US Army Corps of Engineers®

Kansas Citys, Missouri and Kansas Flood Risk Management Project

FINAL FEASIBILITY REPORT

NOVEMBER 2013

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Kansas City District
Northwestern Division

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Kansas Citys, Kansas and Missouri
Flood Risk Management Project

Final Feasibility Report
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November 2013

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MAPS

Armourdale Unit
CID Unit

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[1] Due to the large number of pages in the Engineering Appendix it has not been included with this printed document. This appendix is available electronically.

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Executive Summary

The existing Kansas Citys, Missouri and Kansas, Flood Risk Management Project provides local flood risk management for the metropolitan areas of Kansas City, Missouri, and Kansas City, Kansas. The Kansas Citys project is a unit of the Missouri River basin comprehensive plan authorized and modified by the 1936, 1944, 1946, and 1954 Flood Control Acts. The last major modification to raise some of the levee units comprising the Kansas Citys Project was authorized in 1962.

The Kansas Citys project is authorized as seven levee units. This project extends over the lowest 10 miles of the Kansas River (at its confluence with the Missouri River) and a 20 mile reach of the Missouri River flanking the mouth of the Kansas River. These units act in concert to manage flood risks for an area of dense industrial and commercial development and minor areas of farmland all together covering about 32 square miles. Five of the seven units protect residential development. Communities within the study area include Kansas City, Missouri; North Kansas City, Missouri; Randolph, Missouri; Birmingham, Missouri; and Kansas City, Kansas.

Although the project is designed and functions as a coordinated system, its components are located on opposite banks of two major rivers within two states and various political jurisdictions. Thus, the seven levee units are operated and maintained independently by five non-federal sponsors. Most of the Federally constructed works date to the 1940's and 1950's. Significant Federal modifications to several units were accomplished in the 1970's. While this metropolitan flood risk management system is designated as a Federal project, it has long been turned over to the sponsors for operation and maintenance. The Corps of Engineers continues to conduct regular inspections and technical review of significant modifications to the system.

The entire metropolitan system of seven levee units withstood the Missouri River Flood of 1993, but some components were nearly overtopped or experienced underseepage issues. As a result, there was a concern that the levees may provide less than the intended design level of flood risk management. Section 216 of the 1970 Flood Control Act provides the authority to reexamine a completed civil works project and recommend modifications or improvements.

An Interim Feasibility Report, published in September 2006, recommended performance improvements in four of the units: Argentine, North Kansas City, Fairfax-Jersey Creek, and East Bottoms. The Interim Report concluded that no improvements were needed in the Birmingham Unit. This Final Feasibility Report addresses the remaining two levee units; the Armourdale and Central Industrial District Units. The study included a continual and extensive independent Agency Technical Review.

This report focuses on identifying, describing, and offering recommendations to improve identified performance weaknesses in the Armourdale and Central Industrial District Units by reducing the risk of flooding due to overtopping, underseepage, or structural failure. This study recommends raising the height of both the Armourdale and Central Industrial District Units reduce flooding risks and address the study objective of ensuring a uniform reliability across the metropolitan levee system consistent with the intent of the original authorizations. The desired reliability is achieved by establishing a new top of levee elevation using a flood profile

approximately 3 feet above the nominal 0.2% chance event (500-year) flood and is thus referred to as the 500+3 profile. Actual unit raises range between 0.2 and 5.2 feet depending on location.

In each unit, an array of methods is proposed to achieve the increase in unit height depending on the type and condition of the existing features and adjacent real estate and environmental concerns. Additional height increases the need for associated improvements and modifications to the geotechnical underseepage control features and appurtenant structural components and pump stations.

Individually and collectively, the Recommended Plan for the two units addressed in this Final Report is economically justified. These recommendations do not impact the status of the Interim Report recommendations. This report categorizes the identified weaknesses and the related solutions as reconstruction (a subcategory of new work), requiring new authorization.

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. Very minor mitigation is required to compensate for the loss of less than 1 acre of wetland. Hazardous waste and CERCLA issues are addressed within the recommended solutions. There is no real estate taking. The Environmental Impact Statement published with the Interim Feasibility Report documented the existing and expected future environmental conditions in all the levee units of the Kansas City system, including Armourdale and CID.

The total implementation cost of these measures is $316.7M (October 2012 price level) shared with the two non-Federal levee sponsors. The total annual benefits are $57.4M; annual costs are $18.4M and the net benefits are $39M. The resultant Benefit-Cost Ratio (BCR) is 3.1 to 1. The sponsors will receive credit for the cost of any necessary lands, easements, rights-of-way, relocations or disposal area (LERRD). The aggregate Federal share of the plan is $205.8M or 65% (percent) of the total cost and the sponsor share is $110.8M, or 35%. The sponsors will take ownership of project improvements and assume all operation, maintenance, repair and replacement costs of the completed works.

REVIEW OF COMPLETED PROJECT
KANSAS CITYS LEVEES, MISSOURI AND KANSAS
FINAL FEASIBILITY REPORT

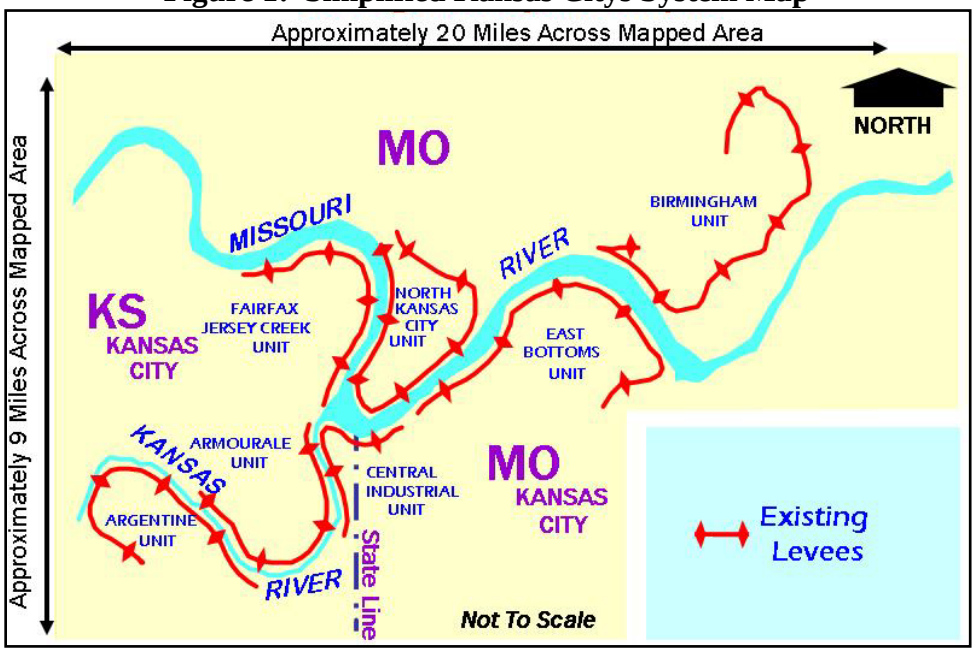
I. Introduction and Study Background

A. Introduction

The existing Kansas Citys Flood Risk Management Project provides local flood risk management benefits for the metropolitan areas of Kansas City, Missouri, and Kansas City, Kansas. The U.S. Army Corps of Engineers, Kansas City District, designed and constructed the system.

The Kansas Citys project is authorized as seven separate units along the Kansas and Missouri Rivers. Together these units provide flood risk management benefits to an area of dense industrial and commercial development, and minor cropland, altogether covering about 32 square miles. In addition, five of the seven units protect residential development. Figure 1 below provides a simplified graphic of the existing Kansas Citys system.

Figure 1: Simplified Kansas Citys System Map



While the project operates as a system, its components are located on opposite banks on two major rivers governed by multiple geo-political jurisdictions. Thus, the seven levee units are, for the most part, operated and maintained independently by five non-federal sponsors. While the metropolitan flood risk management system is designated as a Federal project, it has been turned over to the sponsors for nearly 50 years. The Corps of Engineers continues to conduct regular inspections and technical review of significant modifications to the system.

B. Reason for Study

The entire metropolitan system withstood the Missouri River Flood of 1993, but the general performance of the system was severely tested as the flood crest reached within one foot of overtopping at least one location. Not only were stages extreme, but durations were lengthy. Concerns arose about the reliability of the system to prevent overtopping and adequately handle underseepage. Further, there was a concern that the levees may provide less than the original authorized and intended level of performance.

The Kansas Citys metropolitan population and economy have grown significantly since the last system improvements were authorized in 1962. Much of the metropolitan economy is dependent on the areas within the levee system. Parts of the existing system are well over 60 years old. Project failure would endanger lives and create massive physical flood damages.

Both natural and man-induced geomorphologic changes have occurred since the last project authorization. Reservoirs have reduced some of the river systems' sediment load, and navigation structures have contributed to the Missouri River's cross-sectional adjustments.

In response to the performance observed in 1993, both Kansas City, Kansas, and Kansas City, Missouri, wrote letters to the Kansas City District expressing concern for the adequacy of the system. A Reconnaissance Report was prepared and published in August 1999 which found that there was a Federal interest in proceeding with a Feasibility Study. The Reconnaissance Report was approved by Corps of Engineers Headquarters in July 2000.

C. Feasibility Study Authority and Cost Sharing Agreement

Section 216 of the 1970 Flood Control Act 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 in September 2000 with the execution of a Feasibility Cost Sharing Agreement between the Corps of Engineers and the local non-Federal levee sponsors. The study is cost-shared 50% Federal and 50% non-Federal

D. Purpose and Scope of the Study

The purpose of the feasibility study effort is to review the existing conditions of the flood risk management system, identify potential weaknesses and areas of concerns, and analyze alternatives for potential improvements to increase the project performance and reduce the risk of flooding risk to local communities. The initial investigation of all seven units resulted in the identification of specific remedies and improvements that could be most readily analyzed and evaluated within budget and schedule constraints.

In order to enable the study of the overall system to progress in an efficient and orderly manner within available funding, the study was separated into Phase 1 and Phase 2 efforts in 2006. This two-step reporting process meant the complete feasibility study would generate two sets of recommendations.

At the time the phasing decision was made, hydrology and hydraulics modeling and analysis was complete for the entire system. However, structural and geotechnical analysis and calculations were not complete for all units. Those units wherein the analyses were complete were included in Phase 1, while those units for which the level of detail desired was not yet fully developed, or significant uncertainties remained, were included in Phase 2 of the study for further evaluation.

The Phase 1 study effort resulted in the Interim Feasibility Report (Interim Report), published in Aug 2006, which presented recommendations for the Argentine, North Kansas City, East Bottoms, and Fairfax-Jersey Creek Units. A fifth unit, the Birmingham Unit, was determined to meet the authorized level of performance assuming continued adequate operations and maintenance efforts. These recommendations were subsequently authorized by the Water Resources Development Act of 2007 and have proceeded with design and implementation.

The Phase 2 effort has resulted in this Final Feasibility Report (Final Report) which addresses the two remaining units: the Armourdale and Central Industrial District (CID) Units. This Final Report documents the existing conditions, evaluation of alternatives, and improvement recommendations for these two units. These recommendations are intended for authorization and implementation under a separate authorization schedule following the approval of this report. Historical and reference information on the entire system is provided in this report where needed for context and continuity. For additional details on the other units of the system, please refer to the Interim Report.

Moving to this two-phased approach to authorization and implementation had several advantages, among which was the ability to better handle the large magnitude of the overall study area and the numerous features under study. It also better adapted the study and implementation schedules to a more manageable Federal (and non-Federal) funding stream.

The Interim and Final Reports are complementary efforts that view the Kansas Citys project as one complete system.

E. Study Area

The overall feasibility study effort addresses the areas within the existing seven units of the Kansas Citys system and directly affected adjacent areas. These areas include all or portions of the communities of Kansas City, Missouri; North Kansas City, Missouri, Randolph Missouri, Birmingham, Missouri, and Kansas City, Kansas.

Within this Final Feasibility Report, the terms “study area” and “project area” refer only to the Armourdale and CID units, unless specifically noted otherwise.

F. Non-Federal Sponsors

The Phase 2 study has been conducted in conjunction with two sponsors: the Kaw Valley Drainage District and the City of Kansas City, Missouri. The Kaw Valley Drainage District (KVDD) is the owner-operator of the Armourdale Unit and the Kansas Section of the CID Unit. The City of Kansas City, MO (KCMO) is the owner-operator of the Missouri Section of the CID Unit.

G. Relevant Prior Studies and Reports

The Corps of Engineers projects covered discussed have been authorized by specific legislation, as documented in the reports of Congress, and have been implemented through a series of definite project reports (DPR's), design memorandums (DM's), and operations and maintenance (O&M) manuals. Following original project implementation, multiple report and studies have been prepared and published at various times including reservoir regulations, post-flood assessments, river hydrology updates, and flood plain hazard evaluations. These documents are too numerous to list. Information and data contained in these prior reports was reviewed for relevance to this study effort.

H. Project History

The existing Kansas Citys project was created and subsequently modified by the Flood Control Acts authorized in 1936, 1944, 1946, 1954, and 1962. Following the 1936 Flood Control Act, construction of the first Federal levees began around 1940. The original Federal construction included some incorporation of, and improvements to, previously existing local levees. Much of the authorized system was nearing completion at the time of the 1951 Kansas River Flood. In this catastrophic flood, the Argentine, Armourdale, CID, and Fairfax levees were overtopped and heavily damaged. Based on this experience, Congress later authorized the Kansas River basin reservoir system in the 1954 Flood Control Act.

The Kansas Citys system, especially along the Kansas River, was re-examined during the post-1951 period as the Kansas River basin reservoirs were being designed and constructed. This led to a major modification (raise) of the Armourdale, Argentine, and CID Units authorized by Public Law 87-874 on October 23, 1962 (the “1962 modification”). Construction of these modifications began in 1971.

The modified design of the Kansas Citys project, including the authorized design discharges for the Kansas River levee units, was predicated on construction and operation of the Kansas River Basin system of reservoirs as authorized in 1954. Most of the lakes in that system are in place and operating, but three of the smaller originally authorized lakes in the system (Woodbine, Grove and Onaga) were not built.

II. Existing Project Conditions and Flood History

A. Existing Project Descriptions

The existing protective works consist principally of levees, floodwalls, bridge and approach alterations, and some limited channel improvement and alteration. The project extends over the lower 10 miles of the Kansas River and on the Missouri River from 6.5 miles upstream to 12.5 miles downstream of the mouth of the Kansas River. The 32-square-mile study area includes the heavily industrialized floodplains of the two rivers. Complete effectiveness of the overall project is contingent on adequate reservoir control in the upper Missouri and Kansas River basins.

Each unit was designed and constructed to successfully pass a specified river discharge. Discharge and level of performance is a complex issue for this system due to the confluence of the Kansas River with the Missouri River occurring within the study area, and given that each river has an independent runoff basin. Additional details relating to design hydraulics are provided later in the report.

1.0 Armourdale Levee Unit

The Armourdale Unit is located in Wyandotte County Kansas, along the left bank of the Kansas River from mile 7 (Mattoon Creek) to mile 0.3, near the confluence of the Kansas and Missouri Rivers. Prior to the Federal project, levees and floodwalls were constructed by the Kaw Valley Drainage District. These original works were modified and expanded in the initial Federal projects. Construction of the Federal project began in 1949 and was completed in 1951. More recent improvements, separately authorized under the 1962 Modification, were completed in 1976. The levees and floodwalls of the Armourdale Unit are currently authorized to pass a maximum Kansas River flow of 390,000 cfs coincident with a Missouri River flow of up to 220,000 cfs.

The primary components of the unit consist of earthen levees, floodwalls, riprap and toe protection on riverward slopes of levees, toe drains along the concrete floodwalls, sandbag gaps, stoplog gaps, drainage structures, relief wells and pumping plants. The floodwalls, in two reaches, vary from 11 to 17 feet high and total approximately 6,200 feet. The levees, in three reaches, vary from 4 to 17 feet high and total about 5.3 miles.
Existing underseepage control features include approximately 13,400 LF of riverside impervious fill cutoffs, 1,550 LF of landward underseepage berm, and 39 relief wells with collector systems in several reaches. Additional detail of these features is provided in Appendix A, Chapter 4.
The unit begins with a stoplog gap across the Union Pacific (UP) Railroad which creates a tieback from high ground west of Mattoon Creek. The first levee section heads downstream

approximately 1.28 miles along the left bank of the Kansas River, incorporating a portion of the UP embankment near the mouth of Mattoon Creek, and ends just north of the West Kansas Avenue Bridge. The first section of floodwall then extends downstream approximately 1,740 feet, ending just south of the Osage Pump Station. The second section of levee continues downstream approximately 3.3 miles to a point downstream (north) of the Chicago, Rock Island and Pacific (CRI&P) railroad bridge. This section contains one stoplog gap at the Kansas City Terminal (KCT) railroad bridge, five pumping stations, and a short reach of floodwall at the East Kansas Avenue Bridge. The second major reach of floodwall continues downstream another 4,493 feet to connect with the final levee section downstream of the Central Avenue Bridge. This section contains two sandbag gaps at the UP and Missouri Pacific (MO Pac) railroad bridges, and two pumping stations. The final levee section extends another 4,156 feet and ties back into high ground at the embankment of the Lewis and Clark Viaduct.

2.0. Central Industrial District (CID) Levee Unit

Although the CID Unit is one continuous levee unit, it crosses the Kansas and Missouri State Line and is subsequently operated and managed as two separate and distinct sections: the CID-Kansas section, and the CID-Missouri section.

The CID-Kansas Section (CID-KS), is located in Wyandotte County, Kansas, and extends along the right bank of the Kansas River from mile 3.4 to the mouth, then downstream along the right bank of the Missouri River to the State Line. This section was originally developed by the Kaw Valley Drainage District, and initial Federal improvements began construction in 1948. Most of the Federal improvements, including repairs to damages from the 1951 Flood, were completed by 1955. The most recent improvements authorized under the 1962 Modification were completed in 1979. The CID-KS section is authorized to pass a Kansas River discharge of 390,000 cfs coincident with a Missouri River flow of 220,000 cfs.

The unit consists of two levee reaches, three floodwall reaches, riprap and levee toe protection, a surfaced levee crown and ramps, a stoplog gap, a sandbag gap, eight pumping stations, drainage structures, and relief wells. The levees total approximately 1.7 miles long and the floodwalls about 7,900 feet. The section varies from zero to 14.5 feet high.

Existing underseepage control features in CID-KS includes a buried collector system, approximately 1,800 LF of area fill, and 19 relief wells with collector system. Additional details of these features are provided in Appendix A, Chapter 4.

The CID-Missouri section (CID-MO) is located in Kansas City, Jackson County, Missouri. This section extends along the right bank of the Missouri River (river mile 365.7) to the Kansas-Missouri state line (river mile 367.2). The initial construction began in 1946. Significant improvements and repair of 1951 Flood damage followed the initial construction and were completed in 1955. The CID-MO section is designed to pass a Missouri River flow of 540,000 cfs.

The CID-MO section consists of levee, floodwalls, a levee drainage system and pumping plants, sandbag and stoplog gaps, toe and bank protection, and slope protection on the riverward slope. The floodwalls total 1.5 miles and the levee is about 430 feet.

B. Construction History and Design Discharge

Table 1 provides a summary of the major periods of construction and the current design discharge conveyance targets for each of the units in the project.

Table 1
Summary of Levee Unit Construction History and Design Discharge

Levee Unit	Initial Federal Project Completed (year)	Last Federal Modification (year)	River	Original Design Discharge (cfs)
Armourdale	1951	1976	Kansas	390,000
CID, Kansas	1948	1979	Kansas	390,000
CID, Missouri	1947	1955	Missouri	540,000

1.0 Inventory of Existing Levee Features

An inventory and listing of all existing levee features was developed early in the feasibility study, providing detailed levee feature information and a listing of all significant components that comprise the Kansas Citys system. The inventory for all units of the system was published in the Interim Report, Engineering Appendix, Chapter A-1. Specifically, the Armourdale inventory is found in Exhibit A-1.2, and the CID Kansas and Missouri inventories are found in Exhibits A-1.4 and A-1.5, respectively. In the interest of space, these exhibits are not reproduced in this report and are considered included by reference.

