114th Congress, 2d Session – – – – – – – – – – – – – – House Document 114–98

CITY OF MANHATTAN, KANSAS LOCAL PROTECTION PROJECT

COMMUNICATION

FROM

THE ASSISTANT SECRETARY OF THE ARMY, CIVIL WORKS, DEPARTMENT OF DEFENSE

TRANSMITTING

THE CITY OF MANHATTAN, KANSAS LOCAL PROTECTION PROJECT: FLOOD RISK MANAGEMENT FEASIBILITY STUDY FOR APRIL 30, 2016, PURSUANT TO PUBLIC LAW 91–611, SEC. 216; (84 STAT. 1830)

FEBRUARY 4, 2016.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

U.S. GOVERNMENT PUBLISHING OFFICE

98–488 WASHINGTON : 2016

AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

NOV 24 2015

Honorable Paul Ryan
Speaker of the House of Representatives
U.S. Capitol Building, Room H-232
Washington, DC 20515-0001

Dear Mr. Speaker:

The Secretary of the Army recommends authorization to modify the Manhattan, Kansas Local Protection Project. The proposal is described in the report of the Chief of Engineers dated April 30, 2015, which includes other pertinent reports and comments. This report was prepared under the authority of section 216 of the Flood Control Act of 1970, which authorizes the Secretary of the Army to review the operations of projects constructed by the Army Corps of Engineers when found advisable due to significantly changed physical, economic, or environmental conditions. If authorized, the Secretary of the Army plans to implement the project at the appropriate time, considering National priorities and the availability of funds.

This Final Feasibility Study presents recommendations for modifications to the existing project to improve flood risk management in the vicinity of the city of Manhattan, Kansas. The recommended modification plan would include raising approximately 14,600 feet of levee (includes 10,200 feet of levee plus adding a 500 feet levee tie-back extension on the northern end of the project on the Big Blue River and 3,900 feet on the Kansas River) generally on the landward side of the existing levee embankment an average of 1.5 feet, and as much as 3.3 feet, above its current height, primarily on the Big Blue River; adding under seepage control measures including 29 relief wells with over 4,900 linear feet of collector system and 2,500 linear feet of under seepage control berms to accommodate the levee raising; replacing five existing drainage structures; one sand bag closure structure at Hayes Drive; and relocating various utility crossings. The recommended plan is the National Economic Development plan. The recommended plan significantly improves project performance and flood risk management benefits at the 1% (1/100) annual exceedance probability event.

The estimated project first cost of the recommended plan, based on October 2015 price levels, is $24,274,000. In accordance with the cost sharing provisions of section 103 of the Water Resources Development Act of 1986, as amended, the Federal share of the first costs of the flood risk management features would be $15,778,100 (65 percent) and the non-Federal share would be $8,495,900 (35 percent).

Based on October 2015 price levels, a discount rate of 3.125-percent, and a 50-year period of economic analysis, the total equivalent average annual costs of the project are

estimated to be $1,102,600, including Operation, Maintenance, Repair, Rehabilitation and Replacement. The expected annual benefits are estimated to be $4,174,100 with net annual benefits of $3,071,500. The benefit-cost ratio is approximately 3.8 to 1.

The Office of Management and Budget (OMB) advises that there is no objection to the submission of the report to Congress and concludes that the report recommendation is consistent with the policy and programs of the President. However, OMB also noted that should the Congress authorize this project for construction, it would need to compete with other proposed investments for funding in future budgets. A copy of OMB's letter, dated November 5, 2015, is enclosed. I am providing a copy of this transmittal and the OMB letter to the Subcommittee on Water Resources and Environment of the House Committee on Transportation and Infrastructure, and the Subcommittee on Energy and Water Development of the House Committee on Appropriations. I am also sending an identical letter to the President of the Senate.

Very truly yours,

Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

Enclosures

3 Enclosures

1. Report of the Chief of Engineers, April 30, 2015
2. OMB Letter, November 5, 2015
3. Manhattan, Kansas, Local Protection Project, Section 216 Final Feasibility Report, August 2014

DEPARTMENT OF THE ARMY
CHIEF OF ENGINEERS
2600 ARMY PENTAGON
WASHINGTON, DC 20310-2600

REPLY TO
ATTENTION OF

DAEN

APR 3 0 2015

SUBJECT: City of Manhattan, Kansas Flood Risk Management Study

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on proposed modifications to the City of Manhattan, Kansas flood protection project authorized by the U.S. Congress in Section 203 of the Flood Control Act of 1954, Public Law 83-780. It is accompanied by the report of the district and the division engineers. These reports were prepared under the authority of Section 216 of the Flood Control Act of 1970, Public Law 91-611, which authorizes the Secretary of the Army to review the operation of projects constructed by the U.S. Army Corps of Engineers when found advisable due to significantly changed physical, economic or environmental conditions. Preconstruction engineering and design activities, if funded, would be continued under the Section 216 authority.

2. The reporting officers recommend authorization of a plan to modify the existing project to improve flood risk management in the vicinity of the City of Manhattan, Kansas. The existing project which consists of a single 5.5-mile earthen levee unit along the left bank of the Kansas River (3.1 miles) and the right bank of the Big Blue River (2.4 miles), two pumping stations, interior drainage gate wells, relief wells and under seepage control berms provides flood risk management for 1,600 acres of urban industrial, commercial, public, and residential development including 2,300 structures (including about 1,700 residential structures) with an estimated population of 7,600. Approximately $1.2 billion in private and local governmental investments are protected by the levee unit. The recommended modification plan would include raising approximately 14,600 feet of levee (includes 10,200 feet of levee plus adding a 500 feet levee tie-back extension on the northern end of the project on the Big Blue River and 3,900 feet on the Kansas River) generally on the landward side of the existing levee embankment an average of 1.5 feet, and as much as 3.3 feet, above its current height, primarily on the Big Blue River; adding under seepage control measures including 29 relief wells with over 4,900 linear feet of collector system and 2,500 linear feet of under seepage control berms to accommodate the levee raising; replacing five existing drainage structures; one sand bag closure structure at Hayes Drive; and relocating various utility crossings. The recommended project, the National Economic Development (NED) Plan will reduce flood risks and hazards in the community; minimize impacts to human safety, health, and welfare; and have minimal impact to the natural environment. The increased reliability is achieved by constructing a new top of levee elevation set at the flood profile to reduce flood damages from a 1 in 100 annual exceedance probability flood event (1% annual chance of occurring in any given year). In the 1% chance flood event, there is currently only a 52.6 % chance of the project preventing damage from overtopping or breach failure. This probability would be improved to 96.3% in

the with-project condition. The long-term risk of a damaging flood over 50-year period would be less than 1 in 6, compared to a current 50-year risk of approximately 1 in 2. The proposed project would have no significant long-term effects on environmental resources. No compensatory mitigation would be required.

3. The recommended plan is the NED Plan. The estimated project first cost of the recommended plan, based on October 2014 price levels, is $23,754,000. The federal share of the first costs of the flood risk management features is estimated to be 65 % or $15,440,100, and the non-federal share is estimated to be 35 % or $8,313,900, including the provision of lands, easements, rights-of-way, relocations, and dredged or excavated material disposal areas (LERRDs) The City of Manhattan is responsible for the operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) of the project after construction, a cost currently estimated to be about $54,000 annually. Based on a discount rate of 3.375 %, October 2014 price levels and a 50-year period of analysis, the total equivalent average annual costs of the project is estimated to be $1,177,660, including the OMRR&R. The proposed plan would reduce expected annual damages by 59 %, with a residual expected annual damage of approximately $2.85 million. The expected annual benefits are estimated to be $4,074,440 with net annual benefits of $2,896,780. The benefit-cost ratio is approximately 3.5 to 1.

4. The goals and objectives included in the Campaign Plan of the U.S. Army Corps of Engineers have been fully integrated into the Feasibility Study process. The recommended plan has been designed to avoid or minimize environmental impacts, to reduce risk of loss of life, and to reasonably maximize economic benefits to the community in coordination with the existing flood risk management system. The feasibility study team organized and participated in stakeholder and public meeting throughout the process and worked to achieve a balance of project goals and public concerns. The study report fully describes local flood risks associated with the Kansas and Big Blue Rivers and risks that will not be reduced. The residual risks have been communicated to the non-federal sponsors and they understand and agree with the analysis. The feasibility study team has reviewed current available information on the estimated future impact of climate change in the region. While a trend towards wetter conditions in the future has been identified, the impacts are expected to be within the range of uncertainty addressed by the current hydrologic model.

5. In accordance with the Corps guidance on review of decision documents, all technical, engineering and scientific work underwent an open, dynamic and rigorous review process to ensure technical quality. This included an Agency Technical Review (ATR), and Type 1 Independent External Peer Review (IEPR), and a Corps Headquarters policy and legal review. All concerns of the ATR have been addressed and incorporated into the final report. An IEPR was completed by Battelle Memorial Institute in August 2014. A total of eight comments were documented. In summary, the IEPR comments related to report completeness in areas of project performance compared to the original project design, alternative plan evaluation, hydrologic and hydraulic uncertainty, climate change, and residual risks. This resulted in expanded narratives throughout the report to support the decision-making process and justify

the recommended plan. All comments from the above referenced reviews have been addressed and incorporated into the final document. A safety assurance review (Type II IEPR) will be conducted during the design phase of the project.

6. Washington level review indicated that the plan recommended by the reporting officers is technically sound, economically justified, and environmentally and socially acceptable. The plan complies with the essential elements of the U.S. Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Land Related Resources Implementation Studies. The recommended plan complies with other administrative and legislative policies and guidelines.

7. The views of interested parties, including federal, state and local agencies have been considered. The USEPA requested additional information on the interagency efforts of the Corps local Silver Jackets program in the Big Blue River and Wildcat River watersheds and adjacent areas of the Kansas River. In response to this request, the U.S. Environmental Protection Agency was provided additional information including a web link for additional program information.

8. I concur with the findings, conclusions and recommendation of the reporting officers. Accordingly, I recommend that improvements for flood risk management for the City of Manhattan Flood Risk Management Project be authorized generally in accordance with the reporting officer's recommended plan at an estimated project first cost of $23,754,000. My recommendation is subject to cost sharing, financing, and other applicable requirements of federal and state laws and policies, including Section 103 of the Water Resources Development Act (WRDA) of 1986, as amended (33 U.S.C. 2213). The non-federal sponsor would provide the non-federal share and all LERRDs. Further, the non-federal sponsor would be responsible for all OMRR&R. This recommendation is subject to the non-federal sponsor agreeing to comply with all applicable federal law and policies, including but not limited to:

a. Provide the non-federal share of total project costs, including a minimum of 35 % but not to exceed 50 % of total project costs as further specified below:

(1) Provide 35 % of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

(2) Provide, during construction, a contribution of funds equal to 5 % of total project costs;

(3) Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material

all as determined by the government to be required or to be necessary for the construction, operation, and maintenance of the project;

(4) Provide, during construction, any additional funds necessary to make its total contribution equal to at least 35 % 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 WRDA 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 partnership 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, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 Code of Federal Regulations (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, OMRR&R of 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, OMRR&R 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 three 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 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; the Age Discrimination Act of 1975 (42 U.S.C. 6102); the Rehabilitation Act of 1973, as amended (29 U.S.C. 794), and Army Regulation 600-7 issued pursuant thereto; and 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (labor standards originally enacted as the Davis-Bacon Act, the Contract Work Hours and Safety Standards Act, and the Copeland Anti-Kickback Act).

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), 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

DAEN
SUBJECT: City of Manhattan, Kansas Flood Risk Management Study

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 the Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the WRDA of 1986, 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.

9. The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It neither reflects 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 before they are transmitted to Congress as a proposal for authorization and implementation funding. However, prior to transmittal to Congress, the sponsors, the state, interested federal agencies, and other parties will be advised of any modifications and will be afforded the opportunity to comment further.

THOMAS P. BOSTICK
Lieutenant General, USA
Chief of Engineers

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

November 5, 2015

The Honorable Jo-Ellen Darcy
Assistant Secretary of the Army (Civil Works)
108 Army Pentagon
Washington, DC 20310-0108

Dear Ms. Darcy:

As required by Executive Order 12322, the Office of Management and Budget has reviewed an August 2014 Army Corps of Engineers (Corps) feasibility study recommending improvements to the Manhattan, Kansas Local Protection Project, with a first cost of $23,754,000 (October 2014 price level).

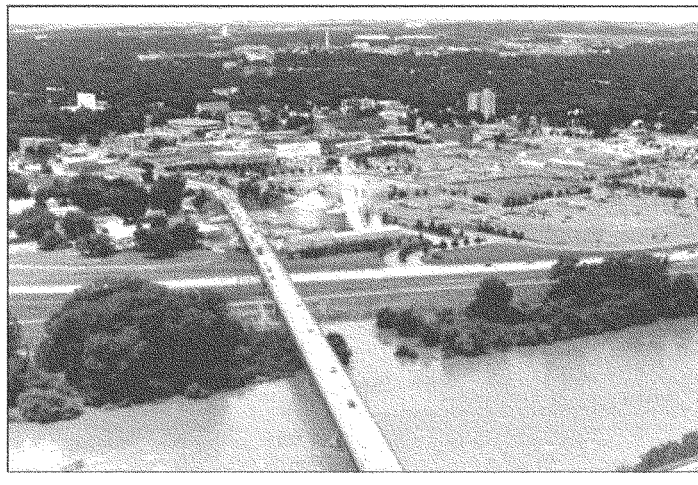
Based on our review of the Corps' report, an authorization to construct this project would be consistent with the programs and policies of the President. The Office of Management and Budget does not object to your submitting this report to Congress. When you do so, please advise the Congress that should the Congress authorize this project for construction, the project would need to compete with other proposed investments for funding in future budgets.

Sincerely,

John Pasquantino
Deputy Associate Director

US Army Corps
of Engineers®

Manhattan, Kansas
Local Protection Project
Section 216 Feasibility Study



FINAL FEASIBILITY REPORT

August 2014

Kansas City District
Northwestern Division

Manhattan, Kansas
Local Protection Project
Final Feasibility Report

August 2014
Table of Contents

Executive Summary vii
I. Introduction and Study Background 1
A. Introduction 1
B. Reason for Study 1
C. Feasibility Study Authority and Cost Sharing Agreement 2
D. Purpose and Scope of the Study 3
E. General Geographic Area and Study Area Descriptions 3
F. Non-Federal Sponsor 4
G. Relevant Prior Studies and Reports 4
II. Existing Project Conditions and Flood History 5
A. Existing Project Description 5
B. Review of Existing Levee Features, Operations, Construction and Modifications 5
B1.0 Existing Levee Features 6
B2.0 Project Operations, Maintenance and Inspections 7
B3.0 Maintenance & Repair History 7
B4.0 Foundation and Underseepage Conditions 7
C. Review of River Basin Characteristics and Flood History for the Manhattan Area 8
C1.0 Kansas River Basin 8
C2.0 Big Blue River Basin 9
C3.0 Historical Flood Events and Damages 9
C3a. The 1903 Flood 10
C3b. The 1951 Flood 10
C3c. The 1993 Flood 11
D. River Discharge Evaluations and Existing Project Hydraulic Characteristics 11
D1.0 Comparison of Designed and Observed Project Performance 12
D2.0 Operation of Kansas River Basin Reservoir System 13
D3.0 Description of Upstream Reservoirs 15
D4.0 Recent River Discharge Evaluations 15
E. Review of Economic Conditions 18
E1.0 Manhattan Economic Overview 18
E3.0 Economic Investment Surveys for Flood Damage Modeling 19
E4.0 Detailed Socioeconomic Characteristics 20
E4a. Economic Analysis Area (EAA) Population and Housing Units 20

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

E4b. Economic Analysis Area Investment 20
F. Review of Existing Environmental and Cultural Resources.....22
F1.0 Threatened or Endangered Species.....22
F2.0 Wetlands 23
F3.0 Cumulative Effects.....23
F4.0 Cultural Resources 23
F5.0 Hazardous, Toxic and Radioactive Waste (HTRW) Assessment 24
F6.0 Recreation Resources.....25
G. Review of Levee Elevations, Model Elevation Inputs, and Survey Information 25
H. Conclusions Regarding Existing Levee Integrity 26
III. Future Without Project Condition Scenario..... 28
A. Socioeconomic Considerations of the Without Project Condition Scenario29
B. Hydrologic and Hydraulic Considerations of the Without Project Condition Scenario.....29
C. Other Considerations of the Without Project Condition Scenario.....30
D. Period of Analysis and Related Assumptions.....31
E. Climate Change.....31
F. Future Without Project Condition Scenario Conclusions.....33
IV. Plan Formulation..... 33
A. Introduction.....33
B. Six Step Planning Process.....34
C. Step 1 - Indentifying Problems and Opportunities 34
C1.0 Planning Goal and Objectives.....35
C2.0 Planning Criteria 36
C3.0 Planning Constraints 37
D. Step 2 – Inventory and Forecast Conditions.....37
E. Step 3, 4, 5 – Formulating, Comparing and Evaluating Alternative Plans37
E1.0 No Federal Action.....38
E2.0 Flood Risk Management Measures.....39
E2a. Traditional Non-Structural Measures 39
E2b. Other Site-Specific Non-Structural Measures 41
E2c. Non-Structural Measures – Summary and Conclusions 44
E2d. Structural Measures 45
E2e. Conclusions Regarding Appropriate Measures to Carry Forward into Plan Formulation 48
E3.0 Identification of Key Uncertainties in Plan Formulation...50
E4.0 Early Array of Plans.....51
E5.0 Final Array of Plans 53
E5a. Detailed Descriptions of the Final Array of Plans 53
E5b. Economic Evaluation of Alternatives 54
E5c. HTRW Considerations of the Final Array 56
E5d. Other Evaluation Criteria Used in the Comparison of the Final Array 57
V. Description of the Recommended Plan..... 58

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

A. Step 6 – Selecting a Plan 58
B. Design and Construction Considerations 60
C. Cost Estimate Development 61
C1.0 Cost Estimate Code of Accounts Information 62
C2.0 Other Cost Estimate Information 63
C3.0 Summary Cost Estimate Tables 63
D. Real Estate Considerations 64
D1.0 Lands and Damages Costs 64
D2.0 Borrow Considerations 65
D3.0 Relocation Costs 65
D4.0 Transportation Facilities Impacts 65
E. Operation and Maintenance Considerations 65
F. Economic Analysis of the Recommended Plan 66
G. Recommended Plan Performance and Accomplishments 68
H. Induced Damages 68
I. Residual Risk 70
I1.0 With-Project Damages and Impacts 71
I2.0 Life Safety Risk Assessment 73
I3.0 Residual Risk Management 75
J. Environmental and Cultural Considerations 76
J1.0 Environmental Justice 76
J2.0 Wetlands and Aquatic Resources 76
J3.0 Mitigation 76
J4.0 Floodplain Impacts 76
J5.0 Environmental Conclusions 78
K. Environmental Operating Principles 78
L. USACE Campaign Plan 79
VI. Plan Implementation 79
A. Work Categorization 80
B. Implementation Approach 80
C. Project Management 81
D. Implementation Schedule 81
E. Institutional Requirements 82
F. Division of Plan Responsibilities 82
F1.0 Federal 82
F2.0 Non-Federal 82
G. Financial Capability Analysis 82
H. Views of the Local Sponsor 82
I. Views of Other Agencies 82
J. Summary of Coordination, Public Review, and Comments 83
J1.0 General 83
J2.0 Public Scoping Meeting 83
J3.0 Draft Report Public Comment Period and Closure 83
K. Status of Corps of Engineers Review Process 84
K1.0 Agency Technical Review Status 84

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

K2.0 Independent External Peer Review Status 84
L. Future Project Schedule 85
VII. Conclusions 85
VIII. Recommendation 86

REPORT FIGURES

Figure 1: Manhattan, Kansas, Levee Unit 1
Figure 2: The Kansas River Basin 9
Figure 3: Kansas Basin Reservoirs Upstream of Manhattan 14
Figure 4: Manhattan Transportation Routes 19
Figure 5: Economic Cost Optimization Curve 59
Figure 6: Induced Damages of the Recommended Plan 69

REPORT TABLES

Table 1: Summary of Levee Unit Construction History and Design Discharge 6
Table 2: Major Floods at or near Manhattan 10
Table 3: Kansas River Basin Reservoirs Releases: Downstream Flow Limits 14
Table 4: Big Blue River Flood Discharges 16
Table 5: Kansas River Flood Discharges 17
Table 6: Study Reaches Used in HEC-FDA Analysis 20
Table 7: Population and Housing 20
Table 8: Economic Analysis Area Investment Summary in Dollars 21
Table 9: Economic Analysis Area Investment Category Percentages 21
Table 10: Summary of Known HTRW Sites in the Study Area 24
Table 11: Summary of Existing Conditions Areas of Reliability Concern 27
Table 12: Existing Conditions Engineering Performance - Overtopping or Breach 28
Table 13: Existing Conditions Engineering Performance – Overtopping Only 28
Table 14: Summary of Evaluation of Initial Measures 49
Table 15: Levee Raises and Lengths of Raise for Early Array of Alternatives 52
Table 16: Benefits and Costs Analysis -- Final Array 56
Table 17: Recommended Plan Components 60
Table 18: Cost Sharing Summary -- Recommended Plan 63
Table 19: Total Project Costs by Category – Recommended Plan 64
Table 20: Annual OMRR&R Cost for the Recommended Plan 66
Table 21: Recommended Plan Cost Summary 66
Table 22: Recommended Plan Economics Summary 67
Table 23: Economic Performance of the Recommended Plan 67
Table 24: Engineering Performance of the Recommended Plan 68
Table 25: Existing and Future Life Safety Assessment 74

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

ENCLOSURES TO THE REPORT

Enclosure 1: Lower Big Blue River Northern Unprotected Area -- Map and Illustration
Enclosure 2: Map of the Manhattan, Kansas Levee Unit Raise for the Plan 2
Enclosure 3: Map of the Manhattan, Kansas Levee Unit Raise for the Plan 3
Enclosure 4: Map of the Manhattan, Kansas Levee Unit Raise for the Plan 4
Enclosure 5: Final Alternatives Array – Evaluation Criteria and Comparison Matrix

ENVIRONMENTAL ASSESSEMENT and FEASIBILITY REPORT TECHNICAL APPENDICES

Report Mapbook Appendix
Environmental Assessment and Appendices
Economics Appendix
Engineering Appendix Volume 1 - Existing Conditions
Engineering Appendix Volume 2 - Alternatives Analysis
Real Estate Plan
Cost Engineering Appendix
Public Involvement Appendix

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

Executive Summary

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

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

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

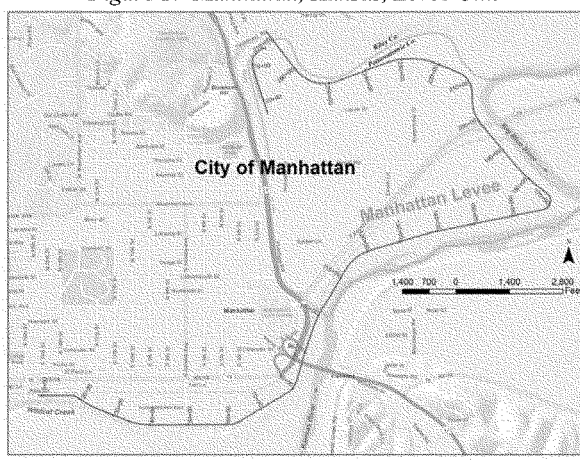
Manhattan, Kansas, Local Protection Project
Feasibility Study
Final Feasibility Report

I. Introduction and Study Background

A. Introduction

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

Figure 1: Manhattan, Kansas, Levee Unit



B. Reason for Study

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

C. Feasibility Study Authority and Cost Sharing Agreement

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

D. Purpose and Scope of the Study

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

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

E. General Geographic Area and Study Area Descriptions

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

F. Non-Federal Sponsor

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

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

G. Relevant Prior Studies and Reports

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

II. Existing Project Conditions and Flood History

A. Existing Project Description

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

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

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

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

B1.0 Existing Levee Features

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

B2.0 Project Operations, Maintenance and Inspections

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

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

B3.0 Maintenance & Repair History

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

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

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

B4.0 Foundation and Underseepage Conditions

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

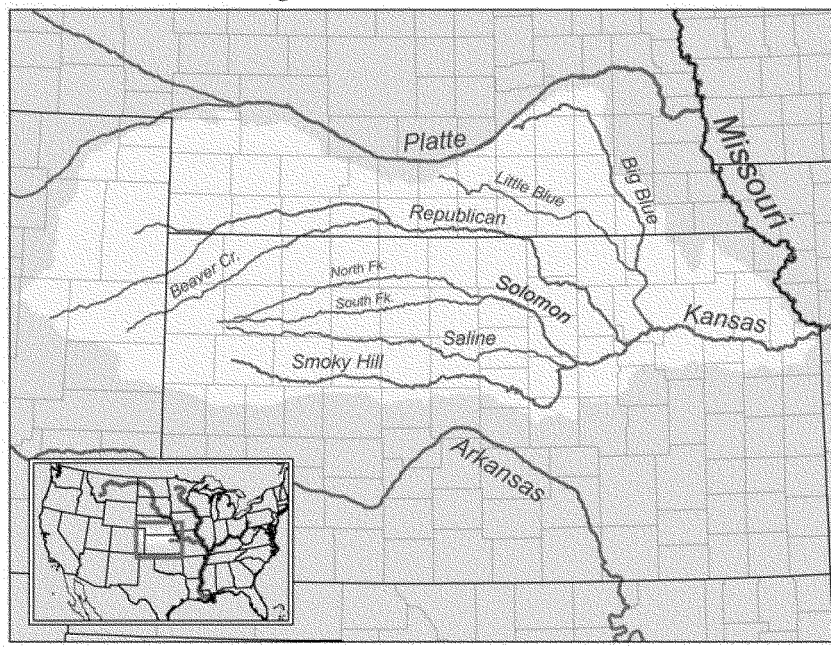
C1.0 Kansas River Basin

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

Figure 2: The Kansas River Basin



C2.0 Big Blue River Basin

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

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

C3.0 Historical Flood Events and Damages

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

Table 2: Major Floods at or near Manhattan

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

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

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

C3a. The 1903 Flood

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

C3b. The 1951 Flood

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

C3c. The 1993 Flood

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

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

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

D. River Discharge Evaluations and Existing Project Hydraulic Characteristics

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

D1.0 Comparison of Designed and Observed Project Performance

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

D2.0 Operation of Kansas River Basin Reservoir System

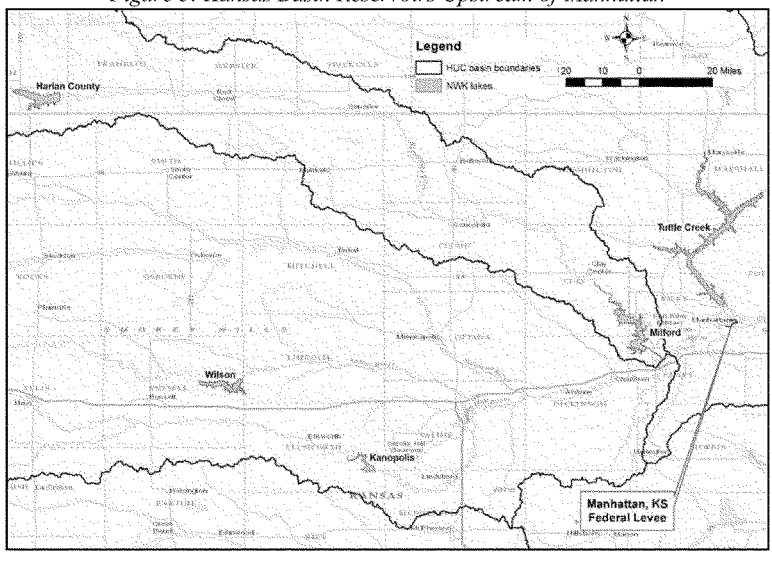
Construction of reservoirs in the Kansas River basin was first authorized by Congress in 1938. An expanded and coordinated multi-purpose system of reservoirs and levees throughout the Kansas River basin was authorized in the Flood Control Act of 1944. Eighteen (18) federal lakes/reservoirs now exist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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

