top of levee elevation along the entire existing levee unit, and the location of levee appurtenances. A Corps of Engineers National Levee Database (NLD) survey was also conducted for the Manhattan levee in 2007.

For hydraulic modeling purposes, the study used HEC-GeoRAS which requires a Triangulated Irregular Network (TIN), or digital representation of the earth's surface, to acquire elevation data. The TIN was created using a total of four ground sources: Western Air Maps spots and breaks from an aerial photo collection flown in 2001; LIDAR mapping (2006) acquired from Riley County; USGS Seamless 10 meter DEM data, and the Kansas City District field survey (2006). The top of levee elevations for the model came from the NLD survey (2007).

The use of data from multiple sources introduces a potential uncertainty, as each data set has its own set of uncertainties and data collection tolerances. The 2006 LIDAR data was collected as part of a larger effort throughout Kansas and Missouri specifically for the purpose of collecting data for FEMA compliant hydraulic/hydrologic model development and floodplain map modernization. The LIDAR collection effort specified a vertical tolerance of 18.5 cm with 95% confidence. The 2007 NLD survey efforts specified the use of National Standard for Spatial Data Accuracy (NSSDA) Class 1 standards, which equate to horizontal and vertical accuracies of 0.3 feet at 95% confidence for hard surface features, and 0.5 feet at 95% confidence for natural ground features. These standards for uncertainty and data tolerance are in compliance with the guidance of EM 1110-1-1000 "Engineering and Design Photogrammetric Mapping" and ensure that the data collected is the best and most readily available at an acceptable level of detail, and is appropriate for conducting planning studies.

The hydraulic model boundary conditions were established sufficiently downstream of the project, approximately 19 river miles, to reduce sensitivity to downstream conditions or Kansas River backwater effects. A fringe of mature vegetation currently exists along the majority of the Kansas River channel within the modeled reach, with adjacent lands primarily in agricultural

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production. Given the regional and national importance of the high value agriculture industry in central Kansas, which is not likely to diminish in a reasonable time horizon, it is considered unlikely that additional forestation along the river will occur affecting n-values, or that a significant portion of agricultural property will be converted to other more dense uses in the future.

As the study progressed, the feasibility hydraulic modeling results developed around 2008 showed that most flood profiles for the study area were markedly higher than those recorded on FEMA floodplain mapping in use at the time. The FEMA floodplain maps were circa 1990 but the supporting analysis may have actually dated to the original levee design in the 1960's. The updated floodplain modeling conducted in this study showed that Big Blue flood levels for annual chance events between 2% and 0.2% are much higher than was generally understood prior to this study. This was a major finding which was integrated into this study, and led to a coordinated City-Corps-FEMA floodplain remapping effort that will conclude in 2014 with formal publishing of updated FEMA floodplain maps.

The presence of a Big Blue segment "low area" spurred the sponsor to undertake the Section 408 minor modification approval process in coordination with Kansas City District so as to construct a small levee raise. This small raise rectified the low area for purposes of 1% event FEMA levee accreditation which was achieved in 2013. The low area was filled, resurveyed, and recorded in both City and Kansas City District records. Levee elevation adjustments were subsequently made to the feasibility hydraulic models and existing conditions analysis to reflect the completion of this small raise. There are no correlating data or observations to indicate that the Big Blue levee low area was due to post-construction settlement of the levee. The cause can be traced to the new hydraulic profiles and FEMA accreditation requirements which specify a minimum requirement of 3 ft of levee height above the 1% event profile. As the new flood profiles emerged from this study, it became apparent that certain top of levee elevations along the Big Blue segment did not meet the minimum accreditation requirement.

All elevation data is presented in North American Vertical Datum of 1988 (NAVD88) unless noted otherwise. Survey information was obtained from a variety of sources and is discussed in a series of memos contained in Appendix D9 – Summary of Survey Sources. Most of the recent information is in North American Datum of 1983 (NAD 83) (Horizontal) and NAVD 88 (Vertical). Some of the older information such as Corps of Engineers record drawings is in NAD 27 (H) and National Geodetic Vertical Datum of 1929 (NGVD 29) (V). The PDT is aware of the differing survey datums, and adjusts information as required to ensure consistency in the results presented. There is approximately 0.4 foot difference between 29 and 88 vertical datum in this area, though the exact difference varies slightly with location.

H. Conclusions Regarding Existing Levee Integrity

The study assessments provide insight to both the existing levee performance and the economic damages expected under existing conditions for any potential levee failure due to an array of high water events. The results of the feasibility risk and uncertainty analysis, and observations

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of the Manhattan levee performance during the 1993 flood event, form the study basis for identifying risk reduction opportunities.

The study findings for overtopping risk show that the levee does not reliably achieve the authorized design conveyance target. This indicates the need to increase the existing overtopping protection especially in those portions of the levee most at risk of overtopping – primarily the Big Blue River segment of the unit. While the specific flood conditions may to some extent affect the Big Blue River overtopping location, the most likely point of initial overtopping is in the proximity of levee Station 245+00.

Geotechnical risks associated with flood conditions were analyzed for the entire levee unit. Those reaches indicating excessive geotechnical risk under flood conditions (to include underseepage failure and slope stability risks) were identified. These reaches were determined through consideration of several factors including levee height, slope, and soil type, and the computed risks for underseepage pressures and slope stability characteristics. Levee structural features were also analyzed and compared to the current minimum factor of safety (FS) for hydraulic uplift, strength, and stability. Structures that did not meet the minimum required factor of safety were further evaluated to determine probability of failure (PoF) with water at the top of the levee.

After completing this comprehensive set of analyses for geotechnical and structural risks, a listing was developed of those levee reaches and features which exhibit a high probability of failure under flood conditions; this listing appears at Table 11. These high risk elements are termed “areas of concern” within this report. The details of the engineering performance analyses of geotechnical and structural features of the Manhattan levee unit including floodwalls, drainage structures, closure structures, and pump stations, are provided within the appropriate chapters of the Engineering Appendix.

Table 11: Summary of Existing Conditions Areas of Reliability Concern

Location (Levee Stationing)	High Risk Feature	Factor of Safety Not Met for	Consequence of Failure
40+00 to 64+00	Landside Levee Toe	Underseepage	Unit will flood
73+00 to 82+00	Landside Levee Toe	Underseepage	Unit will flood
101+70	Landside Levee Toe	Underseepage	Unit will flood
104+65 to 137+00	Landside Levee Toe	Underseepage	Unit will flood
165+12 to 176+63	Underseepage Berm	Underseepage	Unit will flood
14+78	Gatewell	Structural Strength	Unit will flood
62+20	Gatewell	Structural Strength	Unit will flood
89+83	Gatewell	Structural Strength	Unit will flood
163+00	Gatewell	Structural Strength	Unit will flood
269+50	Gatewell	Structural Strength	Unit will flood

Probability of failure curves (probability of failure vs. water surface elevation) were prepared for the areas of concern and combined in the economic analysis to determine overall probability of failure under various flood conditions. Details of this analysis are presented in the H&H section of the Existing Conditions Engineering Appendix. The concern at Station 101+70 was

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determined to be an Operations and Maintenance responsibility of the local sponsor and is currently being addressed. The risk associated with this area of concern is not included in the future without project analysis.

The existing condition engineering performance of the Manhattan levee is shown in Table 12 and Table 13. The extent of the three levee reaches evaluated was previously described in Table 6.

- The "Conditional Exceedance Probability – Overtopping or Breach" represents the probability of levee unit failure from all failure modes (overtopping, geotechnical, and structural). The existing failure risk for the Manhattan levee unit is significant.
- The "Conditional Exceedance Probability – Overtopping Only" represents that portion of the existing failure probability attributable to overtopping failure. If all geotechnical and structural failure risks were addressed, a significant long-term overtopping risk would still remain for major flood events.

Table 12: Existing Conditions Engineering Performance - Overtopping or Breach

Manhattan Levee	Confluence Reach	Kansas Reach	Big Blue Reach
Conditional Non-Exceedance Probability			
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	28.6%	29.0%	36.8%
50 years	42.9%	43.5%	53.4%
Expected Annual Exceedance Probability	1.1%	1.1%	1.5%

Table 13: Existing Conditions Engineering Performance – Overtopping Only

Manhattan Levee	Confluence Reach	Kansas Reach	Big Blue Reach
Conditional Non-Exceedance Probability			
1%	93.4%	94.0%	88.9%
0.4%	51.1%	51.2%	21.8%
0.2%	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%

III. Future Without Project Condition Scenario

Establishing a consistent basis for the comparison of various potential solutions to flood risk management problems involves the analysis and forecasting of the most likely future without project condition. The future without project condition for this study describes (in narrative format) the prevailing significant water and related land resources conditions and their impacts if no major federal action is taken towards solving the Manhattan flood risk management problems.

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Furthermore, for this study, the future without project condition is the essentially the same as the "no action" alternative described in the National Environmental Policy Act (NEPA). A critical assumption (based on discussions with the sponsor) used in this future conditions projection examination is that: no local projects are planned to solve the major flood risk problems presented within this report, and that absent a federal project, the study area will remain exposed to potential flood damages similar to those associated with the existing condition.

A. Socioeconomic Considerations of the Without Project Condition Scenario

The flood-prone portions of the study area are essentially fully developed. In keeping with current trends, only gradual, minor changes in population, employment, and land use are expected. Large-scale changes to the area through redevelopment or changed property usages are possible, but not confirmed at this time. However, if current trends continue, other portions of the City of Manhattan outside the current study area will see significant growth along with accompanying road and highway improvement projects that may extend into the study area. Based on strong historical evidence, the overall economic activity in the City of Manhattan is expected to increase.

Opportunities for new development within flood-prone study areas are limited by the dense urbanization already existing and the scarcity of available open land. Redevelopment efforts, or other changes from the current land use, may be restricted by floodplain zoning and flood insurance requirements in some cases. Any development riverward of the levee along the Big Blue or Kansas Rivers is precluded by the regulatory floodway.

While the identified trends and assumptions indicate that the existing socioeconomic fabric of the flood-prone area will remain relatively stable with some minor growth, the risk of a damaging flood remains a key consideration. If another catastrophic flood occurs within the developed portions of the study area, economic stability would severely suffer. Many of the facilities that provide critical support to other growing parts of the community, including municipal government offices and utilities, are located within the flood-prone study area. Flood impacts and disruptions to these facilities will be felt throughout the community, well beyond the study area boundaries. It is reasonable to assume that some businesses and residents impacted by such a flood would not return to, or rebuild within, the study area. Large regional businesses currently in the study area may choose to relocate jobs completely outside of Manhattan, causing significant regional economic impacts.

B. Hydrologic and Hydraulic Considerations of the Without Project Condition Scenario

From a hydraulic engineering standpoint, the future without project condition for the study represents the: probable stage-discharge relationship at a selected future time (year 2073) based on the best available current data, the incorporation of any definite projects planned to be completed within the study reach, and any long-term natural river processes that may affect future stages. Although changes in the Big Blue River channel and floodplain have occurred since the original project design, future changes affecting flow capacity are not expected to occur as the current model is calibrated to regulated existing conditions accounting for channel vegetation, actual

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flood performance data, and current bed forms. Current modeling techniques employ more advanced risk and uncertainty based methods allowing a better measure of assurance to pass specific flood event discharges and forecast expected future performance. The future without project conditions analysis includes the following hydraulic characteristics.

- For the purposes of this study, the futures without project hydraulic conditions are expected to be essentially static and consistent with present conditions. Consideration of long-term climate change is presented later in this section.
- No projects are planned for the Kansas River or the Big Blue River that will affect the future conditions water surface elevations in the Manhattan area.
- No stage trends are evident in the Big Blue or Kansas River reaches for the high discharge events under study (flood conditions).
- For the flood conditions under study, the operations of Tuttle Creek Lake and Dam, and the upstream Kansas River basin lakes will remain consistent with current operational guidelines.
- The sponsor will maintain the project riverbanks so as to prevent any additional large stands of tree growth along the Big Blue River and Kansas River adjacent to and across from the current levee. Increased channel roughness caused by any additional mature trees could diminish channel conveyance capacity and raise the water surface profiles adjacent to the Manhattan levee unit. Removal of any such new stands of trees must be incorporated into the sponsor's future levee maintenance procedures. The City of Manhattan and other local stakeholders are engaged in efforts to establish a comprehensive floodplain management plan for the Big Blue River which will aid in maintaining capacity.

C. Other Considerations of the Without Project Condition Scenario

The geotechnical and structural condition of the levee will remain fairly constant over time provided that the City of Manhattan continues to perform adequate operation and maintenance. Based on recent annual inspections of completed works (a joint levee inspection performed by Kansas City District and the City of Manhattan), the City's operation and maintenance support activities are considered adequate for most levee components. The City is committed to performing sufficient maintenance into the period of feasibility analysis. Given the age (over 50 years old) of many of the levee structural features a case can be made that in order maintain the current structural and underseepage feature conditions, the maintenance and repair costs could increase over time. The amount of this potential cost increase cannot be easily quantified for this study and thus a relatively constant pattern and level of O&M costs are assumed.

In the future, the existing project area will continue to exhibit current levels of environmental and aesthetic value coupled with moderate recreational values. The riparian corridor riverward of the levees would continue to be subject to the forces of the rivers and perform in an unmanaged, semi-wild state while being negatively influenced by the proximity of the urbanized area. Any minor remaining undeveloped parcels within the levee unit would likely be developed for commercial and industrial use with the associated loss of low-value habitat.

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D. Period of Analysis and Related Assumptions

Both the future with and without condition scenarios are evaluated over a 50 year period of analysis to allow a consistent and appropriate comparison of alternatives. The period of analysis is the time horizon for which project benefits and project operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) costs are evaluated. The period of analysis begins with the base year condition using resources in the study area along with economic and engineering factors thought to exist in the first year a project alternative is expected to become operational. The existing conditions economic analysis was completed in 2012. The base year used for the purposes of 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 interval. 50 years is also the maximum period of analysis allowed per regulation. The future condition was defined as 2073. It is fair to assume that for this economic analysis area, no significant increase in economic development is expected during the 50 year period of analysis as most of the flood prone area is essentially built-out.

These timeline assumptions provide the temporal framework for the future without project scenario. The potential annual flood damage for each year in the period of analysis is then computed, discounted back to present value and annualized to determine the equivalent annual damage for any year during the analysis period.

E. Climate Change

USACE published guidance for incorporating climate change impacts to inland hydrology in civil works studies, designs, and projects in Engineering and Construction Bulletin (ECB) No. 2014-10 on 02 May 2014. The guidance is similar to the preliminary guidance that was reviewed and applied during this feasibility study.

The climate of northeast Kansas near Manhattan, Kansas, trends toward a continental weather pattern of cold winters and hot, humid summers. Topeka typically represents the northeast portion of Kansas for climate surveys. The average temperature in 2013 at Topeka was 60 degrees. The average high temperature was 73 and average low temperature was 47. The average yearly precipitation was about 37 inches of moisture.

A model of future conditions for the central plains of the United States was created by the NOAA National Environmental Satellite, Data and Information Service (NESDIS) and a related report issued in January 2013. This report provides an assessment of climate trends and scenarios into the next 50 to 100 years. The report states that over the period of record for the region of northeast Kansas, both temperature and precipitation has trended above normal, especially over the last 50 years. To account for climate change in the meteorological conditions of northeast Kansas, the future forecast for conditions in the region takes into consideration the past temperature and precipitation records, and then considers future modeled conditions in the area through 2070. According to this report, a warming trend of about 3-5 degrees F and a

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precipitation trend slightly toward wetter conditions can be expected through the next 50 years, but significant uncertainty is associated with these estimates.

To evaluate the hydraulic effects of increased temperatures in 50 years, a sensitivity analysis was conducted using a worst-case scenario developed using published climate change projections. This analysis is described in more detail in the Engineering Appendix Volume, Chapter 2. The analysis found that for the plan recommended by this report the flood profile rose by an average of 1.0 feet and a maximum of 1.8ft. This is only one possible future scenario.

Trend analysis was conducted as part of this feasibility study on observed annual peak flow data on the Kansas River to help determine whether evidence exists that supports future wetter conditions. Since the period of record is small at the Kansas River gage at Manhattan (USGS 06879820), the Wamego river gage, which is approximately 19 river miles downstream of Manhattan, was used for this analysis. The stage trends on the Kansas River at Wamego, Kansas are shown in the Engineering Appendix Vol. 2, Chapter 2. For river flows less than 73,000 cfs, there is a general decrease in river stages over the available period of record. There is insufficient evidence of a stage trend at higher discharges, adding significant hydraulic uncertainty when predicting the future rating curve for the gage in Wamego, Kansas. Based on available information, evaluation of trends in climate, stage trends, and expected floodplain management, the existing conditions model was assumed to be adequately representative of the future without project conditions.

The feasibility study also undertook a local level analysis for first order detection of any changes in Big Blue River floods occurring over the period of record. From 22 July 1959 through 21 January 2010, daily observations of discharge for inflow into Tuttle Creek Lake were analyzed. Details of that analysis appear in the Engineering Appendix Vol. 2, Chapter 2. This analysis showed a relatively small but statistically significant trend towards smaller annual maximum daily discharges as well as smaller annual maximum three-day average discharges. The downward stage trends are counter to projections of wetter precipitation from the NOAA modeling reports. No significant trends are present in the less frequent flow frequencies that could affect levee height design for the Manhattan Levee.