2.0 Project Operations, Maintenance and Inspections

The individual units of the Kansas Citys flood risk management system were turned over to the levee unit sponsors following each construction effort. Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R) of the units and features is accomplished by the respective sponsors and annually inspected by the Kansas City District. The primary responsibilities for sponsors of Federal flood risk management projects 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. Also providing guidelines regarding operations and maintenance requirements is Engineering Regulation (ER) 1130-2-530 (Project Operation).

An Operation and Maintenance Manual for each levee unit addresses project specific sponsor responsibilities and contains the full text of Title 33. The sponsors all have operating staff that are familiar with the details of effective maintenance practices. Each 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.

3.0 Major Maintenance & Repair History

Major (and minor) maintenance and repair is conducted by the sponsors on an as needed basis. The specific projects undertaken by the sponsors over the long history of the system are too numerous to list here. Generally, this type of work includes, but is not limited to:

- Periodic and ongoing relief well testing, cleaning, replacement, and rehabilitation.
- Repair of erosion and replacement of stone-fill levee slope protection.
- Repair of outlet structures and outlet channels.
- Sluice gate and pump rehabilitations, pump station repairs and modernization, and pump station outfall repairs.

No major maintenance is needed at this time to satisfy the sponsor's requirements and responsibilities for a fully maintained project.

4.0 Emergency Work and Modifications

Both levee units have continuously met the requirements for eligibility for the Public Law 84-99 emergency assistance program since at least 1992. Corps of Engineers inspections indicate that the levees have been maintained to a high standard. The levee sponsors have responded to maintenance requirements in a timely and adequate manner throughout the life of the Kansas Citys project. The Corps of Engineers has reviewed inspection reports since 1992 and concluded that only occasionally does a defect linger from one year to the next and nearly every maintenance recommendation is addressed within 2 years.

5.0 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 underseepage control is now identified as a greater concern than it may have been in the past. This also has created a greater emphasis on the proper maintenance of existing and proposed underseepage control systems.

For this Kansas Citys study, an investigation was undertaken to determine whether any special foundation or other conditions exist that may create any extraordinary OMRR&R needs for the underseepage facilities. To help in that determination, the feasibility study undertook a review of the status of regular relief well testing and the maintenance efforts needed to maintain well capability by the sponsors. This review did not identify any special or unusual foundation conditions that would place design of wells or pumping facilities outside the scope of normal sound engineering practice. The well testing schedule and maintenance practices are variable among the levee units. The sponsors have adequately accomplished well maintenance and/or replacement as indicated by their associated test results. Some of the remedies identified in this Final Report address existing well systems. This is primarily due to changes in land use and drainage within the study area since original project implementation and not a result of poor well performance.

Table 2 summarizes the relief well testing programs for the levee units under consideration in this report.

Table 2
Pressure Relief Well Testing and Performance

Unit	General Description of Relief Well Systems	Last Tested	Overall Condition of Well Systems & Testing Schedule for Testing
Armourdale Unit	43 pressure relief wells at the toe of the levee -- various locations along line of protection	2010	Adequate. Regularly test 10 wells every 5 years
Central Industrial District Unit	10 pressure relief wells at the toe of the levee -- various locations along line of protection	2010	Adequate. Regularly test 10 wells every 5 years

C. Flood History

1.0 Kansas River Flood Events

Major floods on the Kansas River are usually caused by a series of short duration, high intensity storms following a prolonged period of general widespread precipitation. Table 3 lists the five largest annual discharges and associated stage peaks at the United States Geological Survey (USGS) gage on the Kansas River at Topeka, Kansas. The period of record for this gage is from 1904 to the present, though intermittent and anecdotal information is available from 1869. The USGS gage (06889000) is located on the Sardou Bridge, river mile 83.1. There are several gages on the Kansas River closer to Kansas City (Lawrence, Turner Bridge, 23rd Street); however, historical discharge data is not available for all locations.

Table 3
Kansas River at Topeka Flood History

Year	Discharge (cfs)	Stage (ft)
July 1951	469,000	40.80
May 1903	300,000 (est.)	NA
August 1908	200,000	33.0
July 1993	170,000	34.97
June 1935	154,000	32.7

Flood Stage at Topeka is 26 feet.

2.0 Missouri River Flood Events

Floods on the Missouri River are caused by widespread storm systems over several days or weeks, sometimes combined with runoff of spring snowmelt in Wyoming, Montana, and the Dakotas. Table 4 lists the five largest annual discharges and associated stage peaks at the USGS

gage on the Hannibal Bridge, just downstream of the Kansas/Missouri confluence. The period of record for stage data at this gage is from 1873 to the present. The period of record for flow data at this gage is from 1929 to present. The highest discharge was recorded in 1951, while the highest stage peak was seen in 1993. This reflects the dynamic nature of differing flood events and the river's response to natural and man-made alternations over time.

Table 4
Missouri River at Kansas City Flood History

Year	Discharge (cfs)	Stage (ft)
1951	573,000	46.2
1903	543,000 (est.)	45.0
1993	541,000	48.87
1908	402,000 (est.)	40.3
1952	400,000	40.6

Flood Stage at Kansas City is 32 ft.

3.0 Historical Flood Events and Damages

Floods in the Missouri and Kansas River Basins are of comparatively low velocity and of several days duration. Flow data at the USGS gage on the Hannibal Bridge is available for the period 1929 to present. Before 1929 the major flood events in the Kansas Citys area occurred in 1844 (17.0 feet above flood stage), 1881 (6.8 feet above), 1903 (14.0 feet above), and 1908 (9.3 feet above). While no recorded flow information is available, the 1844 event is considered the greatest known event in the lower Missouri Basin.

In the 1903 Flood, 19 lives were lost in the Kansas Citys area, and an estimated $23,000,000 (1903 prices) in property damages was sustained. The flood of 1903 had an estimated Missouri River discharge of 543,000 cubic feet per second (cfs). The 1903 Flood gave rise to the first well-organized local efforts at major flood risk management works in the Kansas Citys area. These very old local works provided some initial line of protection layouts and features that were subsequently adapted, added to, strengthened and raised under the subsequent Federal project.

a. The 1951 Flood

The 1951 Flood exceeds all other recorded flood events at Kansas City with a discharge of 573,000 cfs on the Missouri River and 469,000 cfs on the Kansas River. A two-month period of above-normal precipitation followed by intense rains over a 72-hour period in early July caused the flooding.

Beginning on Friday July 13, 1951, a sequence of catastrophic overtopping events played out across several of the units existing at that time. Kansas River floodwaters first overtopped the Argentine Unit, then Armourdale and CID. Floodwaters eventually poured through the West Bottoms area and exited into the Missouri River by overtopping and breaching the CID-Missouri segment of levee near the old Kansas City Missouri Municipal Wharf. Packing plants were flooded and railroad transportation was halted due to the flooding with severe damage to tracks,

rail cars, and rail yards. The flood filled the units with water depths of 15 to 30 feet. Exhibit #2 is a photograph of the 1951 Flood along the Kansas River in Kansas City.

After devastating the three Kansas River units, the floods then threatened the intact levees located opposite and upstream of the Kansas and Missouri River confluence area. Floodwaters eventually breached a section of levee near Jersey Creek and flowed into the Fairfax District the following morning. At the peak of the flood, the Kansas River stretched from the Armourdale bluff to the Argentine bluff, with very few structures reaching above the floodwater. Of the five levee districts near the Kansas and Missouri Rivers confluence, only North Kansas City was completely saved. Altogether about 11 square miles were flooded in the metropolitan Kansas Citys area. At least 5 persons died, and about 15,000 people were evacuated. Many residents were left homeless. The flood caused a reported $425 to $870 million (1951 price level), or in 2013 terms between $7.3 billion and $9 billion in damages within the study area alone.

b. The 1993 Flood

The 1993 Flood event crested at 48.9 feet (Hannibal Bridge gage reading) on July 27, 1993, with a Missouri River discharge of 543,000 cfs. Although this discharge was less than the 1951 flood (peak 573,000 cfs), the 1993 crest of 48.9 feet exceeded the 1951 crest stage of 46.2 feet. This is likely due to changes in the river channel in the intervening years and different dynamics of Kansas vs. Missouri river flooding, upstream levee breaches, etc. All the levees in the Kansas Citys project held, although some units saw floodwaters near the top of levees, and underseepage problems were evident in several units. Several of the levees sustained some line-of-protection damages and were subsequently repaired.

An estimated $4.57 billion (1993-1994 price level) in damages were prevented by the Kansas Citys flood risk management project (The Great Flood of 1993, Post-Flood Report, U.S. Army Corps of Engineers, Sept 1994). Even though all levees in the Kansas Citys project held, some flood associated damages were sustained within the protected area; likely due to indirect (seep water) or local tributary flooding. Damages to Kansas City, Kansas utilities reached several million dollars. Kansas City, Missouri reported more than $15 million in damage to public infrastructure. Kemper Arena and the American Royal Building suffered about $2.5 million in water damage to flooring and electrical circuits. The downtown airport sustained damages of nearly $3 million, and pollution control and public works facilities sustained an estimated $8 million in damage. Exhibit #3 shows the Missouri River hydrograph for the 1993 Flood.

c. Recent Flood Events

Several flood events occurred during the course of this study that were significant to the Missouri River Basin, even though they did not directly impact the Kansas Citys System. Events in 2007, 2010, and 2011 caused overtopping breaches and loaded levee systems both up and downstream of Kansas City, but did not create significant concern locally. The peak discharges for these three Missouri River events at Kansas City were 286,000 cfs, 212,000 cfs, and 245,000 cfs, respectively. The 2011 event is particularly notable due to the prolonged duration of the event, 145 days; a result of record discharges from the upstream basin reservoir system.

D. Authorized Project Design Hydraulics

The original authorized design discharges are contained in the October 31, 1936 report titled "Missouri & Kansas Rivers, Kansas Citys, Flood Control Project, Project Report." The report relates that the project should accommodate a probable maximum flow in the Kansas River of 370,000 cfs, and a combined flow of the Missouri and Kansas Rivers of 630,000 cfs. However, the construction plans for the levee units indicate 540,000 as the design discharge for units downstream of the confluence, 460,000 cfs for Missouri River units upstream of the confluence, and 390,000 for Kansas River units. The larger combined design discharge of 630,000 cfs was never subsequently adopted into the units' construction history.

The design discharges depended on assumptions about the center of storm events. The following excerpt was taken from House Document No. 342 (Congress 1943): "With an excessive storm centered principally over the Kansas River basin, the design-flood discharge at the Kansas Citys would be 170,000 cfs from the Kansas River and 330,000 cfs from the upper Missouri River, or a total of 500,000 cfs. Conversely, with an excessive storm centered principally over the Missouri River basin, the design flood discharges would be 80,000 cfs from the Kansas River and 460,000 cfs from the upper Missouri River, or a total of 540,000 cfs."

After the catastrophic 1951 Flood, the Kansas River levee units were reauthorized to pass higher design discharges. Table 5 shows the increased design discharges along with coincident Missouri River discharges. However, the Missouri River levees downstream of the confluence were not improved as a result of the 1951 Flood event, even though the 1951 Flood discharge exceeded the original design discharge of these units.

Table 5
Revised Design Discharges for the Kansas River Levees ("1962 Mod")

Levee Unit	Kansas River Authorized Design Discharge (cfs)	Missouri River Coincident Discharge (cfs)	
		u/s of Kansas River	d/s of Kansas River
Armourdale	*390,000	220,000	610,000
CID (Kansas)	*390,000	220,000	610,000
Argentine	*390,000	220,000	610,000

Notes: u/s = upstream; d/s = downstream

In general, the "1962 Mod" discharges were used to develop higher design water surface profiles for levee raises in the affected units. The final elevation of the levee was determined by taking the design water surface profile and adding freeboard. The levee units were authorized to pass specified discharges on the Kansas and Missouri Rivers with either 2 or 3 feet of freeboard. The other units along the Missouri River have a design level of performance as authorized in 1944. Subsequently, the Liberty Bend Cutoff was constructed along the Missouri River in the 1950's and aided in overall conveyance of flood discharges through the Kansas Citys reach.

1.0 Effects of Kansas River Basin Reservoir System

A multi-purpose system of reservoirs in 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. The seven Corps lakes are large enough and close enough to the Kansas City area to have a major effect on flows passing through the Kansas City system.

This system was authorized, in part, to act in concert with the system of Federal levees in Kansas City and other areas to reduce flood damages in the areas protected by the levees (the levees in the Kansas City area had been previously authorized). Modifications to this original 1944 lakes authorization have appeared in subsequent Flood Control Acts, but the basic objective of providing a coordinated flood risk management system on the Kansas River, as outlined in the 1944 Act, has been preserved. The Kansas City District operates these reservoirs in compliance with the original intent of that Act.

2.0 Effects of Missouri River Basin Reservoir System

There are six major Federal lakes/reservoirs on the main stem of the Missouri River in the Dakotas and Montana. The reservoir furthest downstream is Gavins Point in southern South Dakota, which is about 440 river miles upstream of the Kansas City area. This system of reservoirs provides flood risk management benefits all along the Missouri River, but the system does not operate specifically for the Kansas City area. Any release at Gavins Point undergoes a five day travel lag before arrival of that water at Kansas City. The Kansas River levee units can be indirectly impacted by Missouri River reservoir operations when considering Missouri River backwater effects and the possibility of coincident flooding scenarios.

3.0 Recent Evaluations of Reservoir Effects

Following the flood of July 1993, the Corps of Engineers undertook a major reevaluation of the flow frequency of the upper Mississippi, Missouri and lower Illinois Rivers. The resulting Upper Mississippi River System Flow Frequency Study (UMRFFS) constituted an update of the previous flow frequency estimates then in use for these rivers. On the Missouri River, the old (previous) flow estimates were completed and published in 1962. The UMRFFS study provided revised flow frequency estimates and revised flood profiles. The results of the UMRFFS study were incorporated into this feasibility study.

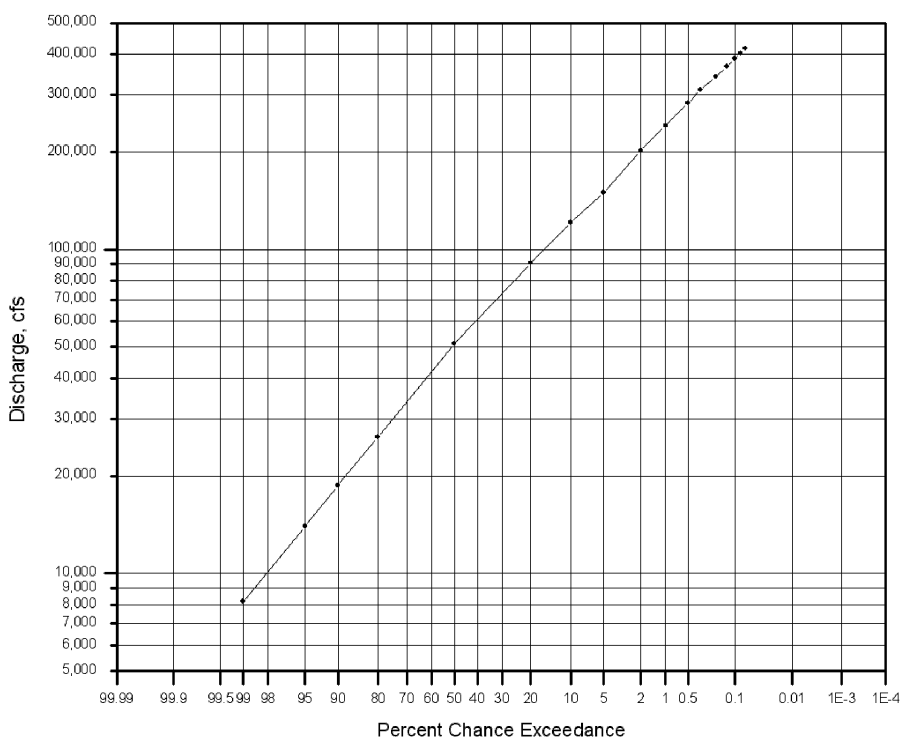
Because it was necessary to fully evaluate the operations of the Kansas River basin reservoir system as part of the UMRFFS study, updated flow information was also generated for the Kansas River. This information was then incorporated into an update of the flow frequency estimates for the Kansas River from its mouth to Manhattan, Kansas. These revised flow frequency estimates have been incorporated into this feasibility study. Table 6 summarizes the regulated flow frequency estimates as applicable to the Kansas Citys study.

Table 6
Study Area Flow Frequency Data
(Upper Mississippi River System Flow Frequency Study, 2001; and the Kansas River Hydrology Report, 2002)

Frequency in Annual Percent Chance of Exceedance	Missouri River Downstream of Blue River (cfs)	Missouri River Downstream of Kansas River (cfs)	Missouri River Upstream of Kansas River (cfs)	Kansas River at Mouth (cfs)
0.2	537,000	530,000	358,000	341,000
0.5	459,000	454,000	316,000	283,000
1	405,000	401,000	287,000	241,000
2	354,000	351,000	257,000	202,000
5	292,000	289,000	220,000	150,000
10	247,000	245,000	192,000	121,000
20	203,000	201,000	162,000	90,700
50	143,000	142,000	120,000	51,200
80	104,000	103,000	89,500	26,400
90	89,100	88,300	77,200	18,700
95	78,800	78,100	68,500	14,000
99	63,400	62,900	55,100	8,200

The Kansas River data from the table above is presented graphically in the following figure.

Figure 2
Discharge-Frequency Curve – Kansas River at Mouth



Discharges developed from recent studies have been used to establish the existing conditions flow frequency data used in this study. Since flood events above the 0.2% chance of exceedance (500-year) event need to be considered in this study, the discharge-frequency curves were extended up to the 0.067% chance of exceedance (1,500-year) flood event. Table 7 summarizes all of the discharges developed for use in this study.

Table 7
Summary of Flood Discharges Used in this Study

Frequency in Percent Chance of Exceedance	Missouri River Downstream of Blue River (cfs)	Missouri River Downstream of Kansas River (cfs)	Missouri River Upstream of Kansas River (cfs)	Kansas River at Mouth (cfs)
0.067%	637,000	625,000	414,000	417,000
0.080%	621,000	610,000	403,000	403,000
0.100%	600,000	590,000	390,000	388,000
0.133%	573,000	565,000	377,000	367,000
0.200%	537,000	530,000	358,000	341,000
0.500%	459,000	454,000	316,000	283,000
1.000%	405,000	401,000	287,000	241,000
10.000%	247,000	245,000	192,000	121,200

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 authorized levee design.

The basis for the hydraulic analysis was the development of an existing conditions HEC-RAS model. 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 cross-section data and bridge data. Once the model was calibrated, a series of steady flow water surface profiles was created based on flood discharges previously discussed.

Once the model was calibrated, existing conditions water surface profiles were generated for the 10% (10-year), 1% (100-year), 0.5% (200-year), 0.2% (500-year), 0.13% (750-year), 0.1% (1,000-year), 0.08% (1,250-year), and 0.067% (1,500-year) chance of exceedance flood events. Details of the modeling are found in the Hydrology and Hydraulics Chapter of the Engineering Appendix.

E. Economic Conditions & Inventory Overview

The economic analysis identifies the economic impact from flooding for the existing project and, on a comparable basis, evaluates the array of study alternatives for increasing the project performance. The economic analysis first developed a risk-based analysis of the flood problem under the existing condition (existing levees and floodwalls). Development of future without project condition followed the existing conditions. Finally, a similar risk-based evaluation was prepared for with-project alternatives in terms of benefits, costs, and performance. Refinements and some interactions of the existing conditions and the future without project conditions were accomplished as new information surfaced. The analysis encompasses all flood-prone properties within the study area.