Figure 3: Kansas Basin Reservoirs Upstream of Manhattan



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

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

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

Cfs = cubic feet per second

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

D3.0 Description of Upstream Reservoirs

Tuttle Creek Reservoir

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

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

Other Upstream Reservoirs

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

D4.0 Recent River Discharge Evaluations

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

Table 4: Big Blue River Flood Discharges

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

Table 5: Kansas River Flood Discharges

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

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

E. Review of Economic Conditions

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

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

E1.0 Manhattan Economic Overview

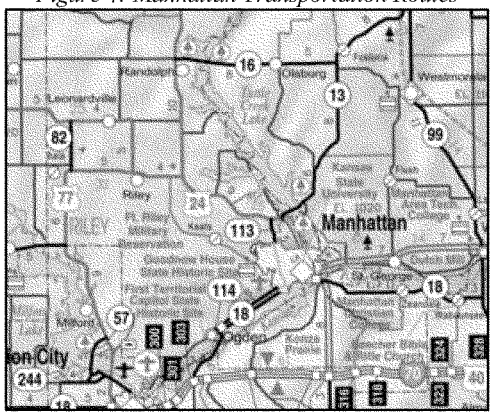
The City of Manhattan serves as a regional economic hub and retail market for surrounding rural counties. It greatly benefits from the presence of Kansas State University and Fort Riley. Federal, state, and local governmental functions, retail, and agribusiness form a substantial portion of the growing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

E2.0 Major Transportation Characteristics

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

Figure 4: Manhattan Transportation Routes



E3.0 Economic Investment Surveys for Flood Damage Modeling

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

Table 6: Study Reaches Used in HEC-FDA Analysis

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

E4.0 Detailed Socioeconomic Characteristics

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

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

Table 7: Population and Housing

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

E4b. Economic Analysis Area Investment

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

Table 8: Economic Analysis Area Investment Summary in Dollars

Investment (x $1000) FY14 Price Level						
Confluence Reach	**Commercial**	**Industrial**	**Public/ Municipal**	**Residential**	**Streets and Roads**	**Total**
Structures	212	21	42	984	-	**1,259**
Structure Value	$156,213.8	$11,752.0	$26,240.3	$104,940.4	$17,462.6	**$316,609.1**
Content and Other Value	$230,274.9	$12,301.4	$19,127.3	$88,717.0	$0.0	**$350,420.6**
Total	$386,488.7	$24,053.4	$45,367.6	$193,657.4	$17,462.6	**$667,029.7**
Kansas River Reach						
Structures	125	54	39	719	-	**937**
Structure Value	$32,284.4	$6,692.1	$26,808.1	$54,191.1	$17,640.5	**$137,616.1**
Content and Other Value	$46,502.0	$22,448.4	$24,386.0	$57,809.2	$0.0	**$151,145.5**
Total	$78,786.3	$29,140.5	$51,194.0	$112,000.3	$17,640.5	**$288,761.6**
Big Blue River Reach						
Structures	53	33	13	0	-	**99**
Structure Value	$35,721.9	$33,724.7	$5,844.9	$0.0	$6,435.2	**$81,726.8**
Content and Other Value	$84,486.4	$42,893.9	$12,048.7	$0.0	$0.0	**$139,429.0**
Total	$120,208.3	$76,618.6	$17,893.6	$0.0	$6,435.2	**$221,155.8**
Total Number of Structures	**390**	**108**	**94**	**1,703**	**-**	**2,295**
Total Value	**$585,483.3**	**$129,812.5**	**$114,455.2**	**$305,657.7**	**$41,538.4**	**$1,176,947.1**

Table 9: Economic Analysis Area Investment Category Percentages

Investment by Category and Percentage				
Structure, Content, and Other Value				
	Confluence Reach	**Kansas River Reach**	**Big Blue River Reach**	**Total**
Commercial	57.9%	27.3%	54.4%	49.7%
Industrial	3.6%	10.1%	34.6%	11.0%
Public/Municipal	6.8%	17.7%	8.1%	9.7%
Residential	29.0%	38.8%	0.0%	26.0%
Streets and Roads	2.6%	6.1%	2.9%	3.5%
Total	56.7%	24.5%	18.8%	100.0%

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

F. Review of Existing Environmental and Cultural Resources

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

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

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

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

F1.0 Threatened or Endangered Species

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

F2.0 Wetlands

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

F3.0 Cumulative Effects

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

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

F4.0 Cultural Resources

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

F6.0 Recreation Resources

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

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

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

H. Conclusions Regarding Existing Levee Integrity

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

Table 11: Summary of Existing Conditions Areas of Reliability Concern

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

Table 12: Existing Conditions Engineering Performance - Overtopping or Breach

Manhattan Levee	Confluence Reach	Kansas Reach	Big Blue Reach
Conditional Non-Exceedance Probability			
1% event	62.4%	62.8%	52.6%
0.4% event	22.5%	22.4%	9.4%
0.2% event	6.4%	6.2%	3.5%
Long Term Exceedance Probability			
10 years	10.6%	10.8%	14.2%
30 years	28.6%	29.0%	36.8%
50 years	42.9%	43.5%	53.4%
Expected Annual Exceedance Probability	1.1%	1.1%	1.5%

Table 13: Existing Conditions Engineering Performance – Overtopping Only

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

III. Future Without Project Condition Scenario

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

A. Socioeconomic Considerations of the Without Project Condition Scenario

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

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

C. Other Considerations of the Without Project Condition Scenario

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

D. Period of Analysis and Related Assumptions

Both the future with and without condition scenarios are evaluated over a 50 year period of analysis to allow a consistent and appropriate comparison of alternatives. The period of analysis is the time horizon for which project benefits and project operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) costs are evaluated. The period of analysis begins with the base year condition using resources in the study area along with economic and engineering factors thought to exist in the first year a project alternative is expected to become operational. The existing conditions economic analysis was completed in 2012. The base year used for the purposes of analysis is 2023, the year the project is expected to be completed. The existing conditions and base year have the same assumptions and condition. A 50-year period of analysis was used as the beneficial effects of the levee could not be confidently forecasted beyond this interval. 50 years is also the maximum period of analysis allowed per regulation. The future condition was defined as 2073. It is fair to assume that for this economic analysis area, no significant increase in economic development is expected during the 50 year period of analysis as most of the flood prone area is essentially built-out.

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

E. Climate Change

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

F. Future Without Project Condition Scenario Conclusions

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

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

IV. Plan Formulation

A. Introduction

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

B. Six Step Planning Process

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

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

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

C. Step 1 - Indentifying Problems and Opportunities

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

C1.0 Planning Goal and Objectives

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

C2.0 Planning Criteria

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

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

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

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

C3.0 Planning Constraints

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

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

D. Step 2 – Inventory and Forecast Conditions

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

E1.0 No Federal Action

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

E2.0 Flood Risk Management Measures

E2a. Traditional Non-Structural Measures

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

E2b. Other Site-Specific Non-Structural Measures

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

E2c. Non-Structural Measures – Summary and Conclusions

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

E2d. Structural Measures

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

E2d3. Levee and Floodwall Raises (Structural Measure)
Levee and floodwall raises are normally an economical means of reducing levee overtopping risks when an existing levee or floodwall is in relatively good condition. The existing real estate assets within the project boundary are typically owned or held in easement thus reducing the need for expensive and time-consuming real estate acquisition. A further advantage of the existing Manhattan levee is the absence of major floodwalls; thus, these high-cost structures are not involved in a potential levee raise.

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

E2d4. Geotechnical and Structural Feature Strengthening (Structural Measure)
The existing conditions analysis was used during formulation to develop measures for alleviation of existing levee vulnerabilities /weaknesses. Potential solutions to specific weaknesses were analyzed using the new hydraulics modeling and hydraulic loading for the various flood events under study. Levee reliability improvements were evaluated for levee sections both within and outside the potential raised segments. This total unit review was necessary to provide an entire levee unit that meets the Corps' current design criteria and factors of safety -- applicable for improvements to the levee cross section and foundation, strengthened structural elements, and more robust underseepage control.

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

- Modify the existing spillway apron.
- Raise the top of dam 6 feet in order to maintain the existing (minimum) surcharge storage as well as the 2.15 feet of freeboard for wind/wave concerns during the spillway design flood. Based on 2009 storage-elevation curves in the Tuttle Creek Lake Regulation Manual, this would require a new top of surcharge at elevation 1163 msl and a new top of dam at about elevation 1165 msl (approximately 6 feet above the existing top of dam elevation 1159 msl). Numerous modifications would comprise this work to include:
    - Partial dewatering of lake
    - Remove and replace rip-rap upstream of dam
    - Remove and replace highway on top of dam
    - Controlled placement of embankment material sufficient to raise dam 6-feet
    - Install additional relief wells downstream due
    - Seismic modifications to dam
    - Add or modify existing upstream pumps stations
    - Modify the outfall conduit and associated tower to accommodate the embankment modifications.
- Modify (i.e. levee raises) the three existing upstream levee units at the cities of Maryville, Blue Rapids, and Frankfort to protect against the higher pool. These units are located in the upper end and headwaters of Tuttle Creek Lake.
- Modify upstream bridges crossing the lake to accommodate the pool raise.
- Undertake acquisition of easements or title to an additional 8,000 acres of lands around the perimeter of the lake resulting from additional inundation during higher pool elevations in extreme events.

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

Table 14: Summary of Evaluation of Initial Measures

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

E3.0 Identification of Key Uncertainties in Plan Formulation

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

E4.0 Early Array of Plans

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

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

Early Array of Plans

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

E5.0 Final Array of Plans

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

E5a. Detailed Descriptions of the Final Array of Plans

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

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

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

E5b. Economic Evaluation of Alternatives

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

E5b1. Costs for Operation, Maintenance, Repair, Rehabilitation, and Replacement
Costs for operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) were estimated for each alternative and are based on life cycle cost analysis. The analysis only includes the new (net) additional OMRR&R costs the sponsor would be expected to incur based on the proposed unit modifications. The analyses considered and accounted for the new additional OMRR&R in each year of occurrence, and then computed a present worth value of the future OMRR&R costs. The present worth value was then annualized using prescribed federal interest rate and a 50 year period of analysis. The assumptions (based on Kansas City District experience in this area) used in determining the new additional OMRR&R costs for each alternative are as follows: Each new relief well is assumed to be maintained every 4 years at an estimated cost of $5,000 per well. Wells are assumed to be replaced with new wells after 40 years at the replacement cost of either $55,000 or $65,000 depending on the type and size of the well used.

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

E5b2. Other Economic Benefits Not Quantified
The benefit evaluation process involves analysis of the economic losses to the subject study area from flooding, and the potential gains to the study area from the successful prevention of flooding. Some of the economic impacts that are likely to occur from flooding in the without-project condition may be of major significance to a metropolitan area or community, but may not have any net impact on the national economy. For example, if a flood interrupts production at a

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

Table 16: Benefits and Costs Analysis -- Final Array

October 2013 (FY14) prices, 50 year period of analysis, 3.5% interest rate, 1000's				
Damages and Benefits	**Plan 2**	**Plan 3**	**Plan 4**	**Plan 5**
EAD W/O Project	$6,745.3	$6,745.3	$6,745.3	$6,745.3
EAD Residual	$3,571.6	$2,769.8	$1,681.4	$2,694.7
Residual as a % of without project	52.9%	41.1%	24.9%	39.9%
Annual Benefits - Screening Level	$3,173.8	$3,975.5	$5,064.0	$4,050.7
Costs				
First Costs	$21,376.0	$22,042.0	$46,273.0	$53,003.0
Annual Costs - Screening Level	$1,038.9	$1,071.3	$2,249.0	$2,576.1
O&M Costs	$52.1	$52.1	$52.3	$80.9
Total Annual Costs	$1,091.0	$1,123.4	$2,301.3	$2,657.0
Net Benefits	$2,082.8	$2,852.1	$2,762.7	$1,393.8
Benefit-Cost Ratio	2.9	3.5	2.2	1.5

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

E5c. HTRW Considerations of the Final Array

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

V. Description of the Recommended Plan

A. Step 6 – Selecting a Plan

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

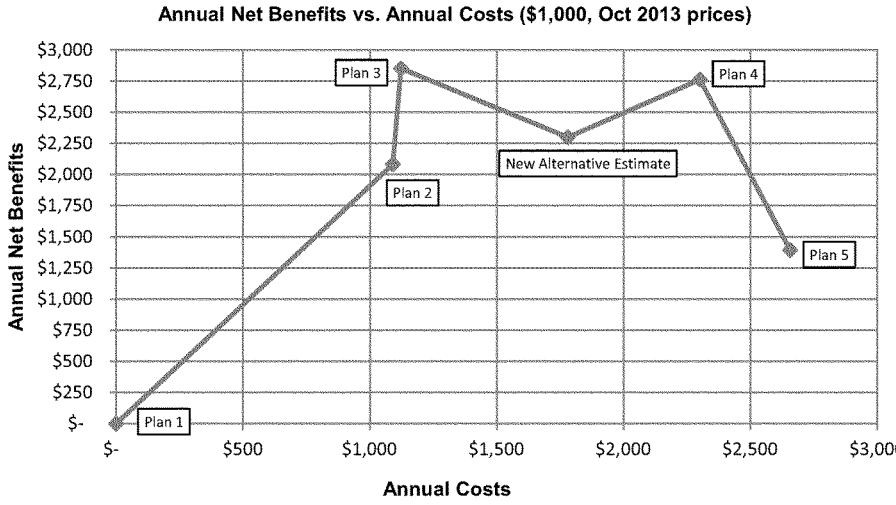
To further support plan selection, the PDT estimated and analyzed a potential raise between Plan 3 and Plan 4 not previously included in the Final Array. This analysis showed that raising the levee more than a few inches beyond the Plan 3 top of levee elevation would increase costs exponentially by expanding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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

Figure 5: Economic Cost Optimization Curve



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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

Table 17: Recommended Plan Components

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

B. Design and Construction Considerations

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

C. Cost Estimate Development

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

C1.0 Cost Estimate Code of Accounts Information

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

C2.0 Other Cost Estimate Information

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

C3.0 Summary Cost Estimate Tables

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

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

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

Table 18: Cost Sharing Summary -- Recommended Plan

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

Notes:

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

Table 19: Total Project Costs by Category – Recommended Plan

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

Notes:

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

D. Real Estate Considerations

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

D1.0 Lands and Damages Costs

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

D2.0 Borrow Considerations

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

D3.0 Relocation Costs

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

D4.0 Transportation Facilities Impacts

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

E. Operation and Maintenance Considerations

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

F. Economic Analysis of the Recommended Plan

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

Table 21: Recommended Plan Cost Summary

Item	COST
Levees	$16,387.0
Relocations	$880.0
Lands and Damages	$1,609.0
PED (*all construction contracts*)	$3,531.0
Construction Management	$1,347.0
Total First Costs	**$23,754.0**
IDC	$3,207.0
Annual Costs	**$1,123.7**
O&M	$54.0
Total Annual Costs	**$1,177.7**
October 2014 prices (FY15), 3.375% interest rate, 50 year period of analysis, 1000's	

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

Table 22: Recommended Plan Economics Summary

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

Table 23: Economic Performance of the Recommended Plan

Total EAD (equivalent annual damages)	
Without Project Damages	$6,929.4
Residual Damages (with project)	$2,852.8
Damages reduced (benefits)	$4,076.6
Benefits By Category	
Commercial	$2,453.4
Industrial	$724.5
Public/Municipal	$221.1
Residential	$306.1
Streets and Roads	$40.0
Emergency	$275.5
Cleanup	$55.9
Probabilistic benefit estimates	
0.75	$2,709.6
0.5	$3,686.5
0.25	$4,923.6
October 2014 price level (FY15), 3.375% interest rate, 50 year period of analysis, 1,000's	

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

G. Recommended Plan Performance and Accomplishments

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

Table 24: Engineering Performance of the Recommended Plan

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

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

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

H. Induced Damages

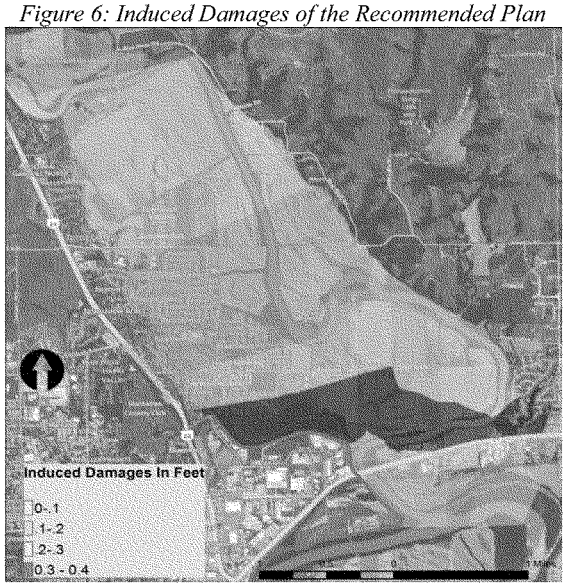
Minor induced damages from implementation of the Recommended Plan will occur under certain conditions in limited locations. Upstream induced damages as a result of the Recommended Plan will only occur at flood event profiles above the exiting top of levee and up to the proposed future top of levee. These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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

Figure 6: Induced Damages of the Recommended Plan



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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

I. Residual Risk

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

I1.0 With-Project Damages and Impacts

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

I2.0 Life Safety Risk Assessment

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

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

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

Table 25: Existing and Future Life Safety Assessment

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

I3.0 Residual Risk Management

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

J. Environmental and Cultural Considerations

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

J1.0 Environmental Justice

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

J2.0 Wetlands and Aquatic Resources

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

J3.0 Mitigation

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

J4.0 Floodplain Impacts

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

2. Conduct early public review, including public notice.

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

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

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

4. Identify impacts of the proposed action.

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

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

No impacts are expected.

6. Reevaluate alternatives.

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

7. Present the findings and a public explanation.

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

8. Implement the action.

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

J5.0 Environmental Conclusions

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

K. Environmental Operating Principles

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

L. USACE Campaign Plan

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

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

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

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

VI. Plan Implementation

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

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

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

A. Work Categorization

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

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

B. Implementation Approach

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

C. Project Management

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

D. Implementation Schedule

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

E. Institutional Requirements

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

F. Division of Plan Responsibilities

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

F1.0 Federal

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

F2.0 Non-Federal

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

G. Financial Capability Analysis

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

H. Views of the Local Sponsor

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

I. Views of Other Agencies

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

J. Summary of Coordination, Public Review, and Comments

J1.0 General

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

J2.0 Public Scoping Meeting

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

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

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

J3.0 Draft Report Public Comment Period and Closure

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

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

K. Status of Corps of Engineers Review Process

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

K1.0 Agency Technical Review Status

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

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

K2.0 Independent External Peer Review Status

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

L. Future Project Schedule

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

NOV 2014	Feasibility Report Approval by the Civil Works Review Board
MAR 2014	Approval of the Report of the Chief of Engineers recommending the project to Congress for authorization *(tentative -- TBD)*
JUN 2015	Execution of Project Design Agreement with local sponsor and initiation of Pre-Construction Engineering and Design Phase (pending availability of design phase funding).
MAR 2017	Execution of the Project Partnership Agreement with the Local Sponsor (subject to Congressional project authorization and the availability of construction funding). Initiation of land and easement acquisition by the local sponsor.
APR 2018	Initiate project construction (5 year construction period)
DEC 2022	Complete project construction

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

VII. Conclusions

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

VIII. Recommendation

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

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

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

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

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

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

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

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

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

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

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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;

This document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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

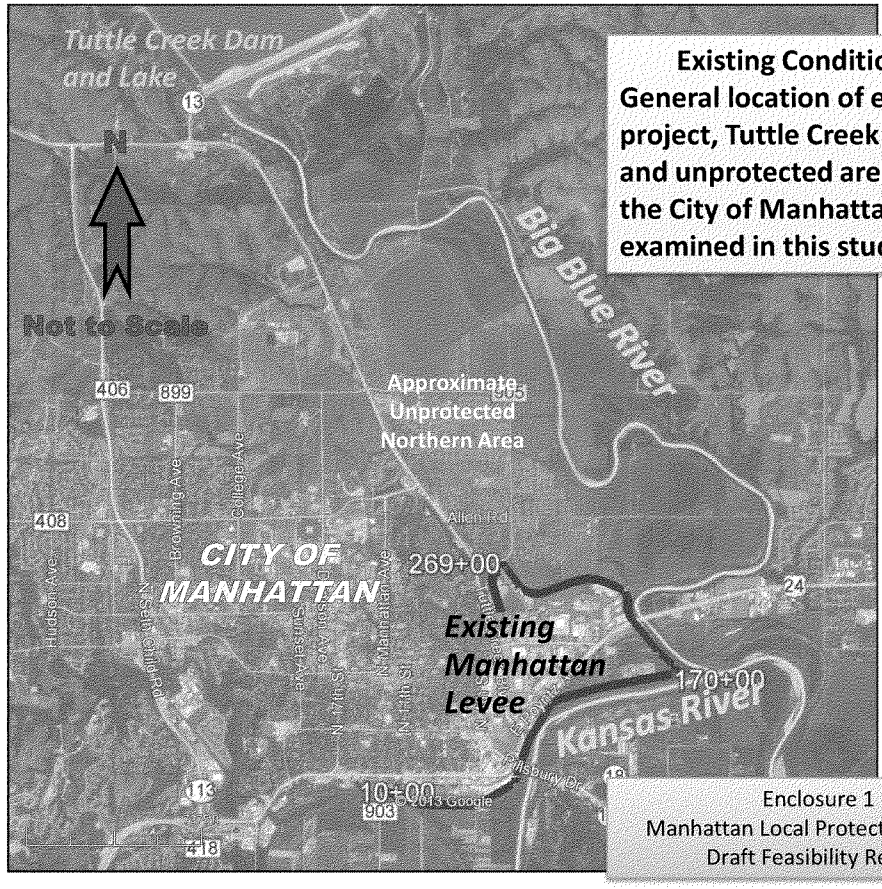
q. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213(j)), which provides that the Secretary of the Army shall not commence the construction 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 document is based on the information available at the time of publication. The Corps of Engineers planning process is dynamic and responsive to public and stakeholder input; it is possible that the content herein may change as a result of review comments received. This document does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the federal government.

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.

11AUG14

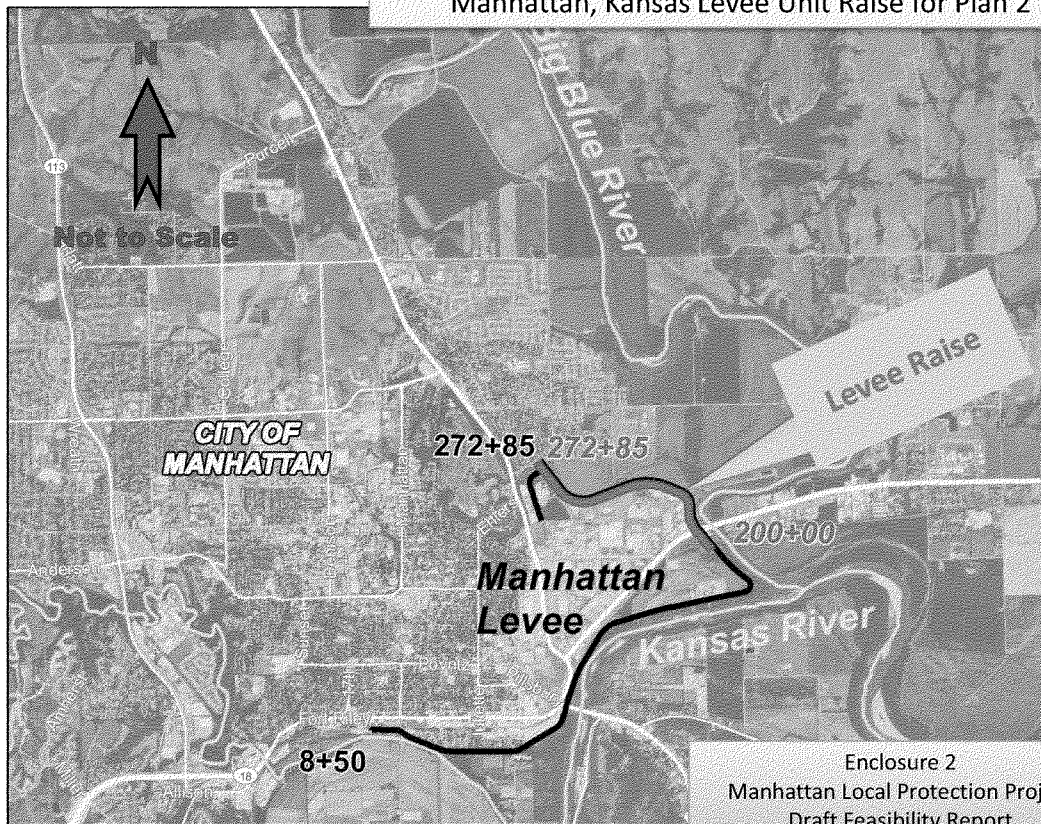
Andrew D. Sexton (date)
Colonel, Corps of Engineers
District Commander



Existing Conditions
General location of existing project, Tuttle Creek Lake, and unprotected areas of the City of Manhattan examined in this study.