It is also beneficial to consider the general with-project condition for any trend towards increased flood magnitudes. Hypothetically, larger future floods will increase the benefits of any proposed project. However, the increases in flood magnitudes would also adversely affect project performance in terms of Non-exceedance Probability thus increasing the potential flood damages (larger deeper flood coverage and more frequently flooded areas). Any trend towards decreases in flood magnitudes would have the opposite effects: decrease potential project benefits, and essentially improve the project performance relative to frequency of overtopping and thus reduce potential flood damages over time.

In conclusion, the NESDIS and other literature proffer slightly wetter future conditions in NE Kansas which could lead to higher river stages. However, this feasibility analysis of Kansas River trends and Tuttle Creek Lake inflow records show a slight trend towards smaller annual maximum daily discharges as well as smaller annual maximum three-day average discharges.

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The results of the NESDIS study that suggest an increasing trend in future precipitation are not supported by the finding of decreasing historical discharge trends within this study. As time progresses and additional flood events occur, the current hydrological studies may need future updates. For now, given the uncertain nature of present Tuttle Creek Lake inflow trends and the long-term forecast precipitation scenario, the study has addressed the uncertainties surrounding quantification of local area climate change through the use of appropriate bands of uncertainty in the existing condition hydrological analysis.

F. Future Without Project Condition Scenario Conclusions

In the future, absent a federal project, the study area will remain exposed to potential flooding and flood damages essentially similar to those associated with the existing condition. The potential amount of future flood damages may increase as some limited development continues to occur within the protected area. Significantly, the land available for development within the City is constrained by institutional boundaries (U.S. Army Fort Riley and Kansas State University) and physical barriers (the Kansas River and the Big Blue River). Population growth and development within and around the general study area continues to result in pressure for development of any available tracts of open land. Increasing land demand around Manhattan that leads to extensive re-development and higher property values within the protected area could make the future flood damage projections in this report conservative.

The conditions, trends, assumptions, and conclusions discussed above establish a future scenario in which the without project conditions and various alternative with-project conditions can be analyzed and compared. The specific details and results of these analyses are discussed in later sections of the report.

IV. Plan Formulation

A. Introduction

Early problem definition efforts required that the study establish the existing performance condition and future without project condition scenario for the levee unit and the surrounding study area. The primary means of quantification of the baseline conditions for the levee was through the development of risk and reliability metrics (for flood condition performance) by using risk and un**c**ertainty (R&U) principles and the Corps of Engineers HEC-FDA program. This was accomplished through the analysis of the numerous elements and features of the levee unit resulting in the quantification of performance weakness at specific locations (areas of concern). Much of the analysis used data and observations from the Flood of 1993. This updated engineering analysis, along with the environmental, HTRW, and economic existing conditions analysis, establishes a complete R&U approach to estimating existing conditions flood damages.

The existing conditions evaluations during the early portion of this study allowed subsequent formulation efforts to focus on known problems, opportunities and potential flood risk management improvements (measures). Screening evaluations ensured the final candidate

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measures would offer sound economic return on investment. The various measures and combinations of measures were assembled into alternative plans that were reviewed for compatibility with the basic planning objectives and constraints for this study and other critical evaluation criteria. The final array of potential flood risk management plans were developed, evaluated and refined consistent with Corps of Engineers practice, and the levee design and performance experiences acquired within the Kansas City District.

B. Six Step Planning Process

The Corps of Engineers uses a six step planning process to guide project studies, as detailed in ER 1105-2-100 "Planning Guidance Notebook". This process is a structured approach to problem solving which provides a rational framework for sound decision making. The six steps are:

1. Identifying problems and opportunities
2. Inventorying and forecasting conditions
3. Formulating alternative plans
4. Evaluating alternative plans
5. Comparing alternative plans
6. Selecting a plan

The six step planning process was used in this study. Feasibility efforts in Planning Steps 1 and 2 are discussed in the earlier Sections II and III of this report (Existing Conditions and Future Without Project Conditions) and are integrated with the Plan Formulation process as described immediately below. Details of Planning Steps 3, 4, and 5 appear in this section (Section IV) and Planning Step 6 appears in later in Section V. The six step planning process is iterative. A normal by-product of the planning process and information generation is iteration among the various planning steps. As more information and insight developed, it was necessary at times to review and update and refine certain previous steps – all of which leads to a better recommendation.

C. Step 1 - Indentifying Problems and Opportunities

Step 1 of the Planning Process essentially began with the start of the study. Step 1 seeks to identify the problems and opportunities for the study area, and establish planning objectives and constraints that will guide efforts to solve the problems and achieve the desired opportunities.

Observations from the 1993 Flood showed that the existing levee withstood the 1993 Flood (60,000 cfs on Big Blue River and peak flows of 100,000 cfs on the Kansas River), but the 60,000 cfs release from Tuttle Creek Dam created a near overtopping situation at some Big Blue River locations along the levee. The 1993 event raised concerns that the levee may actually provide much less than the design level of performance. The Big Blue River tieback elevation was (originally) designed for 110,000 cfs release from Tuttle Creek Lake plus 2 feet of freeboard, concurrent with 210,000 CFS on the Kansas River. Accordingly, the study undertook

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reviews of the existing conditions and identified the following specific problems for the study area:

- The existing levee unit provides less than the level of performance for which it was authorized. As noted in Table 13, the Big Blue River reach of the unit has a 0.6% annual chance of overtopping, which equates to a flow of approximately 100,000cfs.
- Project failure due to overtopping, underseepage, or structural inadequacy presents a significant life safety concern. Levee failure would cause massive property damage to urban development in the protected area.
- The existing Manhattan levee unit includes components over 50 years of age. While the unit has been adequately maintained, the state of the art of design, construction, and reliability analysis has changed significantly since the original construction. The concerns over reliability of the levee features will grow as the levee ages.
- The flood risk for unprotected areas within the updated Big Blue River floodplain below the Tuttle Creek Dam is higher than generally thought prior to this study.

Following problem definition, the major opportunities were identified for the study area:

- Assess the updated flood risks within the Manhattan study area.
- Identify and present feasibility recommendations for implementation of viable flood risk management measures in the study area.
- Assist the City of Manhattan with development of their local comprehensive flood risk management plan that includes the protected area and other flood-prone areas within the City.

C1.0 Planning Goal and Objectives

The overall Planning Goal for the study is to assist the people of the Manhattan, Kansas area with improved management of flood risks originating from the Big Blue and Kansas Rivers as an integral part of the City's overall long-term planning.

Planning objectives are specific statements that describe the desired measurable results of the planning process by solving the identified problems and exercising the opportunities. The planning objectives will be used in the formulation and evaluation of alternative plans. Three study objectives were developed as follows:

- Apply modern understanding of flood risk and uncertainty, updated river modeling techniques, and a longer period of record so as to adequately evaluate the current reliability and performance of the existing Manhattan, Kansas, levee unit,
- Provide planning support and assist the City of Manhattan in effectively managing flood risk along the nearby reaches of the Big Blue and Kansas Rivers to include formulation of associated flood risk management plans,
- Formulate an array of project plans for increasing the existing Manhattan levee unit safety, reliability and performance particularly along the Big Blue River segment through

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an appropriate combination of engineered measures... *and if such plans are deemed feasible and in the federal interest, then evaluate & select an appropriate plan.*

C2.0 Planning Criteria

This study examines and addresses the federal criteria of completeness, efficiency, effectiveness, and acceptability. To adequately address these criteria, the development and early screening of potential alternatives considered of a number of evaluation factors. Primary among those factors are the following:

- Engineering and flood risk management adequacy (effectiveness)
- Ability to contribute to meeting the planning objectives (completeness of the solution)
- Consistency with planning constraints and authorities (no violations of constraints)
- Acceptability (includes sponsor, environmental, cultural and public aspects)
- Induced Damages from alternative implementation
- Early cost indicators (early efficiency indicators for screening purposes)
- Construction site constraints and real estate requirements (topography, location conflicts, adjacent development, etc.)

Engineering and Flood Risk Management Adequacy: The engineering adequacy of alternatives was analyzed and reviewed. All alternatives and their constituent measures were evaluated and developed so as to meet minimum technical criteria for the expected flood conditions. This is a key effectiveness criterion and normally must be met. The amount of engineering analysis necessary to develop these alternatives was considerable and is contained in the Engineering Appendix Volume 2 (Alternatives Engineering).

Environmental Acceptability: Environmental acceptability of alternatives was reviewed in concert with appropriate resource agency guidance.

Cultural Acceptability: Cultural acceptability did not play a large role in alternatives formulation due to the prior ground disturbance from the existing levee construction. Cultural acceptability did play a significant role in the evaluation of potential borrow sites.

Early Cost Indicators (efficiency): Early approximate cost indicators related to the various alternatives were used to determine if an alternative was prudent for further examination. As the evaluation process continued, cost estimates and economics were refined. The later detailed cost estimating and economic analysis normally focused only on those alternatives that remained viable solutions after early screening criteria were passed.

Induced Damages: This evaluation factor addresses the possibility of induced impacts (increased water surface profiles from the implementation of an alternative) in areas outside the immediate project area especially during extreme flood events.

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The early planning criteria were narrowed and more focused as the study moved further into the evaluation of the final array of alternatives. The evaluation of the final alternatives array is addressed later in the report.

C3.0 Planning Constraints

Constraints are restrictions that limit both the planning process and potential solutions. Plans should be formulated to meet the objectives and avoid violating the constraints. All civil works planning studies are subject to general constraints including resource availability and legal and policy constraints. Constraints specific to this Manhattan study and which affect the formulation, evaluation, and selection process decisions are listed below.

- Flooding Source and River Confluence Effects Constraint: Manhattan levee performance is affected by the confluence of two major rivers and operational releases from Tuttle Creek Dam must be considered. Both the Kansas River and the Big Blue River flows and coincident flooding effects play vital roles. The Big Blue River segment cannot be considered in isolation from the Kansas River.
- Environmental Acceptability Constraint: Any formulation of a structural project must minimize the disturbance of habitat areas near the Manhattan levee especially along the adjacent riparian corridor.
- Compatibility Constraint: To the extent practical, the formulated project should be compatible and avoid conflicts with the surrounding city development, infrastructure, and city master plan.
- Floodway Conveyance Constraint: Early in the plan formulation process, a general site constraint was adopted: any measures which negatively impact the established floodway conveyance capacity should be avoided if possible. This was deemed especially important along the Big Blue River as the conveyance area is already restricted at some critical points near bridge crossings. This principle is consistent with floodway “no rise” criteria as promulgated under FEMA regulations.

D. Step 2 – Inventory and Forecast Conditions

This planning step is addressed in feasibility report Section II and Section III. Reference is made to the extensive discussion and conclusions drawn in those sections. The Future Without Project Condition forms the basis for formulating, comparing and evaluating alternatives.

E. Step 3, 4, 5 – Formulating, Comparing and Evaluating Alternative Plans

Alternative plans are formulated to achieve planning objectives within the constraints. In this study, alternative plans consist of a combination of structural and/or nonstructural measures, strategies, or actions that meet, fully or partially, various planning objectives.

The initial plan formulation exercises involved the generation of preliminary concepts and examination of specific measures for flood risk management from both a structural and non-structural approach.

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At times additional measures and alternatives surfaced leading to the formulation of new plans or plan reformulation. As the alternatives passed through subsequent evaluation and screening processes, the economic analysis of each alternative was used as a critical ranking factor in the final selection process. Having passed review for engineering adequacy, environmental and public acceptability, and the other alternatives evaluation criteria as described herein, the remaining alternative with the highest net benefits to the national economy was identified as the National Economic Development Plan (NED Plan).

E1.0 No Federal Action

Evaluation of the No Federal Action plan is closely related to the future without project condition scenario and involves the likely course of action that local entities may take given the lack of federal involvement. The implementation of flood risk management measures involving substantial levee performance improvements is unlikely without direct federal involvement given the substantial financial resources required.

The No Federal Action plan cannot and does not successfully address the planning objectives. The No Federal Action alternative does not alleviate risks to public health and safety and flood-prone properties. While some local emergency preparedness plans can be updated and general awareness of the flooding risks can be increased, this is an inadequate measure when taken alone. The No Federal Action plan will result in a significant long-term flooding risk for the City of Manhattan.

The economic implications of the No Federal Action alternative are broadly negative. The investment at risk within the unit is so large that No Federal Action will subject the study area to the possibility of an overall long-term adverse impact on the local economy, and dislocations of commercial and industrial development could result. In the short term, assuming an absence of flooding, the current trends in-place for the local economy, tax base, population, and employment are expected to remain intact. However, if major flooding occurred and the levee unit failed, the long term effects are likely to include: diminished economic stability, business interruptions that could jeopardize workers jobs and wages, potential losses in population and employment, reductions in the tax base (given net movement out the protected areas), and generally diminished property values.

The No Federal Action alternative results in no changes to the existing environment in and around the levee unit unless catastrophic levee failure occurs. A failure of the Manhattan levee could result in direct and indirect impacts through inundation of the habitat of terrestrial populations; and release of flooded area contaminants to the adjacent river systems or flood plain environments. Direct impacts during flood events would be the displacement of mobile organisms and the loss of organisms unable to escape inundated areas behind the failed levee. Manhattan levee failure and inundation of stored chemicals would likely release a variety of chemicals within the protected communities and allow introduction of these contaminants into the Big Blue and Kansas Rivers impacting water quality and contaminant loading of the rivers during these events. Potential impacts are possible to aquatic populations (fish and benthic

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communities) from the degradation of water quality and contaminant loading that would result from chemical release during flood events. Subsidence of flood waters could also result in the introduction or redistribution of chemical contaminants across the foreshore floodplain and impact terrestrial communities (plants and animals) utilizing the foreshore habitat. Impacts from the No Federal Action alternative could range from no significant impact under non-flood events, to minor to significant impact depending on location of levee failure and the resulting duration and area of inundation.

E2.0 Flood Risk Management Measures

E2a. Traditional Non-Structural Measures

Non-structural measures were examined during feasibility. Nonstructural approaches have merit when the site characteristics and the flooding threat are compatible with the nonstructural capabilities. The intent of non-structural measures is not to prevent the flooding from occurring, but to reduce the damages and consequences caused by the flooding. Some non-structural measures have limited application to the Manhattan levee protected area due to the large, broad, flat floodplain involved. Note that the City does have an extensive emergency/flood warning system (towers with enunciators, and phone/message notification capability) that will be used in concert with established emergency response measures for advance warning in flood situations.

E2a1. Flood-fighting (Non-structural measure). This measure attempts to reduce flood damages and address all objectives through temporary means implemented during a flood event. Plans for flood fighting procedures are in-place at Manhattan and were used in the Flood of 1993. This measure is of limited reliability and best thought of as a last-line of flood defense. Due to the temporary nature of this measure it offers no complete or effective long-term solutions for major flood risk management problems. Reliance on flood fighting is not efficient due to high cost and manpower needs and is only acceptable on an emergency basis. While flood fighting is in important tool for emergency response planning it is not carried forward as a measure for further consideration in this study.

E2a2. Relocation (Non-Structural Measure). The permanent relocation or evacuation of existing developments subject to flood damages involves the acquisition of land and structures in the flood plain. Following this action, commercial and industrial developments and residential properties in the flood plain are either dismantled or moved to a site away from the flood-prone area. Lands acquired in this manner could be used for other purposes consistent with wise floodplain management. Permanent floodplain evacuation and relocation could offer a complete solution to reducing flood damages and consequences, but does not reduce the potential frequency of flood events. The effectiveness and efficiency of relocations in a large and densely developed high-value area, such as within the existing Manhattan levee, are limited by the large number of structures, the high cost of land acquisition, and the limited areas available for resulting relocation sites. This measure may require relocation well outside the current city limits, which is not desirable, practical, or publicly acceptable. While relocation of some critical facilities may be identified and pursued by local interests, structure relocation is not carried forward for further consideration in this study

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E2a3. Tree clearing (Non-Structural Measure). Tree clearing measures address floodway conveyance and levee overtopping. If vegetative obstructions are cleared in critical flow areas so as to allow a greater discharge capacity, the water surface profile of the design flood event may potentially be lowered. While this could improve overtopping risks, it does not offer a complete solution for other reliability concerns. In the case of Manhattan, some tree growth has occurred since the completion of the original project in the 1960's. An extensive wide-scale clearing operation at the critical points in the floodway might increase flood conveyance. However, any wide-scale clearing would have several negative aspects:

1) Long-term effectiveness and efficiency of any capacity improvements will be difficult to maintain and would require regular and potentially costly vegetation control efforts.
2) Environmental acceptability of tree clearing is considered very low to unacceptable. Disruption of established mature tree growth inevitably degrades habitat and wildlife populations in the areas cleared. Adverse comment from other agencies is likely.
3) Most of the critical tree growth is outside of the sponsor's levee easements and levee property right of way. The probability of accomplishing the extensive real estate actions necessary to clear major parcels of private lands is considered uncertain (or even unlikely) given the generally negative public perceptions of wide-scale "clearing" operations.
4) Mature trees often serve a useful purpose in holding channel alignment and river banks in-place. Trees on the river foreshore normally reduce erosive forces on bank-lines and levee toes. Tree clearing could create the opportunity for unpredictable erosive forces forming during flood situations -- leading to increased risk of levee embankment failure.