For purposes of the study, each levee unit protected area was designated as a separate study reach. The CID Unit, located near the confluence of the Missouri and Kansas Rivers, can be directly impacted by both Missouri River and Kansas River flooding. Table 8 lists the study reaches, their river mile (R.M.) boundaries and the designated index point location for each reach. In accordance with standard Corps of Engineers practice, the reach index point is used as a common location to aggregate the stage-damage relationships for the different categories of investment.

Table 8
Study Reaches Used in HEC-FDA Analysis

Damage Reach Name	Beginning Station (R.M.)	Ending Station (R.M.)	Bank	Index Location Station (R.M.)
Armourdale	KS R. 0.6	KS R. 7.7	Left	KS R. 5.2
CID-MO	MO R. 365.8	MO R. 370.7	Right	MO R. 368.8
CID-KS	KS R. 0.0	KS R. 3.0	Right	KS R. 1.4

1.0 Economic Characteristics of the Study Area

The overall existing project protects highly developed urban portions of the Kansas City metropolitan area. The protected areas encompass a major segment of the Kansas Citys' economy. Flood disruptions to this area would strongly impact the local, regional, and national economy.

a. General Economy

The Kansas City metropolitan area has a diverse and varied economic base. As a centrally located market, it is a major warehouse and distribution center and a leading agribusiness center. It ranks first in the nation as a farm distribution center and as a market for hard wheat. In addition to its agribusiness activities, the metropolitan area has major industrial activities such as auto and truck assembly, steel and metal fabrication, and food processing. The metropolitan area also fosters a growing non-manufacturing sector. Wholesale and retail industries and service organizations are now chief employers in the area.

b. Transportation

The metropolitan area has a network of interstates and major highways that provides excellent access to each of the levee units.

- The CID Unit is accessed by means of I-70, I-35, and by I-670 which crosses over the middle of the protected area.
- The Armourdale Unit is served by U.S. 69, U.S. 169, and I-70.
- Major rail service infrastructure is present in each of the units.

2.0 General Socioeconomic Characteristics

Census 2010 data for 111 census tracts were compiled to describe the socioeconomic characteristics of each levee unit area as well as for the overall study area. Census 2010 data were also compiled for counties in the study area and for the Kansas City (Missouri and Kansas) Metropolitan Statistical Area (KC MSA). Although census tracts cover areas that may typically be somewhat larger than the area protected by a levee unit, the census tract data is considered to be generally representative of the protected area.

a. Study Area Population, Household and Employment

Table 9 displays estimates of population, employment and housing for the census tracts covering each levee unit and the study area as a whole.

Table 9
Estimates of Population, Employment and Housing

Unit	Population	Employment	Housing Units
Armourdale Unit	2,924	6,700	1,025
CID (MO&KS) Unit	1,730	7,494	1,110
Study Area Total	**4,654**	**14,194**	**2,135**

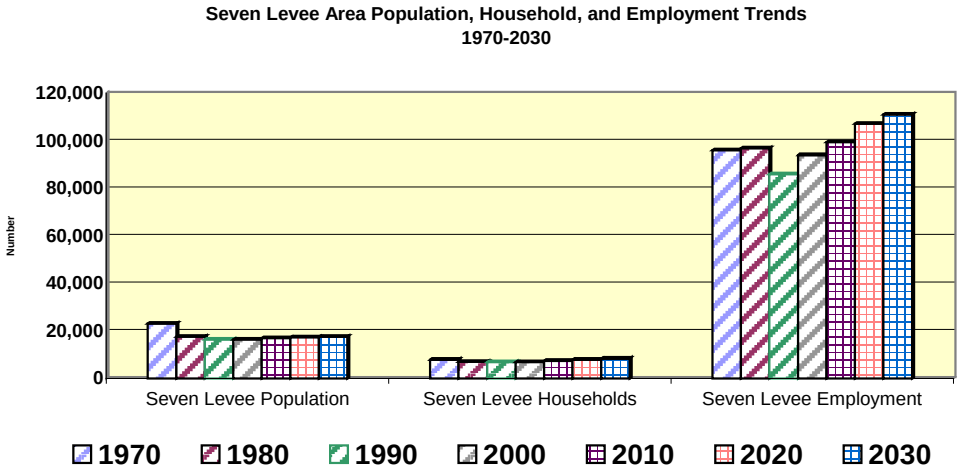
Source: Census 2010.

Census data, 1970 to 2000, and Mid-America Regional Council (MARC) forecasts, 2010 to 2030, for the census tracts in the study area were used to describe general trends in population, households and employment. MARC is the metropolitan planning organization for the bi-state Kansas City region. In 1970 the areas within the metropolitan flood risk management system had total population of 23,124 persons and 7,952 households. Between 1970 and 1990, the total population and number of households in the study area declined. This trend in the study area was reflective of the national trend that occurred in the 1970's and 1980's when there were population shifts to areas outside of central city areas. After 1990 the population and number of households began to stabilize and by 2000 had increased to 19,818 persons and 8,180 households in the overall system study area.

Fluctuations also occurred in the system-wide study area employment, with an overall decline from a 1970 level of 96,069 to 85,949 by 1990 and then increasing by the year 2000 to a level of 94,035. Based on MARC forecast data for the period 2000 to 2030, total employment in the system-wide study area is expected to increase steadily. Population and number of households in

the area are expected to experience steady but modest growth. The figure below displays the general trends in population, households and employment 1970 to 2030 for the entire study area.

Figure 3
Kansas Citys System Study Area Population, Households and Employment Trends



b. Study Area Investment

Total investment within the metropolitan system estimated at **$21.9 Billion** dollars (Oct 212 price levels) 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 in the study area is estimated at $8.3 billion. Businesses and residences have roughly a $13.7 billion investment in contents. Business contents include inventory, office equipment, computers, production equipment and machinery, and other miscellaneous contents. Table 10 shows both the Final and Interim Report study area values for comparison. Table 11 presents the investment breakdown for the Kansas River portion of the overall metropolitan system.

Table 10
Overall Investment Summary
(Oct 2012 prices, rounded and shown without uncertainties)

Levee Units – Basis for Totals	Total Investment	Total Value of Structures	Total Value of Contents
Units Addressed by Final Study (Armourdale and CID)	$5,377,340,000	$2,309,040,000	$3,068,300,000
Units Addressed by Interim Study (Argentine, E Bottoms, NKC, Birmingham, Fairfax-Jersey Creek)	$16,555,600,000	$5,962,300,000	$10,593,300,000
Total System	**$21,932,940,000**	**$8,271,340,000**	**$13,661,600,000**

Table 11
Kansas River Study Area Investment for Structure and Content
(Oct 2012 prices, rounded)

Levee Unit	*Number of Structures*	Total Investment	Total Value of Structures	Total Value of Contents
Argentine	*723*	$ 3,053,000,000	$ 775,000,000	$ 2,278,000,000
Armourdale	*1,468*	$ 2,561,850,000	$ 1,241,370,000	$ 1,320,480,000
CID	*526*	$ 2,815,490,000	$ 1,067,670,000	$ 1,747,820,000
Total	***2,717***	**$ 8,430,340,000**	**$ 3,084,040,000**	**$ 5,346,300,000**

F. Overview of Existing Environmental and Cultural Resources

In accordance with 40 CFR 1500, the Environmental Impact Statement (EIS) previously published with the Interim Feasibility Report addressed all seven units of the Kansas Citys system. Projections of the tentatively preferred alternatives were used in the Armourdale and CID Units where firm detailed conclusions were not yet available. Details of the existing and future environmental conditions and considerations are found in the EIS.

The study area is predominantly urban and highly industrialized. Limited habitat, past disturbances, and dense development has limited the variety of fish and wildlife. However, many species commonly found within a Midwest U.S. urban setting are present. Wildlife populations are lowest in the central core of the study area and increase on the outer edge. Many common species of mammals, birds, reptiles, and amphibians use the habitat riverward of the existing levees. Cultural resources are limited due to deep depositional burial or natural transport processes arising from the rivers, as well as the past and present industrialized nature of the study area.

1.0 Threatened or Endangered Species

Four Federally-listed threatened or endangered species are dependent on the Missouri and Kansas Rivers and their floodplains in the study area.

The bald eagle (*Haliaeetus leucocephalus*), Federally protected, migrates through and temporarily over-winters near large water bodies in or near the study area. The piping plover (*Charadius melodus*), Federally-listed as threatened, is a seasonal spring and fall migrant through portions of Kansas and Missouri along the Kansas and Missouri Rivers, with nesting on the Kansas. Plovers are associated with unvegetated shorelines, sandbars, and mudflats. The Federally-endangered least tern (*Sterna antillarum*) utilizes similar unvegetated wetland habitat, as do the piping plovers in the same geographic regions of Kansas and Missouri. The pallid sturgeon (*Scaphirhynchus albus*) is a moderately large, bottom-dwelling, Federally-endangered fish species that may occur in low numbers in portions of the Missouri River and lower Kansas River. It is believed to require sandbars, chutes, and backwater areas for reproduction.

2.0 Wetlands

Few wetlands remain within the interior of most units. Wetland locations, classifications, and acreages were determined by overlaying study area maps with National Wetlands Inventory (NWI) maps. NWI maps are generally used as a reference for locating existing wetlands. Reconnaissance surveys and a field delineation were conducted to verify the presence or absence of NWI wetlands and any additional wetlands that might be observed. Impact determination and mitigation planning followed during plan formulation. Due to development within the project area, much wetland acreage has been converted into impervious surface since the 1980s NWI mapping in this region.

Feasibility evaluations found no wetlands within the Armourdale or CID Units. One small wetland area is located within the proposed borrow area.

3.0 Cumulative Effects

Although this study involves the evaluation of the existing Kansas Citys levee system, any Federal activity that affects the overall aquatic ecosystem of the Kansas and Missouri Rivers has typically been an area of concern for the resource agencies in this region. The Kansas and Missouri River systems and their 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 these river systems. Major impacts to the riverine environment on these rivers began with modification of the Missouri river channel and stabilization of the river bank to improve navigation. 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 river systems and their floodplains have been through multiple Federal and private initiatives resulting in a changed environment within and along the river and specifically within urban areas bordering these rivers. The cumulative impact of these activities (navigation, flood risk management, industrialization, and residential development) has resulted in a dense, heavily industrialized floodplain protected by levee systems within the Kansas City reach, and a channelized river system showing higher flood stages than the free flowing systems of over a century ago. Development is expected to continue within these urban areas into the foreseeable future as demand for products, services, and flood risk management continues. At the same time, restoration of the Missouri River, including its former side channels and floodplain environment, is on-going. These restoration actions will mitigate some of the past disturbance along the Missouri River up and downstream of the project area. Cumulative impacts of this project related to these past activities have been evaluated to determine the level of significance to the proposed project and to past and foreseeable activities on these riverine environments.

4.0 Cultural Resources

Cultural resources surveys conducted during this study found that historic buildings and properties are located within the general study area. Prior to this study no archaeological surveys had been conducted in the study area as the existing projects predate the current requirements for

cultural resources surveys. Based on these surveys, appropriate avoidance and protective measures were planned and incorporated during the formulation process.

The cultural resources evaluation found no archaeological sites or historic structures listed, or eligible for listing, on the National Register of Historic Places (NRHP) within the project area. The project area, heavily disturbed by past levee and urban related construction, was found unlikely to contain previously unidentified archaeological sites eligible for inclusion in the NRHP. A site of two human burials near the proposed borrow area was identified. This site will be avoided during construction related activities. Cultural resource findings have been coordinated with both the Kansas and Missouri State Historic Preservation Officers who concurred with the Corps recommendations for no further investigations unless an inadvertent discovery is encountered during construction.

5.0 Hazardous, Toxic and Radioactive Waste (HTRW) Sites

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, site testing, and analysis suitable for feasibility phase determinations. For the units addressed within this Final Feasibility Report, hazardous waste and certain regulated non-CERCLA contamination is present at certain sites along the existing protective works.

Specifically, for the Armourdale Unit, it was necessary to carefully consider the type and extent of this contamination when developing feasibility alternatives. Details regarding the manner in which these sites affected planning appear in the Plan Formulation section. The HTRW Appendix contains detailed information on the sites.

6.0 Recreation Resources

Recreation in the project area primarily involves fishing, some hiking, canoeing, and wildlife/bird watching. Further examination of recreational resources and opportunities appears in the EIS.

A 1980 proposal by the Heritage Conservation and Recreation Service (now part of the National Park Service) recommended that the lower Kansas River be designated as a "recreational river" and made a component of the National Wild and Scenic Rivers System. This proposal has not undergone further legislative action.

Local initiatives have led to park facilities within Wyandotte County, Kansas at the Kaw Point Park & Overlook (just north and west of the Kansas- Missouri river confluence), and at several locations on the Missouri River within Kansas City, Missouri.

Trail proponents are actively seeking the incorporation of trails along or near several levee units as part of a long-term implementation strategy for an interconnected metropolitan trail system. The Kansas City District Corps of Engineers has encouraged trail proponents to directly engage the levee unit sponsors/owners in dialog which might bring about a mutually agreeable long-

term trail plan. The Kansas City District has and will continue to participate in general discussions regarding trails when consistent with the intent and purposes of the Federal project authorizations.

G. Review of Levee Elevations

During early portions of the existing conditions assessment, the O&M Manuals and Record Drawings were reviewed and were followed by field visits with sponsor representatives to compare available survey information with actual field conditions.

In 2001, a survey of the top of levee elevation along the entire existing levees system was conducted for verification of the Record Drawing elevations and was used in conjunction with the hydrologic and hydraulic analyses. The survey indicated that some areas along the levee were slightly lower than shown in the Record Drawings. Based on this, a resurvey of portions of the levee was conducted in late 2003. Of these resurvey locations; one was located in CID-KS, one in CID-MO, and two in the Armourdale Unit. The results of the resurvey confirmed that these areas were slightly lower than the Record Drawings.

There is no correlating data or observations to indicate that these low areas are due to post-construction settlement of the levee units. However, the specific cause of the low reaches has not been determined and may be due to errors in either historical or current survey efforts. The verification of the low areas led to discussions with sponsors and additional emphasis on preparations for emergency flood fighting (sandbagging) or local maintenance and repair of the low spots.

H. Final Assessments of Existing Levee Integrity

The study assessments provide insight into both the existing levee performance and the economic damages expected under existing conditions for an array of high water events. Risk and uncertainty analysis results and observations of levee performance during flood events form the basis for the identification of opportunities for risk reduction measures.

Prior findings for overtopping risk in the lower Kansas River system showed that the units do not reliably achieve the authorized 390,000 cfs conveyance target. This indicates the need for a general increase in the existing overtopping protection along the lower Kansas River. The Interim Feasibility Report presented the hydraulic analysis supporting this finding and provided recommendations regarding the Argentine Unit. The overtopping reliability improvements recommended in this Final Report for the Armourdale and CID Units are based on the same hydraulic analyses and conclusions previously published.

The details of the engineering performance analyses of geotechnical and structural features of the Armourdale and CID Units, including floodwalls, drainage structures, closure structures, and pump stations, are provided within the appropriate chapters of Appendix A to this report.

The critical reaches for geotechnical underseepage failure and slope stability risks were identified and analyzed in each unit. Critical reaches for geotechnical risk are determined by

several factors including levee height, slope, and soil type, and are the locations where underseepage or stability risks are expected to be the highest. The structural components of each unit were analyzed and compared to the current minimum factor of safety (FS) for hydraulic uplift, strength, and stability. Features 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 (TOL). The locations and features not meeting the factor of safety and showing the highest probabilities of failure in each unit are summarized in Table 12.

Table 12
Summary of Existing Conditions Areas of Concern

LOCATION	DESCRIPTION	FS NOT MET	PoF	CONSEQUENCE
ARMOUDALE UNIT				
Sta. 185+70	5th Street Pump Station	Uplift	100%	Unit will flood
Sta. 129+20	12st Street Pump Station	Uplift/Strength	100%	Uplift: Unit will flood
Sta. 156+75	Mill Street Pump Station	Uplift/Strength	100%	Strength: Post-flood repair
Sta. 222+00	Slope Stability Critical Location	Slope Stability	24%	Unit will flood
Sta. 276+00	Underseepage Critical Location	Underseepage	8%	Unit will flood
CENTRAL INDUSTRIAL DISTRICT UNIT - KANSAS SECTION				
Sta. 83+52	Ohio Street Pump Station	Strength	100%	Post-flood repair
Sta. 132+20	Closure Structure	Strength	99%	Unit will flood
Sta. 166+31	Closure Structure	Stability	20%	Unit will flood
Sta. 104+51	Closure Structure	Stability	6%	Unit will flood
Sta. 85+00	Underseepage Critical Location	Underseepage	4.5%	Unit will flood
CENTRAL INDUSTRIAL DISTRICT UNIT - MISSOURI SECTION				
Sta. 19+39 to 22+31	Floodwall	Sliding Stability	100%	Unit will flood
Sta. 63+15	Closure Structure	Foundation Stability	64%	Unit will flood
Sta. 0+00 to 3+49	Floodwall	Strength	14%	Unit will flood

Probability of failure curves (probability vs. water surface elevation) were prepared for the most critical features and combined in the economic analysis to determine an overall probability of failure for each unit. The details of this analysis are presented in Appendix B. The overall existing condition engineering performance is shown in Table 13.

The “Conditional Exceedance Probability – Overtop or Breach” represents the probability of levee unit failure from all possible failure modes (overtopping, geotechnical, and structural). As shown in Table 12, the current existing failure risk is significantly high in both units. 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 listed in Table 12 were addressed, a significant overtopping risk would still remain for the target 0.2% chance flood event.

Table 13
Engineering Performance (Existing Conditions)

	Armourdale	CID
Annual Exceedance Probability* (median)	3.5%	0.40%
Return interval (years)	29	250
Long Term Risk (chance of exceedance during indicated period)		
over 10 years	31.4%	5.4%
over 30 years	61.0%	12.9%
over 50 years	84.8%	24.2%
Conditional Exceedance Probability - Overtop or Breach**		
10.0% event	16.4%	0.03%
4.0% event	22.2%	0.07%
2.0% event	31.7%	2.5%
1.0% event	54.5%	15.7%
0.4% event	81.4%	48.9%
0.2% event	91.9%	71.7%
Conditional Exceedance Probability - Overtopping Only		
10.0% event	0.00%	0.03%
4.0% event	0.00%	0.03%
2.0% event	0.62%	0.54%
1.0% event	7.9%	6.6%
0.4% event	36.7%	33.5%
0.2% event	61.4%	58.8%
*Annual exceedance probability is the chance of experiencing any flood event - of whatever magnitude - within any year.		
**Conditional exceedance probability is the probability that specified flood event would overtop or breach the levee.		

III. Future Without Project Condition Scenario

The without condition scenario is a narrative description of the significant water and related land resources conditions and their impacts that could exist if the planning partnership takes no action. In best practice all scenarios are developed after careful consideration of what is reasonably known and not known about the future. When most of the alternative futures are relatively similar, differing only in the details, some of which may be significant, it is both possible and desirable to use a single most likely without condition scenario. Uncertainties in such a scenario can be explored using sensitivity analysis and other risk-based analytical techniques within the framework of that scenario. When uncertainties are so great as to produce significantly different future scenarios it is not reasonable to single out one scenario as most likely. In these instances scenario planning with multiple without condition scenarios may be necessary.

A. Socioeconomic Considerations of the Without Condition Scenario

The Armourdale and Central Industrial District Units last experienced catastrophic flooding in July of 1951. Following this devastating flood these areas struggled for years, even decades, to return to their pre-flood economic vitality. The meat packing industry that thrived in these areas never fully recovered (the Armourdale area took its name from the Armour & Co. plant). One

plant did not reopen and the rest were gone within twenty years. The impact of the flood was not the only factor to affect the meat packing industry, but certainly it was a significant one. The famous Kansas City stockyards began a slow decline with the departure of the meat packing industry, finally closing down for good in 1991. The residential populations within these areas also dropped significantly in the years after the flood as jobs left and people moved out of the flood prone areas. These are just a few examples of the impacts that severe flooding has on affected areas, and ones that could easily be repeated in the future.