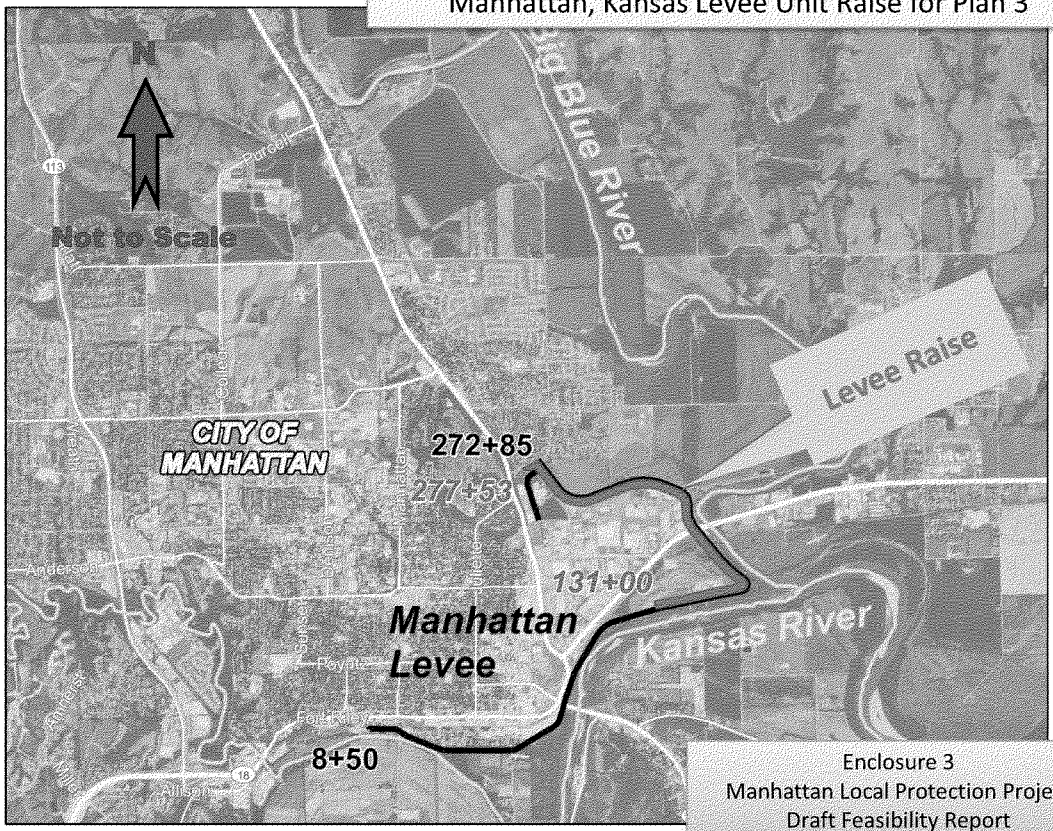
Enclosure 1
Manhattan Local Protection Project
Draft Feasibility Report

Manhattan, Kansas Levee Unit Raise for Plan 2



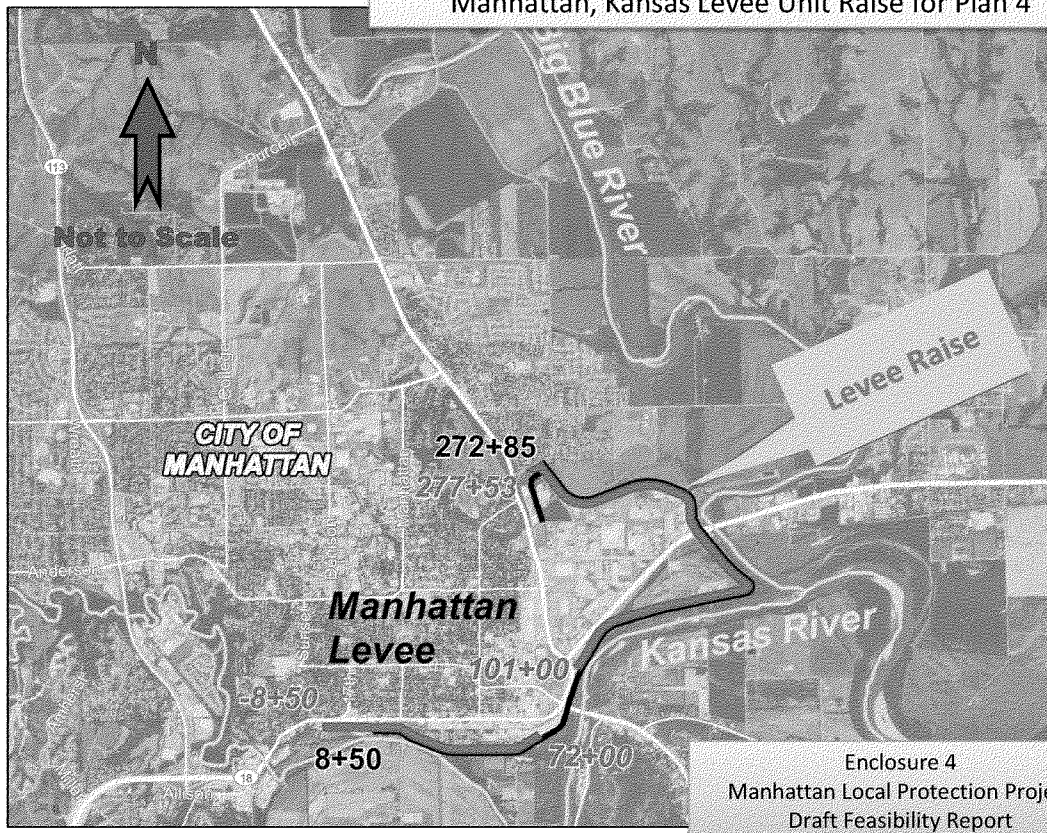
Enclosure 2
Manhattan Local Protection Project
Draft Feasibility Report

Manhattan, Kansas Levee Unit Raise for Plan 3



Enclosure 3
Manhattan Local Protection Project
Draft Feasibility Report

Manhattan, Kansas Levee Unit Raise for Plan 4



Enclosure 4
Manhattan Local Protection Project
Draft Feasibility Report

Manhattan, Kansas, Feasibility Study -- Final Alternatives Array -- Evaluation Criteria and Comparison Matrix

		FINAL ARRAY EVALUATION CRITERIA							
Final Alternatives Array	**Short Description of Each Plan**	**First Cost (Oct 2013) and sponsor affordability**	**Annual Net Benefits**	**BCR (efficiency)**	**Flood Risk Management Effectiveness Rank**	**Environmental & Cultural and Real Estate Effects (Acceptability)**	**Completeness, Effectiveness, Efficiency, Acceptability Summary**	**Annual Induced Damages**	**Ability to Meet Planning Objectives**
Plan 1	No Federal Action	None	na	--	no reduction in risk	None	No -- plan is not effective in reducing flood risks and City finds current level of risk unacceptable in longer-term	None	No cost and no disruption. Future without project condition similar to existing condition. Essentially no contribution to Flood Risk Management. Planning objectives are not met.
Plan 2	Average 0.7 ft. levee riase with accompanying geotechnical and structural reliability improvements.	$21.4M (sponsor-affordable)	$2.08M	2.9	Low	Minor/Insignificant	Marginal -- minimal flood risk reduction; could be unacceptable to sponsor; inefficient given the cost as compared to Plan 3.	Minimal	Minimal overtopping improvements versus existing conditions. Implementation would leave a higher overtopping flood risk than is prudent given the investment. Planning objectives only partially met.
Plan 3 (NED Plan)	Average 1.5 ft. levee raise with accompanying geotechnical and structural reliability improvements.	$22.0M (sponsor-affordable)	$2.85M	3.5	Medium	Minor/Insignificant	Yes. Plan is considered Complete, Effective, Efficient, and Acceptable.	$2,040	Supports long-term City flood risk management and somewhat equalizes Big Blue & existing Kansas River levee segments performance for the more common floods. Planning objectives are met.
Plan 4	Average 2.1 ft. levee raise with accompanying geotechnical and structural reliability improvements.	$46.3M (marginal affordability)	$2.76M	2.2	High	Structural Relocations and/or condemnations are likely	Mixed -- plan is considered Complete, Effective, Efficient. Public acceptability is questionable due to real estate impacts and overall cost of project to the community.	> Plan 3 Damages	Supports long-term City flood risk management and provides substantial additional protection against future uncertainty in major Big Blue and Kansas River flood conditions. Best meets the Planning objectives.
Plan 5	Average 1.3 ft. levee raise with widening of the Big Blue River channel and bridge modifications for increased flood conveyance with accompanying geotechnical and structural reliability improvements.	$53.0M (marginal affordability)	$1.39M	1.5	Medium	Would likely require environmental mitigation	Mixed -- not efficient as this Plan provides essentially the same level of risk reduction as the much less costly Plan 3. Acceptability is marginal due to adverse habitat effects.	Minimal	Supports long-term City flood risk management. Provides more flow under bridges & reduces possibility of debris jams; Channel Widening reduces any induced damages from levee raise. Planning objectives are met.

NOTE: Cost and Economci data presented in this table reflect early screening level analysis and do not include refinements made in the scope or estimate of the Recommended Plan following alternative comparison and evaluation.

US Army Corps
of Engineers
Kansas City District

MANHATTAN LOCAL PROTECTION PROJECT
FEASIBILITY STUDY
MANHATTAN, KANSAS
(Manhattan Levee)

(Section 216 Review of Completed Civil Works)

Project Maps Appendix

August 2014 Final Feasibility Report

Manhattan Levee

Feasibility Study

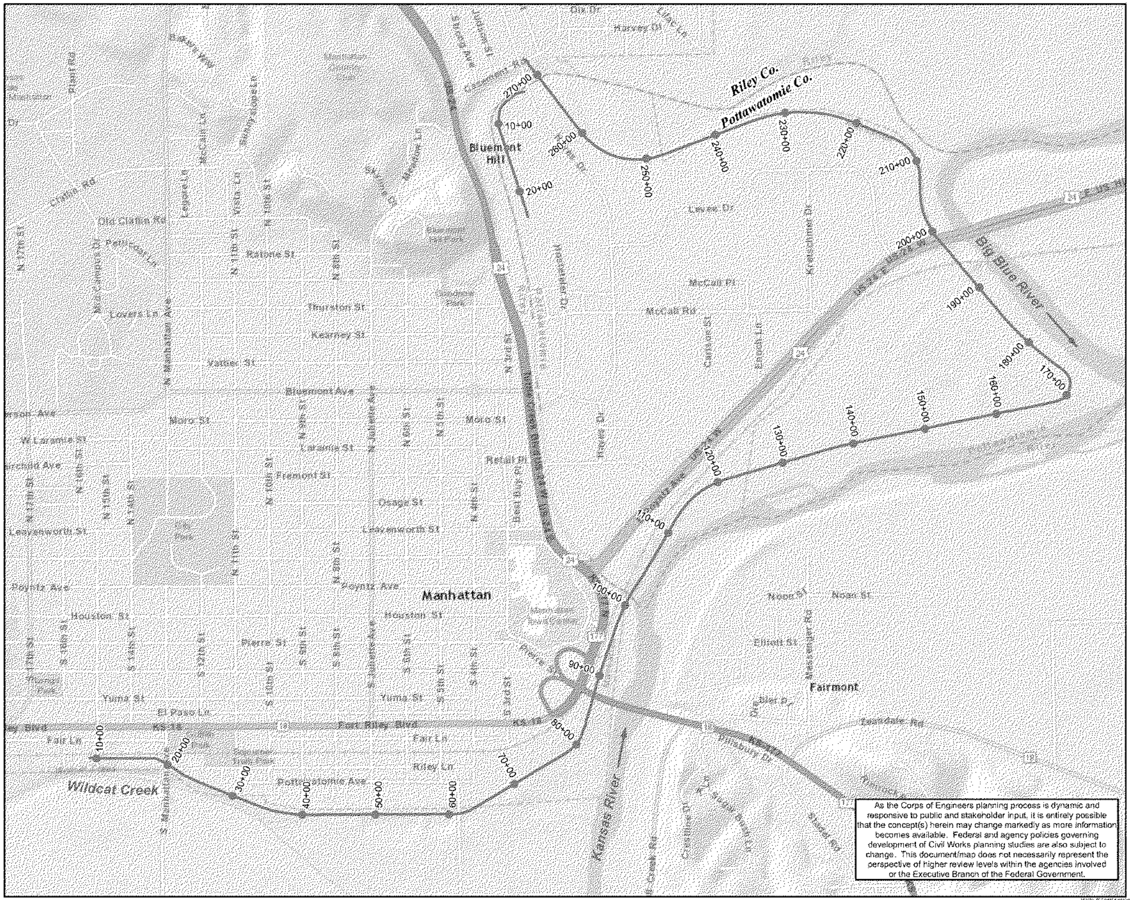
Existing Conditions and Reliability Improvements

JULY 2014

US Army Corps of Engineers
Kansas City District

This is a series of mapping products currently used in the Manhattan Levee Feasibility Study. These maps include existing conditions and potential reliability improvements to the levee. These maps are not yet fully reflective of ongoing local, agency and public input.

As the Corps of Engineers planning process is dynamic and responsive to public and stakeholder input, it is entirely possible that the concept(s) herein may change markedly as more information becomes available. Federal and agency policies governing development of Civil Works planning studies are also subject to change. This document/map does not necessarily represent the perspective of higher review levels within the agencies involved or the Executive Branch of the Federal Government.



Manhattan Levee

Feasibility Study
Existing Conditions and Reliability Improvements

Existing Levee With City Streets View

INDEX

Sheet No.	Description
	Cover
1	Existing Levee With City Streets View
Existing Conditions	
2	Existing Features
3	Existing Utility Features Crossing Unit
4	Not Used
Inundation Maps	
5	Existing Features, 1993 Flood
6	0.33% ACE Event without project
7	0.33% ACE Event with project
8	0.2% ACE Event without project
9	0.2% ACE Event with project
Alternatives	
10	Levee Raises and Geotech Features Diagram
11	Plan 3
12	Plan 4
13	Plan 5
Plan 3 Detail Sheets	
14	Station 0+00 to Station 38+50
15	Station 38+00 to Station 68+50
16	Station 66+00 to Station 93+50
17	Station 93+00 to Station 114+50
18	Station 113+50 to Station 144+00
19	Station 144+00 to Station 184+50
20	Station 184+00 to Station 208+50
21	Station 206+00 to Station 239+00
22	Station 238+50 to Station 272+00
23	Station 3+00 to Station 23+50

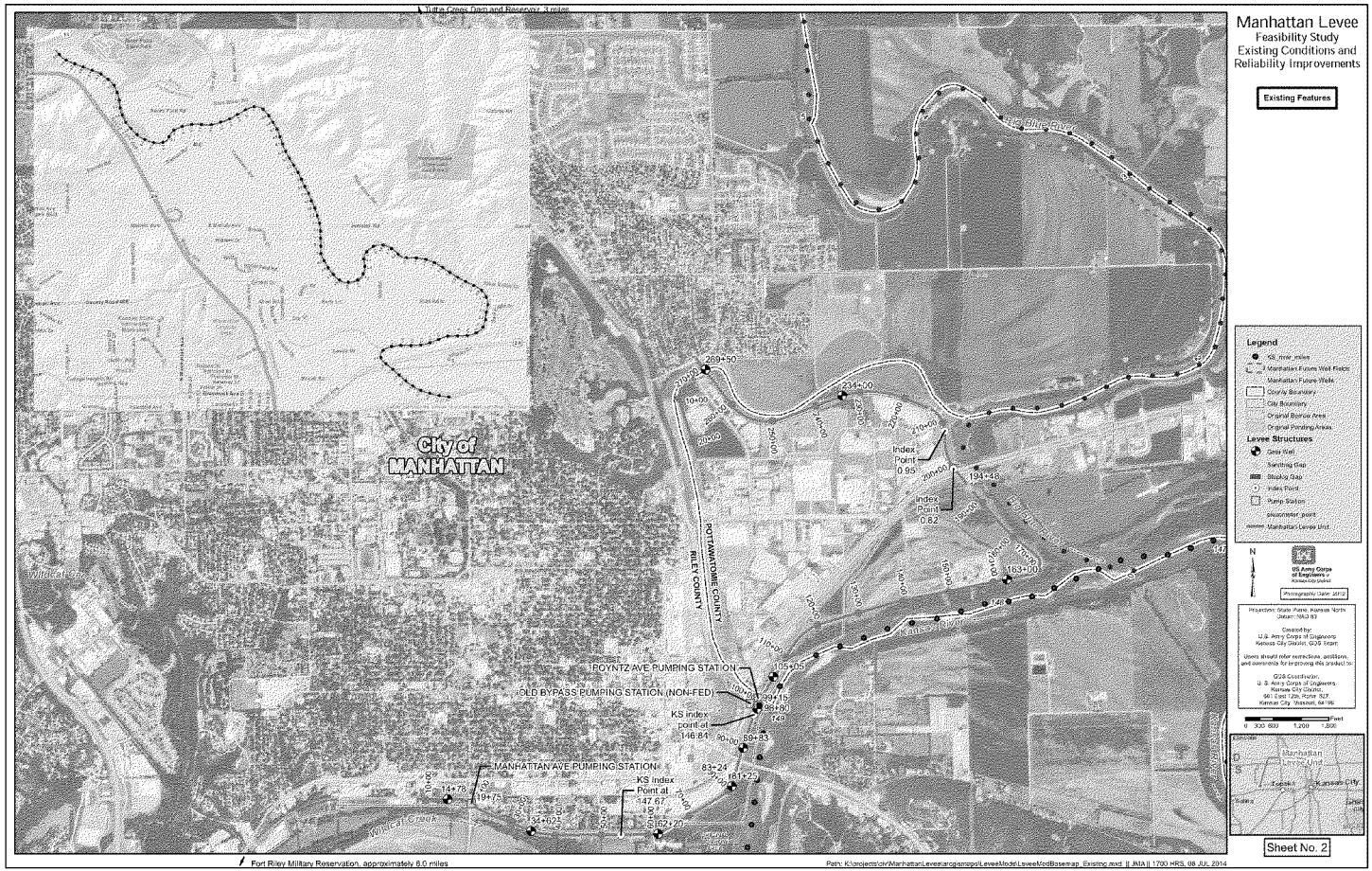
Profile, O+M Sheets 1-10

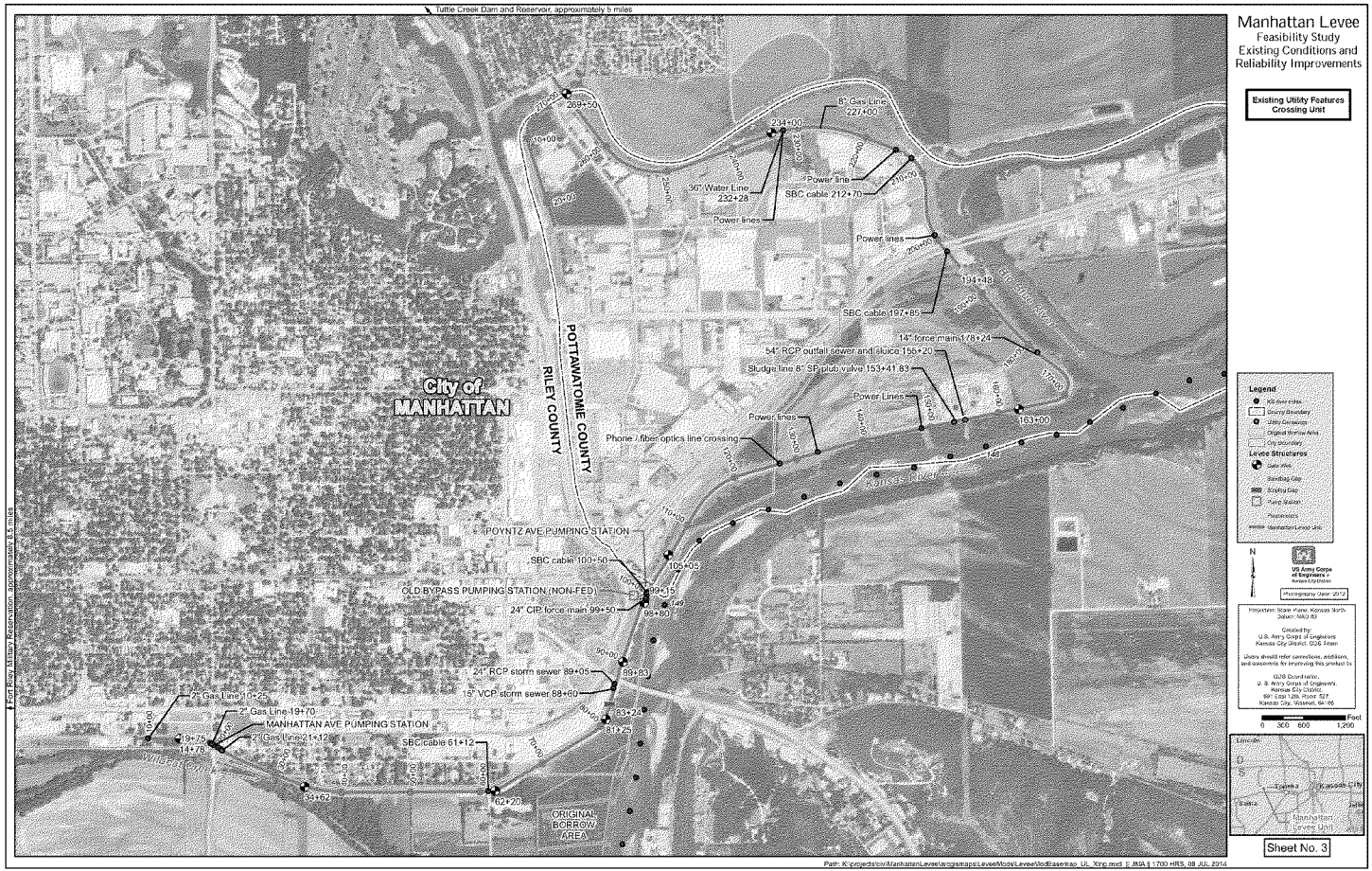
N

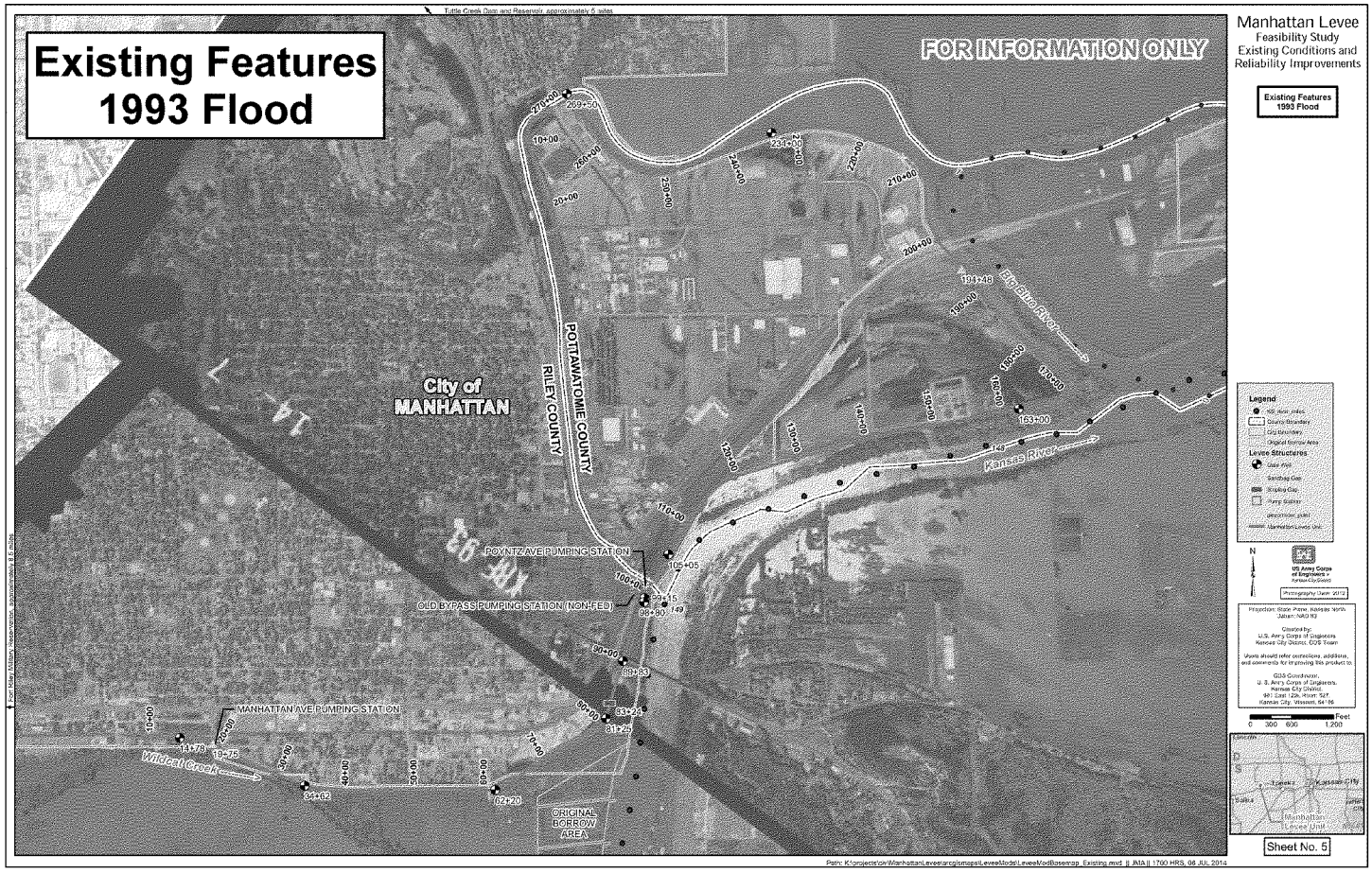
US Army Corps of Engineers
Kansas City District