Tree clearing as a viable measure is not carried forward for further consideration in this study.

E2a4. Flood proofing of individual buildings in flood-prone areas (Non-structural measure). Flood proofing is any combination of changes and adjustments incorporated in the design, construction, and alteration of individual buildings, structures, properties, and contents primarily for the purpose of eliminating or reducing flood water entry and thus reducing flood damages. Although it is more simply and economically applied to new construction, flood proofing is also applicable to existing facilities. Typical flood proofing methods include: (1) raising the elevation of existing and new structures; (2) the provision of individual dikes around existing structures; (3) the provision of temporary and permanent closures for openings in existing structures; (4) the rearranging or protection of damageable property within an existing structure; (5) the protection of roads and utilities; and (6) the anchoring of floatable structures and facilities.

This series of non-structural measures offer reductions in flood damages but do not address flood frequency or any of the identified performance weaknesses of the levee unit, such as overtopping, structural, and geotechnical reliability. While individual structures can be protected from damage these measures cannot be considered a complete solution for critical transportation and utility infrastructure. Flood-proofing does not provide the comprehensive degree of protection sought by the project sponsor. Furthermore, the effectiveness and efficiency of these

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measures are limited by their own capability to withstand severe inundation. Additional discussion of flood-proofing methods is provided below.

Structure elevation may provide some protection from moderate floodwaters, but would be inefficient at preventing significant flood damages such as those associated with catastrophic levee failure. The cost of elevating existing buildings is higher than the cost associated with implementing higher building standards for new construction. The estimated cost to elevate an existing home (FEMA 2009), in 2009 dollars, ranges from $30 to $100 per square foot, depending on the type of home and the amount of raise, up to eight feet. The study area has a total of 2,295 structures including 1,703 residential structures and 592 non-residential structures. Assuming an average home size of 1000 square feet results in a preliminary cost range of $51M to over $170M for residential structures only. The cost to elevate commercial or industrial buildings, if feasible, would likely be substantially higher. Thus, the cost for individual structure elevation within the flood-prone area is expected to be very high.

Structure Flood Proofing. Wet flood proofing allows water to enter the structure but focuses on reducing the damages caused, while dry flood proofing aims at keeping floodwaters outside the structure. The costs associated with flood proofing methods for existing buildings (other than elevation of the buildings) exceed the cost associated with implementing tighter building standards for new construction. The feasibility of flood proofing existing buildings varies based on site and structure constraints. The estimated cost for wet flood proofing an existing home (FEMA 2009) in 2009 dollars, can range from $2 to $17 per square foot depending on the type of structure and the height of flood proofing effort, up to eight feet. Assuming an average home size of 1000 sq ft. will result in a preliminary estimate of $3.4M to $29.0M for residential structures only. Dry flood proofing costs for commercial structures can vary widely depending on structure type, and is generally considered to only be effective up to three feet. The expected flood depths in much of the protected area would be well in excess of three feet. Due to the substantial number of businesses within the levee unit and the lack of protection afforded to other critical infrastructure items (such as roads, vital utilities, signal cables, and traffic control units, etc.), the widespread use of flood proofing as a primary protective measure is not considered efficient or effective.

Flood-proofing measures were not carried forward for additional consideration in this study.

E2b. Other Site-Specific Non-Structural Measures

E2b1. Upstream Reservoir Operational Release Changes (Non-Structural Measure)
Since construction of Tuttle Creek Dam and lake in 1962, several potentially damaging floods have been prevented by the dam. In the 1993 Flood, the peak inflow to Tuttle Creek was 95,400 cfs on July 6 and the peak release was 60,000 cfs on July 25.

This feasibility study undertook evaluation of potential Tuttle Creek Dam operational changes given the interest shown by the sponsor and others in the possibility of modifying the regimen of discharges during major flood events. Given the proximity of the dam to Manhattan, this measure seemed to offer some potential for risk reduction along the Big Blue River levee

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segment. Extensive coordination with the Kansas City District Water Management Section and the Tuttle Creek Dam Project Office was involved in this feasibility screening evaluation. Two options were evaluated: 1) storage reallocations to increase flood control storage, and 2) modifying phased release schedules for flood control operations. In these evaluations, two important facts concerning Tuttle Creek dam discharge characteristics play a key role: the maximum emergency spillway discharge is 579,000 cfs and the maximum outlet works discharge at full pool (top of surcharge) is 45,900 cfs.

Multi-Purpose and Flood Control Pool Reallocation
This evaluation was focused on determining the effects of reallocating all multi-purpose pool storage for the sole purpose of flood control. It was premised that Tuttle Creek Lake would essentially act as a dry detention facility during normal and drier-than-normal conditions. The evaluation showed that:

- After reserving space for sediment through the design life of the reservoir, this single purpose approach would add 0.122 million acre-feet (MAF) to the existing 1.88 MAF of flood control storage allocation and 1.37 MAF of surcharge storage, resulting in an additional 6.5% storage at top of flood control pool and 3.8% additional storage at the top of surcharge zone.
- If the 1993 flood were to reoccur with all of the multipurpose pool allocation converted to flood control, the additional storage volume represents less than 2 days of releases at 35,000 cfs.
- During the 1993 event, releases in excess of 35,000 cfs were exceeded for 14 days and approximately 500,000 acre-feet of additional storage would have been needed to prevent such releases from going above 35,000 cfs. This 500,000 acre-feet of additional storage is about four times the available storage in the existing multi-purpose pool allocation.
- The resulting effects of this single purpose flood control allocation would be at the expense of water supply during drought for downstream Kansas River urban areas such as Topeka, Lawrence, and the Kansas City area. This approach would also be at the expense of water quality on the Kansas River during drought. Furthermore this would eliminate essentially all water-based recreation and fishery benefits on the lake, and eliminate a substantial portion of the supplemental flow source for navigation support on the Missouri River.

Phased Release Schedule Modification
This screening evaluation looked at reducing the frequency at which Tuttle Creek Lake enters surcharge operations. Higher releases at lower pool elevations would be required in an effort to lower the pool faster during flood control operations.

Currently, the Tuttle Creek Lake Regulation Manual designates three levels of regulated discharges known as Phase I, Phase II, and Phase III, each increasing in magnitude of discharge. All of these Phases have downstream flow targets. The Phase II level is generally limited to zero downstream damage and an attempt is made to set the maximum Phase II discharge commensurate with the “flood stage” as determined by the National Weather Service (NWS). Phase I is limited to 80% (maximum) of the discharge for Phase II in the first reach below the

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dam and 60% of Phase II in all remaining reaches downstream. At the Phase III level, the attempt is made to set the maximum Phase III discharge commensurate with the "moderate flood stage", also determined by the NWS. At moderate flood stage, damage will be experienced in those areas where banks are below average in height and agricultural encroachment onto adjacent low bottom lands has been affected.

Given a major immanent flooding event, and if Phase 1 releases were to be eliminated thus moving to the higher Phase II release levels sooner, it can be easily foreseen where high river conditions might develop downstream in the Kansas and Missouri Rivers, with portions of the downstream public calling for reduced Tuttle Creek releases in an effort to prevent exacerbating existing downstream flood damage. If Phase 1 releases were eliminated, more frequent flooding effects would probably be observed far downstream on the Missouri River – possibly all the way to Waverly, Missouri. More frequent (even annual) flooding might develop as the Phase 1 flow target at Waverly is 90,000 cfs, which is now exceeded about 14% of the time (post 1967 daily gage data at USGS gage at Waverly). The Phase 2 flow target of 130,000 cfs has been exceeded about 5% of the time since 1967. The frequency of exceeding these flow targets is expected to increase if Phase II releases are triggered sooner.

The evaluation showed that modifying the phase release schedule will result in more frequent inundation for portions of the far downstream floodplain given that flow targets are more frequently exceeded. Moreover, no assurances can be made that changing the regulated operational regime will beneficially reduce the larger lake surcharge releases. Implementing such a change would appear to be a risk reduction step, but the major flood events under study could not be effectively and predictably managed in this manner.

Tuttle Creek Lake Operations -- Analysis Conclusions
Significant changes in Tuttle Creek operations and releases will require reducing the benefits derived from the other authorized purposes associated with Tuttle Creek Lake. Furthermore, the evaluations show that the maximum potential changes to storage allocations in Tuttle Creek Lake are not expected to significantly improve downstream flood protection. If phased releases were adjusted for a more aggressive release schedule earlier in a flooding event, it is likely that this would intentionally increase minor and moderate flooding without providing adequate assurance that Tuttle Creek surcharge releases could be avoided. These measures lack the effectiveness and efficiency to provide a complete solution and result in unacceptable impacts in other area. Tuttle Creek operational changes were screened out from further consideration..

Operations at Other Upstream Reservoirs
Upstream regulation modifications analyzed at Tuttle Creek Lake on the Big Blue River provided only marginal improvements at the Manhattan Levee. Additional measures at reservoirs located farther upstream on the Kansas River are not expected to provide substantial added benefits at Manhattan any more than those evaluated from Tuttle Creek Lake. The Kansas River portion of the existing levee does not show a height deficiency at existing condition indicating the need for any action in that basin. Furthermore, effects of changes at these other lakes are expected to be attenuated due to the increased distance and amount of unregulated basin between those lakes and Manhattan.

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E2b2. Silver Jackets Program Participation - A Collection of Floodplain Planning Initiatives (Non-Structural Measure)

This feasibility study has worked closely with the inter-agency Silver Jackets Program to ensure that unprotected areas along the Big Blue River and other smaller tributaries are further addressed through long-term local planning initiatives, and potential future nonstructural measures. A Corps of Engineers Silver Jackets Pilot Project is currently underway along the lower Big Blue River near the City of Manhattan. This pilot project includes the State of Kansas, the City of Manhattan, and other local and Federal stakeholders participating in a coordinated effort to accomplish the following:

- Future condition flood inundation mapping in the unprotected areas
- Hydraulic modeling work in concert with flood inundation mapping
- Floodplain management planning in protected and unprotected areas
- Extensive stakeholder and public involvement activities
- Assessment of unprotected residential areas for potentially effective nonstructural flood risk management measures.

The nonstructural Silver Jackets program approach to Big Blue River floodplain areas outside of the levee-protected area is considered a viable non-structural component of an overall flood risk management planning effort by the City of Manhattan. This current effort is expected to be complete in the Fall of 2015. While not a specific measure for evaluation in this feasibility study, recognition of the on-going Silver Jackets efforts will be included throughout the plan formulation process and identification of recommendations.

E2c. Non-Structural Measures – Summary and Conclusions

In the case of the Manhattan Local Protection Project, a relatively sound existing structural flood risk management system continues to provide benefits to the study area. The nature of damages caused by an existing levee failure, and the need and desire for large-scale future risk reduction within the study area, especially from overtopping, far exceeds the normal performance parameters of most nonstructural measures. The value of the dense urban development in the study area precludes consideration of large scale relocation, elevation, or flood-proofing of structures. For these reasons, it was concluded that without structural modification of the existing levee unit, traditional nonstructural measures alone would not provide the desired performance improvements and they were not carried forward for further analysis.

The study also examined “site-specific” nonstructural measures including modification of current Tuttle Creek Lake operations and the continued participation of Manhattan in the Silver Jackets Program. Modifications to Tuttle Creek operations did not prove a reliable means of flood risk reduction. The Silver Jackets Program floodplain planning efforts are considered a viable non-structural component of an overall flood risk management planning effort for the City of Manhattan and are encouraged.

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Consequently, the study concluded that structural modification of the existing levee offers the most feasible means of achieving the necessary broad and robust flood risk management improvements desired. It is recognized that there may be possibilities to find some limited uses for nonstructural measures in coordination with structural alternatives, especially along the fringe of the protected area and for the prevention of damages due to localized interior flooding. These potential limited applications are best identified and pursued independently by the project sponsor.

E2d. Structural Measures

E2d1. Bridge Modification, Retrofit or Replacement (Structural Measure)
Older bridges often exhibit a tendency to partially block the passage of floodwaters through the bridge due to insufficiently sized openings. During high flow events, narrow bridge openings and portions of the bridge structure can trap debris, directly causing higher flow elevations upstream of the bridge. Bridge modification or replacement is effective at reducing backwater flows and debris jams and can be cost-efficient depending on the scope of necessary changes. The acceptability of bridge modifications would require design coordination with the bridge owner to maintain its intended function and purpose. These measures are suitable for additional consideration in this study given the critical location of U.S. Highway 24 and the Union Pacific RR bridges over the Big Blue River just upstream of the Kansas River confluence.

E2d2. Channel Widening Modifications (Structural Measure)
Generally speaking, reduced flood stages can often be achieved by the widening, deepening, and straightening of the stream channel. These methods provide for a more uniform channel cross section that improves hydraulic efficiency and thus allows the channel to carry a larger flow. Channel modification was evaluated as a component measure. However, the potential extent of channel modifications in the Manhattan levee study area was constrained given the need to balance protection of the existing aquatic and terrestrial habitat along the riparian corridor with the disruptive nature of most channel modifications. Channel modification was modeled for the Big Blue River through the study area and the results indicated a small gain in conveyance capacity. However, the conveyances gains are very limited (not fully effective and complete) and do not fully serve to establish a desired level conveyance when compared to other structural measures.

Furthermore, it is expected that channel modification would have a limited life less than the 50-year period of analysis. The natural process of meandering and foreshore building could require repeated dredging or excavation cycles and wide-scale vegetation clearing so as to maintain the expanded floodway. The overall prospect of massive environmental disruption, extensive maintenance dredging adjacent to the existing levees, the potential creation of new underseepage paths, and the general risk associated with effective timing of dredge cycles make the channel-modification measure undesirable when viewed in isolation. However, some limited application of channel widening remains viable for study in conjunction with other measures. A limited application of channel widening in conjunction with other measures can be formulated such that the resulting environmental disruption is at least within the realm of mitigation actions, and the

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periodic channel dredging requirement becomes less critical when used in conjunction with other non-maintenance-intensive measures.

E2d3. Levee and Floodwall Raises (Structural Measure)

Levee and floodwall raises are normally an economical means of reducing levee overtopping risks when an existing levee or floodwall is in relatively good condition. The existing real estate assets within the project boundary are typically owned or held in easement thus reducing the need for expensive and time-consuming real estate acquisition. A further advantage of the existing Manhattan levee is the absence of major floodwalls; thus, these high-cost structures are not involved in a potential levee raise.

Raises of earthen levees typically maintain the existing side-slope profile, resulting in a widening of the levee footprint, often to one side or the other (landside or riverside), or possibly in both directions. In the case of Manhattan, most of the levee raise must take place on the landside slope to comply with the previously mentioned Floodway Conveyance Constraint.

E2d4. Geotechnical and Structural Feature Strengthening (Structural Measure)

The existing conditions analysis was used during formulation to develop measures for alleviation of existing levee vulnerabilities /weaknesses. Potential solutions to specific weaknesses were analyzed using the new hydraulics modeling and hydraulic loading for the various flood events under study. Levee reliability improvements were evaluated for levee sections both within and outside the potential raised segments. This total unit review was necessary to provide an entire levee unit that meets the Corps' current design criteria and factors of safety -- applicable for improvements to the levee cross section and foundation, strengthened structural elements, and more robust underseepage control.

Furthermore, when raising the levee, careful consideration must be given to evaluating and building a series of additional interdependent geotechnical and structural strengthening measures to support overall reliability under the prospective raised conditions. The results of the overall formulation process included the feasibility design of these additional engineered measures for the various levee raises under evaluation.

Engineered measures were developed consistent with the latest Corps design and levee safety guidance resulting in:

- improved structural feature strength and stability,
- improved levee underseepage control,
- reliability improvements that support levee raises for reduction in overtopping risk.

Underseepage control is most economically achieved through the typical use of area fill, impervious berms, buried collectors, or relief wells. Appropriate underseepage control measures were considered during plan formulation when it was determined that the natural impervious soils (termed "blanket") underlying the Manhattan levee are too thin for the design conditions under formulation. Without sufficient underseepage control, the excess upward head created during a flood event may cause soil particle "piping" under the levee and lead to catastrophic levee failure.

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The primary structural features of the Manhattan levee unit are drainage gatewells that often exhibited vulnerabilities for the design conditions under study and such gatewells were examined for appropriate modification or replacement actions.

Screening level optimization and feasibility design was performed on the prospective individual geotechnical and structural reliability measures to support the feasibility cost estimate development. Full optimization of these measures will be performed in the design phase consistent with normal geotechnical and structural engineering practice. Feasibility level engineering design criteria are derived from numerous Engineering Regulations and Manuals which include but are not limited to ER 1110-2-1150, EM 1110-2-1619, EM 1110-2-1415, EM 1110-2-1913, and EM 1110-2-2100. These publications are supplemented by Kansas City District local protection guidance as knowledge of the local river and soil conditions and associated flood experiences provide valuable design and performance insights.