Since the 1951 flood, the industries that remained have recovered and new industries have arrived. Convention facilities, restaurants, artist studios, commercial offices, and other uses have slowly moved into the study area. In keeping with this trend, only gradual, minor changes in population, employment, and land use are expected within the study area. The population of the Kansas City metropolitan area has been relatively stable according to the 1980 through 2010 census. Significant changes in population and land use in relation to existing conditions are not expected. However, several important planned commercial and residential developments have been identified in certain areas during discussions with sponsors and occupants of the study area. In addition, several road and highway improvement projects have been proposed, or are being implemented currently, that will increase access and traffic flow to, and within, the study area. These developments are expected to add to the general overall economic activity.

Opportunities for new development in the future are limited by the dense urbanization already existing and the scarcity of available open ground. Redevelopment efforts, or other changes from the current land use, may be restricted by floodplain zoning and flood insurance requirements. Most of this area would be within the base flood plain if not for the current flood risk management project. Any development along the river outside the line of protection would be precluded by the regulatory floodway which covers the entire span between the left- and right-bank levees.

While the identified trends and assumptions indicate that the existing socioeconomic fabric of the study area will remain relatively the same, and may improve some, the relative risk of a damaging flood increases into the future. Should another catastrophic flood occur with the study area, economic stability would be severely impacted as has been seen before. 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 and national businesses currently in the study area may choose to relocate jobs completely outside of the Kansas City area, causing significant regional economic impacts.

B. Hydrologic and Hydraulic Considerations of the Without Condition Scenario

1.0 General

The Hydrologic Engineering Center River Analysis System (HEC-RAS) computer model is used to calculate the probable stage-discharge relationship at a selected future date based on the best available current data, the incorporation of any known projects planned to be completed within the study area, and any long term natural river processes that may affect future stages. In the

development of the future without scenario, it is important to adequately detail and validate the current data and future assumptions that are input into the model.

2.0 Expected Future Condition Changes

A critical assumption in the future conditions analysis is that hydrologic conditions along the Missouri River and the Kansas River are relatively static and that flows used in the existing conditions study generally apply to the future conditions analysis. This assumption was also used in the development of the *Upper Mississippi River System Flow Frequency Study* (UMRFFS), 2003, which was based on the study of 100 years of gage records along the Mississippi River and tributaries, including the Missouri and Kansas Rivers. The UMRFFS superseded the previous Missouri River hydrology published in 1962 in the report titled *Missouri River Agricultural Levee Restudy Program*. The newly published flows in the UMRFFS were used in this study for both present and future conditions.

The future condition scenario does not anticipate the construction of any major Federal or local projects along the Kansas River that will have the capacity to affect the water surface elevations in the future. However, some of the natural processes occurring on the Kansas River are similar to processes occurring on the Missouri River.

Examination of aerial photography sequences show significant tree growth on certain lower Kansas River foreshore areas during the years from 1955 to the 1990's, especially on the left and right foreshores from the upper limits of the studied reach to approximately Kansas River mile 3.5, a distance of approximately 6.5 miles. Downstream of river mile 3.5, very little vegetation exists on the foreshore. Some accretion is noted along the studied reach, but not to the extent of the Missouri River. This difference may be due to the absence of navigation structures in the Kansas River.

The future without scenario assumes that because the upper reach is heavily vegetated for the existing conditions, the future conditions will not be worsened by further maturity of these growths. Based on a review of the vegetation patterns from 1955 to the present, it is also assumed that the amount and extent of vegetation on the lower reach from river mile 3.5 to the mouth will remain relatively stable. Therefore, the future natural condition along the Kansas River does not change from the existing condition.

3.0 Missouri River Degradation

The Missouri River between miles 340 and 400 in the Kansas City reach has exhibited down cutting of the river bed. This phenomenon has been observed by evaluation of Missouri River gage data collected over a long period of time. As the bed of the Missouri lowers, degradation begins to travel upstream many of its tributaries, including the Kansas River. Bed degradation can have many negative impacts to infrastructure such and bridges and water supply intakes, and can impact the riverward stability of existing flood risk management features.

The potential causes of degradation, documentation of its effects, and potential alternatives for management or mitigation are currently being evaluated under separate study efforts. This

Kansas Citys feasibility study is directed only towards the analysis of levee unit performance under flood conditions. Channel degradation has been considered where it has demonstrable potential effects on flood risk management performance. However it was determined unnecessary to project future degradation changes into future without project for the Kansas Citys study. The results and recommendations of the separate degradation study efforts will be reviewed when available and incorporated into future project design efforts where deemed necessary.

C. 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 (considering resources in the study area and economic and engineering factors) thought to exist in the first year a project alternative is expected to become operational. Engineering and economic data is also developed (projected) for a future year about 20 to 30 years out from the base year. The analysis years used in this Final feasibility study are 2026 for the base year and 2049 for the future year, with the total 50 year period of analysis ending in 2076.

In this study, certain assumptions related to the period of analysis were made:

- River stage uncertainty values were increased from 1.5 ft. to 1.8 ft. in the future year 2049; this reflects the increased difficulty in predicting stages far in the future.
- No significant increase in economic development is projected for the 50 year period of analysis as much of the protected area is essentially built-out.
- Beyond the future condition year of 2049, the expected annual damage is assumed to be constant in the remaining years of the period of analysis.

These assumptions provide the framework of the future without scenario in which the analysis of future flooding impacts is conducted. The expected annual 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.

D. Without Condition Scenario Conclusion

If modifications and improvements to the existing flood risk management system are not implemented through a Federal cost-shared project, the non-Federal Sponsors will be faced with either a significant financial burden of trying to implement the project themselves, or they will have to rely on flood-fighting to protect the study area from future floods. Neither option alleviates the existing flood risks or the increasing risks as the exiting project continues to age.

The trends and assumptions discussed in this section establish a future scenario in which the without-project and with-project conditions and flooding impacts can be analyzed and compared. The specific details and results of these analyses are discussed later in this 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 individual units in the study area. The primary means of quantification of these baseline conditions was through the development of risk and reliability metrics (for flood condition performance) by using risk and uncertainty (R&U) principles and the Corps of Engineers HEC-FDA program. This is significant due to the numerous elements and features of the units which required the identification and quantification of performance weaknesses.

Much of the analysis used data and observations from recent high water events, especially those in 1993 and, to a lesser degree, 2011. This updated engineering analysis, along with the economic existing conditions analysis, establishes a complete R&U approach to estimating existing conditions flood damages. The engineering and economic evaluations were taken together with a summary baseline environmental review and an HTRW review to develop the existing conditions.

The initial broad feasibility evaluations of existing conditions undertaken during the first two to three years of this study allowed subsequent formulation efforts more focus. The development of measures to increase reliability was narrowed to the candidate sites which offered the best opportunity for significant reliability improvements and potential economic return on investment. These candidates were also reviewed for compatibility with the basic planning objectives and constraints which emphasized the desirability of a relatively uniform level of protection across the metropolitan system.

As feasibility progressed, the development of reliability improvements were thus focused on those specific areas identified as having relatively low reliability; areas where low reliability significantly compromised the projects original intended level of performance. Engineered reliability remedies and improvements were developed considering both the improvements to individual unit performance and the performance of the whole system.

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 inventory and forecast of conditions required in Step 2 has already been discussed in this report via the description of the existing project and the future without condition scenario. A description of the intent of each remaining step, and how each was conducted specific to this study, is presented in the following sections. It should be stressed that the six step process is iterative. As more information was developed throughout the study it was necessary to review and update previous steps to reach the final conclusions and analyses presented herein.

C. Step 1 - Indentifying Problems and Opportunities

Step 1 of the Planning Process seeks not only to identify the problems and opportunities within the study area, but also to establish planning objectives and constraints that will guide efforts to solve the problems and achieve the desired opportunities.

Past flood experience raised concerns that the existing system may provide less than the level of performance for which it was designed and constructed. Following the Flood of 1993, several local sponsors wrote letters to the Kansas City District expressing concern for the adequacy of parts of the flood risk management system.

In response to these local concerns, a Reconnaissance Study was undertaken through Section 216 authority. The reconnaissance study examined readily available information, data, and flood performance results, and produced recommendations supportive of further feasibility examination. Accordingly, this feasibility study identified the following problems within the study area:

- The existing system provides less than the level of performance for which it was designed.
- Project failure due to overtopping, underseepage, or structural inadequacy, presents a significant life safety concern and will cause catastrophic damage to the urban development in the study area.
- The existing system includes components between forty and seventy years of age. While the system has been well maintained and is currently in good working condition, the state of the art of design, construction, and reliability analysis has changed significantly since the original construction. This concern will continue to grow as the system ages.

Following the problem definition, the following opportunities were identified in the study area:

- Verify current performance of the existing system versus the original design intent and project authorizations.
- Apply current understanding of large river dynamics and design criteria to assess the reliability of the existing system.
- Identify and present recommendations for designing and implementing viable measures to reduce the risk of flooding and improve the overall safety and performance of the system.

1.0 Planning Objectives

Planning objectives are statements that describe the desired results of the planning process by solving the problems and taking advantage of the opportunities identified. The planning objectives will be used for the formulation and evaluation of alternative plans. They should be clearly defined and provide information on the effect desired, the subject of the objective (what will be changed, the location where the expected result will occur, the timing of the effect, and the duration of the effect. Planning objectives are listed below as they relate to each of the identified project opportunities

- Verify current performance of the existing system.
    - Gather all available data and historical observations, develop updated engineering analysis, and combine with the economic existing conditions to establish a complete Risk &Uncertainty approach to estimating existing conditions flood performance, reliability, and potential consequences of failure. Compare this analysis to the authorized design and intent of the existing system. Achievement of this objective will increase the knowledge and understanding of current system reliability and performance and allow the identification of areas of concern needing to be addressed by alternative measures.
- Identify and present recommendations for reducing the risk of flooding
    - Identify measures to address the identified reliability and performance inadequacies in the existing system, including hydrologic, geotechnical, and structural concerns
    - Develop and evaluate alternatives and recommend a plan to increase the overall reliability of the existing system and reduce flood risk and damages over the 50 year period of analysis.

2.0 Planning Criteria

Planning studies are required to examine and address the Federal criteria of completeness, efficiency, effectiveness, and acceptability. Alternatives and recommendations are also closely examined for their potential to impact the environment. To adequately address these criteria, the development and screening of alternatives should consider of a number of evaluation factors. Primary among those factors are the following:

- Engineering adequacy of the proposed solutions (effectiveness)
- Contribution to planning objectives (completeness of the solution)
- Consistency with planning constraints and authorities
- Environmental, cultural, and public acceptability
- Early cost indicators (early efficiency indicators for screening purposes)
- Induced damages considerations (where applicable)
- Hazardous and regulated waste site constraints (where applicable)
- Constructability (are construction techniques and quality difficult to attain at reasonable price)

- Construction site constraints (given existing features and development)

Engineering Adequacy: The engineering adequacy of alternatives was analyzed and reviewed during the initial screening process. Any alternatives which could not meet the minimum technical criteria for the expected flood conditions were eliminated from further review. This is a key effectiveness criterion and normally must be met. The amount of engineering analysis necessary to perform the engineering review was generally considerable and is contained in the various Engineering Appendices.

Environmental Acceptability: Environmental acceptability of alternatives was reviewed in concert with appropriate resource agency guidance. Any alternative which had major disruptive effects on the environment was normally screened out. A typical formulation exercise would involve adjusting some of the alternative measures so as to minimize any environmental impacts when such impacts could not reasonably be avoided.

Cultural Acceptability: Any cultural resources present were considered as the areas likely to be affected by a solution were determined. Steps were taken during the alternatives screening and refinement process to generally avoid any impacts to culturally significant 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 detailed cost estimating and economic analysis normally focused only on those alternatives that remained viable solutions after early screening criteria were passed.

Induced Damages: While this consideration is similar in some respects to the floodway conveyance factor, the analysis actually goes one step further and addresses the possibility of induced impacts during extremely rare events in which the order of overtopping may be altered by levee raise proposals.

3.0 Planning Constraints

Constraints are restrictions that limit the planning process. Plans should be formulated to meet the objectives and avoid violating the constraints. All studies are subject to general constraints including resource availability and legal and policy constraints. Constraints specific to this Kansas Citys study are discussed in the following paragraphs.

a. Congressional Direction and Headquarters Guidance

Prior to the Feasibility Study, the Reconnaissance Phase study efforts were undertaken with the following Congressional directions:

1) Per the report on the FY 1998 Energy and Water Appropriations Bill, the Senate Committee on Appropriations stated:

Kansas City, MO-KS- The Committee is aware that the Kansas City, MO, and Kansas City, KS, flood control study encompasses two States, two rivers, seven separable units, and five separate sponsors; and, therefore, believes that the study area and issues are too large and complex to be adequately addressed by the standard reconnaissance study simplified analysis of limited scope as set forth in current Corps policy. Accordingly, the Committee directs the Corps to use the additional $300,000 provided to scope potential multifeasibility studies, develop associated project study plans and negotiate feasibility cost sharing agreements related to the study.

2) In its report on the FY 1999 Energy and Water Appropriations Bill, the Senate Committee on Appropriations stated:

Kansas City, MO- The Committee has included $545,000 for the Kansas City, MO, reconnaissance study which is comprised of seven separable levee units, encompasses two States and two major rivers, and has multiple sponsors. Due to the large study area, the complexities, and the large number of interest, the Committee directs that the study not be limited to the 1 year constraint for a reconnaissance study and that the study be scheduled for completion by the end of fiscal year 1999.

at the beginning of the week,

After completion, the reconnaissance report was certified and approved by the Headquarters, U.S. Army Corps of Engineers. Permission to proceed into feasibility studies was granted by Memorandum from HQ-USACE to the Commander, Northwestern Division (NWD), dated 26 Jul 2000, with the following guidance stipulations:

1) The subject report (reconnaissance) and project study plans are approved as the basis for proceeding into the feasibility phase of planning. Based on the intense development behind the levees and the complex interaction between individual levee units we are supportive of limiting the alternatives to be investigated during the feasibility phase to those alternatives that provide a uniform level of protection.

2) The project units of the flood protection plan for the Kansas Citys are so closely related and dependent upon each other for effectiveness that the project can only be analyzed by ***considering the area as a whole****. Given the location of the seven levee units relative to the confluences of the two rivers, formulation based on reaches upstream and downstream of the confluence of the Kansas and Missouri rivers is not technically feasible. The levee units in this study are either at the confluence of the rivers, or within the zone of influence of the confluence. Therefore, all units are interrelated and function as a system in providing flood protection to the area. This is the same challenge that was faced by the Corps when designing the existing levee system. Furthermore, there are conditions under which failure or flooding of certain levee units may adversely affect adjacent levee units.*

This guidance was forwarded from NWD to the Commander, Kansas City District, by Memorandum dated 3 Aug 2000, with the following language:

Reconnaissance Report and Study Plan for the subject project have been approved by HQUSACE as the basis for proceeding into the feasibility phase. Specfically, the formulation of alternatives can proceed on the basis of providing a uniform level of protection, in lieu of doing an incremental analysis for the left and right bank levees.

b. Systems Approach to Plan Formulation

Based on the guidance referenced in the previous section, the Feasibility Study examinations of measures to increase the performance and reliability of the system are guided and constrained by an overarching principle that seeks to achieve a relatively consistent level of performance throughout the seven unit metropolitan system. This essentially means that the study avoids recommending:

- Any measures or plans which would directly or indirectly exacerbate any performance weaknesses (or relative weaknesses) within the system, including any measure or plan that would allow one unit of the system to remain at a lower level of protection or reliability than the level of the overall system, and
- Any measures or plans that would contribute to increasing the level of performance of strong components of the system without a commensurate strengthening of weaker components.

In addition to a uniform system approach, financial and schedule constraints played a significant role in the execution of this study. The large and intensely developed urban study area and the numerous existing protective features within the individual units, present broad possibilities for study and formulation. However, financial realities demanded that the feasibility scope, analysis, and planning efforts focus on those areas, measures and solutions which address pressing needs or significant performance weaknesses within the overall system. This approach provides the greatest opportunity for economical and affordable system-wide reliability improvements.

The Interim Feasibility Report recommended improvements to four units of the system: the Fairfax-Jersey Creek, North Kansas City, and East Bottoms Units on the Missouri River, and the Argentine Unit on the Kansas River. The Missouri River Units were determined to have adequate height to resist overtopping at the design flood level, but require significant underseepage and structural modifications to maintain acceptable overall system reliability. In addition to similar geotechnical and structural reliability concerns, the entire Kansas River portion of the system was determined to be of insufficient height to provide adequate overtopping protection. The Interim Report included the detailed analysis of alternatives for the Argentine Unit. The Argentine NED plan was identified as a unit raise to provide improved reliability to pass the 500+3 water surface profile. This level of flood risk management benefit is consistent with the Missouri River units, and meets economic project justification criteria.

The Armourdale and CID Units are located immediately downstream of the Argentine Unit. In order to achieve a uniform system level of flood risk management benefit, and to reduce the potential for induced damages between units within the system, it was determined that the development of alternatives for these two units would focus on measures consistent with the authorized plan for the upstream unit.

c. Other Project Constraints

Floodway Conveyance Considerations: Very early in the plan formulation process, a general guiding rule was adopted: any measures which negatively impacted the establish floodway conveyance should be avoided. This was deemed essential as in most cases levees lie along both banks of the river reaches within the study area, and are often located either upstream or downstream of another unit. This principle is consistent with floodway "no rise" criteria as promulgated under FEMA regulations. This criterion was maintained during feasibility and the final alternatives are essentially benign in respect to any adverse floodway impact.

D. Step 3 - Formulating Alternative Plans

Alternative plans shall be formulated to identify specific ways to achieve planning objectives within constraints so as to solve problems and realize the opportunities identified. An alternative plan consists of a system of structural and/or nonstructural measures, strategies, or programs that meets, fully or partially, the planning objectives. The first phase in plan formulation is the identification of management measures, followed by combing the measures into plans as appropriate.

The results of the existing conditions analysis, and observations and effects from historic and recent flood events, were used to identify and formulate potential solutions aimed at lowering the risk of flooding for units under study.

At times additional measures and alternatives surfaced leading to 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 primary ranking factor in the final selection. Having passed review for engineering adequacy, environmental and public acceptability, and other evaluation criteria as described below, the remaining alternative with the highest net benefits to the national economy was identified as a component of the overall recommended plan.

1.0 No Federal Action

In accordance with current policy it is necessary to fully evaluate the No Federal Action alternative for purposes of comparison to other alternative and future with-project conditions. This measure does not address any of the project's objectives. Evaluation of the No Action plan is closely related to the without condition scenario and requires the projection of what course of action local entities may take given the lack of Federal involvement. It is possible that some of the recommended measures may be undertaken by the local sponsors. These local initiatives are likely to be focused on the underseepage measures which are generally the least costly of the recommendations offered herein. However, the major requirements associated with structural feature reinforcements, and increased overtopping protection, are just as likely not to be accomplished under a local initiative. This would mean significant long-term risk remaining.

The No Federal Action alternative does nothing to alleviate risks to public health and safety. While some local emergency preparedness plans can be updated and general awareness of the risks can be increased, this could be considered an inappropriate small scale response to significant life and safety risks.

The economic implications of the No Federal Action alternative are broadly negative. The investment at risk within each 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 industry may even result. In the short term, with an absence of flooding, the current trends in-place for the local economy, tax base, population, and employment may remain intact. However, if major flooding occurred and one or more of the levee units 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, and reductions in the tax base (given net movement out the protected areas) and generally diminished property values.