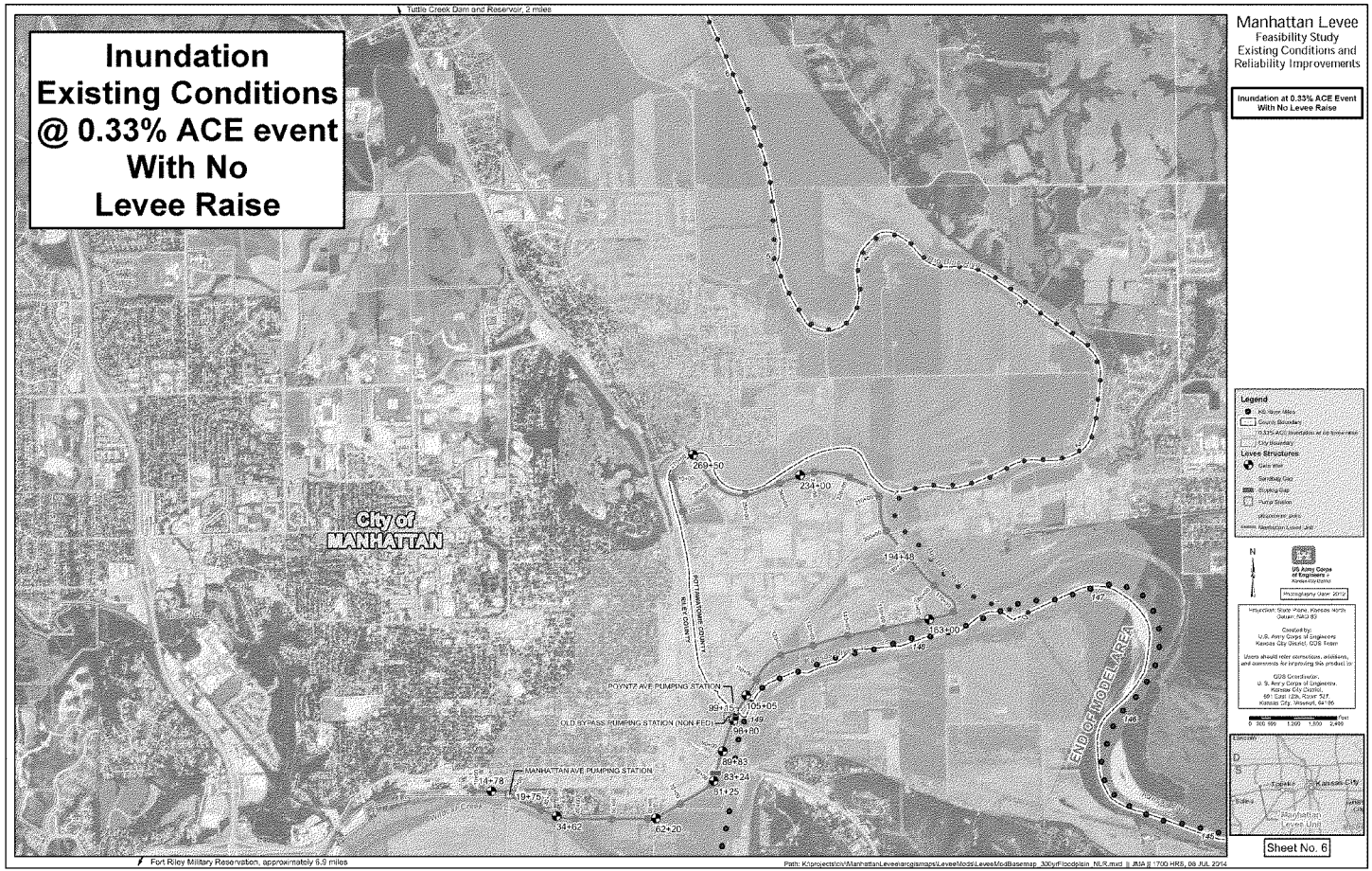
0 400 800 1,600 2,400 3,200 Feet

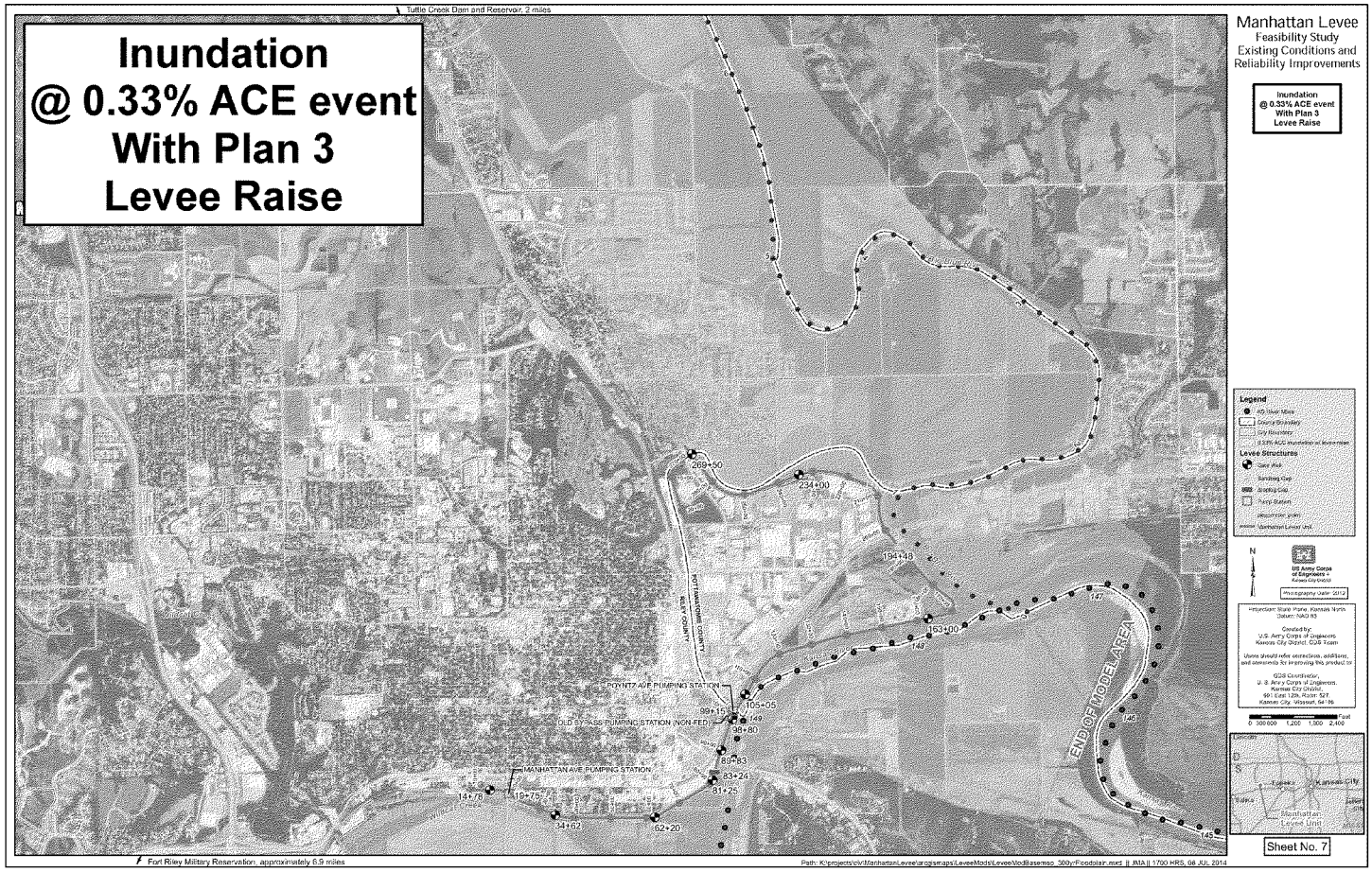
Sheet No. 1

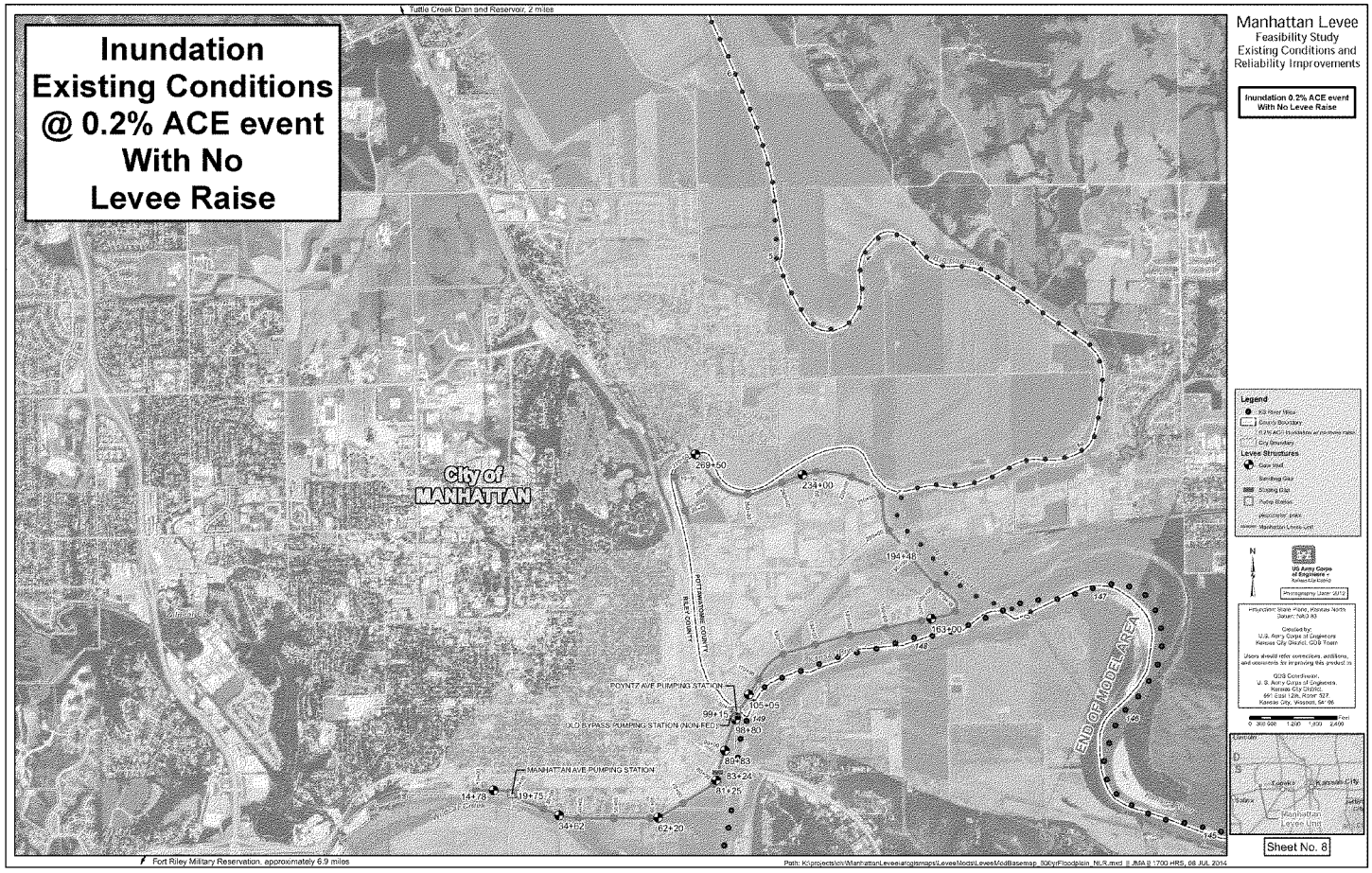

Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Existing Features
Legend
Levee Structures
City of MANHATTAN
POTTAWATOMIE COUNTY
RILEY COUNTY
Index Point 0.95
Index Point 0.82
POYNTZ AVE PUMPING STATION
OLD BYPASS PUMPING STATION (NON-FED)
KS index point at 146.84
MANHATTAN AVE PUMPING STATION
KS index Point at 147.67
Wildcat Creek
Kansas River
Blue River
Sheet No. 2
Fort Riley Military Reservation, approximately 8.0 miles

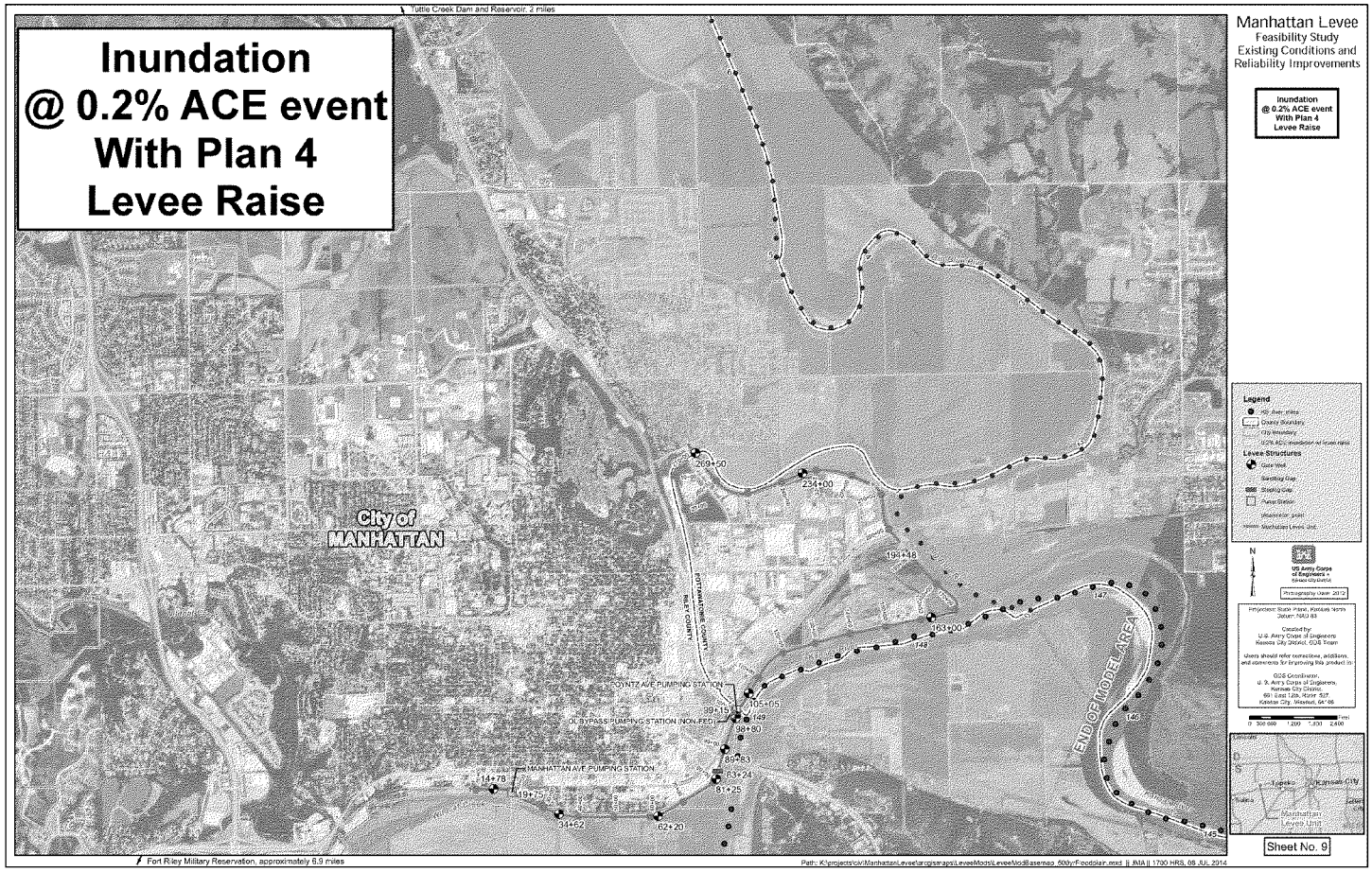

Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Existing Utility Features
Crossing Unit
Tuttle Creek Dam and Reservoir, approximately 5 miles
Fort Riley Military Reservation, approximately 8.5 miles
City of MANHATTAN
RILEY COUNTY
POTTAWATOMIE COUNTY
Kansas River
Wildcat Creek
269+50
234+00
8" Gas Line 227+00
36" Water Line 232+28
Power line
SBC cable 212+70
Power lines
194+48
SBC cable 197+85
14" force main 178+24
54" RCP outfall sewer and sluice 155+20
Sludge line 8" SP plub valve 153+41.83
Power Lines
163+00
Phone / fiber optics line crossing
POYNTZ AVE PUMPING STATION
SBC cable 100+50
105+05
OLD BYPASS PUMPING STATION (NON-FED)
99+15
24" CIP force main 99+50
98+80
24" RCP storm sewer 89+05
89+83
15" VCP storm sewer 88+60
83+24
81+25
2" Gas Line 10+25
2" Gas Line 19+70
MANHATTAN AVE PUMPING STATION
2" Gas Line 21+12
19+75
14+78
SBC cable 61+12
34+62
62+20
ORIGINAL BORROW AREA
Legend
Levee Structures
US Army Corps of Engineers
Kansas City District
Sheet No. 3
Path: K:\projects\civ\ManhattanLevee\arcgismaps\LeveeMods\LeveeModBaseMap_UL_Xlrp.mxd || JMA || 1700 HRS, 08 JUL 2014

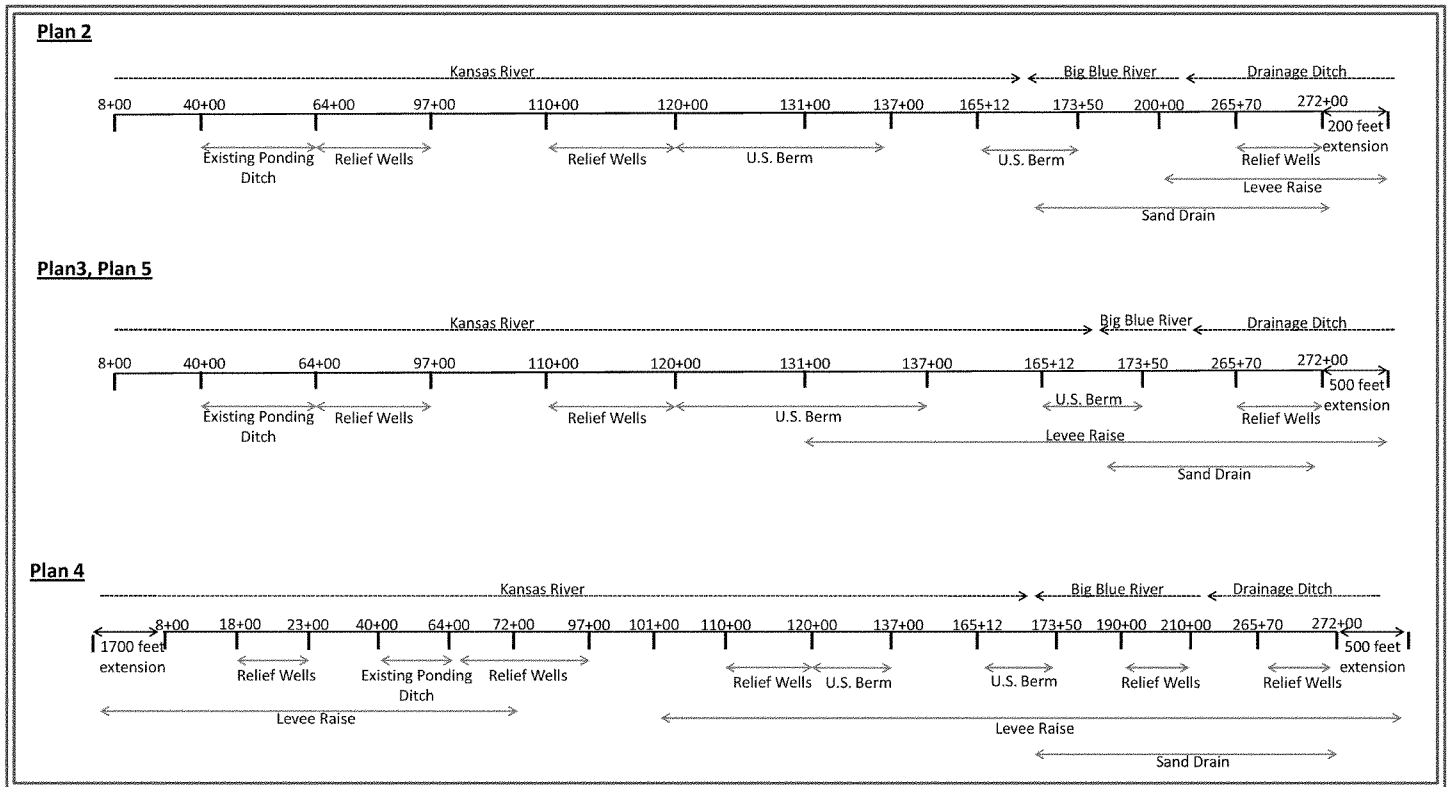

Existing Features
1993 Flood
FOR INFORMATION ONLY
Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Existing Features
1993 Flood
City of
MANHATTAN
POTTAWATOMIE COUNTY
RILEY COUNTY
POYNTZ AVE PUMPING STATION
OLD BYPASS PUMPING STATION (NON-FED)
MANHATTAN AVE PUMPING STATION
Wildcat Creek
Kansas River
ORIGINAL
BORROW
AREA
Legend
Levee Structures
Photography Date: 2012
Feet
0 300 600 1,200
Sheet No. 5


Inundation
Existing Conditions
@ 0.33% ACE event
With No
Levee Raise
Tuttle Creek Dam and Reservoir, 2 miles
Fort Riley Military Reservation, approximately 6.9 miles
City of MANHATTAN
ROTTAWATOMIE COUNTY
RILEY COUNTY
END OF MODEL AREA
POYNTZ AVE PUMPING STATION
OLD BYPASS PUMPING STATION (NON-FED)
MANHATTAN AVE PUMPING STATION
269+50
234+00
194+48
163+00
105+05
99+15
98+80
89+83
83+24
81+25
62+20
34+62
19+75
14+78
147
146
145
Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Inundation at 0.33% ACE Event
With No Levee Raise
Legend
Levee Structures
US Army Corps of Engineers
Kansas City District
Sheet No. 6


Inundation
@ 0.33% ACE event
With Plan 3
Levee Raise
Tuttle Creek Dam and Reservoir, 2 miles
Fort Riley Military Reservation, approximately 6.9 miles
Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Inundation
@ 0.33% ACE event
With Plan 3
Levee Raise
Legend
Levee Structures
US Army Corps
of Engineers
Kansas City District
Sheet No. 7
POTTAWATOMIE COUNTY
RILEY COUNTY
POYNTZ AVE PUMPING STATION
OLD BYPASS PUMPING STATION (NON-FED)
MANHATTAN AVE PUMPING STATION
END OF MODEL AREA
269+50
234+00
194+48
163+00
105+05
99+15
98+80
89+83
83+24
81+25
14+78
19+75
34+62
62+20
147
146
145
Kansas City
Manhattan
Levee Unit


Inundation
Existing Conditions
@ 0.2% ACE event
With No
Levee Raise
Tuttle Creek Dam and Reservoir, 2 miles
Fort Riley Military Reservation, approximately 6.9 miles
City of MANHATTAN
POYNTZ AVE PUMPING STATION
OLD BYPASS PUMPING STATION (NON-FED)
MANHATTAN AVE PUMPING STATION
END OF MODEL AREA
269+50
234+00
194+48
163+00
105+05
99+15
98+50
89+83
83+24
81+25
62+20
34+82
19+75
14+78
Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Inundation 0.2% ACE event
With No Levee Raise
Legend
Levee Structures
Sheet No. 8


Inundation
@ 0.2% ACE event
With Plan 4
Levee Raise
Tuttle Creek Dam and Reservoir, 2 miles
Fort Riley Military Reservation, approximately 6.9 miles
City of MANHATTAN
END OF MODEL AREA
COYNTZ AVE PUMPING STATION
OL BYPASS PUMPING STATION (NON-FED)
MANHATTAN AVE PUMPING STATION
Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Inundation
@ 0.2% ACE event
With Plan 4
Levee Raise
Legend
Levee Structures
Sheet No. 9



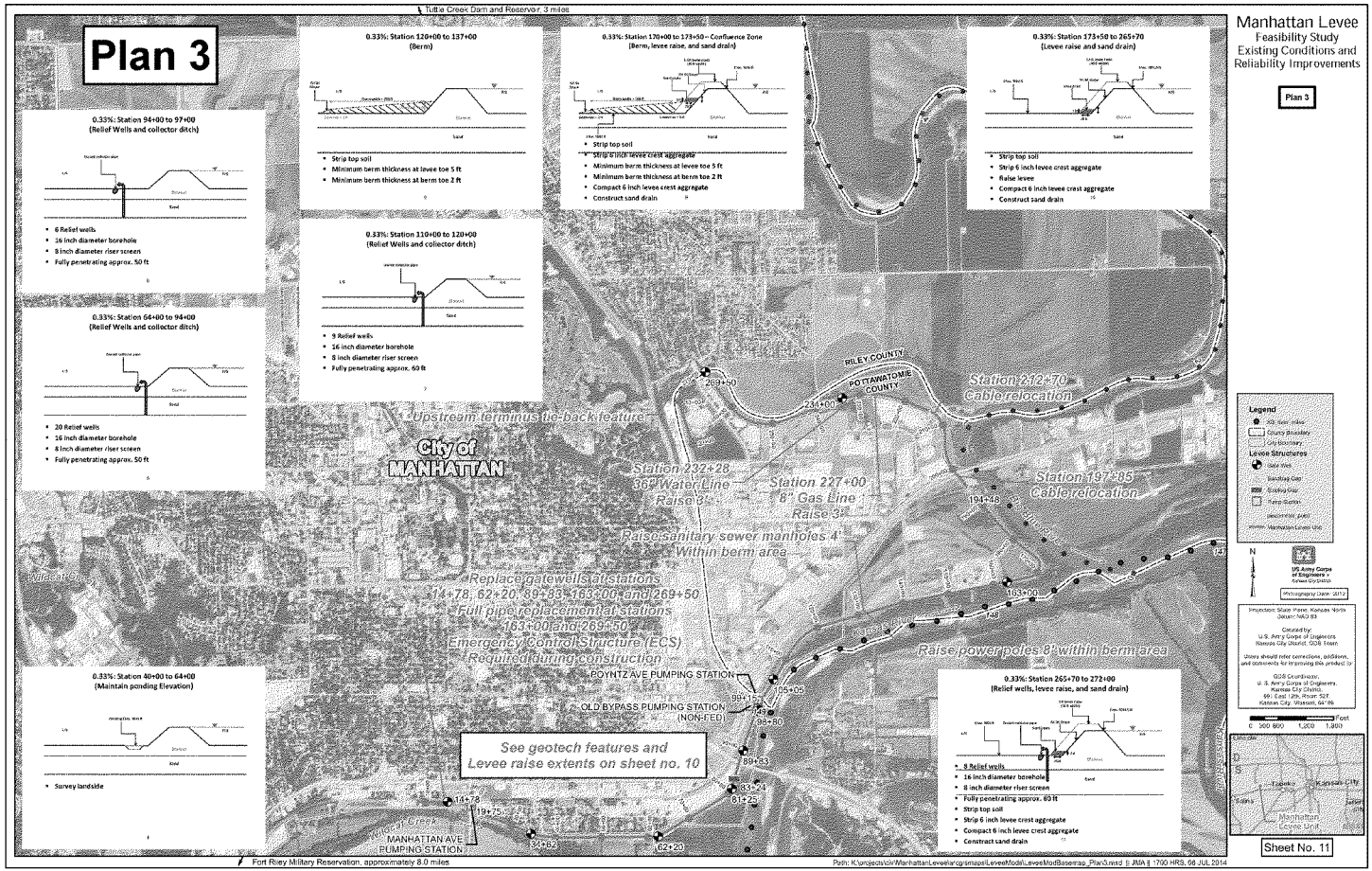
US Army Corps of Engineers
Kansas City District

Notes:
1. Distances not to scale
2. U.S. = underseepage
3. All Geotech features are new unless indicated otherwise

Manhattan Levee
Feasibility Study
Existing Conditions and Reliability Improvements

Diagram of Levee Raises and Geotechnical Features

Sheet No. 10


Tuttle Creek Dam and Reservoir, 3 miles
Plan 3
0.33%: Station 120+00 to 137+00
(Berm)
Strip top soil
Minimum berm thickness at levee toe 5 ft
Minimum berm thickness at berm toe 2 ft
0.33%: Station 170+00 to 173+50 – Confluence Zone
(Berm, levee raise, and sand drain)
Strip top soil
Strip 6 inch levee crest aggregate
Minimum berm thickness at levee toe 5 ft
Minimum berm thickness at berm toe 2 ft
Compact 6 inch levee crest aggregate
Construct sand drain
0.33%: Station 173+50 to 265+70
(Levee raise and sand drain)
Strip top soil
Strip 6 inch levee crest aggregate
Raise levee
Compact 6 inch levee crest aggregate
Construct sand drain
0.33%: Station 94+00 to 97+00
(Relief Wells and collector ditch)
6 Relief wells
16 inch diameter borehole
8 inch diameter riser screen
Fully penetrating approx. 50 ft
0.33%: Station 110+00 to 120+00
(Relief Wells and collector ditch)
9 Relief wells
16 inch diameter borehole
8 inch diameter riser screen
Fully penetrating approx. 60 ft
0.33%: Station 64+00 to 94+00
(Relief Wells and collector ditch)
20 Relief wells
16 inch diameter borehole
8 inch diameter riser screen
Fully penetrating approx. 50 ft
0.33%: Station 40+00 to 64+00
(Maintain ponding Elevation)
Survey landslide
0.33%: Station 265+70 to 272+00
(Relief wells, levee raise, and sand drain)
8 Relief wells
16 inch diameter borehole
8 inch diameter riser screen
Fully penetrating approx. 60 ft
Strip top soil
Strip 6 inch levee crest aggregate
Compact 6 inch levee crest aggregate
Construct sand drain
Upstream terminus tie-back feature
City of MANHATTAN
RILEY COUNTY
POTTAWATOMIE COUNTY
Station 212+70
Cable relocation
Station 232+28
36" Water Line
Raise 3'
Station 227+00
8" Gas Line
Raise 3'
Raise sanitary sewer manholes 4'
Within berm area
Station 197+85
Cable relocation
Replace gatewells at stations
14+78, 62+20, 89+83, 163+00, and 269+50
Full pipe replacement at stations
163+00 and 269+50
Emergency Control Structure (ECS)
Required during construction
Raise power poles 8' within berm area
POYNTZ AVE PUMPING STATION
OLD BYPASS PUMPING STATION
(NON-FED)
See geotech features and
Levee raise extents on sheet no. 10
MANHATTAN AVE
PUMPING STATION
Fort Riley Military Reservation, approximately 8.0 miles
Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Plan 3
Legend
Levee Structures
Sheet No. 11