E2d5. Tuttle Creek Dam Modifications for Increased Detention (Structural Measure)
Tuttle Creek Dam and Reservoir is located in the northeast section of Kansas between Marysville and Manhattan. Discharges from Tuttle Creek flow into the Big Blue River and directly past the Manhattan levee which is six miles downstream of Tuttle Creek Dam. Modification of Tuttle Creek Dam was considered as a potential structural measure. This modification would be configured to increase the existing flood pool storage and thus enable a decrease in flood flows past the Manhattan levee under certain flood conditions. The evaluation of this measure took an abbreviated path as a full detailed evaluation could be considered a study unto itself.

In starting this evaluation, one approach is to ask a key question concerning the 1993 Flood: "How high would both the dam and the spillway gates need to be raised to provide enough additional flood storage to prevent Tuttle Creek from entering surcharge during the 1993 event? If the surcharge pool could have been avoided, then surcharge releases could have been avoided for this event. Framing this question only partially answers the much more expensive and complex question of how much raise is required for the dam and spillway gates to provide downstream risk reduction for greater events, but it does provide an a good basis for determining viability of a dam raise.

The analysis indicates that, during the 1993 event, approximately 500,000 acre-ft of flood storage was needed to prevent the dam from entering surcharge operations. This storage estimate is based on the 14 days of releases made in July of 1993 that were in excess of the surcharge (35,000 cfs) threshold. This data was derived from daily release records retained by Kansas City District. To contain that additional amount of flood storage, the following modifications would need to be made to Tuttle Creek Dam:

- Modify the top of the spillway gates to elevation 1145 msl, or about 9 feet higher than they currently exist at elevation 1136 msl. This would involve removal of existing spillway bridge spillway/tainter gates and associated elevation and strengthening of the supporting structures.

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- Modify the existing spillway apron.

- Raise the top of dam 6 feet in order to maintain the existing (minimum) surcharge storage as well as the 2.15 feet of freeboard for wind/wave concerns during the spillway design flood. Based on 2009 storage-elevation curves in the Tuttle Creek Lake Regulation Manual, this would require a new top of surcharge at elevation 1163 msl and a new top of dam at about elevation 1165 msl (approximately 6 feet above the existing top of dam elevation 1159 msl). Numerous modifications would comprise this work to include:
    - Partial dewatering of lake
    - Remove and replace rip-rap upstream of dam
    - Remove and replace highway on top of dam
    - Controlled placement of embankment material sufficient to raise dam 6-feet
    - Install additional relief wells downstream due
    - Seismic modifications to dam
    - Add or modify existing upstream pumps stations
    - Modify the outfall conduit and associated tower to accommodate the embankment modifications.

- Modify (i.e. levee raises) the three existing upstream levee units at the cities of Maryville, Blue Rapids, and Frankfort to protect against the higher pool. These units are located in the upper end and headwaters of Tuttle Creek Lake.

- Modify upstream bridges crossing the lake to accommodate the pool raise.

- Undertake acquisition of easements or title to an additional 8,000 acres of lands around the perimeter of the lake resulting from additional inundation during higher pool elevations in extreme events.

The extent of these actions would require a major NEPA review (Environmental Impact Statement) given the widespread extent of the federal changes involved. Previous studies of similar types of modifications at other dam projects have produced cost estimates in excess of $100M, which far exceeds the expected costs and environmental impacts of other structural measures under study which provide similar flood risk reduction; thus this measure was screened out from further consideration.

E2e. Conclusions Regarding Appropriate Measures to Carry Forward into Plan Formulation

A summary of the measures considered and their evaluation using the Planning Criteria is provided in Table 14. For this study, bridge widening, channel modification, and raises to the existing Manhattan levee accompanied by geotechnical and structural feature strengthening offer the most promise for net benefits among the various structural measures considered. Various alternatives plans will be formulated and examined using appropriate combinations of these measures.

Continued Kansas City District and City involvement in the Silver Jackets Big Blue Pilot Project is carried forward as a non-structural measure suitable for incorporation into an overall flood risk

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management plan. Given that this effort has separate source of funding and authority and is an ongoing initiative, no further feasibility evaluation is necessary under Section 216 authority and participation in the Pilot Project is considered an integral part of the overall recommended plan for this study area. Coordination of other feasibility study recommendations with the pilot project efforts is inherent to this recommendation.

Table 14: Summary of Evaluation of Initial Measures

	Complete	Effective	Efficient	Acceptable	Carried Forward?
Non-Structural Measures					
Floodfighting	Limited reliability.	Temporarily. No long term solution.	High cost and manpower needs	Only on emergency basis	No
Relocation of structures	Addresses damages; Not frequency	Removes risk of damages. Not practical in dense urban area.	Very costly– many structures. Limited available relocation sites.	Not publicly acceptable	No
Tree clearing	Only for overtopping risk	Capacity improvements difficult to maintain	Implementation and O&M costs high for small improvement in capacity	No. Large Environmental impact and real estate required.	No
Flood-proofing of structures.	Addresses damages; Not frequency	Capabilities overwhelmed by expected flood depths	Cost effective within limits of capability.	Minimal. Other infrastructure still at risk.	No
Upstream reservoir operation modifications	Only for overtopping risk	Limited	Adverse impacts to other lake purposes	No. Adverse impacts areas downstream	No
Structural Measures					
Bridge Modification or Replacement	Only for overtopping risk near bridges.	Reduces risk of backwater or debris build-up	Can be costly to implement depending on scope.	Yes. Pending coordination with bridge owner.	Yes
Channel Modification	Only for overtopping risk	Capacity improvements difficult to maintain	Implementation and O&M costs high for small improvement in capacity	Potential large Environmental impact	For limited evaluation with other measures
Levee Raises	Only for overtopping risk	Yes	Cost effective at optimized height	Yes	Yes
Replace/Expand Underseepage Control	Only for geotechnical risk	Yes	Multiple cost effective measures	Yes	Yes
Replace/Modify Structural Features	Only for structural risk	Yes	Multiple cost effective measures	Yes	Yes
Upstream reservoir storage increases.	Only for overtopping risk	Limited	Very high cost.	No. Large environmental impact.	No

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E3.0 Identification of Key Uncertainties in Plan Formulation

Key uncertainties were identified and examined and resolved to the extent possible during the study.

- *Impact of future vegetation growth or development within the Big Blue River floodway.* The potential for floodplain fill is hard to predict, both where and how much. In the future it is possible that land development or additional heavy vegetation growth and new stands of mature trees could take hold in the Big Blue River floodway, especially in the left (east) bank areas across from the Manhattan levee. There is some precedence when considering the floodway history following construction of the original levee project. A risk of one foot increase at the 1% chance flood event could be present, assuming the floodplain is filled to the edge of the 1% floodway. Hydraulic sensitivity analysis conducted for the 0.33% annual chance event determined that the most significant impact to future flood hydrographs would occur if the left bank of the Blue River were allowed to become heavy forest, resulting in an increase of up to 0.8 feet in flood stages. Much of this area is currently in high value, high yield, agricultural production which is an important regional industry and is, by best estimates, likely to continue; thus it is considered an unlikely future scenario that it would be converted to forest. This study sponsor and other regional stakeholders are currently taking a proactive approach with multiple efforts underway to conduct floodplain management planning, floodplain mapping and investigate management measures on a watershed scale of flood risk management. These efforts are expected to result in flood risk management measures that will reduce the potential for development to occur and lessen the potential impacts to levee performance in the future. For the purposes of evaluating future without project conditions it is not considered realistic that urban development or significant quantities of mature trees would occur in this reach of the floodway or flood fringe. Further, this study assumed that the floodway conveyance would not be reduced. The potential for future increases in the hydraulic profile was therefore not included in the recommended levee height. It is recommended that the sponsor monitor the future conditions in the floodway. As most of the open and low-density of use floodway areas are outside the City of Manhattan jurisdictional limits, the sponsor will need to work with the adjoining Pottawatomie and Riley County authorities to maintain floodway conveyance capacity to the extent practical. One possible method is to consider encouraging the preservation of the present conforming land use of open areas, low-height vegetation, and cropland areas near critical points in the floodway by implementing a systematic land purchase program. Some of these conveyance areas may even be suitable for dual-purpose use as both recreational sites and a natural floodway preservation corridor. Based on the on-going floodplain management efforts, the assumptions regarding future vegetation are considered low risk.

- *Impact of raised water surface profiles on the two existing Big Blue River bridges.* Two bridges cross the lower Big Blue River within the study area. Raising the levee will increases the flood profiles, leading to higher lateral hydraulic loading effects on these bridges, more potential for debris impacts, etc. In the case of the Manhattan levee unit, the levee is located so distant from the bridge spans that an induced levee failure from a bridge

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failure is extremely unlikely. Furthermore, the probability of a flood high enough to fail the bridges is small, making the bridge-induced levee failure scenario very remote and unlikely, and not justifying the formulation of specific remedial measures in this study. Given that the bridges and the abutments form a critical narrow flow point in the Big Blue channel, it is advisable that the respective bridge owners (the State of Kansas DOT for the Highway 24 bridge, and Union Pacific Rail Road for the railroad bridge) should anticipate raising these bridges and widening the distance between abutments when the bridges are due for replacement. The City of Manhattan should also attempt to maintain some capabilities to prevent or remove flood-borne debris piles from the upstream face of the bridge spans in their emergency flood risk management planning.

E4.0 Early Array of Plans

The identification, development, and screening of the above structural and nonstructural measures was followed by combining the remaining individual measures into a set of early alternatives including the No Federal Action alternative. Levee raise measures were evaluated based on the flows resulting from the hydraulic model for several increasing flood event magnitudes. Having identified that the highest existing overtopping risk exists on the Big Blue River, at a flow of approximately 100,000 cfs, the next three highest available flood profiles and associated river flows, as listed in Table 4, were chosen for initial alternative development to determine technical feasibility and requirements When these flow profiles were combined with engineering measures necessary to meet current design criteria, the resulting alternatives showed enough potential for meaningful net benefits that the study pursued cost and benefit evaluation using screening-level cost estimates. The multiple levee raises in this early array permit levee optimization examination and incremental justification per ER 1105-2-100 paragraph 2-4.c.(5).e methodology. A single separate plan was formulated combining one of the chosen levee raise plans with Big Blue River channel widening and bridge modifications to examine the impact of these measures on overall plan performance.

Flooding problems in the residential neighborhoods located upstream and north of the existing levee along the Big Blue River, and not protected by the existing levee, were recognized early in the study in discussions with the study sponsor. Further interest in the northern area arose during contacts with the public in the April 2013 public scoping session. This area is known as the “northern unprotected area” or "northern area" (reference Enclosure 1 for an illustration of this area). Although consideration of areas outside the existing levee was not originally part of the scope of this study, in agreement with the study sponsor a potential new levee alternative plan for this area, with and without channel medications, was included in the early array for screening evaluation.

<u>Early Array of Plans</u>

Table 15 summarizes the pertinent details of the various levee raises included within the early array of plans.

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Table 15: Levee Raises and Lengths of Raise for Early Array of Alternatives

	Avg Raise (ft)	Max Raise (ft)	Raise Length (LF)	Big Blue River Flow (cfs)	Additional Plan Details
Plan 1	No Federal Action				
Plan 2	0.7	1.5	7,200	115,800	Five gatewell replacements; 29 new relief wells
Plan 3	1.5	3.3	14,100	151,700	Five gatewell replacements; 29 new relief wells
Plan 4	2.1	3.9	23,500	167,700	13 gatewell replacements; 45 new relief wells; pump station strengthening
Plan 5	1.3	2.6	14,100	151,700	Five gatewell replacements; 29 new relief wells; Big Blue River channel widening; expansion of the US 24 bridge; replacement of the Union Pacific RR bridge.
Plan 6	Same as Plan 3 with the construction of a new northern levee to protect additional areas.				
Plan 7	Same as Plan 5 with the construction of a new northern levee to protect additional areas.				

The study developed and reviewed two early alternatives that would include a new levee segment to encompass the northern area; early array items 6 and 7 above. The northern area is residential development northeast of the main downtown area and lies along the right bank of the lower Big Blue River just upstream of the existing levee. Given the strong interest demonstrated in the northern unprotected area, the study considered what measures might be able to help this area. This eventually resolved into the need and desire for formulation and evaluation of alternatives plans that would address the northern area flooding consistent with the study objective for effectively managing flood risk along the nearby reaches of the Big Blue River. After initial consideration of several alignment options and impacts to the existing neighborhoods, the new northern levee was conceptually aligned around the upstream unprotected area to include several Casement Road subdivisions resulting in a length of approximately 3.3 miles with a levee height up to 30 feet and an average height of 7.9 feet (measured from surrounding ground elevation). Drainage features including multiple gatewell closure structures and three pump stations would be required. Significant real estate acquisitions would be required to construct the new levee. Additional details of the new levee design concept are included in the Engineering Appendix, Vol. 2.

The study developed screening level features, cost estimates, and economic analysis for the early array. The economic evaluation led to the screening-out of the two northern levee plans due to a lack of positive net benefits. The net benefits of the new northern levee segment were negative and the benefit to cost ratio was well below 1.0. This lack of positive economic characteristics results from the high initial costs of building the new northern levee, and the fact that the northern unprotected area was developed many decades ago and is almost entirely residential housing, which limits the benefits available. Even at a lower levee height many of the project features would be very similar, including real estate and environmental impacts, drainage

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features, structural and geotechnical components, construction methods, etc. Providing risk management to a smaller portion of the neighborhood for lower flood profiles would shorten a proposed levee and reduce the costs, but also decreases the number of properties providing project benefits. The study evaluations indicated that any structural levee options, regardless of the levee height and design flood profile, would not be economically justified. The economic results truncated the detailed analysis of other levee options for this areas and the evaluation of other critical planning criteria.

The study is continuing to coordinate with the Kansas City District Silver Jackets Program and the City to address improved local floodplain planning and potential nonstructural flood risk management strategies for the northern area. Several local and state governmental entities are supporting local flood risk management efforts in the northern area. Costs for any northern area nonstructural measures are not included in this study's project cost estimates as these are seen as local/state initiatives.

E5.0 Final Array of Plans

The early alternatives array screening process resulted in the elimination of Plans 6 and 7. All other alternative plans were retained in the final array which underwent full evaluation and comparison.
ee Enclosures 2, 3, and 4 for illustrations of the various lengths of levee raise involved in each alternative. For each alternative the portions of levee requiring a raise were determined based on a comparison of existing levee height to the height required for acceptable assurance to pass the selected flow profile without overtopping.

E5a. Detailed Descriptions of the Final Array of Plans

The following are descriptions of the construction features involved with each of the final plans.

Description of **Plan 2** Features -- Construction Summary

- **Real Estate Lands & Easements:** Obtain 26 acres of temporary/permanent easements. Required easements are generally located landward of the existing levee within the limits shown in Table 15.).
- **Levee Raise & Underseepage Solutions:** 7,200 lf of 0.75 ft avg. levee raise; underseepage berms; sand drains; and numerous relief wells.
- **Gatewell & Pump Station Mods:** Replace 5 gatewells and recommend the City abandon 1 old bypass structure.
- **Utility Relocations:** Raise 11 manholes & numerous power poles; relocate 36" water line & 8" gas line and SBC cable relocations.
- **Other**: Construct levee extension for tie-in along Casement Road upper end of Big Blue River levee segment to include new sandbag gap.

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Description of the **Plan 3** Features -- Construction Summary

- **Real Estate Lands & Easements:** Obtain 29 acres of temporary/permanent easements
- **Levee Raise & Underseepage Solutions:** 14,100 lf of 1.5 ft avg. levee raise; underseepage berms; sand drains; and numerous relief wells.
- **Gatewell & Pump Station Mods:** Replace 5 gatewells and recommend the City abandon 1 old bypass structure.
- **Utility Relocations:** Raise 11 manholes & numerous power poles; relocate 36" water line & 8" gas line, and SBC cable relocations.
- **Other**: Construct levee extension for tie-in along Casement Road upper end of Big Blue River levee segment to include new sandbag gap.

Description of the **Plan 4** Features -- Construction Summary

- **Real Estate Lands & Easements:** Obtain 57 acres of temporary/permanent easements
- **Levee Raise & Underseepage Solutions:** 23,500 lf of 2.1 ft avg. levee raise; underseepage berms; sand drains; & numerous relief wells.
- **Gatewell & Pump Station Mods:** Replace 13 gatewells, raise 1 gatewell, strengthen 1 pump station, and recommend the City abandon 1 old bypass structure.
- **Utility Relocations:** Raise 30 manholes & numerous power poles; relocate 36" water line & 8" gas line and SBC cable relocations.
- **Other**: Construct levee extension for tie-in along Casement Road upper end of Big Blue River levee segment to include new sandbag gap.
- **Other**: Construct 1700 ft levee extension for tie-in along Wildcat Creek and Riley Lane upper end of Kansas River levee segment.