The No Federal Action alternative would leave several of the busiest rail yards in the nation at significant risk. Levee failure(s) would halt or at least significantly impede the nationwide movement of goods by rail, and major interstate highways could also shut down. During any such failure, it is also expected that production centers, wholesale distribution, and containerized shipping centers would close. Following the flood, subsequent restoration periods could be months or years depending on the damage involved.

The No Federal Action alternative also raises the possibility of permanent loss of local manufacturing employment through industrial relocation to developing countries. Certain industries may see moving outside the United States as a more viable option in lieu of industrial re-investment and rebuilding after any widespread flood damage. Were this to occur, it could severely degrade the industrial base of the metropolitan area for decades.

The No Federal Action alternative results in no changes to the existing environment in and around the levee units unless catastrophic levee failure occurs. Levee failure at specific locations or across the system could result in direct and indirect impacts through inundation of habitat of terrestrial populations and through release of contaminants to the river systems or flood plain environment. Direct impacts during flood events would be the displacement of mobile organisms and the loss of organisms unable to escape inundated areas. Direct and indirect impacts could also result from the introduction of contaminants currently controlled or contained by businesses and industries interior of the levee systems. Levee failure and inundation of currently contaminated soils, stored chemicals, and the variety of chemicals released within the protected communities would allow introduction of these contaminants into the Kansas and Missouri Rivers impacting water quality and contaminant loading of the rivers during these events. Potential impact to aquatic populations (fish and benthic communities) from the degradation of water quality and contaminant loading 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 of inundation.

2.0 Identification of Management Measures

The following management measures were identified and studied for the applicability to each feature of the exiting unit and their ability to meet the project objectives.

a. Non-Structural Measures

- Floodfighting. This measure attempts to address all objectives through temporary means implemented during a flood event.

- Tree clearing and/or channel modification. The related objective addressed is inadequate reliability against overtopping. If the channel can be modified or cleared of obstructions to allow a greater discharge capacity, the water surface profile of the design flood event can potentially be lowered.

- Relocation or flood-proofing of individual structures. This measure aims to reduce or prevent damages in the study area by removing structures or preventing floodwaters to enter them. It does not address any of the objectives specific to the existing system (i.e. overtopping or structural and geotechnical reliability of the existing features).

b. Structural Measures

- Modify or replace existing pump stations. The related objective addressed is inadequate reliability against structural failure. All pump stations will be initially evaluated using current criteria and required factors of safety for uplift, strength, and hydraulic capacity. Those found not meeting criteria for any of these failure modes will be proposed for modification or replacement. If evaluation shows that the original purpose of the pump station is no longer required for operation of the project, the pump station will be recommended for abandonment.

- Modify or replace existing floodwalls. The related objective addressed is inadequate reliability against structural failure. All existing floodwalls will be initially evaluated for strength, stability, overturning, and foundation reliability. Any floodwall not meeting criteria for any of these failure modes will be proposed for modification or replacement.

- Replace or expand underseepage control features. The related objective addressed is inadequate reliability against geotechnical underseepage failure. Each unit will be initially evaluated using current criteria and required factors of safety for underseepage. Areas showing low reliability for this failure mode will be proposed for replacement or expansion of existing underseepage control features, or if no existing features are present, new installations. Underseepage control is typically achieved through the use of area fill, impervious berms, underground slurry cut-off walls, buried collectors, or relief wells.

- Unit Raise. The related objective addressed is inadequate reliability against failure due to unit overtopping.

- 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. If levee width increases are not possible, other methods available include adding retaining walls to limit width increase, adding floodwalls on top of the levee, or replacing the levee with a floodwall.
- Concrete floodwall raises are typically achieved through structural modification, as long as the existing wall base and foundation can provide sufficient support. If modification is not possible, the wall can be removed and replaced with a higher wall on a new foundation.

- New CID floodwall tieback. This measure was added for consideration in the CID Unit after the first iteration of screening and alternative formulation. The related objective addressed is to economically achieve reliability against all potential failure modes. The floodwall at the upstream end of the CID Unit has been raised previously and would require very expensive modifications for additional raise, or possibly a complete replacement. A higher floodwall also requires a large number of new underseepage relief wells. The proposed measure consists of constructing a new wall to tie the existing unit into the bluff at a different location, thus eliminating the cost of modification or replacement of a long reach of the existing unit. This would result in a portion of the study area where the current flooding risk would remain; however, this area contains only railroad tracks and no businesses or residences, ensuring no continued life safety risk.

3.0 Identification of Key Uncertainties

A number of preliminary uncertainties were identified and investigated as thoroughly as possible during the study. These uncertainties are important consideration in selection of effective management measures. These included the following:

- Impact of Missouri River bed degradation on the Kansas River. A separate Corps of Engineers study is currently underway examining bed degradation in the Missouri River. As the Missouri river bed scours itself lower, there is potential for this degradation to begin travelling up tributary streams, such as the Kansas, and alter future water surface profiles, undercut river bank slopes, etc. At this time, the study has not reached any conclusions or recommendations to slow or reverse the degradation, but that is part of the study's goals and objectives. For the purposes of evaluating future flood risk management on the Kansas River, it is assumed that some future measures will be in place to address degradation, and that the future water surface profile models used for establishing new levee heights will not be significantly impacted. The future findings and results of the degradation study will need to be monitored and incorporated into actual design of future levee modifications as needed.

- Impact of raised water surface profiles on Kansas River bridges. A large number of bridges cross the Kansas River within the current study area. Raising the system on either side of the river increases the future water surfaces, leading to higher lateral loads

on these bridges, more potential for debris impacts, etc. A qualitative assessment was conducted using all known and available bridge inspection reports and information to identify the most highly impacted bridges and rank their potential for failure under multiple scenarios. Of critical concern to this study was the possibility that a bridge failure might directly cause a failure of the flood risk management system leading to inundation of the study area. The results of this assessment determined that if any of the affected bridges were to fail during a flood, there would be no direct failure impact to the adjacent flood risk system. Furthermore, the probability of a flood high enough to impact the bridges is small, and, even at that flood level, the probability of an actual bridge failure is small, making the overall scenario a remote and rare occurrence that does not justify the formulation of specific measures or alternatives. Additional detail of the bridge assessment is provided in Appendix A.

- Condition of existing CID floodwall foundations. At the beginning of the study there was significant uncertainty regarding the existing condition of the original timber pile foundations supporting the floodwalls in the CID unit. It was assumed they would be inadequate to support a raise of the walls. The walls would therefore need a large number of new adjacent piles to support buttressing of a raise, or the walls and foundations would need complete replacement. After several iterations of plan formulation and cost screening with this constraint in place, the team decided there was value in conducting excavation and testing of the foundation piles to address this uncertainty. Two locations were excavated and the piles were visually inspected and samples were laboratory tested. The resulting data reduced the uncertainty concern, and the subsequent structural analysis concluded that the existing piles were still capable of providing support of a raise, eliminating the need to consider wall replacement, and reducing the number of additional piles needed.

4.0 Combining Management Measures into Alternative Plans

The identified management measures can be combined in a number of different ways to develop potential alternative plans. To help establish the initial array of plans, three general types of alternative plans were established: non-structural plans, non-raise structural plans, and unit raise structural plans.

a. Non-Structural Alternatives

Nonstructural approaches have merit when the site characteristics and the flooding threat are compatible with the nonstructural capabilities. Non-structural plans for flood risk management often include such items relocation or flood-proofing of affected structures, modification of river channels to change the nature of the flood threat, and reliance upon flood fighting techniques. The dense urban development in the study are precludes consideration of large scale relocation or flood-proofing of structures. Channel modification and flood fighting will be further evaluated as separate alternative plans.

b. No-Raise Structural Alternatives

The management measures discussed previously would be combined to improve the levee system reliability by implementing modifications to structural features (pump stations, gatewells, closures, floodwalls, etc.) and improvements to the underseepage control system, without raising the existing height of the levee units. The different available methods for structural modification and underseepage control allow for the development of multiple alternative plans under a no-raise scenario.

c. Unit Raise Structural Alternatives

This group of alternatives would improve levee system reliability by implementing the modifications to structures and underseepage control necessary to address identified weaknesses in combination with raising the height of both units. These plans address all potential failure modes. The different available methods for structural modification and underseepage control allow for development of multiple alternative plans for screening under a unit raise scenario. As the unit height is increased, there are many dependencies and conflicts created among the various types of management measures identified. The alternative plans under this scenario must consider all of the following concerns:

- As the levee height is increased, stress on the adjacent structural and geotechnical features also increases, causing associated changes in the scope and viability of the different management measures.
- Measures considered for one feature may cause impacts, either positive or negative, to other features.
- Some existing features which can be modified with no raise, or even a short raise, may need replacement at a higher raise. Similarly, different underseepage control methods will perform differently, and may lose effectiveness, when a raise is considered.
- The raise of an earthen levee requires an expansion of the levee footprint and the need for additional permanent right-of-way on one or both sides of the levee. Considering the urban development of the study area, this is not possible in all levee reaches. Levee raises may need to be constructed with retaining walls to limit footprint expansion, installation of floodwalls on top of the levee, or completely replacing the levee with a new floodwall.

E. Step 4 – Evaluating Alternative Plans

1.0 Unit-Raise Structural Alternatives

Based on the stated study objectives and evaluation criteria, the highest priority was placed on evaluation and screening of the unit-raise structural alternatives. In accordance with the Planning Constraint of maintaining a uniform level of protection throughout the Kansas Citys system, the initial evaluation of raise alternatives focused on a future levee height approximately three feet above the 0.2%-chance (500 year) water surface profile. Use of the 500+3 water surface profile as a desired top of levee elevation results in an actual physical raise of 1.2 to 5.2 feet in the Armourdale Unit, and 0.2 to 3.9 feet in the CID Unit.

The management measures for structural and geotechnical components were evaluated for their feasibility and effectiveness under the hydraulic conditions expected at the 500+3 raise. The alternative plans combining the most effective measures were retained for further cost-estimating and economic analysis. Discussion and results of these evaluations specific to each unit are presented in the following sections.

a. Central Industrial District Unit

Floodwalls. Investigation and engineering analysis confirmed that the floodwall sections can be modified to support the additional increase in height without need for replacement.

Levees. Sufficient real estate is available in the levee reaches for the expansion of width associated with an earthen levee raise.

Underseepage. To control underseepage at the new levee height, area fill to raise the landside ground elevation is proposed for reaches with sufficient real estate availability. In more congested reaches, both relief wells and slurry cut-off walls were feasible at the selected raise. A preliminary estimate of the relative cost of these two measures was calculated for comparison. The overall life-cycle cost of the relief wells was found to be less than the construction of a slurry cutoff wall. The slurry cut-off wall measure was eliminated and only relief wells were included in the final alternative plans.

Existing Pump Stations. The existing pump stations were evaluated for their ability to withstand increased hydraulic uplift pressures and handle flows from additional relief wells. Several stations were found to need strength and capacity modifications, and two smaller stations were determined to be no longer needed and are proposed for abandonment. Since these modifications are primarily driven by the new levee height, they are necessary in any final alternative plan.

Unit Tieback. The inclusion of a new tie-back connection between the existing unit and the river bluff was determined feasible on several different alignments. Where the tieback connection is located along the existing alignment impacts the resulting number of new relief wells needed, whether or not a new pump station is required to handle the relief well flows, and the number and locations of new railroad crossings and closure structures. These options allow for several alternative plans to be considered for the final analysis.

b. Armourdale Unit

Due to the varying existing conditions and characteristics of the study area, it was necessary to separately evaluate alternative plans for discreet reaches of the overall unit. For underseepage evaluation, the unit was divided into reaches of similar geotechnical conditions (unit height, impervious soil blanket thickness, aquifer thickness, seepage entrance condition, etc.). Evaluation of the different raise measures in each reach considered existing protection (levee vs. floodwall), adjacent development, the potential

for real estate conflicts, and potential encroachment into known areas of Hazardous, Toxic, and Radioactive Waste (HTRW) contamination.

Floodwalls. Each reach of existing floodwall was evaluated to determine if the existing wall and foundation were adequate, or could be modified successfully, to support additional height. Analysis indicated that the existing floodwall from stations 60+40 to 77+80 cannot be modified to support a raise leaving only replacement as a viable measure. The existing floodwall from stations 257+65 to 302+58 can be modified to support the raise, except for the section from 274+36 to 277+21 that must be realigned to avoid conflicts between new closure structures and the Missouri Pacific and Union Pacific Railroad Bridges. A new section of raised floodwall incorporating new closures to replace the existing wall is the most feasible alternative at this location.

Levees. Where possible, earthen levee raises are the preferred, and typically least cost, alternative. As discussed previously, earthen levee raises create a wider levee footprint, either landside or riverside of the existing levee. In almost all reaches of this unit, the levee is immediately adjacent, or integral, to the Kansas River bank slope, eliminating the possibility of a riverside raise. Landside levee width increases are significantly complicated by the potential for real estate conflicts with adjacent businesses, railroads, utilities, pump stations, and areas of environmental concerns. Additionally, in some reaches, certain measures would create limitations to unit access needed for maintenance, inspection, and operation.

In the initial evaluation of alternatives in each reach, the PDT decided to eliminate all levee raise alternatives that caused encroachment on adjacent buildings, infrastructure, and known areas of environmental contamination. In the reaches where earthen levee raise would not fit this constraint, the evaluation next considered levee raises with retaining walls to limit width increase, then floodwalls on top of the existing levee, and finally replacing the levee entirely with a new floodwall. The evaluation of alternatives thus focused on the avoidance of real estate relocation costs. If the conflicts were strictly concerns of real estate easements or project access, the alternatives were retained for the final evaluation.

Those levee reaches with no HTRW or real estate concerns were only evaluated to be raised by typical earthen levee methods. All other alternatives in these reaches were eliminated from further consideration.

The existing unit ends at Station 61+00LE. Downstream of Station 42+00LE the required levee height increase to match the 500+3 profile is less than 1.2 feet. While a landside levee raise is technically feasible in this reach, the implementation of this raise will conflict with the adjacent active railroad track. This single track is the only existing infrastructure receiving benefits in this reach. On the opposite side of the track is the high ground embankment of an existing city street (James Street). It is feasible to tie into this existing high-ground with a sand bag closure structure across the railroad track at Station 42+00, this shortening the unit by almost 2,000 linear feet. The existing levee would remain in place providing benefits to the lower reach up to its current elevation. If

this reach is overtopped, the sand bag gap would prevent floodwaters from backing up into the rest of the study area. This alternative would eliminate the railroad impacts of a raise. Both alternatives for this reach are retained for the final evaluation.

Underseepage. Three reaches of the unit were identified as potentially not meeting required underseepage factors of safety under the proposed future raise. In all identified reaches, the proximity of urban development eliminated consideration of additional or expanded berms. The evaluation next considered the use of pressure relief wells or a slurry cut-off wall at each location. However, similar to the CID-KS evaluation discussed previously, the cost of a slurry wall installation was found to be greater than the life-cycle cost of relief wells, making the use of wells the preferred alternative. In the reach from Station 295+00 to 313+00, thirty-five new relief wells are needed to address increased hydraulic pressures. In the reach from station 62+00 to 82+00 adjacent railroad tracks and facilities would need to be relocated for relief well installation. Additionally, this reach overlaps with an identified groundwater contamination concern between stations 45+00 and 75+00. A slurry cut-off wall constructed to bedrock is the only remaining option. In the reach from 257+65 to 295+50,which includes the railroad "slot", the existing ground surface is significantly lower than surrounding areas. Placement of area fill in this low area was deemed sufficient to improve underseepage safety.

Pump Stations. Six pump stations require modifications at the 500+3 raise due to either insufficient strength, potential for flotation, or inadequate capacity to handle relief well flows. Two additional pump stations are no longer needed as the facilities they were built to service are no longer in existence. These pump station modifications are necessary regardless of how the unit is raised and are common to all final alternative plans.

c. Consideration of Other Raise Profiles

As stated previously, the selection of management measures and development of alternatives was initially focused on achieving and maintaining a uniform level of flood risk management for the Kansas Citys system. Preliminary economic analyses were prepared in 2006 to assist in the screening of the initial array of alternatives. At that time, cost and benefit estimates were prepared for different scales of levee raise and associated modifications. It should be noted that these lower raise alternative plans do not meet all of the study objectives and were prepared only for cost and economic comparison. Cost estimates for the Argentine Unit were included for comparison of the Kansas River three-unit system total. The results are shown in Table 14.

The 2006 screening results indicated that the total net benefits of the three-unit Kansas River system were maximized at the 500+3 raise profile. These results verified the selection of this levee height profile for the system. The description, analysis, and recommendation for the Argentine Unit are included in the Interim Feasibility Report. For the Armourdale and CID units, further alternative evaluations focused on the plans to implement this raise and address the associated underseepage and stability concerns.

Table 14
Screening Analysis of Alternative Raise Profiles

Oct 2005 prices; 5.125% interest rate					(*Prepared Feb 2006*)
500+1 Profile Raise					
Unit	**First Cost**	**Total Annual Cost**	**Total Annual Benefits**	**B/C**	**Net Benefits**
Argentine	$33,042,548	$2,093,795	$16,322,473	7.80	$14,228,678
Armourdale	$51,723,299	$3,371,286	$5,234,014	1.55	$1,862,728
CID-KS	$39,959,191	$2,563,797	$3,266,651	1.27	$702,854
TOTAL	$124,725,038	$8,028,878	$24,823,138	3.09	$16,794,260
500+2 Profile Raise					
Unit	**First Cost**	**Total Annual Cost**	**Total Annual Benefits**	**B/C**	**Net Benefits**
Argentine	$33,945,404	$2,150,335	$16,560,871	7.70	$14,410,536
Armourdale	$61,233,118	$3,984,373	$5,553,332	1.39	$1,568,959
CID-KS	$40,482,623	$2,597,032	$3,454,202	1.33	$857,170
TOTAL	$135,661,145	$8,731,740	$25,568,405	2.93	$16,836,665
500+3 Profile Raise					
Unit	**First Cost**	**Total Annual Cost**	**Total Annual Benefits**	**B/C**	**Net Benefits**
Argentine	$35,313,745	$2,278,318	$17,081,997	7.50	$14,803,679
Armourdale	$63,411,583	$4,138,267	$5,744,664	1.39	$1,606,397
CID-KS	$41,759,697	$2,686,581	$3,608,586	1.34	$922,005
TOTAL	$140,485,025	$9,103,166	$26,435,247	2.90	$17,332,081

2.0 Non-Raise Structural Alternatives

While a non-raise structural alternative plan would provide improvements to the structural and geotechnical reliability of the units at their current height, they would not address the potential failure due to overtopping. A no-raise alternative does not meet the stated goals, objectives, and constraints of the study.

3.0 Non-Structural Alternatives

a. Channel Modification Alternative.

Channel modification would be aimed at attempting to establish a more efficient cross-sectional flow area along substantial lengths of the levee foreshore. Channel modification was modeled for both sides of the Kansas River through the study area and the results indicated some additional conveyance capacity under modified conditions. However, the conveyance gains are very limited (not totally effective and complete) and do not fully serve to establish the desired design discharge.

Furthermore, it is expected that channel modification would have a limited life much less than the 50-year period of analysis. The natural process of meandering and foreshore

building would require repeated dredging cycles 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 and potential floods make the channel-modification measure undesirable.

b. Floodfighting

Flood fighting is generally best thought of as an aid to manage unpredictable and unforeseen problems during flood events. For large levee units where substantial investment is protected, some flood fighting can be planned and implemented for limited low-risk situations. But, in general, when exposed to massive flood events, flood fighting measures will often prove unreliable. For the levee units and problems under examination in this study, flood fighting is generally not an acceptable planning alternative when compared to engineered solutions. Flood fighting generally will not prevent underseepage failures when dealing with very high pressures, nor can flood fighting reliably prevent structural floodwall failures under extreme load conditions. Nor is flood fighting a reliable option for substantially raising the elevation of a large levee unit.

c. Non-Structural Summary

There is already an extensive existing structural flood risk management system providing benefits to the study area. The need for additional large-scale risk reduction within the study area, especially from system overtopping, far exceeds the normal performance parameters of typical nonstructural measures. For these reasons, it was concluded that structural modification of the existing system is the most feasible means of achieving the necessary performance improvements. Non-structural methods were eliminated from further consideration as potential stand-alone solutions.