Plan 4

Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements

Plan 4

Tuttle Creek Dam and Reservoir, 3 miles

0.20%: Station 100+00 to 104+95AH
(Levee raise)

- Strip top soil
- Strip 6 inch levee crest aggregate
- Raise levee
- Compact 6 inch levee crest aggregate

0.20%: Station 120+00 to 170+00
(Berm and levee raise)

- Strip top soil
- Strip 6 inch levee crest aggregate
- Minimum berm thickness at levee toe 5 ft
- Minimum berm thickness at berm toe 2 ft
- Compact 6 inch levee crest aggregate

0.20%: Station 170+00 to 173+60 – Confluence Zone
(Berm, levee raise, and sand drain)

- Strip top soil
- Strip 6 inch levee crest aggregate
- Minimum berm thickness at levee toe 5 ft
- Minimum berm thickness at berm toe 2 ft
- Compact 6 inch levee crest aggregate
- Construct sand drain

0.20%: Station 210+00 to 265+70
(Levee raise and sand drain)

- Strip top soil
- Strip 6 inch levee crest aggregate
- Raise levee
- Compact 6 inch levee crest aggregate
- Construct sand drain

0.20%: Station 71+00 to 70+00
(Levee raise)

- Strip top soil
- Strip 6 inch levee crest aggregate
- Raise levee
- Compact 6 inch levee crest aggregate
- Construct sand drain
- Analyze need for landside ditch between Sta. 40+00 and 64+00

0.20%: Station 94+00 to 97+00
(Relief Wells and collector ditch)

- 6 Relief wells
- 16 inch diameter borehole
- 8 inch diameter riser screen
- Fully penetrating approx. 50 ft

0.20%: Station 104+95AH+00 to 120+00
(Relief wells and levee raise)

- 28 Relief wells
- 16 inch diameter borehole
- 8 inch diameter riser screen
- Fully penetrating approx. 60 ft
- Strip top soil
- Strip 6 inch levee crest aggregate
- Compact 6 inch levee crest aggregate

0.20%: Station 150+00 to 210
(Relief wells, levee raise, and sand drain)

- 10 Relief wells
- 16 inch diameter borehole
- 8 inch diameter riser screen
- Fully penetrating approx. 60 ft
- Strip top soil
- Strip 6 inch levee crest aggregate
- Compact 6 inch levee crest aggregate
- Construct sand drain

0.20%: Station 18+00 to 23+00
(Relief wells, levee raise, and sand drain)

- 6 Relief wells
- 16 inch diameter borehole
- 8 inch diameter riser screen
- Fully penetrating approx. 50 ft
- Strip top soil
- Strip 6 inch levee crest aggregate
- Compact 6 inch levee crest aggregate

0.20%: Station 8+00 to 18+00
(levee raise, and sand drain)

- Strip top soil
- Strip 6 inch levee crest aggregate
- Raise levee
- Compact 6 inch levee crest aggregate

0.20%: Station 64+00 to 94+00
(Relief Wells and collector ditch)

- 20 Relief wells
- 16 inch diameter boreholes
- 8 inch diameter riser screen
- Fully penetrating approx. 50 ft

0.20%: Station 265+70 to 269+50
(Relief wells, levee raise, and sand drain)

- 8 Relief wells
- 16 inch diameter borehole
- 8 inch diameter riser screen
- Fully penetrating approx. 60 ft
- Strip top soil
- Strip 6 inch levee crest aggregate
- Compact 6 inch levee crest aggregate
- Construct sand drain

Upstream terminus tie-back feature

City of MANHATTAN

RILEY COUNTY

POTTAWATOMIE COUNTY

Station 232+28
36" Water Line
Raise 3'

Station 227+00
8" Gas Line
Raise 3'

Raise sanitary sewer manholes 4' Within berm area

Station 197+86
Cable relocation

Station 212+70
Cable relocation

Raise power poles 8' within berm area

POYNTZ AVE PUMPING STATION

OLD BYPASS PUMPING STATION (NON-FED)

See geotech features and Levee raise extents on sheet no. 10

Abandon and fill Old By-Pass Pump Station at 98+80

Strengthen walls and slab For Pump Station at 20+13

1700 ft. levee extension to tie into high ground

Full pipe replacement and Replace all gatewells except at 98+80

10 temporary Emergency Control Structures (ECS) Required during construction

MANHATTAN AVE PUMPING STATION

Fort Riley Military Reservation, approximately 8.0 miles

Legend
- POI (levee, inlet)
- Levee Structures
- Gate Inlet
- Sluicing Gate
- Pump Station
- Manhattan Levee Unit

US Army Corps of Engineers
Kansas City District

Emergency Level 2012

Projection: State Plane, Kansas North Zone; NAD 83

Created by:
U.S. Army Corps of Engineers
Kansas City District, GIS Team

Users should refer corrections, additions, and comments for improving this product to:

GIS Coordinator
U. S. Army Corps of Engineers
Kansas City District
601 East 12th, Room 827
Kansas City, Missouri, 64106

0 300 600 1,200 1,800 Feet

Lawrence, Topeka, Kansas City, Manhattan, Levee Unit

Sheet No. 12

Path: K:\projects\cir\ManhattanLevee\arcgismaps\LeveeMods\LeveeModBasemap_Plan4.mxd || JMA || 1700 HRS, 08 JUL 2014

Plan 5

Tuttle Creek Dam and Reservoir, 3 miles

0.33%: Station 94+00 to 97+00
(Relief Wells and collector ditch)

- 6 Relief wells
- 16 inch diameter borehole
- 8 inch diameter riser screen
- Fully penetrating approx. 50 ft

0.33%: Station 64+00 to 94+00
(Relief Wells and collector ditch)

- 20 Relief wells
- 16 inch diameter borehole
- 8 inch diameter riser screen
- Fully penetrating approx. 50 ft

0.33%: Station 40+00 to 64+00
(Maintain ponding Elevation)

- Survey landslide

0.33%: Station 120+00 to 137+00
(Berm)

- Strip top soil
- Minimum berm thickness at levee toe 5 ft
- Minimum berm thickness at berm toe 2 ft

0.33%: Station 110+00 to 120+00
(Relief Wells and collector ditch)

- 9 Relief wells
- 16 inch diameter borehole
- 8 inch diameter riser screen
- Fully penetrating approx. 60 ft

0.33%: Station 170+00 to 173+50 – Confluence Zone
(Berm, levee raise, and sand drain)

- Strip top soil
- Strip 6 inch levee crest aggregate
- Minimum berm thickness at levee toe 5 ft
- Minimum berm thickness at berm toe 2 ft
- Compact 6 inch levee crest aggregate
- Construct sand drain

0.33%: Station 173+50 to 265+70
(Levee raise and sand drain)

- Strip top soil
- Strip 6 inch levee crest aggregate
- Raise levee
- Compact 6 inch levee crest aggregate
- Construct sand drain

0.33%: Station 265+70 to 272+00
(Relief wells, levee raise, and sand drain)

- 8 Relief wells
- 16 inch diameter borehole
- 6 inch diameter riser screen
- Fully penetrating approx. 60 ft
- Strip top soil
- Strip 6 inch levee crest aggregate
- Compact 6 inch levee crest aggregate
- Construct sand drain

RILEY COUNTY
POTTAWATOMIE COUNTY
City of MANHATTAN
Wildcat Creek
Kansas River
Fort Riley Boulevard
Seventh Street Trafficway
Tuttle Creek Blvd
Anderson Ave
Kansas Highway 18
Fort Riley Military Reservation, approximately 8.0 miles

269+50
234+00
184+48
163+00
148
105+05
99+15
98+80
89+83
83+24
81+25
62+20
34+62
19+75
11+78

Upstream terminus tie-back feature
Station 217+70 Cable relocation
Land affected by Channel widening Bridge Alterations
Station 137+85 Cable relocation Channel Widening
Station 232+28 36" Water Line Raise 3'
Station 227+00 8" Gas Line Raise 3'
Raise sanitary sewer manholes 4' Within berm area
Replace gatewells at stations 11+78, 62+20, 89+83, 163+00, and 269+50
Full pipe replacement at stations 163+00 and 269+50
Emergency Control Structure (ECS) Required during construction
Raise power poles 8' within berm area
POYNTZ AVE PUMPING STATION
OLD BYPASS PUMPING STATION (NON-FED)
MANHATTAN AVE PUMPING STATION
See geotech features and Levee raise extents on sheet no. 10

Path: K:\projects\UrManhattanLevee\gis\groups\LeveeMod\LeveeModBaseMap_Plan5.mxd || JMA || 1700 HRS, 08 JUL 2014

Manhattan Levee
Feasibility Study
Existing Conditions and Reliability Improvements

Plan 5

Legend
GIS River Miles
County Boundary
City Boundary
Channel Widening Area
Area affected
Area affected
Levee Structures
Gate Well
Sandbag Gap
Sliding Gate
Pump Station
Manhattan Levee Unit

N
US Army Corps of Engineers - Kansas City District

Photography Date: 2012

Projection: State Plane, Kansas North
Datum: NAD 83

Created by
U.S. Army Corps of Engineers
Kansas City District, GIS Team

Users should note corrections, additions, and constraints for improving this product to:

GIS Coordinator,
U. S. Army Corps of Engineers,
Kansas City District,
601 East 12th, Room 327,
Kansas City, Missouri, 64106

0 300 600 1,200 1,800 Feet

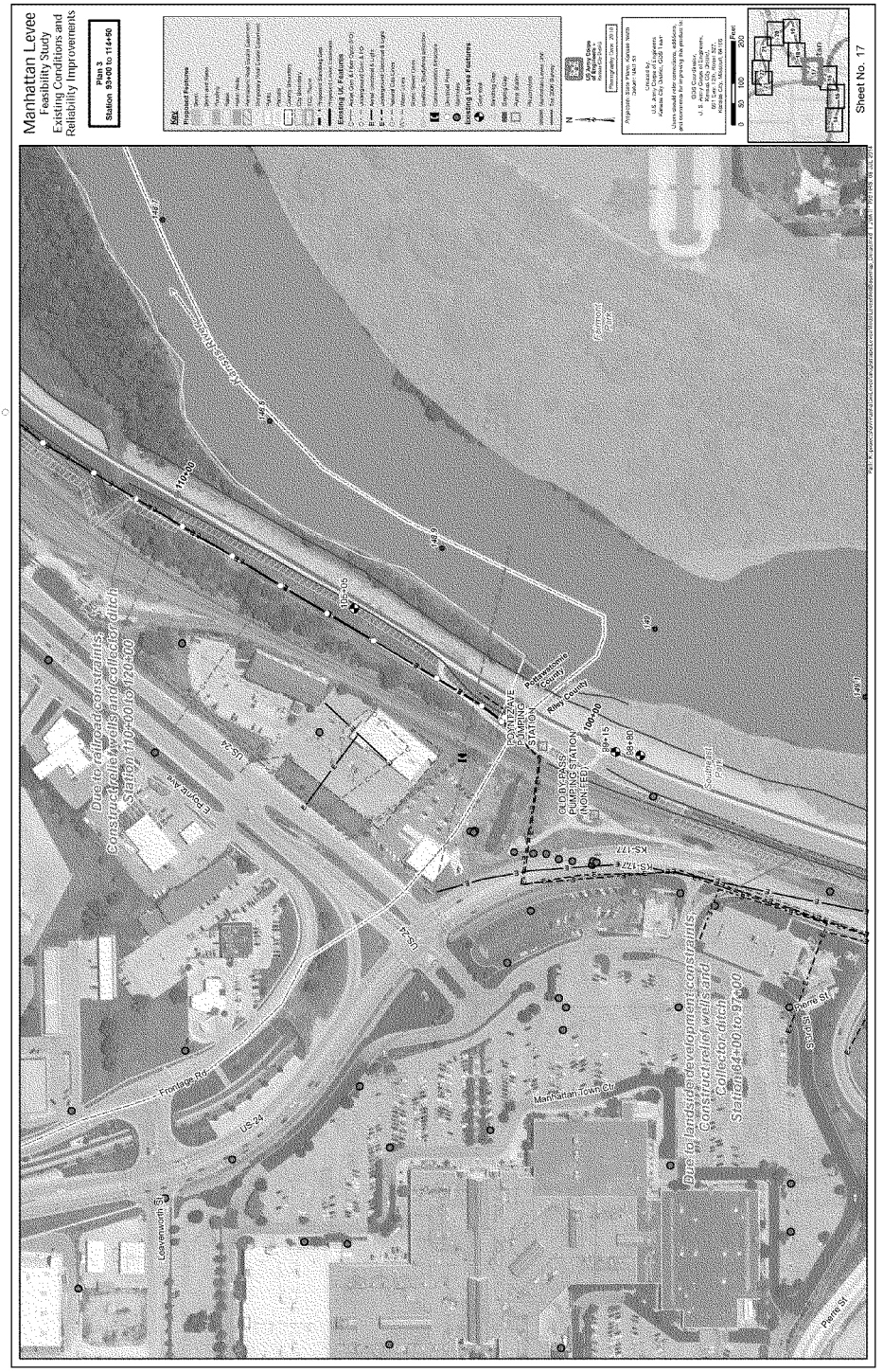
Lincoln
Kansas City
Salina
Manhattan Levee Unit

Sheet No. 13

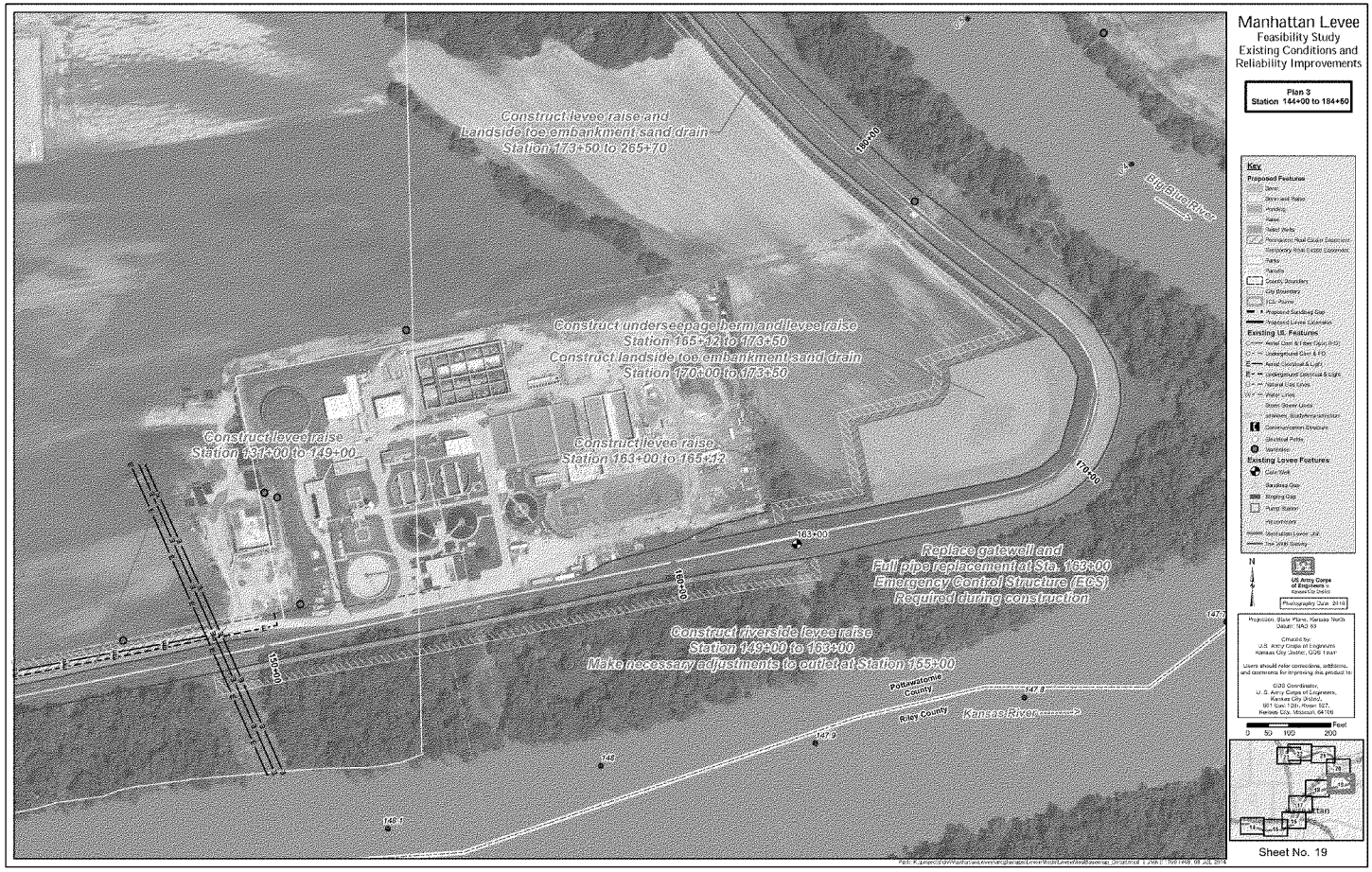
Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Plan 3
Station 0+00 to 38+50
El Paso Ln
S 14th St
S 12th St
Douglass Park
KS-18
S 15th St
Fair Ln
Griffith Park
S 11th St
S 10th St
Riley Ln
14+78
10+00
19+75
MANHATTAN AVE PUMPING STATION
S Manhattan Ave
Pottawatomie Ave
Sojourner Truth Park
Brookwood Ct
Pottawatomie Ct
Greenfield Ct
Wildcat Creek
Replace gatewell at Sta. 14+78
Emergency Control Structure (ECS)
Required during construction
30+00
34+62
Key
Proposed Features
Existing UL Features
Existing Levee Features
US Army Corps of Engineers
Kansas City District
Photography Date: 2019
Projection: State Plane, Kansas North
Datum: NAD 83
Created by:
U.S. Army Corps of Engineers
Kansas City District, GIS Team
Users should refer corrections, additions, and comments for improving this product to:
GIS Coordinator,
U. S. Army Corps of Engineers,
Kansas City District,
601 East 12th, Room 527,
Kansas City, Missouri 64106
Feet
0 50 100 200
Sheet No. 14

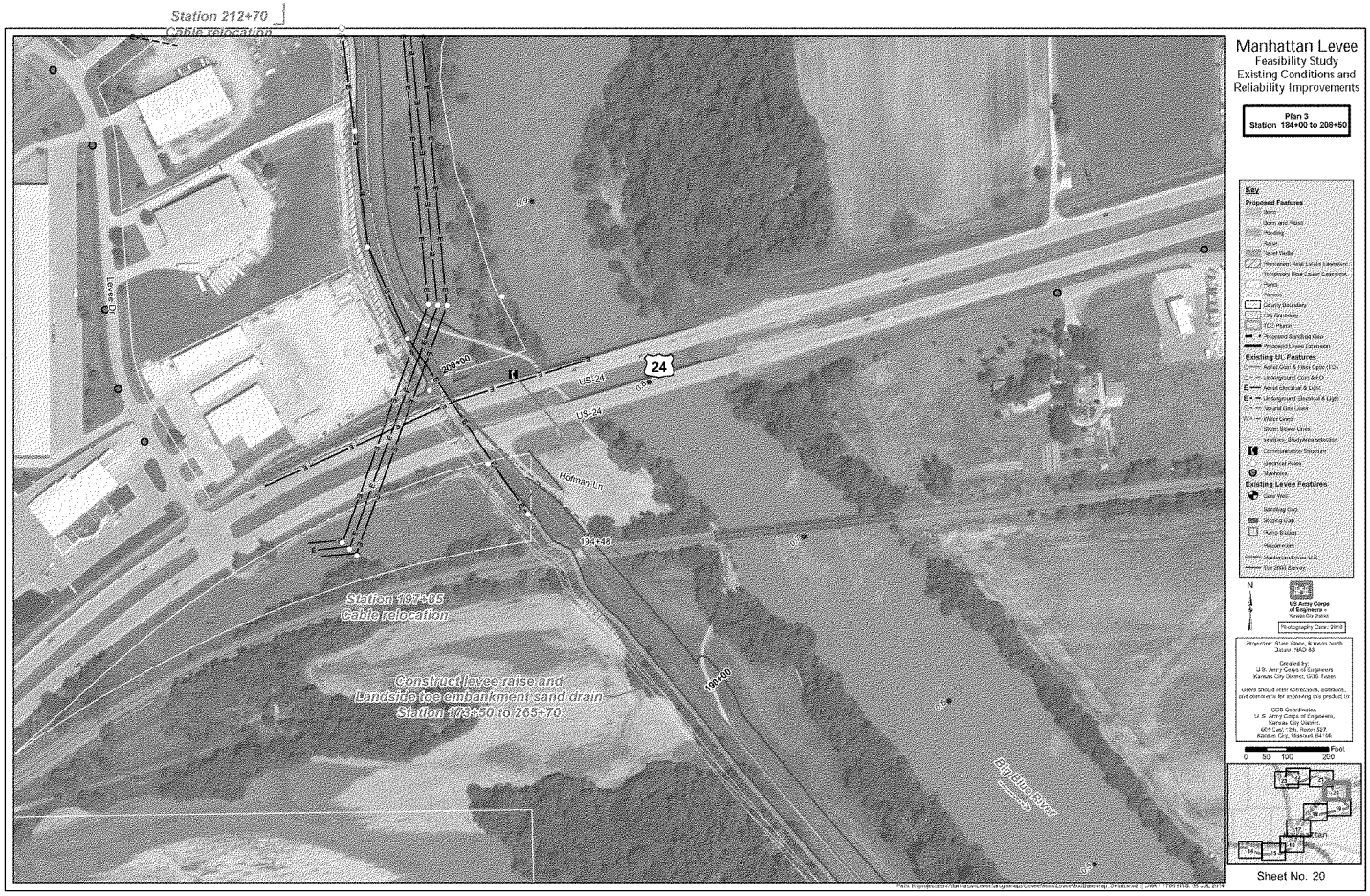
Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Plan 3
Station 38+00 to 68+50
Key
Proposed Features
Existing UL Features
Existing Levee Features
Sheet No. 15
Due to landside development
Constraints, construct relief wells
And collector ditch
Station 64+00 to 97+00
Minimum ponding elevation 1015 ft.
Maintain minimum ponding elevation
(O&M manual update)
Station 40+00 to 64+00
Replace gatewell at Sta. 62+20
Emergency Control Structure (ECS)
Required during construction
S 4th St
S 5th St
S 6th St
S 8th St
S 9th St
S Juliette Ave
Riley Ln
Pottawatomie Ave
Fair Ln
KS-18
Glenstone Cir
Sunrise Cir
Southeast Park
Templet-n
62+20
60+00
50+00
40+00
Wildcat Creek

Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Plan 3
Station 66+00 to 93+50
Replace gatewell at Sta. 89+83
Emergency Control Structure (ECS)
Required during construction
Due to landside development
Constraints construct relief wells
And collector ditch
Station 64+00 to 97+00
Colorado St
Yuma St
El Paso Ln
Fair Ln
Riley Ln
Pottawatomie Ave
Pierre St
S 3rd St
S 2nd St
S 4th St
KS-18
KS-177
Fort Riley Blvd
Southeast Park
Fairmont Park
Kansas River
Mcdowell Creek Rd
177
89+83
83+24
81+25
80+00
70+00
149.1
149.2
149.3
149.4
149.5
Key
Proposed Features
Existing UL Features
Existing Levee Features
Feet
0 50 100 200
Sheet No. 16


Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Plan 3
Station 93+00 to 114+50
Key
Proposed Features
Existing UL Features
Existing Levee Features
Sheet No. 17
Due to railroad constraints,
Construct relief wells and collector ditch
Station 110+00 to 120+00
Due to landside development constraints,
Construct relief wells and
Collector ditch
Station 64+00 to 97+00
Kansas River
Fairmont Park
Pottawatomie County
Riley County
POYNTZ AVE PUMPING STATION
OLD BY-PASS PUMPING STATION (NON-FED)
Southeast Park
Manhattan Town Ctr
Frontage Rd
US-24
E Poyntz Ave
Leavenworth St
Pierre St
S 3rd St
KS-177
110+00
105+05
100+00
99+15
98+80
148.7
148.8
148.9
149
149.1

Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Plan 3
Station 113+50 to 144+00
Key
Existing UL Features
Existing Levee Features
Sheet No. 18
Construct levee raise
Station 131+00 to 149+00
Raise sanitary sewer manholes 4'
Within berm area
Raise power poles 8' within berm area
Construct underseepage berm
Station 120+00 to 137+00
Due to railroad constraints,
Construct relief wells and collector ditch
Station 110+00 to 120+00
140+00
130+00
120+00
Kansas River
Riley County
Pottawatomie County
Enoch Ln
US-24
E Ronk Ave


Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Plan 3
Station 144+00 to 184+50
Construct levee raise and
Landside toe embankment sand drain
Station 173+50 to 265+70
Construct underseepage berm and levee raise
Station 165+12 to 173+50
Construct landside toe embankment sand drain
Station 170+00 to 173+50
Construct levee raise
Station 131+00 to 149+00
Construct levee raise
Station 163+00 to 165+12
Replace gatewell and
Full pipe replacement at Sta. 163+00
Emergency Control Structure (ECS)
Required during construction
Construct riverside levee raise
Station 149+00 to 163+00
Make necessary adjustments to outlet at Station 165+00
Big Blue River
Kansas River
Pottawatomie County
Riley County
180+00
170+00
163+00
160+00
150+00
147.7
147.8
147.9
148
148.1
Key
Proposed Features
Existing UL Features
Existing Levee Features
US Army Corps of Engineers
Kansas City District
Feet
0 50 100 200
Sheet No. 19


Station 212+70
Cable relocation
Station 197+65
Cable relocation
Construct levee raise and
Landside toe embankment sand drain
Station 173+50 to 265+70
US-24
24
Hofman Ln
Big Blue River
Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Plan 3
Station 184+00 to 208+50
Key
Proposed Features
Existing U/L Features
Existing Levee Features
Sheet No. 20

Candidate borrow area

Manhattan Levee

Feasibility Study
Existing Conditions and Reliability Improvements

Plan 3
Station 206+00 to 239+00

Riley County

Pottawatomie County

Northeast Community Park

234+00

231+00

227+00

220+00

240+00

Station 232+28
36" Water Pipe
Raise 3'

Station 227+00
8" Gas Pipe
Raise 3'

Construct levee raise and
Landside-toe embankment sand drain
Station 173+50 to 265+70

Station 212+70
cable relocation

Levee Dr

Kaiserhood Dr

1 drain

Key

Proposed Features
Berm
Berm and Raise
Pondrive
Raise
Raise Gates
Permanent Real Estate Easement
Temporary Real Estate Easement
Parks
Parcels
County Boundary
City Boundary
FCC Plans
Proposed Building Gap
Proposed Levee Extension

Existing UL Features
Aerial Conc & Fiber Cable (FO)
Underground Conc & FO
Aerial Electrical & Light
Underground Electrical & Light
Natural Gas Lines
Water Lines
Storm Sewer Lines
Sanitary, Stormwater collection
Storm Isolation Structure
Utilities Poles
Manholes

Existing Levee Features
Gate Well
Sandbag Gap
Existing Gap
Pump Station
Monuments
Manhattan Levee Line
Doc 2004 Survey