Description of the **Plan 5** Features -- Construction Summary

- **All of the Plan 3** features, PLUS:
- **CW: Real Estate Lands & Easements:** Obtain 10 acre temporary/permanent on left bank of Big Blue River -- across from levee in a constricted channel bend.
- **CW: Channel Widening:** 200,000 cy excavation by clamshell bucket; 1,100 lf of riprap armor around bridge abutments, & estimated 28.3 ac of habitat impact.
- **CW: Highway 24 ($5M) & Union-Pacific RR ($3M) Bridge Modifications and Expansions**.

E5b. Economic Evaluation of Alternatives

The evaluation and comparison of the final array of alternatives focused on those plans that maximized cost effectiveness, thereby increasing the net economic benefit. Economic screening and evaluation was conducted during 2013 and 2014 and used the prices and interest rates for FY14.

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Screening level cost estimates and projected construction periods for each of the final alternatives were developed in accordance standard Corps of Engineers estimating practice. Interest during construction (IDC) for each alternative was calculated based on the total first cost for each alternative, the starting and completion dates for each phase, assumed equal monthly expenditures during each phase. Potential federal funding constraints were considered to some degree in the starting and completion dates of the implementation phases -- funding streams similar to recent Kansas City District experience for similar projects was assumed.

The total first cost for each alternative includes the estimated construction cost, cost for lands, easements and rights of way, engineering and design cost, supervision and administration cost, and contingencies. Interest during construction calculated for each alternative was then added to the total first cost to derive the economic cost of each alternative. The economic cost was then annualized for a 50-year period of analysis and the appropriate interest rate. Other direct costs of project implementation were determined and included in the total annual project implementation cost. Potential induced damages were subtracted from the respective flood damage reduction benefits.

E5b1. Costs for Operation, Maintenance, Repair, Rehabilitation, and Replacement

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 prescribed federal interest rate and a 50 year period of analysis. The assumptions (based on Kansas City District experience in this area) 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. Wells are assumed to be replaced with new wells after 40 years at the replacement cost of either $55,000 or $65,000 depending on the type and size of the well used.

Other current sponsor OMRR&R costs for the existing project are considered constant across the final array, and thus are not included in the analysis of any proposed project. The annual increase in OMRR&R costs are less than $100,000 per year for each of the alternatives and are considered reasonable for a levee unit of this size and importance. The existing Manhattan levee unit is adequately maintained and the sponsor complies with annual inspection requirements. Thus it is assumed that the sponsor's current OMRR&R costs for the existing project will continue along with the addition of the additional new project OMRR&R costs.

E5b2. Other Economic Benefits Not Quantified

The benefit evaluation process involves analysis of the economic losses to the subject study area from flooding, and the potential gains to the study area from the successful prevention of flooding. Some of the economic impacts that are likely to occur from flooding in the without-project condition may be of major significance to a metropolitan area or community, but may not have any net impact on the national economy. For example, if a flood interrupts production at a

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given business in one community, that community suffers a loss. However, if the lost production is replaced by production at another plant elsewhere in the country, the loss to the local community does not represent a net loss to the national economy. Per prescribed procedures, these regional (RED) impacts are not included in determining the NED benefits in this study.

E5b3. Benefits and Costs Summary for the Final Array of Alternatives

Screening level benefits and costs of the Final Array are summarized in Table 16. Where it is possible to implement an earthen levee raise, such raises usually prove to be the least cost alternative. For Manhattan, this was demonstrated in the evaluation of individual structural measures and the alternatives screening. The correlation between the height of raise and project cost increase is logical given that the amounts of material and features involved will increase with each successive raise.

Table 16: Benefits and Costs Analysis -- Final Array

October 2013 (FY14) prices, 50 year period of analysis, 3.5% interest rate, 1000's				
Damages and Benefits	**Plan 2**	**Plan 3**	**Plan 4**	**Plan 5**
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%
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

Earthen levee raises create a wider levee footprint, either landside or riverside of the existing levee. The increase in landside levee width for the Plan 2 and 3 levee raise heights proved to be highly practical with no major real estate conflicts (and associated additional costs) due to no adjacent buildings and improvements; except that specifically around the Manhattan wastewater treatment plant the proximity of facilities to the landward levee toe requires the levee raise footprint increase to be moved riverside. The footprint widths associated with Plan 4 did increase the landside real estate conflicts during the formulation process, which in turn caused the cost of the plan to substantially increase as compared to lower raises.

E5c. HTRW Considerations of the Final Array

Discussion of the HTRW impacts of each alternative in the Final Array is presented in Section 4.3 of the Environmental Assessment.

All of the proposed levee raise plans in the final array will cross the sub-surface plume of Trichloroethylene (TCE) that extends under the levee between stations 215+00 to 218+00. The owner of the property identified as the contamination source, in coordination with the Kansas

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Department of Health and Environment, is currently treating the plume with injections of sodium lactate to enhance anaerobic bioremediation of the contaminants. Borrow would be placed on top of the area of the plume for the levee raise. A sand drain would be constructed on the landward side of the levee. The depth of the sand drain would be shallow enough that it would not intersect with the plume and bring contaminants to the surface. It is not anticipated that these proposed alternatives will interfere with the existing plume or the on-going treatment activities. No costs or project components are included in the alternatives to address additional HTRW remediation.

Plan 4 includes a 1,820 foot extension of the southern segment of the levee. The proposed alignment of that extension would go through the private disposal site. The extension would also go through or near the Manhattan Avenue Battery Site. Junk yards and industrial areas typically have a higher probability for containing contaminants. If this alternative was chosen a more thorough survey of contaminants would need to be performed to identify any HTRW concerns and possible routing shifts.

In conjunction with the levee raise plans, relief wells are proposed from stations 64+00 to 97+00 and 110+00 to 120+00. Although no known groundwater contamination has been identified in these areas, the potential exists. Due to the urban nature of the area, there is always a small chance of discovering an unknown site during the design and construction phases. Removal of contaminated areas found during design that interfere with the project implementation is a 100% non-Federal responsibility, including cost, and must be complete prior to the beginning of construction. If contamination is found during construction, all work in the area would cease until an evaluation is made by an HTRW expert.

E5d. Other Evaluation Criteria Used in the Comparison of the Final Array

See the final alternatives comparison matrix at Enclosure 5 for additional evaluation criteria used in the comparison process, and a detailed presentation of the associated alternative characterizations and comparison results. Construction methods and impacts were not specifically used as a component of plan comparison. Raises of the existing levee proposed and evaluated in the final array of alternative are all located in and adjacent to the existing project footprint. The construction methods and equipment would be essentially the same among all alternatives. Differences in the final levee length and width between the alternatives are captured in the evaluation of differing temporary and permanent easements, quantities of materials, utilities impacted, and structures impacted. Differences in construction time and labor are addressed within the project cost estimate. Only the Plan 5 alternative including channel widening would be significantly different given water based excavation, hauling away of material, potential reuse of that material, and necessary environmental design features. Again, these individual factors are addressed and included within the quantities and cost estimates.

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V. Description of the Recommended Plan

A. Step 6 – Selecting a Plan

When evaluating alternative levee raises, incremental economic analysis strongly affects the optimization and selection process. Levee raise costs typically increase as the levee height increases. These cost increases arise from the various components of cost that increase along with levee height: additional material and construction requirements, additional real estate costs, and a longer construction period. Other life cycle costs, such as operation and maintenance costs over the period of analysis, are included in the analysis. The optimal raise is the one with the greatest net economic benefits as computed for an array of flood events. As the evaluation progressed, Plan 3 was shown to be an efficient raise with the highest net economic benefits, limited land disturbance, limited real estate conflicts with no relocations, limited environmental impacts, and essentially no HTRW site disturbance.

To further support plan selection, the PDT estimated and analyzed a potential raise between Plan 3 and Plan 4 not previously included in the Final Array. This analysis showed that raising the levee more than a few inches beyond the Plan 3 top of levee elevation would increase costs exponentially by expanding the project footprint much farther along the Kansas River section. The benefits would not counterbalance the additional costs. The additional alternative would have a similar footprint to Plan 4, requiring an estimated 90% of the structural costs and 70% of the levee raise costs (earthwork, etc.) for the difference between Plans 3 and 4. The estimated annual costs of this new alternative would be approximately $1.8 million.

A sensitivity run in HEC-FDA using an interpolated levee raise revealed that the new alternative would increase benefits by only about 35% of the difference between the Plans 3 and 4, an increase of about 10% in overall benefits. The estimated annual benefits of this plan would be $4 million. With a Benefit to Cost Ratio of 2.2 and net annual benefits of $2.2 million, this plan is less cost effective than either Plan 3 or Plan 4.

Overall, raises between Plan 3 and Plan 4 would appear to require increases in cost similar to Plan 4 while providing risk management closer to Plan 3. It was determined that the appropriate alternatives were analyzed for selection of the NED plan. Using the costs and benefits of the Final Array presented in Table 16, and adding the estimated values for the new alternative, results in the economic cost optimization curve shown in Figure 5.

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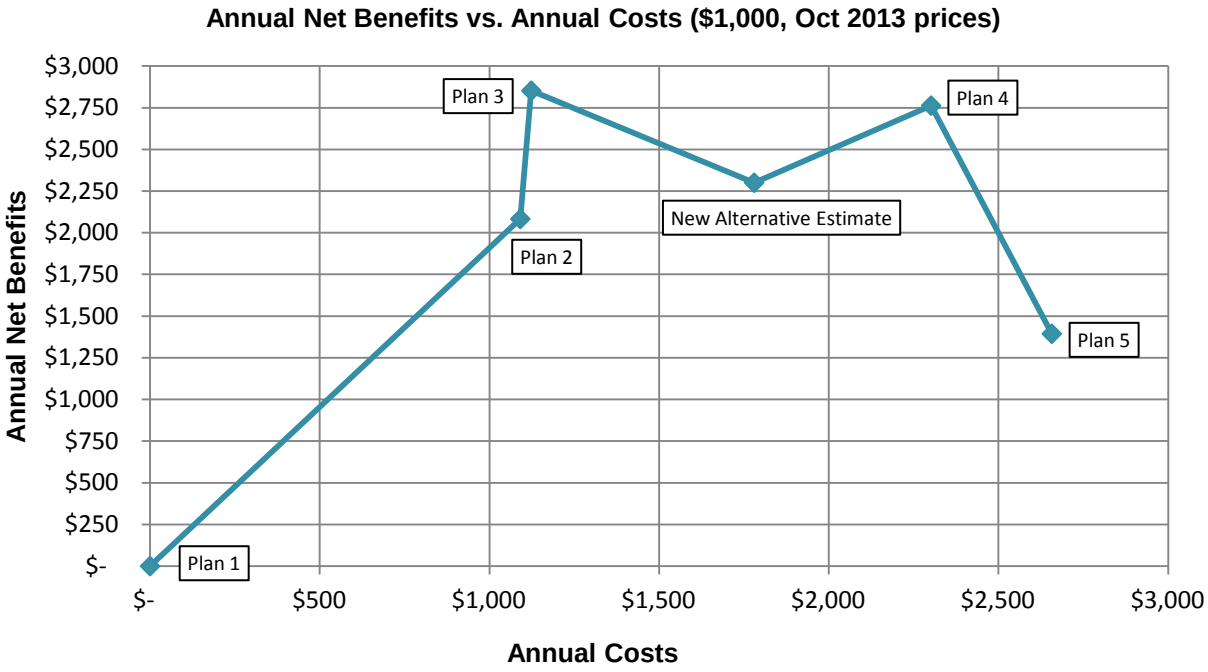
Figure 5: Economic Cost Optimization Curve



Plan selection is based on evaluation and comparison of the final array of alternatives and identifying the NED Plan. The comparison process considers the capacity of each alternative to meet the planning criteria. The alternative evaluation and comparison process shows that Plan 3 is technically viable, furthers national economic development, and is acceptable and relatively benign from an environmental standpoint, while holding several advantages over the other competing plans.

Plan 3 is offered as both the Recommended Plan and the NED Plan, and is recommended for full implementation. This recommendation is supported by the results of the final alternatives evaluation and comparison process. No planning constraints are violated. This recommendation is acceptable to and supported by the local sponsor. The major components of the Recommended Plan are summarized in Table 17.

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Table 17: Recommended Plan Components

Levee Modifications	**Quantity**
Levee Raise (LF)	14,100 lf
Levee Extension Tie-Back for Upper Big Blue Segment	~500 lf
New Sand-bag gap 2 ft high on Hayes Drive (upper end)	90 lf
Install Sand Drain along Big Blue Levee Segment	10,200 lf
Gatewell Replacements	5
Underseepage Control	
New Relief Wells	29
Relief Well Collector System	4,930 lf
Underseepage Berm	2538 lf
Other Associated Items	
Temporary Easement	6.95 acres
Permanent Easements	5.35 acres
Manhole Raises	11 ea.
Utility Relocations	2

B. Design and Construction Considerations

As this study deals with an existing levee unit, the site constraints arising from adjacent infrastructure must be considered during design and construction. During alternatives development and refinement, the study examined design and construction considerations important to an efficient implementation of the Recommended Plan.

The Project Coordination Team (composed primarily of sponsor, Corps of Engineers staff, and other stakeholders deemed appropriate to the work) will take the Recommended Plan and develop the design detail and the contracting documents necessary for successful construction efforts. The PED (design) project management plan (PMP) will address project scope, quality, schedule, communications, safety, and project team roles as the project progresses. The requirements of ER 1110-2-1150 will guide the overall design effort. Highly coordinated efforts will continue as the project moves into the real estate acquisition and construction phases. The Project Partnership Agreement (PPA) will contain specific requirements regarding responsibilities, funding and coordination of construction activities. Additionally, an implementation phase Review Plan (RP) will be developed detailing the level of review that each design and construction package will receive prior to award. It is currently anticipated that this RP will detail the need for IEPR Type II, or Safety Assurance Review, which will include a review of all life safety concerns including emergency action planning.

The Project Coordination Team must conduct specific utilities relocation coordination and design planning prior to levee raise construction contract award. Utility relocation work can be problematic if not thoroughly scheduled and coordinated. Even though the sponsor and utility owners are responsible for most utilities relocations, the Kansas City District will be consulted for approval of the relocation design and schedule. Detailed planning for utility relocations and assignment of responsibilities is fully developed in the latter stages of the PED phase. All parties

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(sponsor, utility owner, and Corps of Engineers) must prepare for a highly coordinated utility relocation effort.

Work alongside rivers must consider the somewhat unpredictable nature of flood hazards. High water conditions may occur while construction is in progress. If the high water conditions were to occur while the line of protection is temporarily down or compromised by construction (such as when a gatewell is being removed), then serious inadvertent flooding could result. This situation is normally handled through the development of specific high-water contingency measures. Requirements for these contingency measures are normally included within the plans and specifications (construction contract) package. The construction package must address high-water contingencies for the Recommended Plan. Such contingencies must aim to provide for at least the 1%-chance annual event as the most basic requirement. Beyond this, an additional level of preparation should be planned to bring the protection back to the preconstruction (design) level if needed under severe flood conditions. Common site measures for water control include dewatering, construction of ring levees, and emergency backfilling of open excavations. Sandbags and pumping can also be used to supplement the effort. It is preferable to schedule work within the levee critical zone for typically dry seasons. Excavation in the levee critical zone must be avoided during periods of ground saturation.

Modification of an existing project must always ensure that the potential to do harm to the existing levee is minimized during construction. The proposed levee raise and associated improvements have little potential to induce harm during construction because they generally will not degrade the levee below its current level of protection. Improvements which require cutting through the levee at discrete locations, such as gatewell replacements will include temporary protection (e.g. cofferdams) and/or emergency backfilling operation plans should a high water event occur during construction. Additionally, construction plans will include provisions for sloped excavations (as opposed to shored vertical surfaces) to reduce the risk of shear planes in the soil. The proposed levee raise and proposed improvements have been laid out for the recommended plan using modern levee design methodology considering typical failure modes (underseepage, stability, piping along penetrations). The proposed project has been formulated to include necessary underseepage control, levee stability improvements, and appropriate filters around penetrations to prevent against development of the failure modes.

The Recommended Plan contains no measures for modification of interior drainage facilities. Interior drainage is a Sponsor responsibility, and therefore was not considered beyond assessment of proposed measures to ensure that they would not adversely affect existing interior drainage conditions. The proposed work does not adversely impact existing interior drainage conditions.

C. Cost Estimate Development

The cost estimate was refined for the Recommended Plan using the Corps of Engineers' MII cost estimating computer program. The unit costs for the construction features were computed by estimating the equipment, labor, material, and production rates appropriate to the project. These

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estimates were developed with a specific price level date and were then escalated for inflation (fully funded) to the anticipated midpoint of construction.

The cost estimate for PED, Construction, and LERRD were developed through frequent and continuing study team meetings and discussions among appropriate study participants. Quantities associated with the construction of each major feature were calculated or reviewed by appropriate staff. The project cost estimates have undergone an Agency Technical Review (ATR) and been certified by the USACE Cost Engineering Mandatory Center of Expertise (MCX).