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 outside the scope of this study and may be pursued independently by the project sponsor.

F. Comparing Alternative Plans

1.0 Central Industrial District Unit

Six alternative plans were retained for the final evaluation. Each plan includes the same raises of the earthen levee and floodwall sections, the same area fill locations, and the same pump station modification and abandonments. The differences among the plans are related to the new tieback measure; whether or not this measure is included, where the tieback connection is located along the existing alignment, the affect of the new tieback on the proposed relief well system, and what

alignment the tieback is constructed on between the existing unit and the bluff. The six alternatives are described briefly as follows:

#1 Unit stops at Sta 130+00 and turns to bluff (adds 4 stop log gaps and 15 new relief wells)
#2 Unit continues to Sta 166+80 (adds 83 relief wells/new pump plant/1 stop log gap)
#3 Unit stops at Sta 138+95 and turns to bluff (adds 2 stop log gaps and 30 new relief wells)
#4 Unit stops at Sta 130+00 and turns to bluff (adds 4 stop log gaps/smaller pump station)
#5 Unit continues to Sta 166+80 (adds 83 relief wells/new pump plant/1 stop log gap/header pipe)
#6 Unit stops at Sta 138+95 and turns to bluff (adds 2 stop log gaps and 30 new relief wells with a new pump plant)

The primary differences between the six plans in the final array is whether or not to modify and raise the existing floodwall upstream of station 130+00, or to essentially shorten the unit by constructing a new tieback to the bluff along the eastern edge of the study area. The existing floodwall in this reach has already been modified and raised in the past. Although the foundation analysis determined that additional raise could be supported, the actual implementation would be technically very complex. The area inside the unit along this reach contains multiple railroad tracks and one abandoned and dilapidated railroad storage warehouse which provide limited economic benefits.

a. No Tieback.

Alternatives Two and Five assume that the existing wall is raised and no tieback is constructed. Each plan includes a new pump station to handle the flow from the additional 83 relief wells and a new stop log closure structure constructed upstream of the existing closure at the end of the unit. Alternative Five has a different configuration of header piping to collect flows from the relief wells. Both alternatives have the same future with and without project conditions. Implementation of either alternative will provide reliable flood risk management up to the 500+3 flood elevation along the full extent of the existing unit alignment. Without project implementation, the reliability of the unit does not meet current criteria and the entire CID study area is subject to inundation from flood events less than the authorized system design event. These alternatives meet all project objectives and are within the project constraints.

b. Tieback at Sta. 130+00

Alternatives One and Four assume that a tieback is constructed to the bluff starting at Sta. 130+00, immediately downstream of the Kansas City Terminal Bridge. The existing floodwall upstream of Sta. 130+00, including the existing stop log closure at the KC Terminal Bridge, would not be raised. The tieback would require four new stop log closure structures and 15 new relief wells. Alternative Four assumes that a new small pump station would be needed to handle additional relief well flows. Alternative One does not include a pump station. Both alternatives have the same future with and without project conditions. Implementation of either alternative will provide reliable flood risk management up to the 500+3 flood elevation along the existing unit alignment

downstream of Station 130+00. Upstream of this location, the existing floodwall would remain in place and continue to provide benefits up to its current elevation. If a flood exceeded this height, this reach would overtop causing inundation of the railroad tracks. The new tieback would prevent these floodwaters from entering the rest of the study area up to the 500+3 elevation.

c. Tieback at Sta. 138+95

Alternatives Three and Six assume that a tieback is constructed to the bluff starting at Sta. 138+95. The existing floodwall upstream of this location would not be raised. Under both alternatives, the existing stop log closure at the Kansas City Terminal Bridge would be raised. The tieback itself would be shorter than in other alternatives, and require only two new stop log closure structures. However, an additional 30 new relief wells are needed. Alternative Six assumes that a new pump station would be needed to handle additional relief well flows. Alternative Three does not include a pump station. Both alternatives have the same future with and without project conditions. Implementation of either alternative will provide reliable flood risk management up to the 500+3 flood elevation along the existing unit alignment downstream of Station 138+95. Upstream of this location, the existing floodwall would remain in place and continue to provide protection up to its current elevation. If a flood exceeded this height, this reach would overtop causing inundation of the railroad tracks. The new tieback would prevent these floodwaters from entering the rest of the study area up to the 500+3 elevation. Without project implementation, the reliability of the unit does not meet current criteria and the entire CID study area is subject to inundation from flood events less than the authorized system design event. These alternatives meet all project objectives and are within the project constraints.

d. Cost Screening Evaluation

Table 15 presents the screening level estimates for the six final alternatives, prepared July 2008.

Table 15
CID-KS Screening Cost Estimates

Alternative Plan	Preliminary Cost ($M)
#1	$ 98,624
#2	$ 130,026
#3	$ 89,918
#4	$ 102,580
#5	$ 130,834
#6	$ 96,136

October 2008 Prices

e. New Pump Station Analysis

Following the initial plan evaluation and cost estimates, further analysis was conducted to determine the technical necessity of a new pump station to handle relief well flows. A

review of the existing interior storm drainage system showed that if all proposed new relief wells were installed as surface discharging, there was adequate capacity to carry the expected flows to existing sewer outlets and pumping facilities. Removing the new pump station from the proposed alternative plans eliminates Alternatives Four, Five, and Six from consideration (they are now identical to Alternatives One, Two, and Three, respectively). Furthermore, with no pump station the estimated cost of Alternative Two is reduced by approximately $8.9 million, for a new estimate of $121.l million. The estimates for Alternatives One and Three are not affected by this pump station evaluation.

f. Floodwall Foundation Investigation

In December of 2010, an investigation was conducted of the existing condition of the timber pile floodwall foundations. The intent of this investigation was to address one of the Key Uncertainties previously identified. In each reach of existing floodwall, an excavation was made on the landside of the wall to expose the existing timber foundation for inspection and analysis. The excavations were at approximately Stations 30+00 and 114+00. At each location the piles were inspected and their condition documented. Sonic Echo Methods/Impulse Response (SE/IR) was used to estimate the length and soundness of the piles. Ultrasonic Pulse Velocity (UPV) testing was attempted at one location with no useful results, and Sonic Pulse Velocity (SPV) testing was used at both locations. Wood cores were obtained from Stations 114+00 for laboratory testing to determine specific gravity, moisture, creosote penetration, and fungal testing.

The results of the inspection and analysis indicated that the existing foundation was in good condition. This led to a revised assumption by the study team concerning the ability of the existing foundation to provide support for floodwall modifications. The previous assumption had been that the foundation would not be able to provide support for modifications and that the existing walls would need complete replacement.

The change from floodwall replacement to modification decreased the cost of all three remaining alternative, but did not alter their relative ranking. Alternative Three is still the lowest cost alternative plan, there by maximizing the net economic benefits. Alternative Three was retained as the Tentatively Selected Plan for the Central Industrial District Unit.

2.0 Armourdale Unit

Pursuant to the alternative evaluation previously discussed in Step 4, in most of the reaches of the unit initially evaluated only one alternative plan was identified as technically feasible and effective to perform the raise and address the respective impacts to appurtenant structural and geotechnical features. These individual reach alternatives are thus common to all final alternative plans for the overall unit. Similarly, structural and hydraulic pump station modifications are necessary based on the new unit height and are common to the final array of plans.

The final evaluation of alternatives thus focused only on those unit reaches where more than one feasible alternative was identified and carried forward. In five separate reaches of the unit, multiple raise alternatives were identified as feasible. These reaches and their alternatives are shown in Table 16.

Table 16
Armourdale Reaches for Further Evaluation

Start Station	End Station	Remaining Alternatives
10+00UE	16+48UE	1. Landside levee raise. 2. Riverside levee raise. 3. Replace levee with floodwall.
77+80	81+00	1. Landside levee raise 2. T-wall on levee. 3. Replace levee with floodwall.
95+00	105+00	1. Landside levee raise. 2. T-Wall on levee
240+00	257+66	1. Landside levee raise. 2. T-Wall on Levee. 3. Replace levee sections with floodwall.
42+50LE	61+00LE	1. Landside levee raise. 2. New sandbag gap closure at Sta. 42+50LE.

In the majority of these remaining reaches, the remaining technically feasible alternatives create access limitations and real estate related conflicts that could require potentially costly relocations. Experience on similar projects in the Kansas City area, and other locations, has shown that real estate access and relocations involving railroads are both very costly and time consuming. This is an important consideration in the final alternative evaluation and selection. Following is a brief discussion of the alternatives in each reach.

Sta. 10+00UE to 16+48UE. A landside levee raise would require relocation of railroad tracks and a riverside levee raise would require modification of two large outfall structures. Replacement of the existing levee with a floodwall eliminates all real estate conflicts. Alternative 3 is recommended.

Sta. 77+80 to 81+00. A landside levee raise would require relocation of railroad tracks. A T-wall on the levee limits top of levee road accessibility to this area of the unit. The access cannot be rerouted to the landside due to the railroad tracks. Replacement of the levee with a new floodwall eliminates the real estate conflicts and maintains access. Alternative 3 is recommended.

Sta. 95+00 to 105+00. A landside levee raise would encroach upon an area needed for access to an adjacent business. A T-Wall on top of the levee limits top of levee road access, but access could be rerouted on the landside in the same area as the business access. Alternative 2 is recommended.

Sta. 240+00 to 257+66. This reach contains two existing levee sections separated by an existing floodwall section. The floodwall has already been identified for replacement as

its foundation cannot support modification for a raise. A landside raise of the levee sections would encroach upon areas used by adjacent businesses for storage and access. A T-Wall on top of the levee would limit top of levee access. Landside access in this reach is already difficult due to the operations of multiple adjacent businesses and the Kansas Ave. bridge approach. Replacement of the levee sections with new floodwall eliminates the real estate conflicts, creates additional area for landside access, and provides for a uniform raise measure for the entire reach. Alternative 3 is recommended.

Sta. 42+50LE to 61+00LE. Even though a landside levee raise would be a very short increase in height, access and implementation of the project would conflict with the adjacent railroad track. A new sandbag gap closure at Sta. 42+50 eliminates this minor unit modification and potentially costly real estate conflict. Alternative 2 is recommended.

The evaluation of the technical alternatives in each discrete reach of the Armourdale Unit resulted in only one feasible method of achieving the levee height increase and address associated structural and geotechnical impacts. The combination of alternatives in each reach results in one complete alternative plan for the Armourdale Unit to meet the consistent system wide uniform level of protection constraint. Thus, there are no other plans for a cost screening evaluation. The remaining Alternative Plan is the Tentatively Selected Plan for the Armourdale Unit.

3.0 Economic Evaluation of Alternatives

Due to the planning constraint to limit the alternatives to only those that maintain the uniform 500+3 level of flood risk management throughout the system, all of the alternatives formulated provide the same level of future economic benefit to the study area. The evaluation and comparison of the final array of alternatives focused on those alternative measures and plans that maximized the cost effectiveness of the project, thereby increasing the net economic benefit. Economic screening and evaluation was conducted in 2008 and used the prices and interest rates current at the time.

Screening level cost estimates and estimated construction periods for each of the 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, and the Federal interest rate of 5.375 percent. Potential Federal funding constraints were not considered in the starting and completion dates of the implementation phases; appropriate funding was assumed available for each phase.

The total first cost for each alternative includes the estimated construction cost, cost for lands, easements and rights of way, preliminary 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 a 5.375% interest

rate. Other direct costs of project implementation (such as potential induced damages) were determined and included in the total annual project implementation cost.

4.0 Costs for Operation, Maintenance, Repair, Rehabilitation, and Replacement

Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R) costs were estimated for each alternative and are based on a life cycle cost analysis. The analyses include only the additional OMRR&R costs that the sponsors would be expected to incur based on the proposed unit modifications. The analyses considered and accounted for the 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 a Federal Interest Rate of 5.375% and a 50 year period of analysis. Following are the major assumptions used in determining the additional OMRR&R costs that the local sponsors would incur with each alternative.

- New Relief Wells: Each new well is assumed to be maintained every 4 years at an estimated cost of $5,000 per well. New wells are assumed to be replaced after 40 years; the replacement cost includes 10% E&D and 7% S&A. The sponsor would continue to incur costs for any existing relief wells but these costs are ongoing for the existing project and are not included in the analysis of the proposed project.

- The levee units in the Kansas Citys project are well-maintained and the sponsors comply with annual inspection requirements. It is assumed that the sponsor's current OMRR&R costs for the existing project will continue.

5.0 Other Economic Benefits Not Quantified

The Corps of Engineers 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 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 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. These regional (RED) impacts are not included in determining the NED benefits and costs, but should receive consideration in the overall decision-making process.

In the Kansas Citys study area, some major production facilities are either a sole producer of a specific product or are one of just a very few in the nation that produces that product. Proctor and Gamble is a prime example in the Armourdale Unit. Loss of production capability in these instances could be an economic loss to the nation unless consumers were able to find a similar product and made the choice to purchase the substitute product. However, these potential NED losses were not quantified for purposes of this study.

G. 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 (damages reduced less project economic costs) as computed for an array of flood events. As the evaluation progressed, the 500+3 profile raise was shown to be an efficient raise with the highest net benefits, and limited land disturbance, real estate conflicts and relocations, environmental impacts, and HTRW material disturbance. All features of the Tentatively Selected Plans identified for CID and Armourdale were retained and combined into the Tentatively Selected Plan for the overall system.

V. Description of the Recommended Plan

The Recommended Plan for improvements to the overall system is the combination of the most technically feasible and cost effective measures to achieve the desired height and reliability in each unit. The economic analysis shows that the overall plan is economically viable and furthers national economic development in manner consistent with Corps of Engineers economic regulations and economic policies. The major components of the Recommended Plan are summarized in Table 17.

Table 17
Recommended Plan Components

	CID	Armourdale	Total
Overtopping/Structural Measures			
Levee Raise (LF)	6,495	13,223	19,718
Floodwall Modification(LF)	4,649	4,208	8,857
Floodwall Replacement (LF)	152	2,105	2,257
New Floodwall (LF)	600	5,392	5,992
New T-Wall on Levee (LF)	-	7,715	7,715
Closure Structure Measures			
New Sandbag Closure	2	3	5
Convert Sandbag to Stop log	1	2	3
Replace Stop log Closure	1	2	3
New Stop log Closure	2	-	2
Underseepage Control Measures			
New Relief Wells	57	74	131
Area Fill (LF)	3,448	-	3,448
Slurry Cutoff Wall (LF)	-	2,000	2,000
Drainage Control Measures			
Pump Station Removal	2	2	4
Pump Station Modification	5	7	12

B. Design and Construction Considerations

As this study deals with an existing levee system, 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.

In particular, 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 floodwall 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 included within the plans and specifications (construction contract) package. The construction package must address high-water contingencies for all sites in the Recommended Plan.

Such contingencies must aim to provide for at least the 1%-chance annual event (the "100-year flood") 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.

The project team will conduct specific utilities relocation coordination and design planning prior to levee raise construction contract award. In recent projects, this relocation work has proven very problematic if not thoroughly scheduled and coordinated. Even though sponsors (and utility owners) are responsible for most utilities relocations (for those utilities deemed without legal compensability), the Kansas City District must 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 (sponsor, utility owner, and Corps of Engineers) must prepare for a highly coordinated utility relocation effort as the levee raise begins.

For all sites, the project coordination team (composed primarily of sponsors, Corps of Engineers staff, and other stakeholders deemed appropriate to the work) will take the Recommended Plan and develop the design detail and contracting documents necessary for successful construction efforts. The project management plan (PMP) will address project scope, quality, schedule, communications, safety, and project team roles as the project develops. 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 each design and construction package will receive

prior to award. It is expected 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.

Additional descriptions of important site-specific design and construction requirements are listed in Exhibit #4: *Additional Design and Construction Considerations for the Recommended Plan.*

C. Cost Estimate Development

The cost estimate supporting the Recommended Plan was prepared 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 estimates were developed with a specific price level date and were then escalated for inflation (fully funded) to the anticipated midpoint of construction.

The product development team included a highly experienced civil works cost engineer. The cost engineer developed the PED, Construction, and LERRD estimates through frequent and continuing team meetings and individual discussions with the appropriate specialists and engineers. Quantities associated with the construction of each major feature were calculated or reviewed by the respective disciplines. The project cost estimates underwent an Agency Technical Review (ATR) and have been certified by the USACE Cost Engineering Center of Expertise in accordance with Corps policies. Appendix E of this report includes additional detail and supporting documentation for the cost estimates. For each Unit an MII summary report is included showing the major components of the estimate. Also provided are Total Project Cost Summary Sheets that provide a very useful summary of the fully funded cost estimate for each unit.

Each estimate prepared underwent a cost risk analysis led by the cost engineer with input from the project delivery 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 Monte Carlo method based model was used to determine the range of possible project costs considering multiple combinations of the identified project risks. The results of this model were used to assign project contingencies that limit cost risks to an acceptable degree of confidence. Consideration was given to the amount of field information currently available in the feasibility phase which significantly affected the uncertainties. A separate Cost Risk Analysis Report was prepared for review by the cost ATR. The Executive Summary of this report and pertinent tables and figures summarizing the most significant risks identified, and the cost and schedule contingency determinations, are included in Appendix E.

1.0 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

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 recognize PL 91-646 assistance to business owners.

02
Relocations

This category includes utility relocations. No other types of public facility relocations were identified. Utility relocations include relocations of utility crossings and relocations of utilities within the critical levee zone affected by increased uplift. 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 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 not a cost-shared project cost).

06
Fish & Wildlife Facilities

An estimate was included within the construction costs for mitigation of anticipated impacts to the environment from borrow area development, overall project construction (both identified and anticipated), and associated mitigation contingencies. A conceptual mitigation plan is included in the EIS which addresses currently identified mitigation requirements.

11
Levees & Floodwalls

This cost category consists of many major construction components across all units in the Recommended Plan. These components typically include: relief wells (underseepage control), borrow site, levee raise (including levee cut and raise, stability and underseepage berms), drainage system modifications, floodwalls, and stoplog gaps (closure structures).

- Relief wells are used in a number of sites. Costs are typically based on 10-inch diameter stainless steel wells. The estimated costs reflect local experience and standard cost factors.

- A borrow site is designated for the levee raise. Borrow area costs include the preparation of the borrow site (including clearing & grubbing) and the final grading of the borrow site when completed. The borrow area covers roughly the same area for all levee raise alternatives, but is dug deeper for higher raise alternatives.

- Quantities for the levee surface preparation were based on the removal of the existing aggregate surfacing on top of the levee, and the stripping of grass and topsoil from landside slope of the existing levee (all significant work is scheduled for the top of levee or the landward slope).

- Quantities for the earthen levee raise were calculated using CAD software and then manually adjusted where necessary for special conditions. Haul distances were calculated based on the borrow site location and the quantities required. The borrow material is excavated, loaded, and hauled using on-highway dump trucks over the existing roadways as identified in the haul route plan. Cost includes an amount for road repair and street sweeping as the borrow operations proceed. A cost is also included for new top of levee (access path) aggregate surfacing, and the final seeding and mulching operations.

- Drainage system modifications include costs for box culvert modifications and associated work on the line of protection, constructing new gatewell structures, abandoning pipes, and the raising of height of existing gatewells to adjust for raised levee elevations and other minor drainage work.

- Floodwall costs include both modification of existing floodwalls and demolition of existing floodwalls and construction of new reinforced concrete floodwalls (depending on location); including all appurtenant features such as the provision and installation of piles, sheetpile cutoff walls, etc. Floodwall heights vary by site.