N

US Army Corps
of Engineers
Kansas City District

Photography date: 2010

Projection: State Plane, Kansas North
Datum: NAD 83

Created by:
U.S. Army Corps of Engineers
Kansas City District, CCB Team

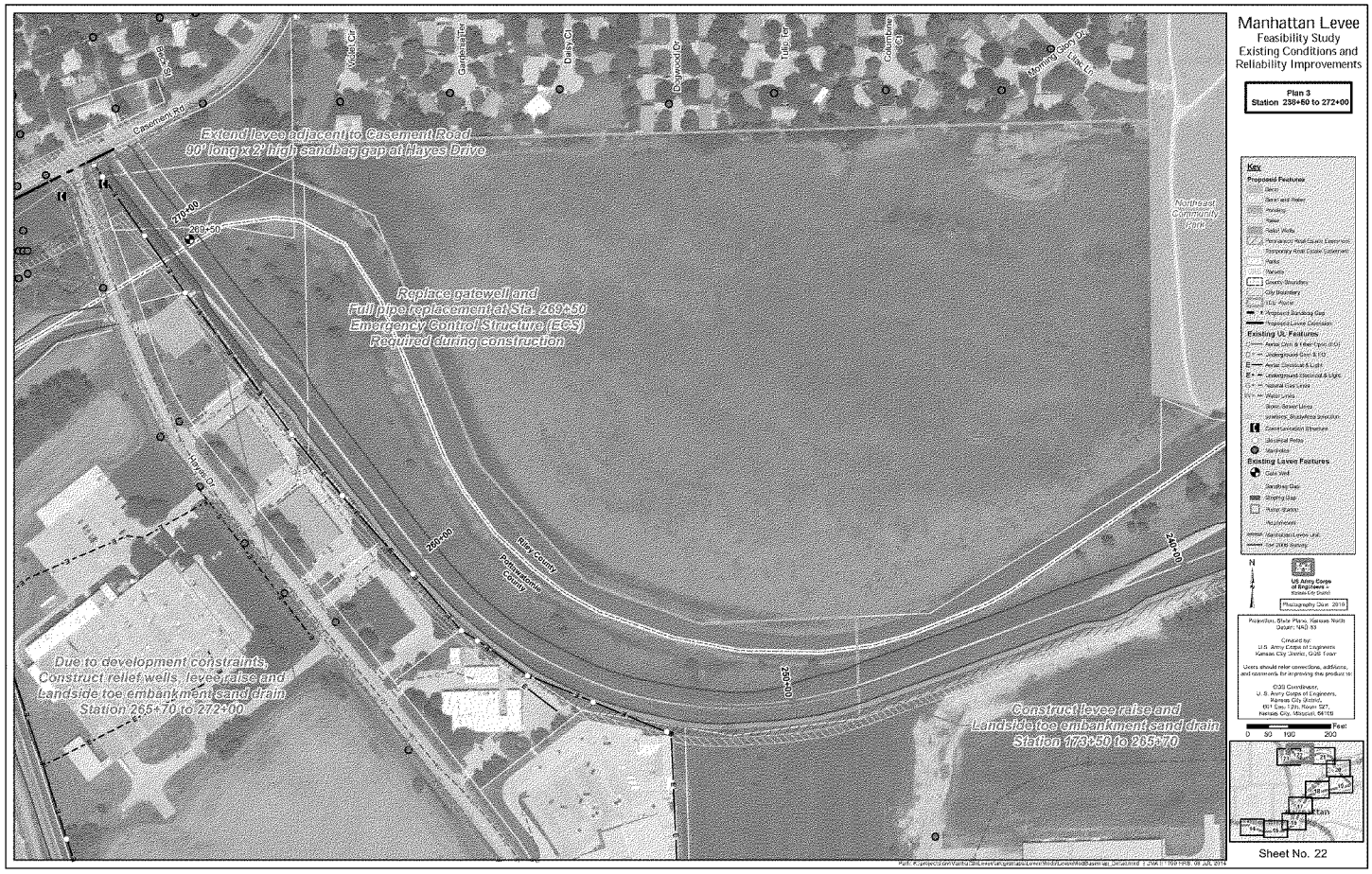
Users should note omissions, additions, and comments for improving this product to:

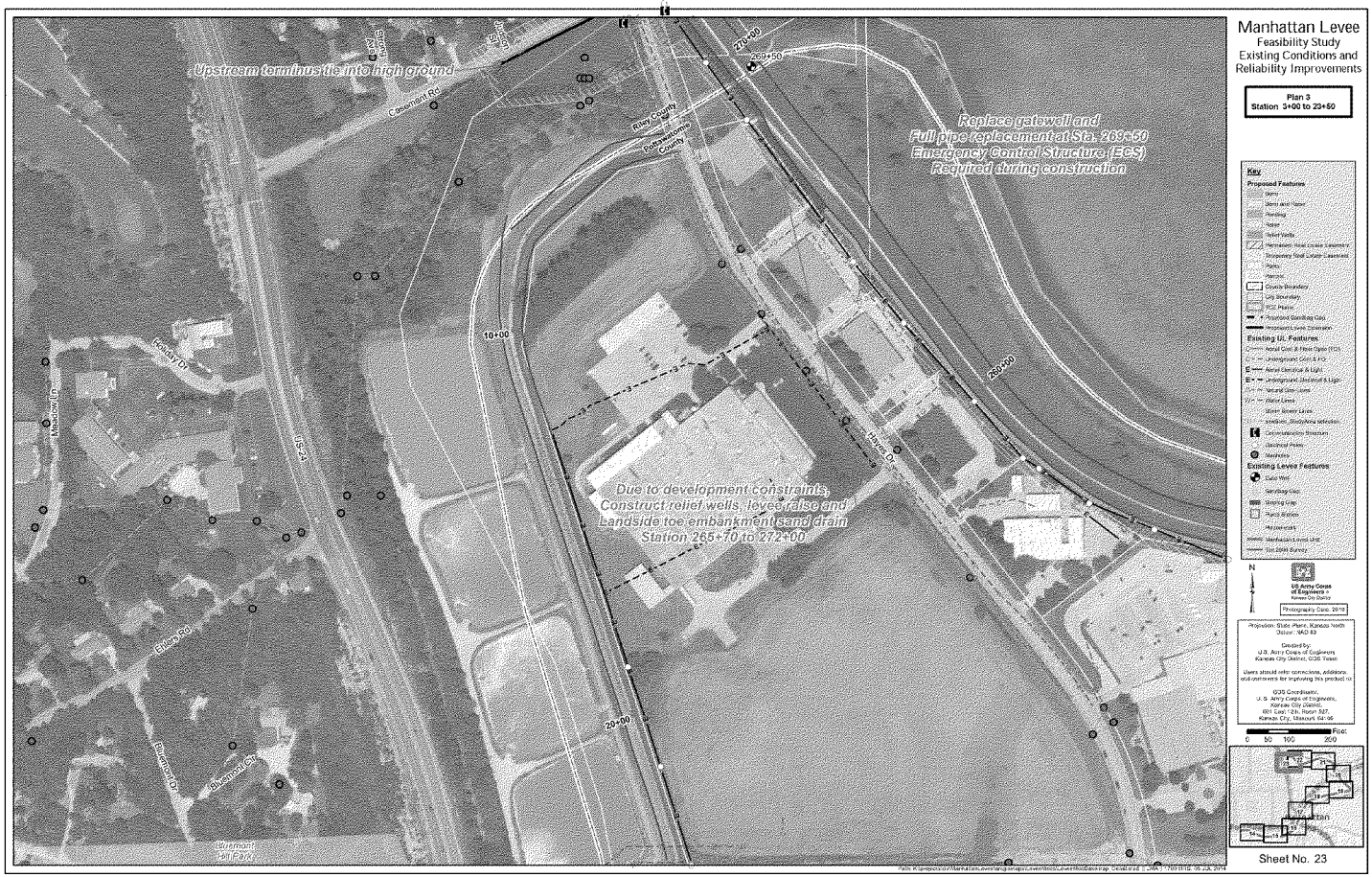
CCB Coordinator,
U. S. Army Corps of Engineers,
Kansas City District,
601 East 12th, room 521
Kansas City, Missouri 64106

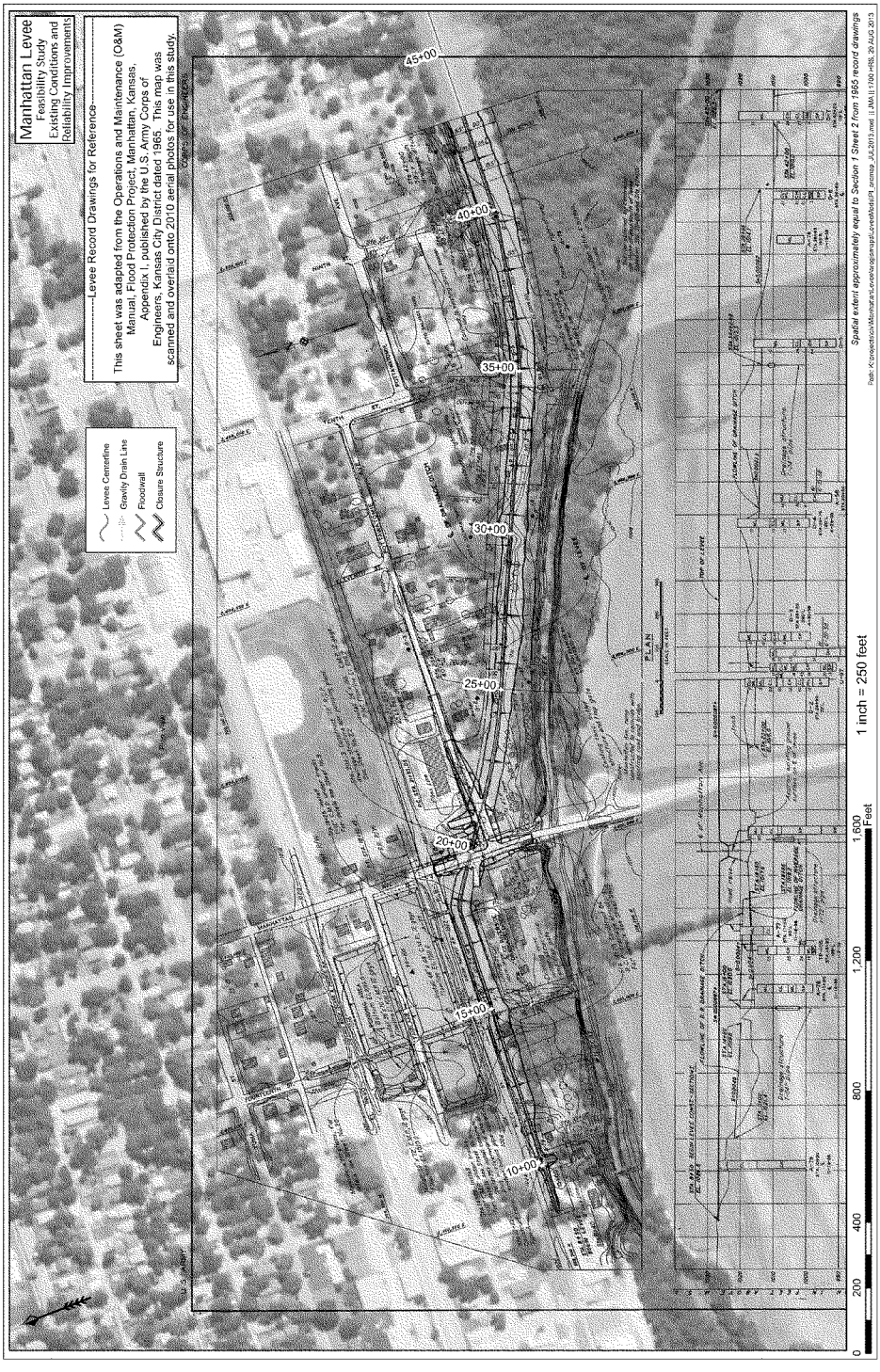
0 50 100 200 Feet

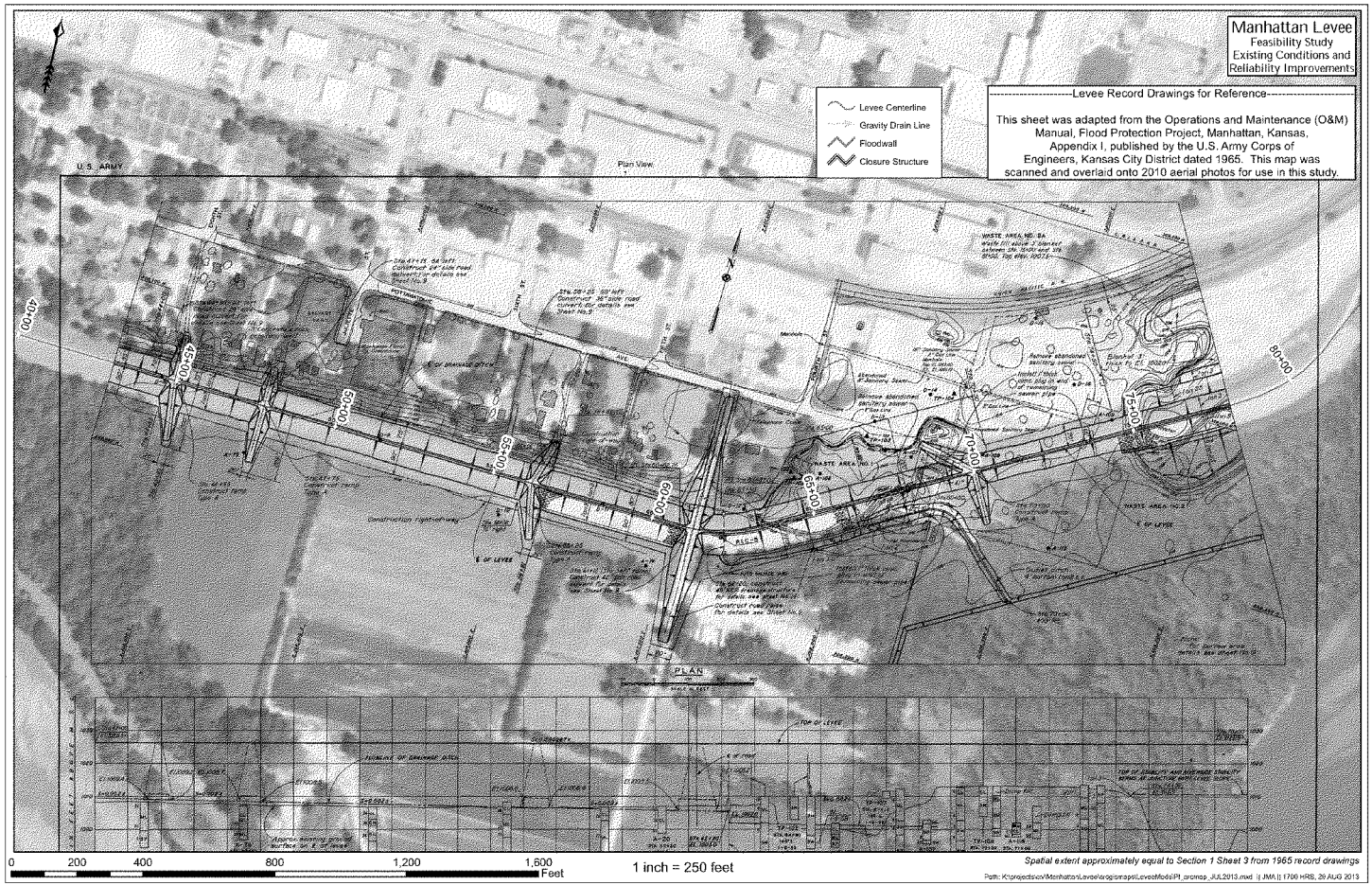
Sheet No. 21

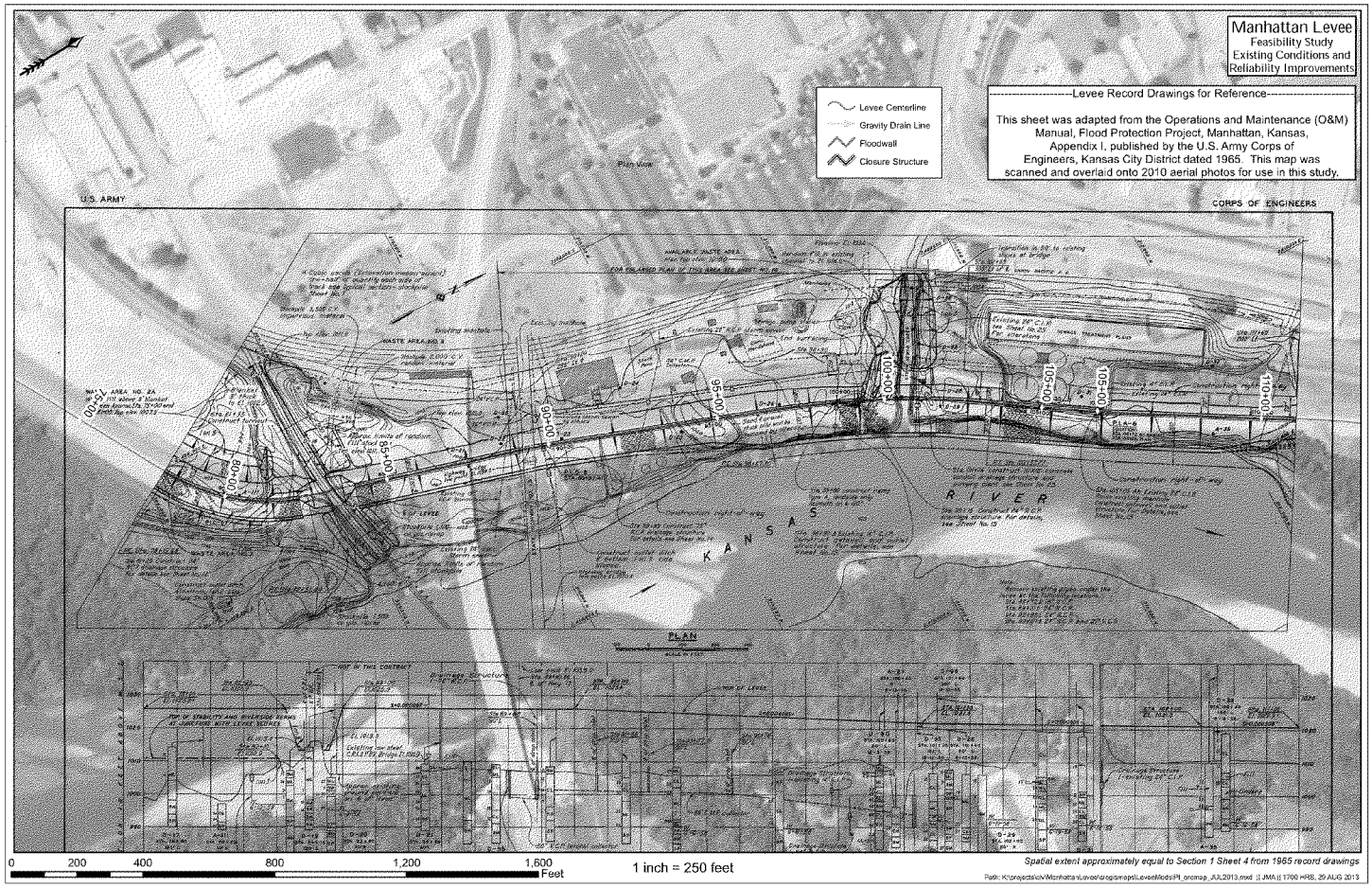
Path: K:\projects\Manhattan\Feasibility\Levee\MapLevelMap.aprx Updated: 7 Jul 2014

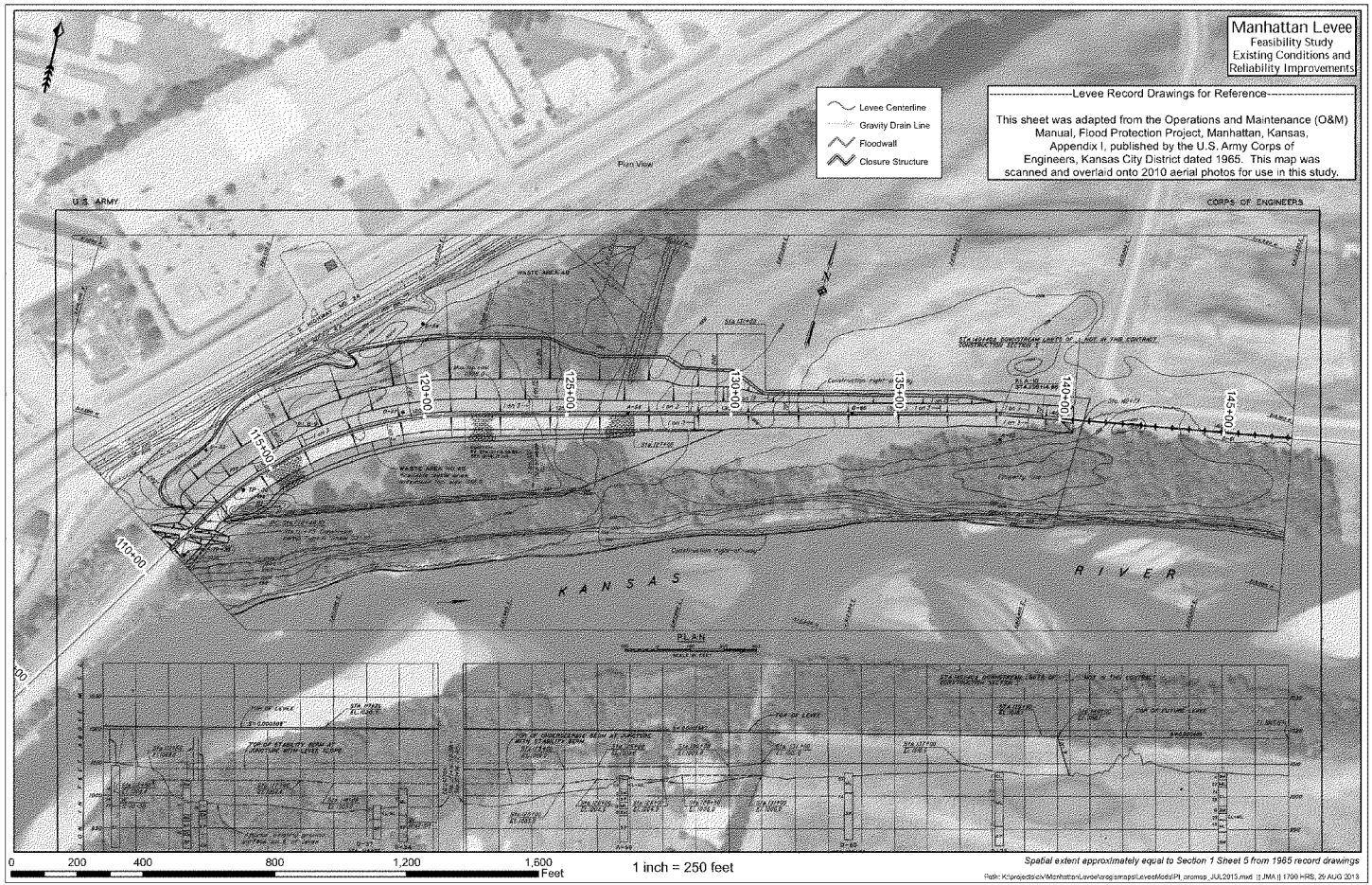

Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Plan 3
Station 238+60 to 272+00
Key
Proposed Features
Existing UL Features
Existing Levee Features
US Army Corps of Engineers
Sheet No. 22
Extend levee adjacent to Casement Road
90' long x 2' high sandbag gap at Hayes Drive
Replace gatewell and
Full pipe replacement at Sta. 269+50
Emergency Control Structure (ECS)
Required during construction
Due to development constraints,
Construct relief wells, levee raise and
Landside toe embankment sand drain
Station 265+70 to 272+00
Construct levee raise and
Landside toe embankment sand drain
Station 173+50 to 265+70
Casement Rd
Hayes Dr
Riley County
Pottawatomie County
Northeast Community Park
270+00
269+50
260+00
250+00
240+00
Feet
0 50 100 200

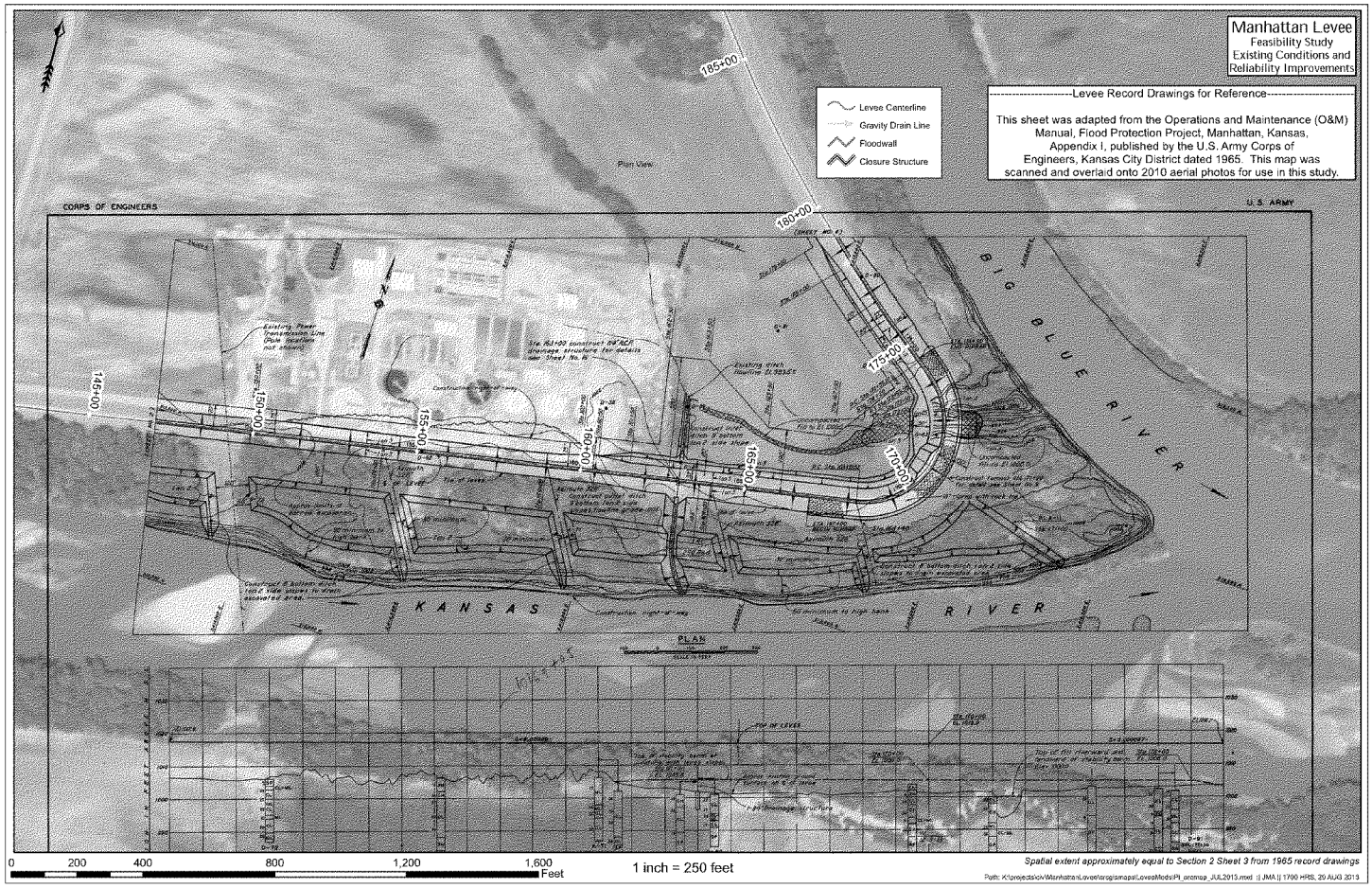

Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Plan 3
Station 3+00 to 23+50
Upstream terminus tie into high ground
Replace gatewell and
Full pipe replacement at Sta. 269+50
Emergency Control Structure (ECS)
Required during construction
Due to development constraints,
Construct relief wells, levee raise and
Landside toe embankment sand drain
Station 265+70 to 272+00
Casement Rd
Riley County
Pottawatomie County
Hayes Dr
US-24
Holiday Dr
Meadow Ln
Elliott Rd
Bluemont Cir
Bluemont Hill Park
10+00
20+00
260+00
270+00
269+50
Key
Proposed Features
Existing UL Features
Existing Levee Features
Manhattan Levee Unit
Sheet No. 23