Each estimate prepared underwent a cost risk analysis and refinement process led by the cost engineer with input from the study team. Meetings and discussions were held by the team to identify and discuss potential project uncertainties and risks that could impact the project cost and schedule. The team developed a risk register of the identified risks including an assessment of the likelihood of occurrence and the magnitude of potential impact. A standardized Corps of Engineers method was used to determine the range of possible project costs considering the identified project risks. The results were used to assign project contingencies that will help address the cost risks.

C1.0 Cost Estimate Code of Accounts Information

The major cost estimating categories for the Recommended Plan are summarized by Corps code of accounts below:

01 Lands & Damages	Costs for non-federal sponsor acquisition of lands in fee title, permanent right-of-way, temporary right-of-way; and associated and incidental costs for legal work, title work, tract appraisals, and land surveys.
02 Relocations	This category includes utility relocations. No other types of facility relocations were identified. Utility relocations include utility crossings and relocations of utilities within the critical levee zone. This category is divided into: a) public utility relocation costs which are deemed compensable and b) those utility relocations without proven real estate rights that are the responsibility of the utility owners (relocation of non-compensable utilities are an associated cost for economic analysis but are not a cost-shared project cost).
11 Levees & Floodwalls	This cost category consists of several major construction components for the levee raise contained in the Recommended Plan. These components can include: relief wells (underseepage control), levee raise (including levee cut and raise, stability and underseepage berms), drainage system modifications, gatewells, and stoplog gaps (closure structures). Purchased borrow material is also included within this category along with borrow material hauling costs.
30 Engineering and Design	An approximately two-year Preconstruction Engineering and Design (PED) period is expected for preparation of the first Design Documentation Report and plans and specifications for the first construction contract. Engineering During Construction (EDC) costs were estimated and included here for the design of future construction contract packages after the construction phase begins. Specifics of the design effort and costs depend on the difficulties and complexities of each individual feature under design.

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31 Construction Management	Based on local experience in recent and ongoing levee projects and related Corps guidance for the construction management function.

C2.0 Other Cost Estimate Information

- As a federal project, no state sales tax was included in the estimated construction costs.
- The source for the labor rates are based on local Department of Labor Davis-Bacon wage rates. A minor cost adjustment factor is applied bringing the rates to appropriate price level date.
- Corps-approved equipment rates were used. An adjustment factor is added to bring the rates to the appropriate price level date.
- Escalation factors used were derived from the Civil Works Construction Cost Index System (CWCCIS) EM1110-2-1304.

C3.0 Summary Cost Estimate Tables

During the plan formulation, screening, and selection processes, all cost estimates used for evaluation and decision making were prepared at the 1 October 2013 (Fiscal Year 2014) price level. For the remainder of this Final Report and recommendation, the total cost estimate and economic analysis of the Recommended Plan has been updated to the 1 October 2014 (Fiscal Year 2015) price level.

The Recommended Plan implementation costs are categorized and apportioned to the federal government and sponsor in Table 18. Standard code of accounts and standard cost share amounts for Flood Risk Management (FRM) apply. The local sponsor is required to pay a minimum of 35% of implementation costs, including responsibility for all lands, easements, rights-of-way, relocations, and disposal areas (LERRD).

A Pre-Construction Engineering and Design (PED) agreement and a Project Partnership Agreement (PPA) will be required. The sponsor is aware of this and concurs with the normal approach to project implementation. The total fully funded project cost (time-escalated) is estimated at $26.9 Million.

Table 18: Cost Sharing Summary -- Recommended Plan

	Total	Federal (65%)	Sponsor (35%)	PED	LERRD	FRM
OCT 2014 PRICE LEVEL ESTIMATE						
Manhattan Levee Unit	$23,754	$15,440	$8,314	$3,531	$2,489	$17,734
FULLY FUNDED ESTIMATE						
Manhattan Levee Unit	$26,934	$17,507	$9,427	$4,164	$2,677	$20,093

Notes:

- *All costs $1000's. Amounts include the estimated contingencies based on cost risk analysis*
- *Fully Funded Costs escalated to the estimated mid-point of each construction contract.*
- *PED = design costs for first construction contract only.*
- *Values in table are rounded. Any summation discrepancies are due to rounding*

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The cost category summary for the Recommended Plan is shown in Table 19.

Table 19: Total Project Costs by Category – Recommended Plan

Code	Category of Cost	October 2014 Price Level	Fully-funded (escalated) Cost
01	Lands and Damages	$1,317	$1,382
02	Relocations	$696	$783
11	Levees & Floodwalls	$12,968	$14,566
30	Planning, Engineering, and Design	$3,054	$3,601
31	Construction Management	$1,100	$1,378
	Contingencies	$4,617	$5,223
Total		**$23,754**	**$26,934**

Notes:

- *All costs $1000's. Estimated contingencies are based on cost risk analysis.*
- *Category 30 Planning, Engineering, Design includes all design costs for all three contracts (by definition).*
- *Values in table are rounded. Any summation discrepancies are due to rounding*

D. Real Estate Considerations

Important aspects of the Lands, Easements, Rights-of-Way, Relocations, and Disposal Areas (LERRD) required for the Recommended Plan are highlighted below.

D1.0 Lands and Damages Costs

For the Recommended Plan, this LERRD category includes the costs for non-federal sponsor acquisition of lands in fee title, permanent right-of-way, temporary right-of-way; and associated and incidental costs for legal work, title work, tract appraisals, and land surveys. These acquisition costs also typically recognize PL 91-646 assistance to business owners; however, PL 91-646 assistance is not required by the Recommended Plan.

Land acquisition anticipated for the Recommended Plan primarily consists of 5.35 acres of flood protection easement and 6.95 acres of temporary work area easement on private and public lands. The total easement acres are less than the estimate discussed previously during screening of the final array of alternatives due to refinements in the required work areas and number of affected land parcels. Fee acquisition is not expressly required for levee rights-of-way (r-o-w). Estates to be acquired by the sponsor include permanent levee easements necessary for the levee raise and associated underseepage berm placement work.

Temporary easements will be used for equipment storage, construction vehicles and staging areas. Temporary access road easements will vary in width along the different work areas but are generally 15 to 30 feet wide. Duration of the temporary easements will also vary for each of the individual work areas, generally running from 2 years to 5 years. The Recommended Plan does not require acquisition of an off-site disposal area.

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D2.0 Borrow Considerations

Approximately 200,000 bank cubic yards (BCY) of borrow material will be necessary for the levee raise, underseepage berms, and stability berms. An acquisition easement will not be obtained for a borrow area. Borrow material will be purchased as a provision of the construction contract which has been determined to be in the best interests of the Government and the sponsor. The cost of borrow material is included within the Construction account of the project cost estimate.

D3.0 Relocation Costs

Some public utility relocations are deemed necessary in the Recommended Plan. No other types of public facility relocations were identified. Utility relocations include relocations of utility crossings (crossing the raised levee) and relocations of utilities within the critical levee zone affected by increased uplift pressures. This category is further divided into: a) public utility relocation costs which are deemed compensable and are included within project LERRD, and b) those utility relocations which were deemed not compensable and are the responsibility of the utility owners (relocation of non-compensable utilities are considered an associated cost but not a project cost). No other facility or building relocations are involved.

D4.0 Transportation Facilities Impacts

No active railroad tracks or railroad facilities require permanent relocation. The existing levee/railroad crossing and closure structure will be modified as needed to raise the levee height. There are no locations where railroad tracks parallel to the levee will be impacted. Temporary adjustments to schedules could be needed during some periods of intense nearby construction activities. Some public road modification may be necessary on in/along the Casement Road area near levee Sta. 272+00 depending on the details of the final design.

E. Operation and Maintenance Considerations

Operation, maintenance, repair, replacement and rehabilitation of the project will remain the responsibility of the non-federal sponsor. The current Manhattan, Kansas local protection project Operation and Maintenance (O&M) Manual will be updated by the Corps of Engineers and provided to the sponsor near the end of the construction phase.

One new sandbag gap structure is planned for the area of the Casement and Hays Road intersection. The necessary coordination and operational considerations of this structure is well understood by the sponsor from past experience. Any changes in the recommended closure plans, i.e. notifications, timing, river elevation action levels, etc., will be documented in revisions to the Operation and Maintenance Manual. The sponsor is also in charge of local city roads so any resulting new closure timing requirements will be inherently coordinated within the City of Manhattan Department of Public Works.

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The majority of the sponsor Operation, Maintenance, Repair, Rehabilitation, And Replacement (OMRR&R) concerns and costs will remain the same as in the current condition. An increase in annual OMRR&R cost is expected due to the increased underseepage berm area, and the larger number of relief wells in the levee unit which require periodic testing and rehabilitation, repairs, and eventual replacements. While the relief well costs are the driver in the overall OMRR&R cost change, their impact on an annual basis indicates a reasonable and manageable increase.

Table 20: Annual OMRR&R Cost for the Recommended Plan

Average Annual OMRR&R Costs*	Incremental Annual OMRR&R for Recommended Plan	Expected With Project OMRR&R Costs
$135,500	+ $54,000	= $189,500

October 2014 prices level. Annual O&M costs were developed using historical costs for similar levee units along the Kansas River. Specific costs for the Manhattan levee were not available.

F. Economic Analysis of the Recommended Plan

Refinement of the economic analysis for the Recommended Plan was performed near the conclusion of the study using updated and refined Recommended Plan costs. The basis year for project cost and benefits were matched. The following series of tables presents the findings and results of the Recommended Plan economic analysis. Note that in Table 21 contingencies have been included within each cost line item.

Table 21: Recommended Plan Cost Summary

Item	COST
Levees	$16,387.0
Relocations	$880.0
Lands and Damages	$1,609.0
PED (*all construction contracts*)	$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**
October 2014 prices (FY15), 3.375% interest rate, 50 year period of analysis, 1000's	

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Table 22: Recommended Plan Economics Summary

Item	COST
Annual Benefits	$4,076.6
Induced Damages	$2.1
Annual Benefits less Induced Damages	$4,074.5
First Costs	$23,754.0
Annual Costs	$1,177.7
Benefit Cost Ratio	3.5
Net Benefits	$2,896.8
October 2014 price level (FY15), 3.375% interest rate, 50 year period of analysis, 1000's	

Table 23: Economic Performance of the Recommended Plan

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
0.5	$3,686.5
0.25	$4,923.6
October 2014 price level (FY15), 3.375% interest rate, 50 year period of analysis, 1,000's	

The primary benefits of the Recommended Plan are the reductions in the potential for flood damage. Because much of the protected area is already developed, implementation of the Recommended Plan will provide continuity to the current employment base. In the long-term, business volume, personal income, employment, and taxes are not expected to change significantly in the protected area as a result of implementing the Recommended Plan.

During the short-term, construction of the Recommended Plan is expected to temporarily increase employment. The temporary presence of construction workers is likely to being a temporary increase in the demand for local area goods and services. Taken together, this is likely to result in a temporary increase in retail business, and increased sales tax receipts at the local level.

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G. Recommended Plan Performance and Accomplishments

The with-project performance, shown in Table 24, provides a significant decrease in the flood risk due to increased levee reliability and additional overtopping protection.

Table 24: Engineering Performance of the Recommended Plan

Annual Exceedance Probability	Without	With
Median	1.3%	0.3%
Expected	1.5%	0.4%
Long-Term Risk		
10 years	14.2%	3.8%
30 years	36.8%	11.1%
50 years	53.4%	17.8%
Conditional Non-Exceedance Probability		
10%	99.7%	100.0%
4%	94.1%	100.0%
2%	76.9%	99.9%
1%	52.6%	96.3%
0.40%	9.4%	61.6%
0.20%	3.5%	25.6%

Under the Recommended Plan, the Manhattan levee unit continues to comply with FEMA base flood (1% event) levee accreditation requirements.

The tax base within the protected area is relatively stable as the protected area is essentially built-out. This limitation on tax base places an upper limit on the potential for totally local initiatives. The Recommended Plan leverages local funding through the federal cost share process. It is likely that all of the proposed major levee improvements will remain un-built if not for the federal cost sharing opportunity provided by the Recommended Plan. The Recommended Plan also provides lower income residents with additional flood risk management benefits which might not otherwise be available through local processes.

H. Induced Damages

Minor induced damages from implementation of the Recommended Plan will occur under certain conditions in limited locations. Upstream induced damages as a result of the Recommended Plan will only occur at flood event profiles above the exiting top of levee and up to the proposed future top of levee. These induced damages would occur in the following areas:

- Unprotected areas within the FEMA 500-year floodplain upstream of the existing levee unit along the Big Blue River
- Unprotected areas across from the existing levee unit along the East bank of the Big Blue River

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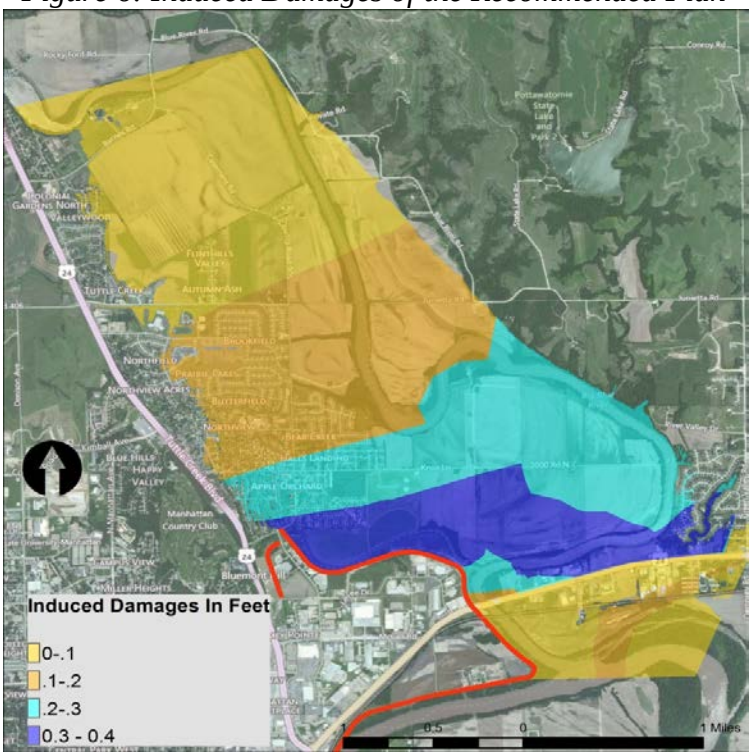
In the existing project condition, the unprotected residential area north of the levee on the right bank of the Big Blue River begins to experience flood damages at about the 1% event. As floodwaters reach the top of the existing levee, these upstream areas currently will experience an average of six to eight feet of flooding. The floodplain in this northern area is much wider than the floodplain immediately adjacent to and downstream of the levee. This additional width allows floodwaters to expand over a much greater area, thus attenuating any upstream depth increase caused by the project, i.e. a one foot levee raise does not create one foot of induced damage. At the proposed future with project condition, hydraulic analysis confirms that the induced damages are much smaller than the average levee raise of the preferred plan, ranging between about 0.2-0.4 feet (approximately two to five inches) of additional depth in the residential area, as shown in Figure 6.

Figure 6: Induced Damages of the Recommended Plan



The maximum induced impact is immediately north of the existing levee, decreasing with distance from the project. Changes in inundation area and flood velocities caused by the induced flooding are undetectable in the current hydraulic model. Flood durations on the Blue River are heavily driven by the operation of Tuttle Creek Dam and would not be impacted by this induced flooding. The induced damage impact of the Recommended Plan on each structure is essentially inconsequential compared to the existing damages that would already be occurring from river flooding in these areas. Additional discussion of the induced damages is provided in the Engineering Appendix, Volume 2, Part 2 – Hydrology and Hydraulics, Section 2.3.2.

While the events that may trigger these induced damages are rare, in accordance with economic policy the costs associated with induced damages are recognized in the study economics by

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reducing project benefits. A comparison of the future with- and without-project hydraulic profiles was conducted using the HEC-FDA program to evaluate the induced impacts. Under future with project conditions, approximately 1,100 of the 1,300 existing residential structures in the affected area will be impacted by the induced depth increase. It should be noted that due to the existing flooding already occurring, all structures affected by the induced damage would already be impacted; no new, or otherwise "dry", structures would be brought into the flooded area. The expected annual damages from flood events of any magnitude over a 50-year period of analysis were calculated by HEC-FDA as $2,110, which is shown in Table 22 as a negative project benefit. Additional detail of this analysis is presented in the Economics Appendix Section 8.1.5.

The predominant threat of flooding in these unprotected areas will remain essentially the same as the without-project condition. As described earlier in this report, early plan formulation efforts evaluated the possibility of extending the existing levee to include the northern residential area, but found that it did not meet Corps of Engineer's policies for project justification. Other methods to address the existing flood risk in this residential area, including flood plain management and non-structural methods, are currently under investigation through the inter-agency Silver Jackets program. Any recommendations of the Silver Jackets study are expected to be implemented using local/state resources separate from the implementation of improvements to the existing Federal levee.