- Stoplog gap costs include the excavation and demolition of the existing stop log gaps. After demolition of the existing structure, the site is backfilled to the new base elevation. H-piles are

driven for load support. A sheetpile cutoff wall is constructed. New abutment walls are built along with a new sill. The concrete sill/foundation/walls are constructed in phases to accommodate railroad traffic. Standard stop-logs are used. Remaining backfill is placed and the railroad lines replaced.

13 Pump Stations — Requirements vary widely by individual site and are described in detail in the Recommended Plan.

30 Engineering and Design — About a three year Preconstruction Engineering and Design (PED) period is expected to prepare a Design Documentation Report and plans and specifications for the first construction contract. Engineering During Construction (EDC) costs were estimated for the design of future construction contract packages after the construction phase begins. Design effort duration varies by site depending on the difficulties and complexities of each individual design requirement.

31 Construction Management — This cost estimate was developed for the Federal construction portion of the Recommended Plan based on local experience in recent and ongoing levee projects and related Corps guidance for the construction management function.

2.0 Other Cost Estimate Information

- Being a Federal project, no state sales tax was included in the estimated construction costs.
- The source for the labor rates used in the estimate is the Department of Labor Wage rates for Wyandotte County, Kansas or Jackson County, Missouri as applicable. A minor cost adjustment factor is added to bring the labor rates to the 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.

3.0 Summary Cost Estimate Tables

The cost estimate summary for the Recommended Plan is shown in Table 18.

Table 18
Total Project Costs By Category – Overall Recommended Plan
FY2013 price level ($1,000s)

Category of Cost	Amourdale Unit	CID Unit	Total
Lands & Damages	$10,640	$5,218	$15,858
Fish & Wildlife Mitigation	$0	$0	$0
Relocations	$5,637	$4,734	$10,371
Levees & Floodwalls	$139,350	$44,483	$183,833
Pumping Plant	$5,823	$1,933	$7,756
Planning, Engineering, & Design	$11,410	$3,895	$15,305
Construction Management	$10,592	$3,616	$14,208
Contingencies	$49,532 (27%)	$19,803 (31%)	$69,335
Total Cost	**$232,984**	**$83,682**	**$316,666**

The Recommended Plan implementation costs are categorized and apportioned in Table 19. Standard code of accounts and standard cost share amounts for Flood Risk Management (FRM) apply.

Table 19
Cost Summary By Levee Unit -- Recommended Plan

All cost shown in $1,000s

Levee Unit & Site	Total	Federal (65%)	Sponsor (35%)	PED	LERRD	FRM
FY2013 PRICE LEVEL ESTIMATE						
Armourdale Unit	$232,984	$151,440	$81,544	11,410	$16,277	$205,297
CID Unit						
Kansas Section	$83,370	$54,191	$29,180	$3,874	$9,952	$69,544
Missouri Section	$312	$203	$109	$21	$0	$291
Totals	**$316,666**	**$205,833**	**$110,833**	**$15,305**	**$26,229**	**$275,132**
FULLY FUNDED ESTIMATE						
Armourdale Unit	$301,823	$196,185	$105,638	$18,790	$24,582	$258,451
CID Unit						
Kansas Section	$107,697	$70,003	$37,694	$5,025	$12,010	$90,662
Missouri Section	$399	$259	$140	$26	$0	$373
Totals	**$409,919**	**$266,447**	**$143472**	**$23,841**	**$36,592**	**$349,486**

Notes: Amounts include the estimated contingencies for each site
Totals in this table are rounded.

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. See the Real Estate Appendix for additional detailed information.

1.0 Lands and Damages Costs

For both units in 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 recognize PL 91-646 assistance to business owners.

Land acquisition anticipated for the Recommended Plan primarily consists of limited permanent and temporary easements on private and public lands. Fee acquisition is not expressly required for levee rights-of-way (r-o-w) on either of the units. Estates to be acquired by the sponsors include permanent levee and floodwall easements necessary for the levee raise (berm placement) and floodwall work.

Temporary easements will be used for borrow, 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 1 year to 2.5 years. The Recommended Plan does not require acquisition of an off-site disposal area.

PL 91-646 assistance for the Recommended Plan specifically applies to the removal and relocation costs for private business structures (less than 10,000 sf total). No residential housing is affected in any unit.

2.0 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).

3.0 Transportation Facilities Impacts

No active railroad tracks or railroad facilities require permanent relocation. Temporary adjustments to trackage or schedules are likely needed during some periods of construction. No public roads or bridge crossings require modification.

E. Operation and Maintenance Considerations

Operation, maintenance, repair, replacement and rehabilitation of the project will remain the responsibility of the non-Federal sponsors. Operation and Maintenance (O&M) manuals will be prepared (or updated as appropriate) by the Corps of Engineers and provided to the sponsors following each implementation contract or phase.

Several closure structures are being converted from sandbags to stoplogs and new structures of both types are being added to the system. The necessary coordination and operational considerations of closure structures are already well understood by the sponsor and the affected stakeholders 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 Operations and Maintenance Manuals. For locations where new stoplog gaps are being places, stoplog storage locations will be identified and the necessary easements or property requirements coordinated through the LERRD process.

The majority of the sponsor O&M concerns and costs will remain the same as the current condition. There will be some savings in costs related to pump station removals, although most of the stations slated for removal are already essentially abandoned and not being fully operated maintained or upgraded currently. There will be an overall net increase in the number of relief wells in the system, requiring periodic testing and rehabilitation, repairs as needed, and eventual

replacements. While these relief well costs are the driver in overall changes to the O&M costs, evaluation of their impact on an annual basis indicates little overall change as shown in Table 20.

Table 20
Annual Operation & Maintenance Cost for Phase 2 Recommended Plan

Levee Sponsor	Average Annual O&M Costs	Incremental Annual O&M Cost for Recommended Plan
Kaw Valley Drainage District	$1,700,000	+$561,000
Kansas City Missouri	$875,000	+$0

F. Economic Analysis of the Recommended Plan

Economic analysis discussed previously identified the expected economic impact of future flooding with the existing project. To aid in comparison of the alternatives, additional economic analysis was conducted to develop a risk-based evaluation in terms of benefits, costs, and performance of the alternatives under the with-project condition. The analysis encompasses all flood-prone properties within the study area.

Extensive economic surveys of the whole Kansas Citys Levees study area were completed in 2002. Economic data developed for this analysis includes values, elevations and depth-damage relationships for homes, businesses, public facilities, roads, and railroads in the study area. Furthermore, a follow up survey was conducted in early FY2012 to update the economic field data. Conditions are evaluated in terms of a base year of 2026 when the project would be operational and a future without-project conditions year of 2049. The same data set was used for both 2026 and 2049 conditions.

A risk-based economic damage analysis was performed using the HEC-FDA software that is standard in the Corps for flood damage reduction analyses. Water surface profiles with stages and discharges were obtained for eight probability events: 0.10, 0.01, 0.005, 0.002, 0.0013, .0001, 0.0008, and 0.0007. The profiles are referenced to 2008 conditions, although it should be noted that no increases in these stages are forecasted through the period of analysis and the same profiles are used for existing, base year, and future conditions. The exceedance-probability relationship for the Kansas River was evaluated using the graphical method, which involves specifying a discharge-probability relationship (including a discharge for the 0.999 probability event) for each index point along with the equivalent record length for the stream. Top of levee stages based on the critical levee low point were translated to each index point, as were exterior-interior stage relationships. Geotechnical and structural probability of failure curves were developed for critical sections on each levee, adjusted to the appropriate index points, and a combined probability of failure was computed using a formula from ETL 1110-2-556, *Risk Based Analysis for Geotechnical Engineering for Support of Planning Studies* (Formula: Pr(f) = 1-(1-p1)(1-p2),,,(1-pn)). The resulting combined probability of failure versus river stage curve was entered into the HEC-FDA study file in the “Levee Features” section. The following series of tables presents the findings and results of the economic analysis.

Table 21
Project Costs Summary

Oct 2012 prices; 3.75% interest rate; 50 year period of analysis; $1,000s		
ITEM	**Armourdale**	**CID**
Construction	$194,705	$66,219
Lands and Damages (LERRD)	$16,277	$9,952
Planning, Engineering & Design (PED)	$11,410	$3,895
Construction Management	$10,592	$3,616
Total First Cost	**$232,984**	**$83,682**
Interest During Construction (IDC)	$60,899	$23,447
OMRR&R	$419	$142
Total Annual Costs	$13,519	$4,917
Total first costs = PED + LERRD + construction + S&A		
Annual costs = ((Total first costs + IDC) x interest & amortization factor of 0.04457) + OMRR&R		
Annual O&M costs include only additional or net costs over and above comparable exisitng costs.		

Table 22
Economic Analysis Summary

Oct 2012 prices, 3.75% interest rate, 50 year period of analysis, $1,000s				
Levee Unit Alternative	**Total Annual Costs**	**Annual Benefits**	**Benefit-Cost Ratio**	**Net Benefits**
Armourdale				
Nominal 500+3 Raise	$13,519	$50,007	3.7	$36,488
Central Industrial District				
Nominal 500+3 Raise	$4,917	$7,389	1.5	$2,472
Total Phase 2 Study Area	**$18,436**	**$57,396**	**3.1**	**$38,960**
Argentine 500+3 Raise*	$3,350	$18,175	5.4	$14,825
Kansas River System	**$21,786**	**$75,571**	**3.5**	**$53,785**
*From Approved FY12 NWK Economic Update - Kansas Citys Levees				

Table 23
Economic Performance of the Recommended Plan
Oct 2012 prices; 3.75% interest rate; 50 year period of analysis; S1000s

	Equivalent Annual Damages		
	Without Project	**With Project**	**Damage Reduced**
Armourdale	$ 53,837	$ 3,830	$ 50,007
CID	$ 10,900	$ 3,511	$ 7,389
Total	$ 64,737	$ 7,341	$ 57,396

Project costs are summarized in Table 21. Costs were prepared by cost engineering for each of the alternatives. All costs include interest during construction computations which assume project completion in mid-2026. All costs reflect an October 2012 price level and the annualized totals reflect the current Federal interest rate of 3.75 percent as well as a 50-year period of

analysis. OMRR&R costs were included in this analysis for those features that will incur a net cost over and above present levels. The additional OMRR&R is due to net increases of 20 relief wells in the CID unit and 59 in the Armourdale unit.

It can be seen in Table 22 that in addition to the strong benefit-cost ratio for the Kansas River system-wide project, each unit is also individually justified. The combined Phase 2 portion of the total project has a benefit-cost ratio of 3.3, while Armourdale unit's benefit-cost ratio is 3.9 and the CID portion stands at 1.7. With Phase 2 net benefits of $40.3 million, the project represents a strong contribution to national economic outputs.

As computed in the HEC-FDA risk analysis model and shown in Table 23, equivalent annual damages (EAD) is reduced by nearly $57.4M for the Phase 2 study area.

The primary benefits of the Recommended Plan are the reductions in the potential for flood damage. Because much of the protected area is already industrial, implementation of the Recommended Plan will provide continuity to the current employment base of the area. In the long-term, business volume, personal income, employment, and taxes are not expected to change significantly as a result of implementing the Recommended Plan. However, with improved flood risk management, new business and investment would be more easily attracted to the protected area if vacancies were to occur.

During the short-term, construction of the Recommended Plan can be 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 associated profits, and increased sales tax receipts at the local level.

G. Final Verification of the System NED Plan

As previously presented in Table 14, a comparison of costs and benefits of different system raise alternatives was conducted in 2006 and identified the 500+3 alternative as the National Economic Development (NED) plan, with the highest net economic benefit for the system.

After completion of the economic analysis of the Recommended Plan, shown in Table 23, it was recognized that the current annual costs and benefits are significantly higher than in the 2006 screening, especially in the Armourdale Unit, even after adjustment for inflation. The earlier calculation of economic benefits was derived from overtopping failure impacts only. Potential geotechnical and structural failure modes identified and evaluated since that time can lead to flooding risks and impacts at lower elevations than overtopping, thus increasing the benefits. Similarly, the relative project costs are greater due to the measures required to address these additional project concerns.

Considering the magnitude of the changes since 2006, a review and verification of 500+3 as the system NED plan was warranted. Revised economic benefits were determined for 500+1 and 500+2 water surface elevations. A review of the Recommended Plan cost estimate was conducted to determine costs for the lower raise alternatives. As the different alternatives are in

the same locations, requiring essentially the same easements, equipment, contracting, design effort, etc., there is only a relatively small cost savings of building a levee one or two feet shorter. The primary cost differences are related to material quantities of earth and concrete for the levee and floodwall raises and underseepage berms, and the number of required relief wells. An update to Table 14 is presented in Table 24. As shown in the table, each of the individual units, and the three-unit Kansas River system collectively, show maximum net benefits at the 500+3 water surface profile raise alternative.

Table 24
Updated Screening Analysis of Alternative Raise Profiles

Oct 2012 prices; 3.75% interest rate; $000s					
500+1 Profile Raise					
Unit	**First Cost**	**Total Annual Cost**	**Total Annual Benefits**	**B/C Ratio**	**Net Benefits**
Argentine	$ 59,812.5	$ 3,279.3	$ 17,367.1	5.30	$ 14,087.8
Armourdale	$ 219,948.0	$ 12,428.9	$ 48,465.7	3.84	$ 35,256.6
CID-KS	$ 74,135.0	$ 4,190.1	$ 5,430.4	1.30	$ 1,240.3
Total	$ 353,895.5	$ 19,898.3	$ 70,483.1	3.54	$ 50,584.8
500+2 Profile Raise					
Unit	**First Cost**	**Total Annual Cost**	**Total Annual Benefits**	**B/C Ratio**	**Net Benefits**
Argentine	$ 61,446.8	$ 3,368.5	$ 17,620.7	5.23	$ 14,252.2
Armourdale	$ 223,814.0	$ 12,640.0	$ 48,465.7	3.83	$ 35,825.7
CID-KS	$ 81,157.0	$ 4,573.5	$ 6,532.1	1.43	$ 1,958.7
Total	$ 366,417.8	$ 20,582.0	$ 72,618.6	3.53	$ 52,036.5
500+3 Profile Raise					
Unit	**First Cost**	**Total Annual Cost**	**Total Annual Benefits**	**B/C Ratio**	**Net Benefits**
Argentine	$ 63,923.7	$ 3,503.8	$ 18,175.2	5.19	$ 14,671.4
Armourdale	$ 232,984.0	$ 13,140.8	$ 50,006.8	3.81	$ 36,866.1
CID-KS	$ 83,682.0	$ 4,711.4	$ 7,389.0	1.57	$ 2,677.7
Total	$ 380,589.7	$ 21,355.9	$ 75,571.1	3.54	$ 54,215.2

H. Recommended Plan Performance and Accomplishments

The with-project (residual) flood risks and damages are shown in Table 25. The residual risk results address all three major aspects of the levee performance analysis: overtopping (hydraulic), geotechnical, and structural. The with-project performance provides a very significant decrease in the flood risk for each of the respective units.

Table 25
Engineering Performance - With Project Conditions

	Armourdale	CID
Annual Exceedance Probability* (median)	0.0012	0.0012
Return interval (years)	833	833
Long Term Risk (chance of exceedance during indicated period)		
over 10 years	0.0162	0.0194
over 30 years	0.0400	0.0478
over 50 years	0.0785	0.0934
Conditional Exceedance Probability - Overtop or Breach**		
10.0% event	0.0000	0.0003
4.0% event	0.0000	0.0003
2.0% event	0.0003	0.0003
1.0% event	0.0126	0.0117
0.4% event	0.1429	0.1206
0.2% event	0.3454	0.3026

*Annual exceedance probability is the chance of experiencing any flood event - of whatever magnitude - within any year.
**Conditional exceedance probability is the probability that specified flood event would overtop or breach the levee.

Tables 13 and 24 compare the without and with-project assurance statistics for the two levee units. The median annual exceedance probability – currently as much as 0.035 for Armourdale and 0.004 for CID in their existing conditions – would improve to 0.0012 for both units. In other words, there would be a 0.12 percent chance of a damaging flood in any year following project implementation.

In the 1 percent-chance flood event, both Phase 2 units would have between a 6 percent and 8 percent chance of experiencing damage. These probabilities would be improved to roughly 1 percent in the with-project condition.

The long-term risk of a damaging flood in both of the Phase 2 units over 50-year period would be less than 1 in 10, compared to a current 50-year risk exceeding 1 in 2 in Armourdale and approximately 1 in 4 in CID.

Under the Recommended Plan, both levee units will comply with FEMA base flood (100 year) levee certification requirements. Furthermore, although no standard exists for a "500 year" certification, both units will have approximately 3 feet of overtopping margin against the median 0.2% chance exceedance flood profile. This can reasonably be interpreted as "500 year" level of protection when classifying performance characteristics. Other performance aspects of the with-project condition are described in some detail within the Exhibit #5: *Perspectives and Discussion of Levee Performance Analysis.*

The tax bases within both of the levee units are relatively stable as the protected areas are essentially built-out. This limitation on tax base essentially 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 several of the major recommendations herein would remain un-built if not for the Federal cost sharing opportunity provided by the Recommended Plan. The

Recommended Plan also provides many lower income residents with additional flood risk management benefits which might not otherwise be available through local processes.

I. Environmental and Cultural Considerations

The Environmental Impact Statement (EIS) published in August 2006 included an environmental and cultural discussion of the levee units and study areas discussed in this Final Feasibility Report. The Recommended Plan presented herein is within the project alternatives and geographic areas previously studied. Review of the project areas has shown no changes in the environmental conditions of the project area since publication of the EIS. A new or supplemental EIS has not been prepared for the recommendations of this report. A brief summary of the findings is included here; for additional detail please refer to the complete document currently available in the Kansas City District website.

1.0 Cultural Resources

The cultural resource evaluation of the project area found no archaeological sites or historic structures listed on or eligible for listing on the National Register of Historic Places (NRHP). The project area, heavily disturbed by past levee and urban related construction, was found unlikely to contain previously unidentified archaeological sites eligible for inclusion in the NRHP. Cultural resource findings were coordinated with both the Kansas and Missouri State Historic Preservation Officers who concurred with Corps of Engineers recommendations for no further investigations unless an unanticipated discovery is encountered during construction.

2.0 Secondary and Cumulative Impacts

Potential cumulative impacts relating to past, present, and projects within the foreseeable future, were evaluated along with the preferred plan to determine the level, if any, of impacts upon the physical and natural environment along the Kansas and Missouri Rivers. The Recommended Plan involves a combination of levee raises and appurtenances that lies primarily within the footprint of the existing levee system. As a result of project implementation, impacts to the existing river systems are relatively minor and not considered significant. Compared to past activities and current operations within these reaches of the rivers, the additional minor impacts created by the increased levels of protection do not create significant additional or cumulative impacts to the environment.

3.0 Induced Damages

The Interim Feasibility Report included the following discussion of induced damages:

Minor induced damages from the Argentine levee unit raise can occur under certain rare and somewhat extraordinary conditions. If one of these rare flood events occurs, then minor induced damages could possibly occur in the following areas:

- *Areas downstream of the Argentine Unit (areas within the existing Armourdale and CID Units)*

- *In a small unprotected area opposite the Armourdale Unit and located below the bluff line*

The flood events for which these induced damages can be calculated to possibly occur are more rare than the 250 year (or 0.4%) event and approaching the 300 year (0.33%) event. In these situations the induced flooding is very small (about 6 inches deep in most cases). Given this, the induced damages amount on each structure is essentially inconsequential compared to the existing damages from normal river flooding. The predominant threat of flooding in these areas remains essentially the same as the without-raise conditions. 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.

These induced damages discussed would occur only if the Argentine Unit were raised and the downstream units, Armourdale and CID, were not. The Tentatively Selected Plan for raising the Armourdale and CID Units eliminates these induced damages. The TSP causes no new induced damages on other areas.