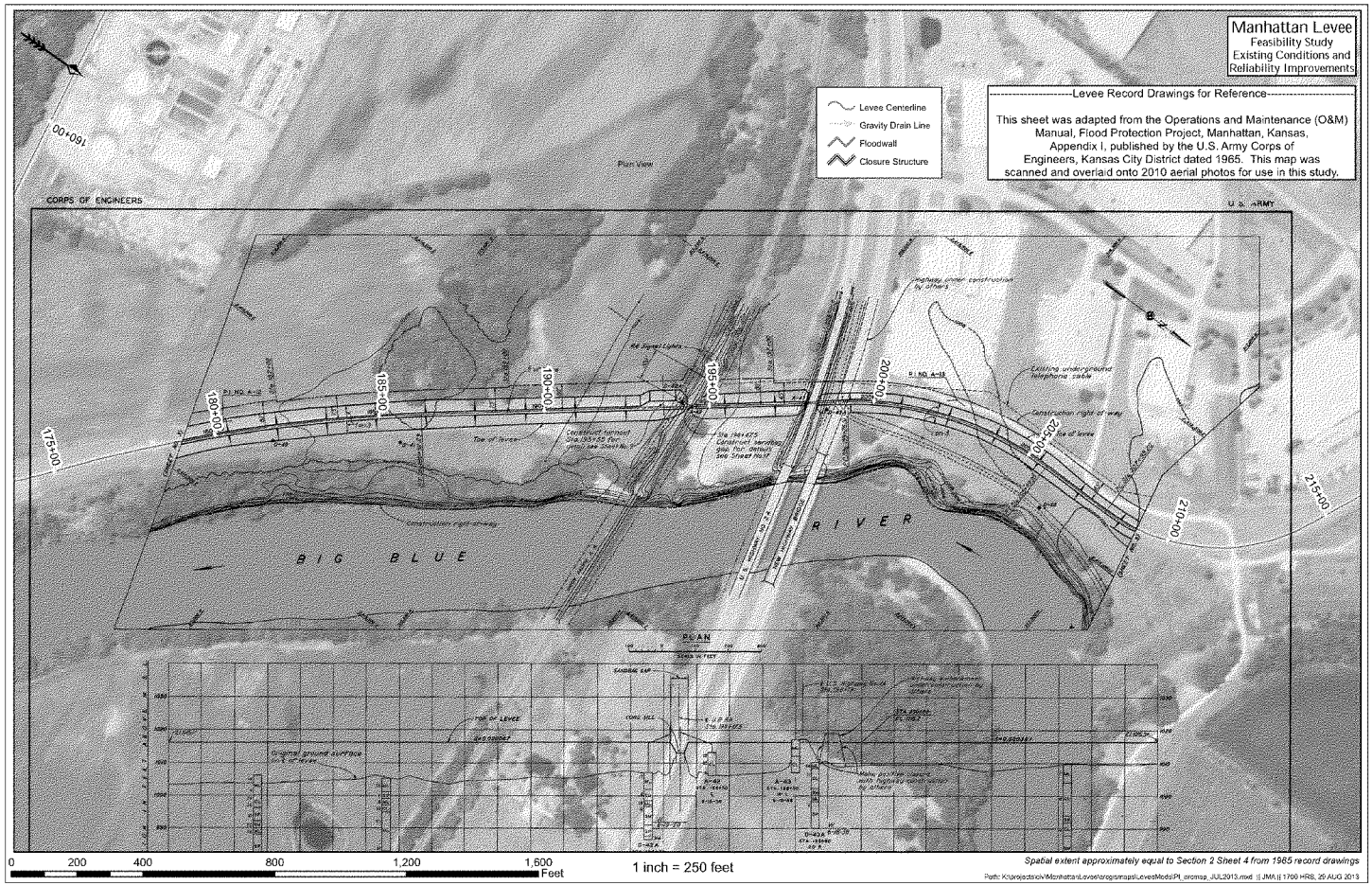

Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Levee Record Drawings for Reference
This sheet was adapted from the Operations and Maintenance (O&M) Manual, Flood Protection Project, Manhattan, Kansas, Appendix I, published by the U.S. Army Corps of Engineers, Kansas City District dated 1965. This map was scanned and overlaid onto 2010 aerial photos for use in this study.
Levee Centerline
Gravity Drain Line
Floodwall
Closure Structure
45+00
40+00
35+00
30+00
25+00
20+00
15+00
10+00
PLAN
1 inch = 250 feet
0
200
400
800
1,200
1,600
Feet
Spatial extent approximately equal to Section 1 Sheet 2 from 1965 record drawings

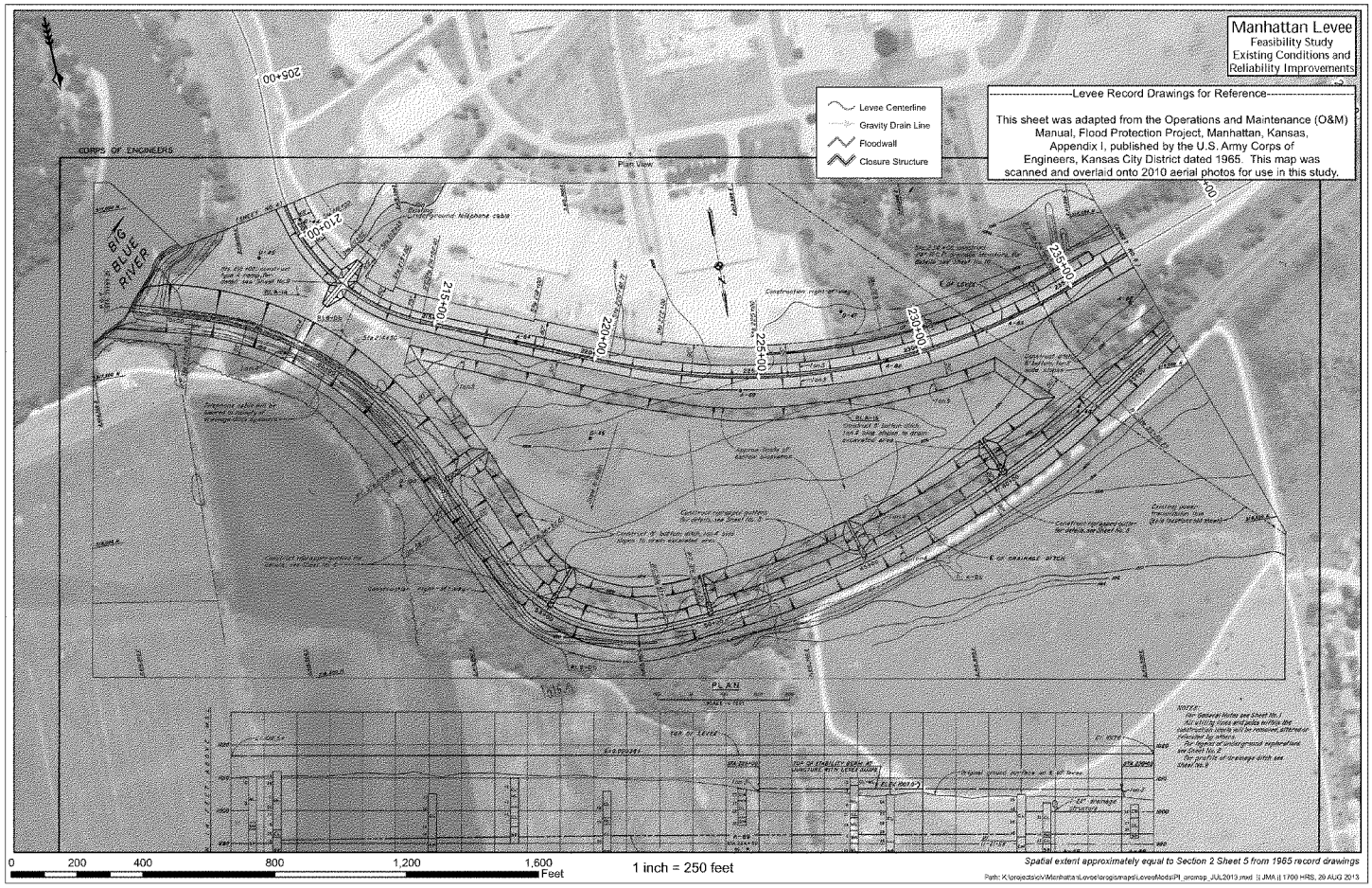

Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Levee Centerline
Gravity Drain Line
Floodwall
Closure Structure
----------Levee Record Drawings for Reference----------
This sheet was adapted from the Operations and Maintenance (O&M) Manual, Flood Protection Project, Manhattan, Kansas, Appendix I, published by the U.S. Army Corps of Engineers, Kansas City District dated 1965. This map was scanned and overlaid onto 2010 aerial photos for use in this study.
U.S. ARMY
Plan View
40+00
45+00
50+00
55+00
60+00
65+00
70+00
75+00
80+00
PLAN
0
200
400
800
1,200
1,600
Feet
1 inch = 250 feet
Spatial extent approximately equal to Section 1 Sheet 3 from 1965 record drawings

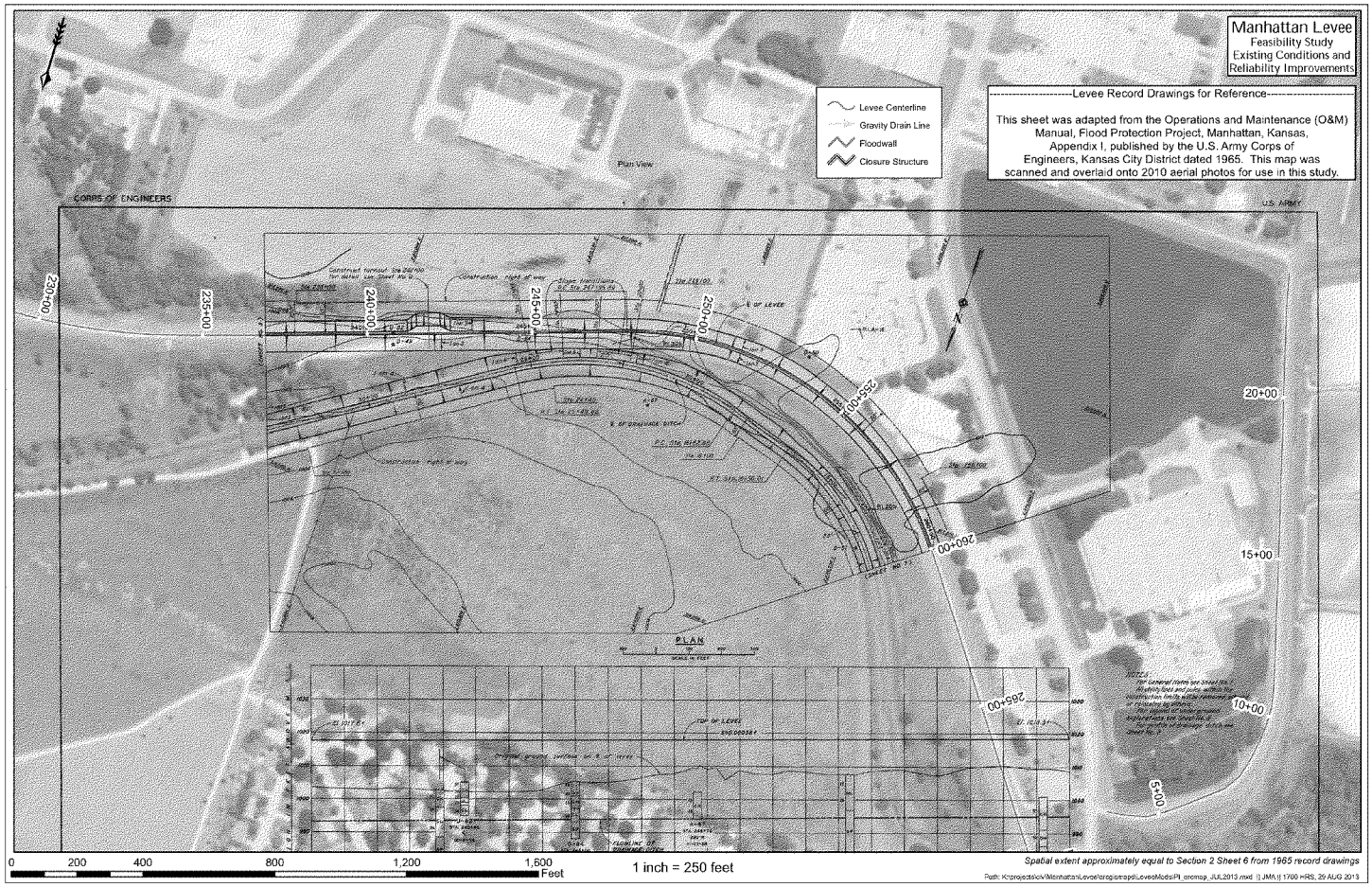

Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Levee Centerline
Gravity Drain Line
Floodwall
Closure Structure
Levee Record Drawings for Reference
This sheet was adapted from the Operations and Maintenance (O&M) Manual, Flood Protection Project, Manhattan, Kansas, Appendix I, published by the U.S. Army Corps of Engineers, Kansas City District dated 1965. This map was scanned and overlaid onto 2010 aerial photos for use in this study.
U.S. ARMY
CORPS OF ENGINEERS
Plan View
KANSAS
RIVER
PLAN
0
200
400
800
1,200
1,600
Feet
1 inch = 250 feet
Spatial extent approximately equal to Section 1 Sheet 4 from 1965 record drawings

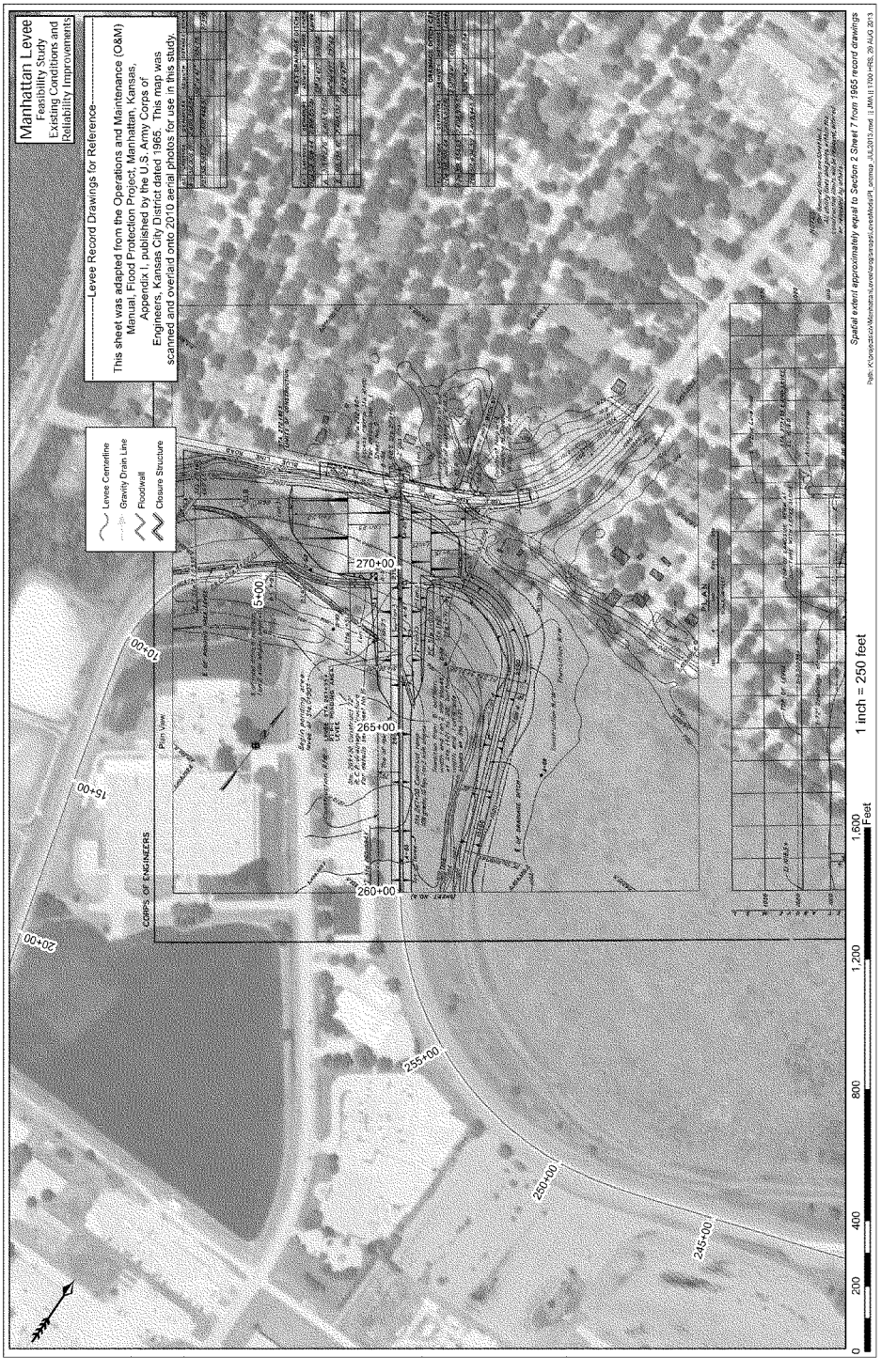

Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Levee Centerline
Gravity Drain Line
Floodwall
Closure Structure
----------Levee Record Drawings for Reference----------
This sheet was adapted from the Operations and Maintenance (O&M) Manual, Flood Protection Project, Manhattan, Kansas, Appendix I, published by the U.S. Army Corps of Engineers, Kansas City District dated 1965. This map was scanned and overlaid onto 2010 aerial photos for use in this study.
Plan View
U.S. ARMY
CORPS OF ENGINEERS
110+00
115+00
120+00
125+00
130+00
135+00
140+00
145+00
KANSAS
RIVER
PLAN
0
200
400
800
1,200
1,600
Feet
1 inch = 250 feet
Spatial extent approximately equal to Section 1 Sheet 5 from 1965 record drawings

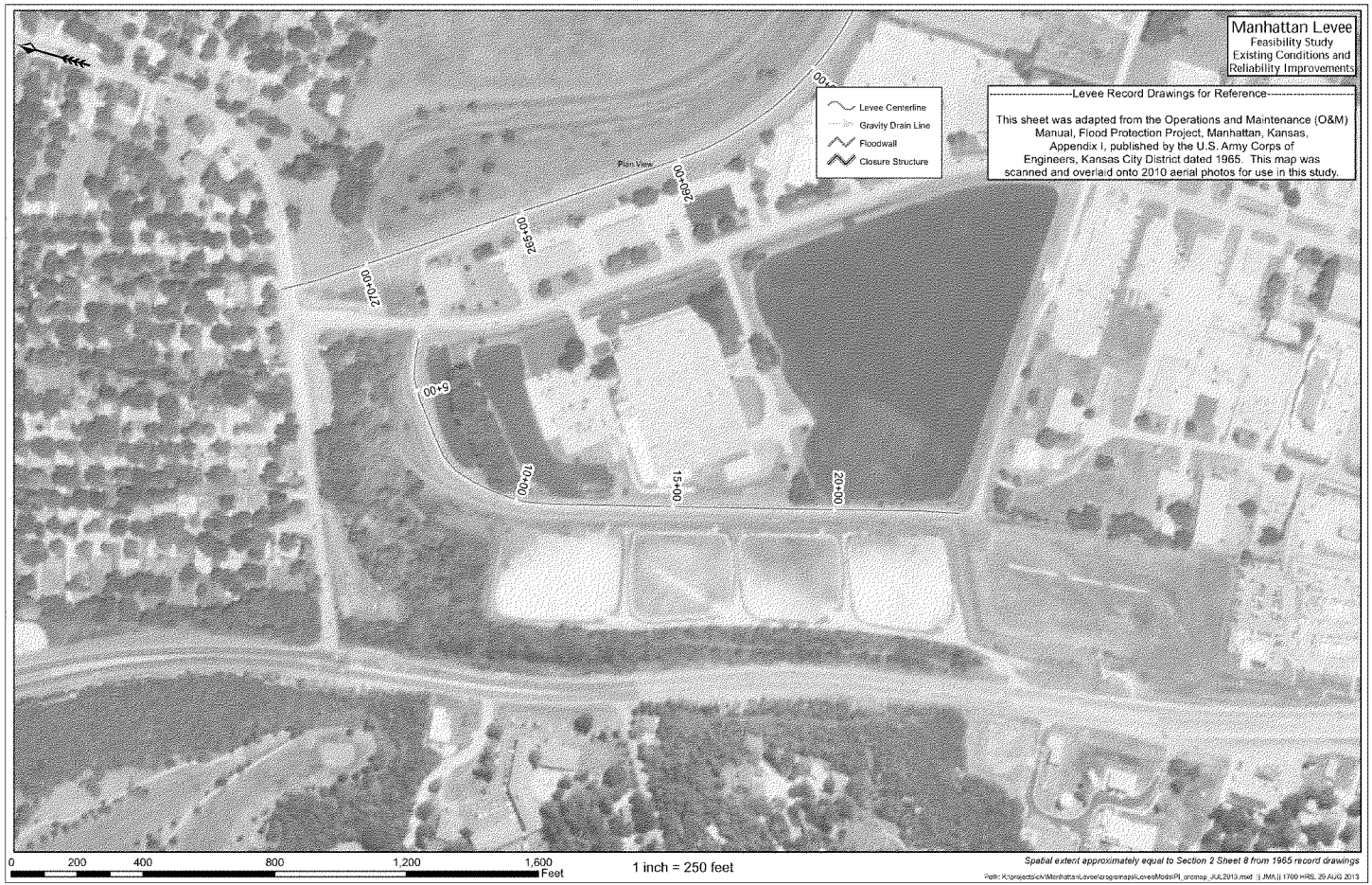

Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Levee Centerline
Gravity Drain Line
Floodwall
Closure Structure
Levee Record Drawings for Reference
This sheet was adapted from the Operations and Maintenance (O&M) Manual, Flood Protection Project, Manhattan, Kansas, Appendix I, published by the U.S. Army Corps of Engineers, Kansas City District dated 1965. This map was scanned and overlaid onto 2010 aerial photos for use in this study.
Plan View
CORPS OF ENGINEERS
U. S. ARMY
145+00
150+00
155+00
160+00
165+00
170+00
175+00
180+00
185+00
BIG BLUE RIVER
KANSAS RIVER
PLAN
0
200
400
800
1,200
1,600
Feet
1 inch = 250 feet
Spatial extent approximately equal to Section 2 Sheet 3 from 1965 record drawings


Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Levee Centerline
Gravity Drain Line
Floodwall
Closure Structure
Levee Record Drawings for Reference
This sheet was adapted from the Operations and Maintenance (O&M) Manual, Flood Protection Project, Manhattan, Kansas, Appendix I, published by the U.S. Army Corps of Engineers, Kansas City District dated 1965. This map was scanned and overlaid onto 2010 aerial photos for use in this study.
Plan View
CORPS OF ENGINEERS
U. S. ARMY
BIG BLUE
RIVER
PLAN
0
200
400
800
1,200
1,600
Feet
1 inch = 250 feet
Spatial extent approximately equal to Section 2 Sheet 4 from 1965 record drawings


Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Levee Centerline
Gravity Drain Line
Floodwall
Closure Structure
Levee Record Drawings for Reference
This sheet was adapted from the Operations and Maintenance (O&M) Manual, Flood Protection Project, Manhattan, Kansas, Appendix I, published by the U.S. Army Corps of Engineers, Kansas City District dated 1965. This map was scanned and overlaid onto 2010 aerial photos for use in this study.
CORPS OF ENGINEERS
Plan View
BIG BLUE RIVER
205+00
210+00
215+00
220+00
225+00
230+00
235+00
PLAN
0
200
400
800
1,200
1,600
Feet
1 inch = 250 feet
Spatial extent approximately equal to Section 2 Sheet 5 from 1965 record drawings


Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Levee Centerline
Gravity Drain Line
Floodwall
Closure Structure
Levee Record Drawings for Reference
This sheet was adapted from the Operations and Maintenance (O&M) Manual, Flood Protection Project, Manhattan, Kansas, Appendix I, published by the U.S. Army Corps of Engineers, Kansas City District dated 1965. This map was scanned and overlaid onto 2010 aerial photos for use in this study.
Plan View
CORPS OF ENGINEERS
U.S. ARMY
230+00
235+00
240+00
245+00
250+00
255+00
260+00
265+00
20+00
15+00
10+00
5+00
PLAN
0
200
400
800
1,200
1,600
Feet
1 inch = 250 feet
Spatial extent approximately equal to Section 2 Sheet 6 from 1965 record drawings


Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Levee Record Drawings for Reference
This sheet was adapted from the Operations and Maintenance (O&M) Manual, Flood Protection Project, Manhattan, Kansas, Appendix I, published by the U.S. Army Corps of Engineers, Kansas City District dated 1965. This map was scanned and overlaid onto 2010 aerial photos for use in this study.
Levee Centerline
Gravity Drain Line
Floodwall
Closure Structure
CORPS OF ENGINEERS
Plan View
270+00
265+00
260+00
255+00
250+00
245+00
5+00
10+00
15+00
20+00
1 inch = 250 feet
0
200
400
800
1,200
1,600
Feet
Spatial extent approximately equal to Section 2 Sheet 7 from 1965 record drawings


Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Levee Record Drawings for Reference
This sheet was adapted from the Operations and Maintenance (O&M) Manual, Flood Protection Project, Manhattan, Kansas, Appendix I, published by the U.S. Army Corps of Engineers, Kansas City District dated 1965. This map was scanned and overlaid onto 2010 aerial photos for use in this study.
Levee Centerline
Gravity Drain Line
Floodwall
Closure Structure
Plan View
270+00
260+00
250+00
5+00
10+00
15+00
20+00
0
200
400
800
1,200
1,600
Feet
1 inch = 250 feet
Spatial extent approximately equal to Section 2 Sheet 8 from 1965 record drawings

US Army Corps
of Engineers
Kansas City District

U.S. Army Corps of Engineers - Kansas City District

Environmental Assessment
&
Finding of No Significant Impact

MANHATTAN, KANSAS, LOCAL PROTECTION PROJECT SECTION 216 FEASIBILITY STUDY

August 2014

DEPARTMENT OF THE ARMY
KANSAS CITY DISTRICT, CORPS OF ENGINEERS
600 FEDERAL BUILDING
KANSAS CITY, MISSOURI 64106-289

Finding of No Significant Impact

MANHATTAN, KANSAS, LOCAL PROTECTION PROJECT SECTION 216 FEASIBILITY STUDY

August 2014

DRAFT

Summary

The city of Manhattan, Kansas, sits at the confluence of the Big Blue and Kansas Rivers. Flow on the Big Blue River is largely controlled by releases from Tuttle Creek Dam, which is approximately 6 miles north of the City of Manhattan or 12.3 miles above the confluence with the Kansas River. The existing Manhattan, Kansas, local protection project is comprised primarily of one levee unit and associated appurtenances. The levee unit withstood the Flood of 1993, but some elements of the system were seriously challenged as the flood crested. This event raised a concern that the levee may provide less than the authorized benefits for which it was designed. The US Army Corps of Engineers in cooperation with the local project sponsor (City of Manhattan, Kansas) are conducting this feasibility study to identify alternatives for flood risk reduction on the current Manhattan local protection project.