I. Residual Risk

Although floodplain users and occupants may desire total protection from flooding, it cannot be overemphasized that this is an unachievable goal. Residual risks of flooding will remain after completion of the Recommended Plan. The primary source of residual flood risk will be from infrequent large flood events that overtop the levees. A number of factors can influence the nature of flood inducing storm events and the performance of flood risk management systems, such that an event of historical magnitude is not necessarily required to overwhelm the project and cause catastrophic damage. However, the implementation of project improvements may lead many floodplain users and occupants to feel that they have near-total protection against flooding. Therefore, it is important to emphasize and communicate the level of flood risk that remains after project implementation such that floodplain occupants are aware of the nature of the flood threats and are able to make informed decisions about acceptable levels of risk.

Communities located downstream of dam structures are inherently at risk of damage from dam failure. These risks will always remain regardless of modification to the existing levee. Regular practices for public information and communication coordination between USACE and the City of Manhattan have been in place since the completion of Tuttle Creek Dam to ensure the public is aware of these risks. Past projects to modify and strengthen the dam have assessed and documented these risks and have included significant public information and awareness efforts including the practicing of dam failure warnings and community evacuations. The discharge capacity of the existing dam spillway far exceeds the protection provided by both the existing levee and the Recommend Plan. In the event of high surcharge releases, or uncontrolled releases due to catastrophic failure of the dam itself, significant risk remains the community. The

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Recommended Plan will reduce the annual chance of levee exceedance from Big Blue River flows and Tuttle Creek releases. It will also provide more reliable protection from high releases such as seen in 1993 and, in the event that spillway discharges or dam failure threaten to overwhelm the levee, it will provide additional time for the implementation of evacuations.

The Recommended Plan addressed by this feasibility report provides a significant increase in reliability against flooding. Flooding will be less frequent; however, the analyses show there is still residual risk of flooding. For the Corps, determining an acceptable level of risk is in most cases a function of the NED process. The goal is to manage the risk of flooding and yet implement a cost effective and efficient flood risk management plan that reasonably maximizes net economic benefits (flood risk management benefits) consistent with protecting the Nation's environment (NED plan).

From the Federal perspective, selection of the NED plan as the recommended alternative is a determination of an acceptable level of residual risk based on trade-offs between potential benefits and the associated level of residual risk versus the cost of a larger and more risk-adverse flood risk management project. Increases in project reliability above what is provided by the NED plan can sometimes be achieved with much larger projects. However, in most instances, costs for larger projects increase dramatically faster than project benefits. The NED plan maximizes net benefits as measured by the difference between annual benefits and annual costs.

From the local perspective, a community or sponsor may desire less residual risk of flooding than that provided by the NED plan. Many persons in a community might express the desire for zero residual risk and no chance of damage from a recurrence of flooding, even though this is an economically unattainable goal. The level of risk a community or sponsor is willing to bear can be indicated by their willingness to pay for each additional increment of flood risk reduction. In accordance with Federal law, if a larger (more costly) "Locally Preferred Plan" than the NED plan is selected (a plan that may have higher benefits, higher costs and fewer net benefits than the NED plan), the project sponsor is required to "buy-up" or pay the difference in cost between the NED plan and the Locally Preferred Plan.

I1.0 With-Project Damages and Impacts

The Recommended Plan substantially increases the exceedance discharge from the existing condition, has substantial economic benefits, and reduces the overall study area equivalent annual damages by approximately 59%. The probability and occurrence of flooding will be greatly diminished but residual equivalent annual damages of approximately $2.85 million remain.

Table 24 compares the existing and future-with-project assurance statistics. Comparing the expected annual exceedance probabilities, there remains a 0.4 percent chance of a damaging flood in any year following project implementation. The with-project assurance to prevent damages due to overtopping or breach failure during the 1 percent-chance flood event is expected to increase to 96.3%, but for the 0.2 percent-chance flood event would be only 25.6%. The long-term risk of a damaging flood over the 50-year period would be less than 1 in 6,

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compared to a current 50-year risk exceeding 1 in 2. While the improvements proposed are substantial, it can be seen that residual risks remain.

The existing project does not have a preferred or designed overtopping location because significant damages are expected within the levee area regardless of where overtopping occurs. For the same reasons, there is no preferred or designed overtopping location included in the Recommended Plan. In the existing conditions, the initial overtopping is expected to occur at the upstream end of the Big Blue River segment. In the proposed with-project future conditions, the initial levee overtopping would occur evenly all along the Big Blue segment and part of the Kansas River segment. During larger flood events the majority of overtopping flow is likely to occur near the confluence. The confluence location represents the "downstream" end of both sections of the levee unit, is the farthest point in the project from protected residential and commercial areas, and allows for increased risk warning time and additional evacuation time if needed.

If the capacity of the Federal levee system is exceeded in a particular event, most of the areas and properties inside the levees would be affected due to the flat floodplain topography. The study area is generally small volumetrically in relationship to the Kansas and Blue River hydrographs. The estimated duration to fill the interior of the levee unit is less than half a day. With the current maintenance of the levee, with good grass cover and clay embankments, the levee is likely to withstand these overtopping conditions for these relatively short overtopping durations. In general, if the amount of water that gets through or over the levees is sufficient to produce severe flood depths, event specific damages in the study area would reach $2 billion or more.

Flood depths resulting from levee overtopping or breach could reach as much as twelve feet within the interior of the study area. Dewatering scenarios depend greatly on the nature of the flooding, i.e. how fast the Kansas and Big Blue Rivers recede, and/or the time needed to evacuate floodwaters from Tuttle Creek Dam and reduce discharges. During full inundation of the study area it is likely, subject to successful flood fighting efforts, that existing pump stations would be overwhelmed resulting in loss of pumping capacity. Even if pumping remained, it would not be as efficient as gravity drainage, which would be controlled by receding river stages. As has been seen in other levee failure situations, it is likely that intentional breaching of the levee would be necessary to aid in drainage. The expectation is that dewatering of a full inundation scenario would be measured in weeks as opposed to days.

Failure of the project and the time to conduct dewatering operations would pose significant risk to critical facilities within the project are, including the water and wastewater treatment facilities, City and County offices, a regional health center, and police and fire stations. Large-scale evacuations of urban neighborhoods would be necessary in advance, followed by humanitarian assistance. A number of highly-traveled highways and streets as well as railroad tracks would be closed and in some cases inundated. Public utilities including power generation and water and wastewater treatment would be interrupted, perhaps for a few weeks.

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I2.0 Life Safety Risk Assessment

The Corps of Engineers Levee Safety Program conducted a levee safety assessment of the Manhattan levee Unit in 2012 using the Levee Screening Tool (LST). The LST evaluates a number of safety criteria and provides a common basis on which to assess the expected performance and inundation consequences for levees across the Nation. One of the results produced by the LST is an analysis of the estimated loss of life that could occur as a result of project breach prior to overtopping (PTOT) and overtopping (OT) breach. For the purposes of this report, the PDT updated the previous evaluation based on current project conditions and to reflect the assumed future with project conditions. This section summarizes the basic details of the LST evaluation process and the assumptions made regarding future conditions as they affect life safety risk.

The LST process begins with general information such as the elevations and geometry of the levee itself, elevations of the study area within the levee, number of structures, population, etc. The Population at Risk (PAR) is representative of the occupants and users within the levee units, and is determined for both day and night conditions. The Recommended Plan does not alter the size or shape of the study area, nor will it promote additional development, and thus will not cause changes (upwards or downwards) in the PAR values. Threatened Population is an estimate of that portion of the PAR that would still be remaining in the floodplain at the time of project failure, either because they choose not to, or cannot, evacuate. The resulting estimate of Loss of Life is determined from the Threatened Population based on expected flood depths and population densities.

The life safety risk is heavily influenced by the total population located within the leveed areas (PAR). However, other important factors include:

1. Probability of overtopping
2. Project reliability at flood levels less than the system capacity
3. Levee and leveed area geometry and inundation characteristics
4. Quality of emergency planning and risk communication prior to project failure

Risk drivers included in the LST analysis for the Manhattan levee without project conditions include existing condition underseepage and stability concerns and the likelihood of overtopping. These risks are related to the first two items in the list above and will be directly addressed by the Recommended Plan. Raising the height of the existing unit will reduce the expected frequency of inundation by almost 33%, and associated stability and seepage improvements to the levee system will improve system reliability for flood levels less than the system capacity. Reducing the frequency of failure can allow the occupants of the floodplain more time to implement emergency procedures and evacuate, if needed, potentially decreasing the threatened population and loss of life expected during the life of the project.

Although the Recommended Plan does not change the size or extent of the study area, it does affect unit geometry and inundation characteristics. A higher levee unit can potentially result in greater inundation depths for a levee breach scenario. Greater inundation depths can result in

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higher fatality rates for individuals unable to evacuate. The LST uses a simplified "bathtub" analysis to estimate the inundation depths for a levee breach. Estimated maximum inundation depths for the current and future with project conditions are 14.3 feet and 15.1 feet, respectively. This increase of less than one foot is small and, when combined with the reduced likelihood of overtopping, is likely to reduce the life safety risk for the project.

Emergency planning and communication is the biggest driver of threatened population and loss of life analysis. If the occupants of the floodplain are well informed of the risks and emergency procedures in advance, and are able and willing to implement those actions when directed including compliance with evacuation orders, the loss of life can be significantly reduced. The Feasibility Study process included public information and involvement, which helped to inform the public of the risks, but the Recommended Plan relies on the local sponsor to implement emergency planning and communication efforts. For the future with project conditions it is assumed that efforts currently being pursued by the sponsor and both local Counties in the areas of community awareness, risk education, and floodplain management will continue, including the implementation of effective evacuation planning. Multiple ongoing flood risk management activities, including activities coordinated by the state Silver Jackets team, involve risk communication and local community engagement. These activities are all likely to improve the risk awareness and evacuation planning for the future with project condition.

Based on the current project conditions and the noted future assumptions, the existing and future life safety assessment results are shown in Table 25. These results, based on an assessment using the LST, should not be taken as precise values. However, they demonstrate that the recommended project is unlikely to result in increased life safety risk but should, when combined with additional flood risk management activities occurring within the community, result in overall reduced life safety risk.

Table 25: Existing and Future Life Safety Assessment

	Existing Condition	Future With Project
Population at Risk		
Day	7,648	7,648
Night	6,886	6,886
Threatened Population		
Breach PTOT		
Day	2,368	1,914
Night	1,868	1,437
OT Breach		
Day	1,436	902
Night	982	475
Estimated Loss of Life		
Breach PTOT	10	9
OT Breach	6	4

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An important part of the data and discussion presented here is to highlight the existing risks to population and emphasize that, although reduced, some life safety risk will remain following project implementation. Additional local efforts beyond implementation of the Recommended Plan will be critical to managing these risks.

I3.0 Residual Risk Management

Informed risk management and emergency preparedness, by both the sponsor and the Corps of Engineers, is the manner in which residual risks and potential exceedance of the system will be addressed. Based on the hydraulic analysis of the existing project it is expected that overtopping would begin at or near the upstream end of each individual section of the levee during either a Blue River or Kansas River flood. There is no advantage or evident solution in managed overtopping, i.e. designing for a specific overtopping location, given the presence of the river confluence and the intensive development throughout the study area. Effective emergency planning in advance is the best way to protect communities and minimize the damage from these rare flood events.

The sponsor operates this project according to an Operations and Maintenance Manual originally prepared by the Corps of Engineers. This manual contains a list of specific actions to be taken during emergency flood operations triggered by Kansas and Blue River stages as measured and reported on the existing USGS gauges. Forecasts and warnings for all gauge locations are issued regularly by the National Weather Service. These forecasts include projected river flows and stages several days in advance. During normal operations these forecasts are issued daily and during flood emergencies, three times a day.

The Corps of Engineers employs a very proactive approach to monitoring and inspecting the system units, provides training for flood preparedness and flood fighting, and activates a comprehensive Emergency Operations Center (EOC), including liaison and technical assistance as needed to assist local entities in their flood response and operation of the system. During flood operations the EOC conducts a daily conference call with sponsors and stakeholders throughout the impacted areas to disseminate and communicate all available flood status and risk information. The Kansas City Water Management Branch and the Northwestern Division Reservoir Control Center in Omaha, NE, are regular participants in these calls and provide updates on reservoir conditions and operations, and their potential impact to expected flows.

Similarly, the sponsor has their own monitoring, emergency response, and evacuation plans that are coordinated with other local County and State emergency response elements and the business and residential areas within the levee. Additionally, the City of Manhattan maintains a close relationship with the operations staff at Tuttle Creek Lake for awareness of potential changes in reservoir operations. All of these efforts tie together in a proactive and coordinated flood response and risk management framework with the Corps of Engineers, both in preparation and training activities as well as during flood response.

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Following implementation of the Recommended Plan, the Corps of Engineers will update the O&M Manual to reflect the new with-project conditions and features, including any changes to the emergency actions list that may be needed. The sponsor will modify any other emergency action, evacuation, or floodplain plans they currently have, or design new plans, to further manage and minimize the residual risks remaining after Recommended Plan implementation.

J. Environmental and Cultural Considerations

A separate Environmental Assessment (EA) and Finding of No Significant Impact has been prepared and is published in conjunction with this Feasibility Report. Detailed discussion of the environmental and cultural impacts of the Recommended Plan is provided within the EA and summarized in the following sections.

J1.0 Environmental Justice

No specific geographic areas of minority or low-income groups were identified within the affected area. A large portion of the affected area is commercial and industrial areas without residential households. The Recommended Plan has no adverse impact on any low-income or minority populations. Description and mapping of the minority population and median income by census block is presented in the EA in Section 3.5 and EA Appendix I.

J2.0 Wetlands and Aquatic Resources

Wetlands within the proposed project are limited in number, size, and quality. The assessment of the project area identified wetlands near or within the protected area; however, these are not impacted by implementation of the Recommended Plan. Construction of the Recommended Plan also would have no impact on any aquatic habitat in the project area since all construction activities would take place on land and would not involve any streams. The area would continue to have very limited floodplain connectivity similar to what is present with the existing levee.

J3.0 Mitigation

After considering the environmental features of the project area, the recommended plan would not affect any wetlands or jurisdictional waters of the United States, nor any significant fish and wildlife habitat. There is a potential for impacts to a limited number of trees from project construction activities which will be avoided to the extent practicable. If it is not possible to avoid select, individual, mature trees during construction, replacement trees of the same species, or a native species if tree removed is non-native, would be planted in the project area.

J4.0 Floodplain Impacts

Executive Order 11988 requires Federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable

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alternative. The guidelines address an eight-step process that agencies should carry out as part of their decision-making on projects that have potential impacts to or within the floodplain.

1. Determine if a proposed action is in the base floodplain (that area which has a one percent or greater chance of flooding in any given year).

Per FEMA mapping, the areas within the Manhattan Levee are outside of the 1% event floodplain. However, the existing levee itself which is proposed to be modified is part of the 1% floodplain.

2. Conduct early public review, including public notice.

A Public Scoping Meeting was held in the project area in April 2013. The Draft Feasibility Report was published for additional review and comment by the public.

3. Identify and evaluate practicable alternatives to locating in the base floodplain, including alterative sites outside of the floodplain.

The proposed project is for modification and improvement of an existing levee and is generally limited to the current location and features of that system. There is no alternative to conducting the project outside the floodplain.

4. Identify impacts of the proposed action.

No floodplain impacts are expected from the proposed action. The existing floodplain area is heavily urbanized and intense development has already been in place for many years. Significant development is not anticipated to be induced by the proposed levee project because very little open space remains and recent development has primarily consisted of improving older structures, or razing old structures and replacing with new structures.

5. If impacts cannot be avoided, develop measures to minimize the impacts and restore and preserve the floodplain, as appropriate.

No impacts are expected.

6. Reevaluate alternatives.

As stated in the response to Question 3, the proposed project is for modification and improvement of an existing levee system and is generally limited to the current location and features of that system.

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7. Present the findings and a public explanation.

Study findings and recommendations as documented in this Feasibility Report were published for public review and comment in June 2014. Comments received with responses are included with this Final Feasibility Report.

8. Implement the action.

The proposed plan detailed in this report is recommended for approval and authorization.

J5.0 Environmental Conclusions

The recommended plan would have no impacts to federally-listed threatened or endangered species, or their designated critical habitat, and would not have negative impacts to sites listed, or eligible for inclusion, on the National Register of Historic Places. Minor long-term impacts would occur to the terrestrial habitat and wildlife as a result of removing some trees along the right of way. With time, the minor long-term impacts would be reduced as trees become reestablished within the construction easement area. The Recommended Plan would best meet the purpose and need of the project by providing for increased flood risk management with limited impacts to the environment in a cost effective manner. For reasons described in the Environmental Assessment, the Recommended Plan would not result in any significant long-term impacts to the human environment. Additional detail of the environmental impacts analysis including documentation of coordination with the U.S. Fish and Wildlife Service and the Kansas Department of Wildlife and Parks is included in the attached Environmental Assessment.

K. Environmental Operating Principles

Under the seven Environmental Operating Principles (EOPs), the Corps of Engineers is mandated to proactively seek and consider ways to improve and sustain the environment. An existing project in an urban area such as Manhattan, KS, with permanent structural features dating back several decades, has inherent limitations to the inclusion of viable environmental improvements.