4.0 Environmental Justice

The Executive Order on Environmental Justice (12898) requires consideration of social equity issues, particularly any potential disproportionate impacts to minority or low-income groups. This is to ensure that issues such as culture and dietary differences are taken into consideration to ensure that adequate risk is evaluated (USEPA, 2003). To determine potential impacts to minority or low-income groups, the racial and income composition of the individual census tracts within, and adjacent to the study area, were examined using 2000 census data. The focus of Executive Order 12898 provides for the protection of both minority and low-income groups.

The results of the Environmental Justice evaluation show that a significant minority population (>25%) is present within the Armourdale and CID levee units. A significant number of persons living at below the national poverty level also reside within the Armourdale Unit. There exists a minor potential for the Recommended Plan to have limited impacts on the Armourdale and CID populations and community cohesion.

Implementation of a levee raise of the Argentine Unit as recommended and approved in the Interim Feasibility Report, prior to any raise in the Armourdale and CID Units, may induce flood damages on the downstream units under extremely rare flood events until such time as equal levels of protection are attained at all three levee units. These potential induced damages are considered temporary and would only occur in the event of a major flood (more rare then the nominal “250 year” event). Impacts to the Armourdale and CID populations are limited by the rarity of coincident circumstances which must occur in order to produce the induced damages. Because significant populations of low income families and cultural and racial minorities reside and work within all the Kansas River Units, there would be no significant difference between implementation of the one unit prior to another. The project would meet the intent of protection of minority and low income populations under Executive Order 12898.

5.0 Wetlands

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.

6.0 Mitigation

After considering the environmental features of the project area, there is a potential for impacts to a limited number of trees from project area construction activities. Should unavoidable impacts occur as the result of construction activities, loss of mature trees will be mitigated.

Should individual mature trees be impacted during construction activities, trees will be mitigated within the project area by replacement of like species at a quantity sufficient to maintain the previous habitat quality. Adequate mitigation funding is included within the Recommended Plan estimated costs to mitigate for the impacts should they occur.

7.0 Environmental Operating Principles

During the feasibility study, various candidate environmental measures were reviewed in recognition of the Environmental Operating Principles. 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 bank line areas within the metropolitan area. 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 system.

It is important to note the other Corps of Engineers projects underway in the general area that have substantial environmental benefits. The Missouri River Fish and Wildlife Mitigation Program provides for a long-term major restoration of areas along the Missouri River. The Riverfront Ecosystem Restoration Section 1135 project in the Kansas City reach of the Missouri River (near river mile 365.7) provides numerous environmental benefits along levee and floodwall areas and is a part of a larger effort to restore habitat and increase recreational opportunities along the Kansas City Missouri riverfront area. The Blue River project in the eastern sections of Kansas City and Jackson County also provides for a number of important environmental benefits in an urban setting. The benefits from all these other projects include: a) improvement of aquatic habitat by measures to improve water quality, bottom diversity, aquatic species spawning and rearing habitat; b) wetland restoration and natural vegetation development to improve habitat function and diversity; and c) improving the hydraulic connection and habitat continuity between riverine habitat areas, tributaries, and the Missouri River.

8.0 Environmental Conclusions

Based on determinations within the Environmental Impact Statement, environmental impacts of the Recommended Plan are limited within the project area. Environmental impacts to the project area are considered minor or not significant with many impacts temporary in nature during construction activities. Cultural resource assessment of the project area showed no significant archaeological sites or historic structures impacted by the Recommended Plan; thereby resulting in no significant impacts. However, if significant archaeological or cultural materials are discovered as the project progresses, then appropriate measures for coordination, documentation, and preservation, if needed, would be undertaken. No significant long term socio-economic impacts were identified for the populations within the project areas. Temporary impacts associated with construction activities would occur but are considered not significant. Based on the environmental analysis, implementation of the Recommended Plan would result in no significant impacts to the environment.

9.0 Contaminated Areas

Given the industrial and commercial nature of the study area, the presence of contamination was anticipated, investigated, and addressed throughout the planning process. Available details of the sites identified and investigated in the Phase 2 units were included in the 2006 Environmental Impact Statement. A more complete HTRW assessment was completed in 2007 and is included in the Hazardous, Toxic, and Radioactive Waste (HTRW) Appendix. Potentially contaminated areas that may be impacted by the Recommended Plan, and how they will be addressed, are summarized below.

Central Industrial District Unit. Potential HTRW concerns have been identified within the study area between station 40+31 and 51+00. Potential encroachment into this area associated with the levee raise is proposed to be avoided by steepening the landside levee slope rather than extending the landside toe. No other locations of HTRW concerns have been identified at this time.

Armourdale Unit. Potential HTRW concerns have been identified within the study area between stations 43+00 to 63+00, 110+00 to 130+00, and 278+00 to 293+00. Furthermore, a former Superfund site is located between stations 130+00 and 157+00. The current proposed action at each of these locations is listed in Table 26.

Considering the urban industrial nature of both areas, it is possible that unidentified concerns are present. Additional soil sampling and testing will be conducted as part of the design phase, as well as close monitoring of material excavated during the project construction, to ensure that any HTRW uncovered is properly handled and disposed.

Table 26
Armourdale Unit Areas of HTRW Concern

Location	Proposed Action
43+00 to 63+00 Proctor & Gamble Manufacturing	Levee raise methods proposed in this reach include T-wall on the existing levee, levee replacement with new floodwall, and floodwall replacement with floodwall, all of which avoid expansion of the levee toe into the area of concern. A slurry cutoff wall will be installed to avoid discharge of contaminated groundwater that may occur with relief wells. Any construction debris encountered near the former Fire Training Area should be removed, sampled, and properly disposed.
110+00 to 130+00 Auto Salvage Yards KC Railcar Services	Levee raise methods proposed in this reach include T-wall on the existing levee and a landside levee raise, which would encroach upon the area of concern. The property will be more fully investigated during the design phase to ensure that surface and subsurface soils are not contaminated and to determine how to dispose of any contaminated soils.
130+00 to 157+00 Trimodal	The levee raise method proposed in this reach is a T-wall on the existing levee. Intrusive activity is limited to areas outside the area of concern. Construction of any haul roads outside the existing right-of-way must be coordinated the Kansas Department of Health and Environment.
278+00 to 293+00 PBI Gordon Corporation	The levee raise method proposed in this reach is a modification of the existing floodwall. No HTRW concern is expected as no invasive activity is planned within the area.

VI. Plan Implementation

A. Work Categorization

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

B. Sponsorship and Product Development During Implementation

In order to maintain the necessary flexibility and control in the acquisition process, and in order to manage the Federal and sponsor funding cycles effectively, it is anticipated that for the most part, the Corps of Engineers will develop and award separate contract packages for each sponsor. This approach will lead to individual PED design agreements and individual Project Partnership (PPA) agreements for each sponsor. Sponsors are aware of this and concur with this approach to implementation. It is anticipated that multiple future construction contracts will be required to implement the Recommended Plan in each unit. As much as possible, these will be planned and sequenced to realize increased benefits as early as possible in the implementation phase.

C. Implementation Approach

The Final 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.

Following Feasibility Report approval, the Corps of Engineers will negotiate and execute Pre-Construction Engineering and Design (PED) agreements with the respective local sponsors for the sites in 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 essential completion of the PED phase (and prior to the acquisition of any required project lands); the Corps of Engineers and the respective sponsors will execute a Project Partnership Agreement (PPA). The Design Documentation Report prepared during PED will guide development of the PPA. Work under the PPA can begin in levee reaches requiring no additional lands. For sites requiring lands, the sponsor will acquire easements, rights-of-way and necessary disposal areas prior to advertisement and award of the first construction contract. The construction contracts are then awarded for the respective sites following real estate acquisition.

D. 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. A project coordination team composed of key Corps and sponsor personnel will be formed under the auspices of the PPA and will guide the construction phase.

E. Implementation Schedule

The overall project schedule for the areas of interest in the Final Feasibility Report analysis 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 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 almost immediate start of design remedies beginning in FY2015, and followed by award of construction contracts for the remedies, pending authorization, in FY18 through FY28. Several factors have been considered when projecting the sequence of future work:

- Construction contracts for different features can be undertaken simultaneously for increased efficiency.
- 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 schedule may be modified before it is transmitted to higher authority for authorization and/or implementation funding.

F. Institutional Requirements

In addition to the cost sharing responsibilities discussed below, the following sections outline additional Federal responsibilities and local cooperation requirements associated with the development of general 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.

G. 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.

1.0 Federal

In meeting the area's needs for flood risk management, 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.

2.0 Non-Federal

The non-Federal sponsors are fully aware of and able to comply with all non-Federal sponsor responsibilities as described within the Recommendation section of this report.

H. Financial Capability Analysis

All construction and design costs referred to in this section are fully funded, accounting for all costs through construction completion including inflation. The total fully funded project cost, including all individual project components, is estimated at $409,919,000. The following discussion of project costs and individual non-Federal sponsor amounts are based on the fully funded project cost.

Of the two non-Federal sponsors, the Kaw Valley Drainage District of Wyandotte County, Kansas (KVDD), is responsible for the largest non-Federal share. KVDD will be responsible for

the non-Federal share of work on the Armourdale Unit and the Kansas Section of the Central Industrial District Unit. Total costs for these two project components are expected to total $409,520,000. The 35 percent non-Federal share is $143,332,000. KVDD will continue to be responsible for annual operation and maintenance costs including the approximately $561,000 in annual costs added by this project. In a letter to the Kansas City District Corps of Engineers dated April 12, 2006, KVDD has asserted their capability and intent to fund non-Federal costs for design, construction, operation and maintenance functions related to these two project components. KVDD currently funds their operations through a tax levy on properties within their district and they have authority under state statutes to issue general obligation bonds to raise funds. Additional possible funding alternatives include increases to their tax levy, expansion of their statutory bonding authority, and identification of local funding partners. It is expected that the proposed projects will be implemented in phases spread over a number of years to lessen the annual impact to KVDD's annual budgets and operations.

The City of Kansas City, Missouri, is responsible for non-Federal cost sharing of the recommended plan in the Missouri Section of the Central Industrial District Unit, with an estimated total cost of $399,000. The non-Federal cost share responsibility would be $139,650. The City will continue to provide annual budgets for levee operations and maintenance in accordance with current practice. This project is not expected to create additional operations and maintenance costs. The City expressed its intent and capability to provide the required non-Federal share in a letter to the Kansas City District dated June 16, 2006. The City anticipates providing the non-Federal share from the Public Improvements Advisory Committee (PIAC) Capital Improvement Funds; the same as they are currently funding such projects.

The Kansas City District is of the opinion, based on the current financial standing and past performance of these sponsors, that their financing plans are reasonable and that they will be capable of meeting their financial obligations for implementation of the Recommended Plan.

I. Views of the Local Sponsors

The non-Federal sponsors strongly support the Recommended Plan. On a daily basis, each of the sponsors accomplish the numerous actions necessary for keeping the project in good condition as evidenced by recent annual inspection reports and by the evaluations undertaken in the feasibility study. The sponsors will continue to provide full cooperation and are prepared to meet the necessary financial obligations associated with the Recommended Plan.

The sponsors are fully aware of and in agreement with the requirements of the model Project Partnership Agreement. Both sponsors have previous experience on similar projects with Kansas City District that have utilized the model agreement with no requests for special conditions. It is anticipated that no special requirements will be requested or required for implementation of the Recommended Plan.

J. Views of Other Agencies

Extensive coordination with several State and Federal agencies took place during initial plan development and evaluation of the Recommended Plan. The following agencies were coordinated with and in some cases have provided comments or participated in the review of this project:

- Kansas Department of Health and Environment
- Kansas Department of Wildlife and Parks
- Kansas State Historic Preservation Office
- Missouri Department of Conservation
- Missouri State Historic Preservation Office
- US Environmental Protection Agency
- US Fish and Wildlife Service
- US National Parks Service

Agency views or concerns expressed during the scoping process or through ongoing study coordination, focused on:

- potential or actual contamination within the industrialized areas of the levee units,
- environmental justice for local communities during the formulation of alternatives,
- potential channelization of the Kansas and Missouri Rivers
- quality of the foreshore riparian habitat along the rivers,
- wetlands within the project area,
- threatened and endangered species,
- cultural resources or historic properties that may be encountered.

Agencies have provided concerns or comments through the public scoping process, through a Planning Aid Letter, through coordination and submittal of the draft Fish and Wildlife Coordination Act Report, through coordination letters to the State Historic Preservation Officer, and through day to day contact with appropriate agencies as the formulation process and EIS developed. As a cooperating agency, the EPA has provided specific input and review on contaminant issues, air quality information, and an Environmental Justice evaluation pursuant to Executive Order 12898.

K. Summary of Coordination, Public Review, and Comments

Review of the Environmental Impact Statement (EIS) supporting these project recommendations was conducted during the Phase 1 Feasibility Study in accordance with the National Environmental Policy Act (NEPA), and Corps of Engineers policies. The NEPA and EIS processes require full disclosure of present, future and cumulative, economic, environmental and social impacts that might occur as a result of implementing the preferred plan examined within this study. Following is a general description of the public involvement process applicable to the final feasibility study.

- 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.

Subsequent to Corps Headquarters (HQ-USACE) approval for public release of the draft Final Feasibility Report a Notice of Availability will appear in the Federal Register. Notice of the report availability will be sent to the study sponsors, elected officials, tribal governments, Federal agencies, state, county, city and local governments, environmental groups, businesses, individuals, news media, libraries, and neighborhood groups and other individuals and organizations on the project mailing list. A press release will be made and the project website updated to include the released information. The Draft Report will be made available for public review on the website, at area public libraries and at the Kansas City District Corps of Engineers office. The comment period on the draft documents will run for 30 days after the Notice of Availability appears in the Federal Register. All substantive comments received during this period will be included in the Final Report with responses.

1.0 Public Scoping Meetings

Scoping meetings for the feasibility study and Environmental Impact Statement were held during Phase 1 of the Feasibility Study. Invitations and announcements for the scoping meetings were sent to the study sponsors, elected officials, tribal governments, Federal agencies, state, county, city and local governments, environmental groups, businesses, individuals, news media, libraries, and neighborhood groups.

Issues and concerns identified by Agencies regarded potential impacts to downstream areas resulting from implementing any flood risk management measures, economic development of the riverfront area, transportation impacts on bridges, highways, barge traffic, channelization of the Kansas and Missouri Rivers, the potential loss of natural resources, impacts on historic trails and sites, and opportunities for Missouri River recreation and levee trails related to the Metro Green Trail System.

The public recognized the need for effective flood risk management; however they also recognized other needs. The priority needs voiced by the public were related to Missouri River recreational opportunities. Many public comments related to incorporating walking and bicycling trails into the Kansas Citys levees system. Comments also related to the interest and need for parks along the rivers and/or levees. The public also voiced concern over the lack of public access to the Missouri River and Kansas Rivers due to the continuous linear nature of the levees. There were some questions concerning peak flows, scouring, and the water resource models that would be used when addressing urban flood risk management issues.

L. Status of Corps of Engineers Review Process

The Alternative Formulation Briefing (AFB) to HQ-USACE occurred on April 24, 2013. The Project Guidance Memorandum (PGM) was submitted to HQ-USACE on July 23, 2013, detailing the AFB comments and issues and the Kansas City District plan for resolution prior to public review of the Draft Final Report.

1.0 Agency Technical Review

An Agency Technical Review (ATR) has been completed, led by the Louisville District and including reviewers from several other Corps District offices. The ATR was conducted as defined in the project's Review Plan to comply with the requirements of EC 1165-2-214. During the ATR, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of: assumptions, methods, procedures, and material used in analyses, alternatives evaluated, the appropriateness of data used and level obtained, and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing US Army Corps of Engineers policy. The ATR also assessed the District Quality Control (DQC) documentation and made the determination that the DQC activities employed appear to be appropriate and effective. All comments resulting from the ATR have been resolved and the comments have been closed in the Corps' DrChecks review tracking system.

Significant concerns and the explanation of the resolution are as follows: Comments were raised regarding: capacity of the current pumping system to remove interior drainage from the protected area after implementation of the recommended improvements to the existing levees; and constructability of some subsurface cutoff walls on the Armourdale unit when given the constraints of nearby utilities, existing overhead bridges, and potential HTRW concerns. Provision of addition detailed materials in the report and appendices resolved these issues with no impact on basic project formulation. No concerns remain. All ATR comments have been answered, back checked, and closed.

A separate ATR Certification Report has been prepared by the ATR Team Lead and reviewed and approved by the Flood Risk Management Planning Center of Expertise (FRM-PCX)

2.0 Independent External Peer Review

Draft engineering and plan formulation documentation has been reviewed by an Independent External Peer Review (IEPR) panel. The IEPR panel is managed by Batelle under contract to the FRM-PCX. The IEPR panel will conduct a second phase of review on this Draft Report and will produce a separate final report detailing the process, comments, and issue resolutions.

M. Future Project Schedule

The project designs, cost estimates and economic analyses presented in this report are based on a future project milestone schedule as follows:

JAN 2014	Feasibility Report Approval by the Civil Works Review Board
MAY 2014	Approval of the Report of the Chief of Engineers recommending the project to Congress for authorization
OCT 2015	Execution of Project Design Agreement with Local Sponsor and initiation of Pre-Construction Engineering and Design Phase (pending availability of design phase funding)

OCT 2018	Execution of the Project Partnership Agreement with the Local Sponsor (pending construction authorization and availability of construction funding); Initiation of Land and Easement Acquisition by the Local Sponsor
OCT 2020	Initiation of Construction
OCT 2030	Completion of Project Construction

Cost estimates were initially prepared on the basis of a single construction contract within each unit. Further cost estimate analysis then assessed the impact of multiple construction contracts, including additional contractor mobilizations, longer construction phase scheduled, interest accrued during construction, etc. See the Cost Estimating Appendix for additional detail. It is expected that the work will be implemented in multiple contracts over a ten year period to accommodate funding availability. These contracts are anticipated to be scheduled consecutively; however, they may overlap or be implemented simultaneously depending on the nature of the work in each contract and the availability of project funding.

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

VII. Conclusions

The Recommended Plan reduces the risk of flooding through project improvements and remedies planned for the two levee units examined in this Final Feasibility Report. In general, the Recommended Plan would implement modifications to improve the reliability and performance of the levee units against overtopping, structural, or geotechnical failure. The plan presented in this report compliments the recommendations in the previous Interim Feasibility Report to ensure a uniform level of protection for the existing Kansas Citys Levees system.

The Recommended Plan will provide a project that functions in a safe, viable, and reliable manner, as was initially intended by its designers. It is not required as a result of changed conditions or inadequate maintenance, is generally limited to the existing features and does not change the relative scope or function of the authorized project. It is also economically justified.

There are no significant long-term social or environmental impacts. Design considerations include avoidance of environmental resources, cultural resources, and HTRW where possible. The long-term environmental and cultural consequences of plan implementation are positive as the increased reliability of the units act to guard the social and environmental fabric that has developed within the protected areas for the last 60 years.

Some of the recommendations carry a small associated increase in OMRR&R. The sponsors have sufficiency to provide all real estate requirements.

VIII. Recommendation

Upon considering the economic, environmental, social, and engineering aspects of making improvements to the existing Kansas Citys Project, Armourdale and Central Industrial District

Units, it has been determined that a project to reduce the risk of flooding is in the public interest. Accordingly, the Corps of Engineers recommends that the Recommended Plan, as described in this report, be submitted to Congress for implementation with such modifications as the Chief of Engineers may find advisable, and in accordance with existing cost sharing and financing requirements.

The estimated implementation cost of the Recommended Plan is $205,833,000 Federal and $110,833,000 Non-Federal for a total estimated cost of $316,666,000 at October 2012 price levels. The net benefits of the Recommended Plan are $38.96M, indicating a very strong contribution to the nation's economic output by the project. The average annual flood risk management benefits of the Recommended Plan exceed the average annual cost by a ratio of 3.1 to 1.

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 the first year of construction, any additional funds necessary to pay the full non-Federal share of design costs;

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

    4. 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;

    5. 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 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;

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.

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.

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