During the feasibility study, various candidate environmental measures were reviewed in recognition of the Environmental Operating Principles (EOPs). In addition, flood risk management engineering measures were developed in a manner which sought to preserve, improve and sustain the environment. After review of the options and consideration of the conditions in this project area, it was generally determined that the best way to comply with the EOPs for this project, would be preservation of the continuity and value of habitat along and adjacent to the Kansas River and Big Blue River bank line areas.

The Recommended Plan has minimal impacts on existing habitat and wetlands and serves to protect the environmental and community fabric that has developed behind the existing levee unit.

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L. USACE Campaign Plan

The USACE Campaign Plan contains four goals: Support the Warfighter, Transform Civil Works, Reduce Disaster Risks, and Prepare for the Future. Project formulation and alternative development furthered three of these four goals

Transform Civil Works: This study effort employed the current strategies in place for delivering enduring and essential water resource solutions. Review processes incorporated in this study included District Quality Control (DQC), Agency Technical Review (ATR), and Independent External Peer Review (IEPR). The ATR was conducted by an interdisciplinary team across several Corps Districts and coordinated with both the Flood Risk Management Center of Expertise and the Cost Estimating Mandatory Center of Expertise. The IEPR was managed by an outside organization employing independent technical experts. Customer and stakeholder engagement was encouraged throughout the planning process.

Reduce Disaster Risks: The overall study and recommendations as presented in this Feasibility Report present a complete analysis of an existing levee unit to ensure overall reliability and performance. Risk and uncertainty based models and methods were employed to examine the existing unit and identify reliability deficiencies. The study team provided early and often communication of risk assessments, finding, and recommendations with the project sponsors and stakeholders using currently accepted terminology and concepts. Alternatives were chosen to reduce the flood risk to existing infrastructure and investment, and improve future reliability. The Recommended Plan provides a complete plan for a safe, reliable, and resilient flood risk management project that mitigates disaster impacts to the local community and the Nation.

Prepare for Tomorrow: The study effort employed the best available technical expertise and experience, and project management and leadership, to establish a dedicated, competent, and capable team to produce a quality project recommendation. The lessons learned by the team in the execution of this study will contribute to sustaining a culture of collaboration and innovation for delivering future solutions.

VI. Plan Implementation

A 5-year construction phase beginning in 2017 is planned, subject to Congressional project authorization and availability of construction funding. The technical scope and magnitude of the project, combined with reasonable assumptions of future funding availability, indicate a likely three construction contract package arrangement for construction of the Recommended Plan. Contract work items would likely be grouped as shown below.

- Contract #1: Replace 2 gatewells (Big Blue River segment) prior to levee raise work. These are within the levee raise area.

- Contract #2: Build entire levee raise, upstream berms, relief wells in levee raise area, and all utility relocations -- largest contract.

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- Contract #3: Replace 3 gatewells (Kansas River levee segment) near conclusion of project. These are outside the levee raise area.

A levee raise requires expansion of the earthen footprint which requires additional real estate. It was determined early in the study that the footprint expansion will normally occur towards the landside (interior) of the levee so as to not constrict the already limited conveyance capacity of the existing Big Blue River channel, and to limit any disruptive environmental or adverse habitat effects. For the feasibility study, the Corps of Engineers determines real estate requirements and the associated cost based on the selected plan footprint and a gross appraisal. More exact real estate requirements are developed during the design phase. The design phase follows completion of the feasibility study.

According to federal law, the sponsor is responsible, with Corps of Engineers guidance, to undertake (pay for) the required real estate actions. The overall project schedule anticipates timely real estate actions, and the sponsor is aware of their responsibilities in this regard. Real estate actions and acquisition required for the project construction will begin prior to the first construction contract award. The Manhattan levee has relatively few utilities requiring relocation. The Corps evaluates the compensable or non-compensable nature of the various utility relocations, in conjunction with the sponsor. The Corps then assigns relocation costs when the utility ownership and real estate rights information is adequate for a compensability determination. Utility relocation design details are developed during the design phase.

During this current period of federal fiscal uncertainty, it is difficult to predict the exact timing of the project funding allocations or whether such allocations are forthcoming for construction. However, the schedule does assume reasonable periods for the design and construction process from the standpoint of Corps of Engineers capabilities.

A. Work Categorization

The existing conditions have been analyzed recognizing the changed changes and employing the observed high flow conditions and levee performance data not available to the original designers. Existing height deficiencies are not attributed to inadequate maintenance or project deterioration over time. It is not believed that any error or omission was made in the original design and there is no finding of a design deficiency.

For the purposes of developing an appropriate implementation plan, the Recommended Plan was examined under established Corps of Engineers criteria and categorized totally as reconstruction improvements requiring new authorization.

B. Implementation Approach

The Feasibility Report is offered to Congress for authorization of the Recommended Plan. Construction activities will not commence until such authorization is received, typically within a Water Resources Development Act.

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Following Feasibility Report approval, the Corps of Engineers will negotiate and execute Pre-Construction Engineering and Design (PED) agreements with the sponsor for the Recommended Plan. Development of the plans and specifications will begin as soon as funding is made available. During the PED phase, the Corps of Engineers will prepare a Design Documentation Report and plans and specification for the initial construction contract.

Following construction authorization and near the completion of the PED phase (and prior to the acquisition of any required project lands) the Corps of Engineers and the respective sponsor will execute a Project Partnership Agreement (PPA). The Design Documentation Report prepared during PED will guide development of the PPA. Work under the signed PPA can begin in levee reaches requiring no additional lands. For project areas that require lands, the sponsor will acquire easements, rights-of-way and any necessary disposal areas prior to advertisement and award of the first construction contract. Construction contracts are then awarded in sequence following real estate acquisition and the appropriate Engineering During Construction efforts.

C. Project Management

The Corps of Engineers will manage the project in accordance with applicable laws, regulations, and policies. The principles of project management within the Corps of Engineers are contained in Engineering Regulation 5-1-11. The Project Coordination Team will be formed under the auspices of the PPA and will guide the construction phase.

D. Implementation Schedule

The overall project schedule is based upon the assumption that a positive Chief of Engineers' Report will be forwarded to the Assistant Secretary of the Army for Civil Works. Funding is assumed available at the earliest practical opportunity for new PED starts. Lack of initial PED funding will shift the schedule out accordingly until such time as the PED funding is made available. Additional refinements to the project schedule will be made as authorization and program guidance is received.

The project schedule provides for an almost immediate start of the Recommended Plan design work (PED) beginning in FY2015, followed by award of construction contracts, pending authorization, in FY17 through FY21. Several assumptions have been used to project the schedule. Among these are:

- Construction contracts are arranged to accomplish logical sequences of work for increased efficiency and to control construction risks.
- Federal and non-federal construction funding is available in the years required
- Real estate actions are completed on schedule.

The project schedule reflects the information currently available and the current departmental policies governing execution of projects. It does not reflect program and budgeting priorities inherent in either the formulation of a national civil works construction program or the perspective of higher review levels within the Executive Branch. Consequently, the proposed

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schedule may be modified before it is transmitted to higher authority for authorization and/or implementation funding.

E. Institutional Requirements

In addition to the cost sharing responsibilities, the following sections outline other federal responsibilities and local cooperation requirements associated with the development of flood risk management projects, as mandated by the Water Resources Development Act of 1986, Public Law 99-662, and other pertinent laws and policy guidance.

F. Division of Plan Responsibilities

Implementation responsibilities refer to actions and financial arrangements of federal and non-federal interests directed toward implementation of the Recommended Plan.

F1.0 Federal

The federal government will be responsible for providing the federal share of project costs and for implementing the Recommended Plan. The Kansas City District will develop the Project Management Plan sections needed for guiding the PED (design) and construction of the project.

F2.0 Non-Federal

The non-federal sponsor will be responsible for providing the non-federal share of the project costs and assuming all future operations, maintenance, repair, rehabilitation, and replacement. The non-Federal sponsor is fully aware of, and able to comply with, all non-federal sponsor responsibilities as described within the Recommendation section of this report.

G. Financial Capability Analysis

The non-Federal Sponsor has executed a self-certification of financial capability to provide the required cost-share funding amounts.

H. Views of the Local Sponsor

The non-federal sponsor strongly supports the Recommended Plan. On a routine basis, the sponsor accomplishes the numerous actions necessary for keeping the project in adequate condition as evidenced by recent annual inspection reports and by the evaluations undertaken in the feasibility study. The sponsor will continue to provide full cooperation and is prepared to meet the necessary financial obligations associated with the Recommended Plan.

I. Views of Other Agencies

The Draft Feasibility Report was published for review and comment by the public and State/Federal resource agencies. All comments received with responses will are included in the

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Public Involvement Appendix. As required by law, the recommendations of this Feasibility Report have been coordinated with the U.S. Fish and Wildlife Service and a Final Coordination Act Report is included with the Environmental Assessment.

J. Summary of Coordination, Public Review, and Comments

J1.0 General

Public involvement provides for general public and agency input and review within the overall NEPA process. The Corps actively solicits input from numerous federal, state and local agencies, businesses, and organizations.

J2.0 Public Scoping Meeting

A public scoping meeting for the feasibility study and Environmental Assessment was held 17 Apr 2013. Invitations and announcements for the scoping meetings were made in public websites, local City announcements, and through contacts in routine communication channels. This public meeting was also preceded by a public City Commission meeting held on 28 March 2013 where the details of the project concepts were briefed and Commission feedback was collected.

Feedback from these meetings showed that the public and officials in the local area recognized the need for effective flood risk management in the City of Manhattan. Issues and concerns raised during the scoping meeting identified the lack of potential structural measures for the upstream unprotected residential areas on the Big Blue River (also known as the “Northern” area). As described earlier in this report, structural measures for these areas were evaluated but did not meet economic justification criteria. Non-structural measures for this area are under evaluation by separate study efforts. Also noted were some concerns over potential induced impacts to these upstream areas from construction of any levee raise. Induced damages in this area resulting from the Recommended Plan were analyzed and found to be of minimal impact above the existing flooding concern. There were also some questions concerning discharges and models used in the study.

Although all of the concerns expressed through the public scoping process were not able to be addressed by this Feasibility Study, the Corps of Engineers has used this input to help guide floodplain management efforts in the Big Blue River being evaluated through the Silver Jackets Program.

J3.0 Draft Report Public Comment Period and Closure

Pursuant to Corps of Engineers Headquarters (HQ-USACE) approval for public release, the Draft Feasibility Report and Environmental Assessment were made available for public review on the Kansas City District Corps of Engineers' website, at the local Manhattan public library and Manhattan City Hall, and at the Kansas City District Corps of Engineers' office. In addition, a notice of the Draft Feasibility Report availability for public review was provided to the study

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sponsor, elected officials, tribal governments, federal agencies, state, county, city, and local governments, environmental groups, businesses, individual property owners potentially affected by the project, news media, libraries, and other interested individuals and organizations. A press release was issued regarding availability for public review. Copies of the Public Notice, Press Release, and listing of the parties contacted for comment are included in the Public Involvement Appendix to this Final Report

The comment period on the Draft Report ran for 30 days. All comments received during the review period with responses are included in the Public Involvement Appendix.

K. Status of Corps of Engineers Review Process

- A Feasibility Scoping Meeting was held on 24 April 2013.
- The Alternative Formulation Briefing was held 25 April 2014.
- District Quality Control was certified by the Kansas City District on June 18, 2014
- Agency Technical Review of the Draft Feasibility Report was certified on June 11, 2014, and for the Final Report in August 2014
- Certification of the Cost Estimate by the Cost Engineering Mandatory Center of Expertise was completed on July 16, 2014.
- A Civil Works Review Board is expected in late Fiscal Year 2014 or early FY 2015.

K1.0 Agency Technical Review Status

The Flood Risk Management Planning Center of Expertise (FRM-PCX) is assigned to this study. The Agency Technical Review (ATR) was led by the Louisville District and included reviewers from other Corps District offices. The ATR was conducted in accordance with the study's approved Review Plan and the requirements of EC 1165-2-214.

- Engineering ATR began with early H&H work several years ago; Draft Engineering Appendix ATR was completed late in 2013.
- An early draft of the cost engineering package was reviewed at the Cost MCX. A final review and certification was completed in July 2014 in conjunction with review of the Draft Feasibility Report.
- ATR review of the Draft Feasibility Report including the Environmental Assessment, Economics Appendix, and Real Estate Plan was completed in June 2014.
- Final ATR of all items incorporating comments and edits resulting from Draft Report reviews was completed in August 2014.

K2.0 Independent External Peer Review Status

The Independent External Peer Review (IEPR) has been conducted with the assistance of the FRM-PCX for the processing of the IEPR contract through the Corps of Engineer's Institute for Water Resources (IWR). A contract was awarded in March 2014 to the Battelle Memorial Institute to provide a panel of independent experts to conduct a review of the Draft Feasibility Report concurrent with public and agency reviews. Comments to the Draft Report were

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provided by the IEPR panel in July 2014. Agency responses to these comments will be published in conjunction with the release of the project Chief's Report.

L. Future Project Schedule

The project designs, cost estimates and economic analyses presented in this report correlate with the following project milestone schedule:

NOV 2014 Feasibility Report Approval by the Civil Works Review Board

MAR 2014 Approval of the Report of the Chief of Engineers recommending the project to Congress for authorization *(tentative -- TBD)*

JUN 2015 Execution of Project Design Agreement with local sponsor and initiation of Pre-Construction Engineering and Design Phase (pending availability of design phase funding).

MAR 2017 Execution of the Project Partnership Agreement with the Local Sponsor (subject to Congressional project authorization and the availability of construction funding). Initiation of land and easement acquisition by the local sponsor.

APR 2018 Initiate project construction (5 year construction period)

DEC 2022 Complete project construction

Costs, economic analyses, and milestones are periodically reviewed during future project phases and reevaluated as needed based on actual project progress and status. Each construction contract package will be reviewed for value engineering to limit the potential for future project cost growth.

VII. Conclusions

The Recommended Plan reduces the risk of flooding for the Manhattan, Kansas, local protection project through improvements as presented in this Feasibility Report. In general, the Recommended Plan would implement modifications to improve the reliability and performance of the Manhattan, Kansas, levee unit against overtopping, structural, or geotechnical failure.

The Recommended Plan will provide a complete project that functions in a safe, viable, and reliable manner. It is not required as a result of changed conditions or inadequate maintenance. The Recommended Plan is generally limited to improvements to an existing civil works project and does not change the relative scope or function of the currently authorized project.

The Recommended Plan is the NED Plan and is economically justified. Design considerations include avoidance of environmental resources, cultural resources, and HTRW where possible.

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The Recommended Plan carries an associated increase in OMRR&R. The sponsor has sufficiency to provide all real estate requirements.

VIII. Recommendation

All items included in the Recommended Plan are necessary to continue providing the flood risk management benefits as intended by Congress. Federal implementation of the recommended project would be subject to the non-federal sponsor agreeing to comply with applicable federal laws and policies, including but not limited to:

a. Provide a minimum of 35 percent, but not to exceed 50 percent of total project costs as further specified below:

    1. Provide the required non-federal share of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

    2. Provide, during construction, a contribution of funds equal to 5 percent of total project costs;

    3. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the government to be required or to be necessary for the construction, operation, and maintenance of the project;

    4. Provide, during construction, any additional funds necessary to make its total contribution equal to at least 35 percent of total project costs;

b. Shall not use funds from other federal programs, including any non-federal contribution required as a matching share therefore, to meet any of the non-federal obligations for the project unless the federal agency providing the federal portion of such funds verifies in writing that expenditure of such funds for such purpose is authorized;

c. Not less than once each year, inform affected interests of the extent of protection afforded by the project;

d. Agree to participate in and comply with applicable federal floodplain management and flood insurance programs;

e. Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), which requires a non-federal interest to prepare a floodplain management plan within one year after the date of signing a project cooperation

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agreement, and to implement such plan not later than one year after completion of construction of the project;

f. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the project;

g. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the level of protection the project affords, hinder operation and maintenance of the project, or interfere with the project's proper function;

h. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

i. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, at no cost to the federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable federal and state laws and regulations and any specific directions prescribed by the federal government;

j. Give the federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

k. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

l. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to state and local governments at 32 Code of Federal Regulations (CFR) Section 33.20;

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m. Comply with all applicable federal and state laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a *et seq.*), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 *et seq.*) and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c *et seq.*);

n. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the federal government determines to be required for construction, operation, and maintenance of the project. However, for lands that the federal government determines to be subject to the navigation servitude, only the federal government shall perform such investigations unless the federal government provides the non-federal sponsor with prior specific written direction, in which case the non-federal sponsor shall perform such investigations in accordance with such written direction;

o. Assume, as between the federal government and the non-federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the federal government determines to be required for construction, operation, and maintenance of the project;

p. Agree, as between the federal government and the non-federal sponsor, that the non-federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA; and

q. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

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This recommendation is contingent upon such discretionary modifications as deemed necessary by the Chief of Engineers and funding requirements satisfactory to the Administration and Congress. The recommendations contained herein reflect the information available at the time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendation may be modified prior to implementation. However, the project partner, the States, interested federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Andrew D. Sexton (date)
Colonel, Corps of Engineers
District Commander

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