Alternatives

This EA addresses alternatives for raising the height of the Manhattan levee located along the Kansas and Big Blue rivers. Five alternatives have been considered for technical feasibility, environmental and social acceptability, and economic efficiency. These alternatives include the No Federal Action alternative, three levee raise plans of increasing height, and a single plan including a combination of a levee raise with channel widening and bridge modifications on a portion of the Big Blue River.

Plan 1 – No Federal Action Alternative: With the No Federal Action option, no increase in the current level of flood protection would occur. Structures within the protected zone would continue to be at a higher risk for flooding during large flood events.

Plan 2: This alternative would raise the current levee between stations 200+00 and 272+85 an average of 0.7 feet and a maximum of 1.5 feet. The plan includes an approximate 200-foot extension for tie-in along Casement Rd. at the upper end of Big Blue River Segment and a new sandbag gap. Gatewells would be replaced at stations 14+78, 62+20, 89+83, 163+00, and 269+50. Landside toe embankment sand drain would be installed along a portion of the Big Blue River levee segment. Relief wells would be constructed at stations 64+00 to 97+00, 110+120+00, and 265+70 to 269+50. Underseepage berms would be constructed at 120+00 to 137+00, and 165+00 to 173+50.

Plan 3 (Recommended Plan): The Recommended Plan would raise the current levee between stations 131+00 and 277+53 an average of 1.5 feet and a maximum of 3.3 feet. The plan includes an approximate 500-foot extension for tie-in along Casement Rd. at the upper end of Big Blue River Segment and a new sandbag gap. Gatewells would be replaced at stations 14+78, 62+20, 89+83, 163+00, and 269+50. Landside toe embankment sand drain would be installed along a portion of the Big Blue River levee segment. Relief wells would be constructed at stations 64+00 to 97+00, 110+120+00, and 265+70 to 269+50. Underseepage berms would be constructed at 120+00 to 137+00, and 165+00 to 173+50.

Plan 4: This plan would raise the current levee–between stations 8+50 and 72+00 and 101+00 to 277+53 an average of 2.1 feet and a maximum of 3.9 feet. There would be an approximate 1700-foot extension for tie-in along Wildcat Creek and Riley Lane at the upper end of Kansas River levee Segment as well as an approximate 500-foot extension for tie-in along Casement Rd at the upper end of Big Blue River Segment and a new sandbag gap. Thirteen gatewells would be replaced, raising of one gatewell, and strengthen one pump station. Underseepage berms would be constructed from stations 120+00 to 137+00, and 165+12 to 173+50. Landside toe embankment sand drain would be constructed along a portion of the Big Blue River Levee Segment. Relief wells would also be installed from stations 18+00 to 23+00, 64+00 to 97+00, 110+00 to 120+00, 190+00 to 210+00, and 265+70 to 272+00.

Plan 5: This plan would raise the current levee in the same locations as plan 3 with the addition of channel widening (CW). This alternative includes all the features of the Plan 3 levee raise alternative with an average raise of 1.3 feet and a maximum of 2.6 feet, in addition to excavation of approximately 200,000 cubic yards of material along the left descending bank of the Big Blue River. Both the Highway 24 and Union Pacific Railroad Bridges would be expanded and approximately 1,100 linear feet of riprap armoring would be placed around the bridge abutments.

Summary of Environmental Impacts

The Recommended Plan would raise the level of the levee, construct and/or replace other associated infrastructure. Construction of the Recommended Plan would result in minor, localized, short-term impacts to noise levels and recreation from the operation of construction equipment and closing of portions of the Linear Trail during construction. There would also be adverse impacts to terrestrial habitat and wildlife from the loss of approximately 6.23 acres of forested habitat and 0.67 acres of shrubland habitat. Efforts will be made to avoid and minimized impacts to forest, shrubland, and other native habitat during clearing and construction activities. Native vegetation may be planted in the construction easement, where appropriate following project construction to minimize the long term impact to terrestrial habitat and wildlife. The Recommended Plan would not result in any impacts to federally-listed threatened or endangered species or their designated critical habitat. The proposed action also would have no impact to sites listed on or eligible for inclusion on the National Register of Historic Places.

Mitigation Measures

The recommended plan would not affect any wetlands or water of the U.S., nor any important wildlife habitat, therefore no mitigation is proposed for this plan.

Conclusion

After evaluating the anticipated environmental, economic, and social effects of the proposed activity, it is my determination that the Recommended Plan for the Manhattan, Kansas, Flood Risk Reduction project does not constitute a major federal action that would significantly affect the quality of the human environment; therefore, preparation of an Environmental Impact Statement is not required.

Date: _____ _____

Andrew D. Sexton
Colonel, Corps of Engineers
District Commander

DRAFT

MANHATTAN, KANSAS,
LOCAL PROTECTION PROJECT
SECTION 216 FEASIBILITY STUDY
ENVIROMNMENTAL ASSESSMENT
August 2014

TABLE OF CONTENTS

1.0 INTRODUCTION 1
1.1 Purpose and Need for Action 1
1.2 Project Location 1
2.0 MEASURES and ALTERNATIVES 2
3.0 AFFECTED ENVIRONMENT 3
3.1 UPhysical Resources 3
3.1.1 Geology and Soils 3
3.1.2 Climate 4
3.1.3 Water Resources and Water Quality 5
3.2 UBiological Resources 6
3.2.1 Aquatic Habitat (including Fisheries and Wetlands) 6
3.2.2 Terrestrial Habitat 7
3.2.3 Wildlife 8
3.2.4 Threatened and Endangered Species 8
3.3 Hazardous, Toxic, and Radioactive Waste (HTRW) 11
3.4.1 Cultural Resource Laws 13
3.4.2 Cultural Resources Background Review 14
3.4.3 Cultural Resource Comments and Future Work 14
4.0 ENVIRONMENTAL CONSEQUENCES (IMPACTS) 16
4.1 UPhysical Resources 16
4.1.1 Geology and Soils 16
4.1.2 Climate 18
4.1.3 Water Resources and Water Quality 19
4.2 UBiological Resources 19
4.2.1 Aquatic Habitat (including Fisheries and Wetlands) 20
4.2.2 Terrestrial Habitat 20
4.2.3 Wildlife 23
4.2.4 Threatened and Endangered Species 24
4.3 Hazardous, Toxic, and Radioactive Waste (HTRW) 26
5.0 CUMULATIVE IMPACTS 31
6.0 CONCLUSION 32
7.0 COORDINATION AND COMMENTS 32
8.0 AGENCY COMPLIANCE WITH OTHER ENVIRONMENTAL LAWS 34
9.0 REFERENCES 35
10.0 LIST OF PREPARERS 35
11.0 APPENDICES 35
Appendix I – Project Maps
Appendix II – Agency Correspondence
Appendix III – Cultural Resources

1.0 INTRODUCTION

The U.S. Army Corps of Engineers Kansas City District (CENWK) and the local project sponsor (City of Manhattan, Kansas) are conducting a feasibility study of the existing local protection project which serves a highly-developed area around downtown Manhattan, Kansas. This is a single purpose study focusing on flood risk management. The existing Manhattan, Kansas, local protection project is comprised primarily of one levee unit and associated appurtenances. The levee unit withstood the flood of 1993, but some elements of the system were seriously challenged as the flood crested. This event raised a concern that the levee may provide less than the authorized benefits for which it was designed.

The city of Manhattan is located in central Kansas, and lies at the confluence of the Big Blue River and the Kansas River (Figure 1 in Appendix I). The Big Blue River is on the east side of the downtown area and connects to the Kansas River on the southeast side of the city. The Manhattan levee unit is located generally west and north of the confluence of the Big Blue River and the Kansas Rivers, and is approximately 28,850 feet long. The levee was typically constructed with a 10-foot crown width and three horizontal to one vertical (3H: 1V) embankment slopes. A limited number of major structural features are associated with this levee.

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

1.1 Purpose and Need for Action

The Manhattan Levee protects the majority of the downtown central business district providing protection for approximately a billion dollars of structures and other infrastructure. The original project started construction in 1961 and was finished and turned over to the local interest in 1963. During the 1993 flood the levee held during the flood crest. However, the water heights on the levee created concern that the levee would not function to the original design specifications. The existing flood risk reduction project needed action to ensure that the system provides the flood risk reduction protection as was originally designed.

1.2 Project Location

The Manhattan Levee is located west and north of the confluence of the Big Blue River and Kansas River in the city of Manhattan, Kansas, in Riley and Pottawatomie Counties. The levee embankment begins at Station 8+50 and ends at Station 272+85. The levee starts north of Wildcat Creek and is roughly aligned with 15th Street in Manhattan, Kansas. The levee follows the alignment of Wildcat Creek from Station 8+50 to Station 35+00, where it begins to parallel Pottawatomie Avenue to station 60+00. The levee alignment then turns to the northeast and turns north at 80+00 to align with the Kansas River. The alignment with the Kansas River continues to the confluence with

the Big Blue River at approximately Station 173+00. From the confluence, the levee turns towards the northwest, aligning with the Big Blue River until Station 209+00, where it turns further to the west and splits off from the Big Blue River. The levee continues in a west-northwest direction and aligns parallel to an existing drainage channel to its end at Station 272+85.

2.0 MEASURES and ALTERNATIVES

The feasibility study originally considered a variety of flood risk management measures and seven alternatives (Plans). However, in the early alternatives screening process, two alternatives that addressed a new northern levee for portions of the currently unprotected northern area subdivisions were not deemed economically feasible and were thus eliminated from further evaluation. Five alternatives were carried forward as a final array and were considered using a variety of planning criteria including technical feasibility, environmental and social acceptability, and economic efficiency among others. These alternatives include the No Federal Action alternative, three levee raise plans of increasing height, and a single plan including a combination of a levee raise with channel widening and bridge modifications on a portion of the Big Blue River.

2.1 Alternatives Considered Early but Rejected from Further Consideration

2.1.1 Levee Raise and New Northern Levee: This alternative includes raising of the existing levee as described in Plan 3, below, and construction of a new northern levee for similar protection of a currently unprotected residential area situated north of the existing protected area. This alternative was eliminated because the cost of the new northern levee produced negative net benefits.

2.1.2 Levee Raise with Channel Widening and New Northern Levee: Includes raising the existing levee as described in Plan 5, below, and construction of a new northern levee. The cost of the northern levee produced negative net benefits.

2.2 Alternatives Evaluated and Recommended Plan

2.2.1 Plan 1 – No Federal Action: With the No Federal Action option, no increase in the current level of flood protection would occur. There is currently a 1.5% (1 in 67) annual chance of a damaging flood occurring from either an overtopping or levee breach failure. Structures within the protected zone would continue to be at a higher risk for flooding during large flood events.

2.2.2 Plan 2: This alternative would raise the current levee between stations 200+00 and 272+85 an average of 0.7 feet and a maximum of 1.5 feet. The plan includes an approximate 200-foot extension for tie-in along Casement Rd. at the upper end of Big Blue River Segment and a new sandbag gap. Gatewells would be replaced at stations 14+78, 62+20, 89+83, 163+00, and 269+50. Landside toe embankment sand drain would be installed along a portion of the Big Blue River levee segment. Relief wells

would be constructed at stations 64+00 to 97+00, 110+120+00, and 265+70 to 269+50. Underseepage berms would be constructed at 120+00 to 137+00, and 165+00 to 173+50.

2.2.3 Plan 3 (Recommended Plan): The Recommended Plan would raise the current levee between stations 131+00 and 277+53 an average of 1.5 feet and a maximum of 3.3 feet. The plan includes an approximate 500-foot extension for tie-in along Casement Rd. at the upper end of Big Blue River Segment and a new sandbag gap. Gatewells would be replaced at stations 14+78, 62+20, 89+83, 163+00, and 269+50. Landside toe embankment sand drain would be installed along a portion of the Big Blue River levee segment. Relief wells would be constructed at stations 64+00 to 97+00, 110+120+00, and 265+70 to 269+50. Underseepage berms would be constructed at 120+00 to 137+00, and 165+00 to 173+50.

2.2.4 Plan 4: This plan would raise the current levee–between stations 8+50 and 72+00 and 101+00 to 277+53 an average of 2.1 feet and a maximum of 3.9 feet. There would be an approximate 1700-foot extension for tie-in along Wildcat Creek and Riley Lane at the upper end of Kansas River levee Segment as well as an approximate 500-foot extension for tie-in along Casement Rd at the upper end of Big Blue River Segment and a new sandbag gap. Thirteen gatewells would be replaced, raising of one gatewell, and strengthening of one pump station. Underseepage berms would be constructed from stations 120+00 to 137+00, and 165+12 to 173+50. Landside toe embankment sand drain would be constructed along a portion of the Big Blue River Levee Segment and the Kansas River segment. Relief wells would also be installed from stations 18+00 to 23+00, 64+00 to 97+00, 110+00 to 120+00, 190+00 to 210+00, and 265+70 to 272+00.

2.2.5 Plan 5: This plan would raise the current levee in the same locations as plan 3 with the addition of channel widening (CW). This alternative includes all the features of the Plan 3 levee raise alternative with an average raise of 1.3 feet and a maximum of 2.6 feet, in addition to excavation of approximately 200,000 cubic yards of material along the left descending bank of the Big Blue River. Both the Highway 24 and Union Pacific Railroad Bridges would be expanded and approximately 1,100 linear feet of riprap armoring would be placed around the bridge abutments.

3.0 AFFECTED ENVIRONMENT

3.1 Physical Resources

3.1.1 Geology and Soils

The project area lies along the boundary of the Great Plains and Central Lowland physiographic provinces. The Blue River watershed north of Randolph, Kansas, is in the Dissected Till Plains section of the Central Lowland, which was glaciated during the Pleistocene time. The Dissected Till Plains section is now covered by glacial drift, which forms a discontinuous mantle over much of the area, attaining a maximum depth of 300 feet. The Lower portion of the Blue River watershed and the lower portion of the Kansas River watershed are located in the Osage Plains section where bedrock is overlain by alluvial deposits of 10 to 50 feet deep. Exposed bedrock along valley walls consist of a sequence of limestones and shales of Permian age belonging to the Council Grove group. Another 200 feet of shales and limestones of the Pennsylvanian age are located below this stratum. The Kansas River watershed covers a large area of the Great Plains provinces, with portions in the Plains Border, High Plains, and Colorado Piedmont sections.

Floodplain soils associated with the Kansas River and its tributaries are derived from alluvium. The alluvium consists of water-laid deposits of silt, clay, sand and gravel and has been modified in the past by natural phenomena such as channel migration and flooding. Other soils in the project area include those formed from the weathering of local parent material and eolian deposits transported to the area by wind. Soils of the Kansas River valley consist of sandy river wash in and immediately adjacent to the river channel and the deep, nearly-level silt and sandy loams of the first and second bottoms in the floodplain. The first bottom is next to the stream and is subject to periodic inundation, sometimes more than once a year. The second bottom represents the higher terraces above the first bottom which are less frequently inundated. Soil associations of the valley are primarily the Eudora-Kimo and Eudora-Haynie-Sarpy types. Soils of the Blue River watershed are also of the Eudora-Haynie-Sarpy type with the Sarpy series being very common in the first bottoms. In the upland areas shallower, sloping, clayey soils will be found, with some areas covered by cherty limestone soils.

3.1.2 Climate

Climate in the Kansas River and Blue River basin varies from moist subhumid in the southeast to dry subhumid in the west. Historically, the climate includes some years with intense prolonged rainfall and some with severe droughts with no cyclic pattern. The average annual rainfall for Manhattan, Kansas, is 34.8 inches. In general, the annual precipitation throughout the basin decreases from east to west. Precipitation during the summer and fall months is usually of the short duration thunderstorm type with small centers of high intensity although widespread general rains occasionally occur. Winter precipitation usually results from the passage of well developed low-pressure systems and active fronts and occurs as either rain or snow. Significant amounts of snowfall are confined to the months of October through April, inclusive, with the highest monthly average in January, February, and March. The average annual snowfall for the basin is 22 inches.

Excessively high and low temperatures are characteristic of the plains area. The average annual temperature varies from about 55° F in the west to 88° F in the east.

Severe winter weather is normally experienced in December, January, and February, and is encountered rather frequently in November and March. July and August are normally the hottest months, but maximum temperatures of over 100° F have been recorded in all months, April through October. Temperatures of -10° F to -25° F have been recorded in November through April, inclusive.

3.1.3 Water Resources and Water Quality

Water resources in the project area include surface water resources and groundwater resources. Surface water resources in or near the project area include the Big Blue River, Tuttle Creek Lake, the Kansas River, their tributaries and adjacent wetlands. Wetlands will be described in the Aquatic Habitat section. Groundwater resources in the project area include alluvial aquifers of the Big Blue and Kansas Rivers and their tributaries along with the Glacial Drift and Dakota aquifers. The city of Manhattan, Kansas, utilizes 16 water wells to supply municipal water needs, with 3 of those wells adjacent to the levee system. Tuttle Creek Lake is located in the Lower Big Blue River Watershed (HUC 10270205). The Upper Kansas River Watershed (HUC 10270101) includes the Kansas River and its tributaries upstream of its confluence with the Big Blue River and the Middle Kansas River Watershed (HUC 10270102) includes the Kansas River and its Tributaries Downstream from Tuttle Creek Lake to near Topeka, Kansas.

Federal water quality standards regulations require that states specify appropriate water uses to be achieved and protected by taking into consideration the use and value of the water body for public water supply, for propagation of fish, shellfish, and wildlife, and for recreational, agricultural, industrial, and navigational purposes, these "uses" are known as "Designated Uses." In designating uses for a water body, the State examines the suitability of a water body for the uses based on the physical, chemical, and biological characteristics of the water body, its geographical setting and scenic qualities, and the socio-economic and cultural characteristics of the surrounding area.

The State then adopts water quality criteria with sufficient coverage of parameters and of adequate stringency to protect designated uses. Once Water Quality Standards have been adopted by the State and approved by the EPA, they are used in determining National Pollution Discharge Elimination System (NPDES) permit limits, impairment status, and Total Maximum Daily Load (TMDL) endpoints. If a water body is determined to be impaired or not meeting water quality standards, then the water body is listed on the Clean Water Act Section 303(d) list.

The Upper Kansas River (HUC 10270101) is listed as "impaired" (not meeting designated uses) due to five water quality standard parameters: total phosphorus, total suspended solids, chloride, fecal coliform, and sulfate. Wildcat Creek a tributary to the Kansas River that runs parallel to a portion of the Manhattan levee is listed as impaired for two parameters: dissolved oxygen and fecal coliform.

Tuttle Creek Lake is currently listed as being impaired for four water quality standard parameters: eutrophication, sedimentation, atrazine and alachlor. TMDLs have been developed and approved by the U.S. Environmental Protection Agency for this high priority water body for eutrophication (860 tons of phosphorus per year), atrazine (reduction of atrazine loads in Big Blue River by 75%, Little Blue River by 58%, and Black Vermillion River by 67%), sedimentation (reduction of historic storage loss rate by 45%), and alachlor (0.70 tons per day), The approved TMDL can be viewed at http://www.kdheks.gov/tmdl/klr.htm.

The Middle Kansas River (HUC 10270102) just downstream of it confluence with the Big Blue River is currently listed as being impaired due to four water quality standards parameters: biology, total phosphorus, total suspended solids, and fecal coliform.

Section 404 of the Clean Water Act (CWA) (33 USC 1344) requires that all activities that involve a discharge of dredged or fill materials into a Water of the United States, unless exempted, requires prior authorization from the Corps of Engineers. In addition, projects authorized under Section 404 of the CWA must also be certified in compliance with applicable state water quality standards. In Kansas the request for Section 401 water quality certification is evaluated by the Kansas Department of Health and Environment – Bureau of Environmental Quality. Since the early 1990's approximately forty Section 404 permits have been issued in the area around the Manhattan levee system. Most of those permits were issued for work on public utilities (installation or maintenance of utility lines).

3.1.4 Air Quality

Air quality monitoring by KDHE indicates that the air in Kansas is relatively clean. Currently there are no designated nonattainment areas in Kansas. Sources of air pollution in the project area would include stationary sources such as electrical power plants and industrial facilities, mobile sources such as vehicle emissions, and area sources such as small businesses and households. Within the State of Kansas, the highest levels of air pollution are associated with the most heavily urbanized areas of the state in Johnson and Wyandotte Counties east of the study area, and Sedgewick County which is far to the South of the study area. As with the vast majority of the state, air in the Manhattan area is considered to be relatively clean.

3.2 Biological Resources

3.2.1 Aquatic Habitat (including Fisheries and Wetlands)

The aquatic ecosystems in the project area consist of the Big Blue River, the Kansas River, and their tributaries and adjacent wetland/riparian areas. There is a 9

mile segment of the Big Blue River, from Tuttle Creek dam to the confluence with the Kansas River at river mile 147. Below Tuttle Creek dam the presence of Rocky Ford dam just 1 mile downstream influences the tailwater elevation in the Tuttle Creek stilling basin and in River Pond. Rocky Ford dam is practicably an impassible barrier to fish moving upstream from the lower Big Blue and Kansas Rivers. Fish populations upstream of Rocky Ford dam and below Tuttle Creek dam are supported by natural reproduction within that area or from fish that move through the conduit from Tuttle Creek Lake. As a result of this movement, the River Pond, outlet and KDWP's Rocky Ford Dam & Fishing Area contain many more typical lake fish like walleye, saugeye, white bass, black crappie, wipers and stripers. Below Rocky Ford dam the Big Blue and Kansas Rivers support a fish population that is typical of the large turbid rivers. Species found in the Kansas River, Blue River, Wildcat Creek, and tributaries in the close proximity to Manhattan include shovelnose sturgeon, paddlefish, longnose gar, shortnose gar, goldeye, American eel, gizzard shad, red shiner, common carp, speckled chub, plains minnow, common shiner, silver chub, emerald shiner, sand shiner, rosyface shiner, Topeka shiner, suckermouth minnow, bluntnose minnow, creek chub, river carpsucker, quillback, white sucker, blue sucker, smallmouth buffalo, bigmouth buffalo, black buffalo, shorthead redhorse, yellow bullhead, blue catfish, channel catfish, slender madtom, stonecat, flathead catfish, misquito fish, white bass, orangespotted sunfish, blue gill, largemouth bass, white crappie, orangethroat dartersauger, and freshwater drum (Cross and Collins, 1995)

A drainage ditch runs along the southern edge of Northeast Park. This ditch was causing large amounts of erosion so the Audubon Society, in cooperation with Kansas State University's Department of Landscape Architecture, developed and installed a meandering channel within a channel that reduced the erosion and provides ephemeral wetland features.

Wetlands on the Big Blue and Kansas River floodplain are relatively scarce, as many of these areas have been drained to facilitate agricultural production. In addition, the lack of out of bank flows, resulting from operation of the Kansas River system for flood control, has reduced or eliminated the hydrology needed to support many of these wetland areas. Most of the wetlands in the immediate project area occur along a small tributary to the Big Blue River (see map of wetland areas). These wetlands are used as settling ponds for the water treatment by the City of Manhattan. Wetland areas typically support the highest diversity and numbers of wildlife and are important to mammals, birds, reptiles, amphibians, and fish.

3.2.2 Terrestrial Habitat

In the protected area of the levee, much of the area is in residential or urban industrial use, thus lending very limited habitat (see landcover map). The undeveloped ground consists of maintained grassland and agricultural row crop production. Riverward of the levee unit, vegetation consists of maintained grassland, areas in agricultural row crop production, and remnants of the wooded riparian corridor along the

Big Blue and Kansas Rivers. Large cottonwoods, suitable as bald eagle roosts and hunting perches, are found along both rivers in the immediate project area. Native tree species within the area include cottonwood, willow, sycamore, American elm, and maple, along with grasses shrubs, and herbaceous species.

Northeast Park lies adjacent to the levee and along an unnamed tributary and contains a 28 acre restored prairie site and a smaller woodland site currently being restored that are maintained by the Northern Flint Hills Audubon Society in cooperation with the City of Manhattan. These, along with the remnant riparian areas, provide the terrestrial habitat near the project area.

3.2.3 Wildlife

Most of the habitat within the project area is found in the floodplains and associated riparian habitats of the Big Blue and Kansas Rivers, which provides rich habitat for a variety of wildlife species. Typically the habitat diversity in the residential and industrial areas is lower and diversity increases as you get to the more natural areas such as the remnant riparian areas. Mammals that would occur in the project area include terrestrial and aquatic furbearers such as beaver, mink, muskrat, opossum, coyote, raccoon, and striped skunk. Important game animals include the white-tailed deer, eastern cottontail, and fox squirrel. Thompson and Ely (1989) report that 424 bird species have been recorded in Kansas due to the state's central location. Birds that utilize the project area include a mix of permanent residents, summer residents, transients and winter residents. In addition, Tuttle Creek Lake and its associated wetlands provide important habitat to waterfowl.

A wide variety of reptiles and amphibians can be found in the more natural portions of the project area. Species reported for Riley County include the collard lizard, ring-neck snake, horned toad, Texas horned lizard, ground skink, tiger salamander, plains spadefoot, great plains toad, Woodhouse's toad, Blanchard's cricket frog, western chorus frog, gray treefrog, plains leopard frog, bullfrog, plains narrowmouth toad, common snapping turtle, ornate box turtle, western painted turtle, midland smooth softshell turtle, western spiny softshell turtle, great plains skink, prairie-lined racerunner, western slender glass lizard, western hognose snake, eastern hognose snake, western worm snake, prairie riingneck sname, western smooth green snake, eastern yellowbelly racer, great plains rat snake, bullsnake, prairie kingsnake, common kingsnake, milk snake, plains black headed snake, flat-headed snake, red-sided garter snake, western plains garter snake, lined snake, Texas brown snake, blotched water snake, diamond-backed water snake, northern water snake, copperhead, timber rattlesnake. Garter snakes and ringnecked snakes are often seen sunning on linear trail

3.2.4 Threatened and Endangered Species

In addition to the Federally listed species below, Sprague's pipit (*Anthus spragueii*) is listed as a candidate species and the Northern long-eared bat (*Myotis septentrionalis*) is proposed for listing under the Endangered Species Act. It is unlikely that the Sprague's pipit would be found in the project area. During the design phase

prior to any construction activities a survey for northern long-eared bat (NLEB) may need to completed to determine if they are present in the project area. It is anticipated that if the NLEB is listed then a survey protocol would be developed by the Service.

3.2.4.1 Interior Least Tern

The interior least tern (*Sterna antillarum*) was federally listed as endangered in 1985. Least terns are birds about 9 inches long with a black "crown" on their head, a snowy white underside and forehead, grayish back and wings, orange legs, and a yellow bill with a black tip. From late April to August, terns use sparsely vegetated sandbars along rivers, sand and gravel pits, or lake and reservoir shorelines for nesting habitat. Terns nest in a shallow hole scraped in an open sandy area, gravelly patch, or exposed flat. They nest in small colonies. The chicks leave the nest only a few days after hatching, but adults continue to care for them, leading them to nearby grasses and bringing them food.

Least terns were first observed nesting on the Kansas River in 1996 at approximately river mile 131, nesting on some sandbars created by the 1993 flood. Birds have since relocated and used different sandbars and off-river habitats over time in response to revegetation of these ephemeral sandbar habitats.

There are no records to indicate that interior least terns utilize the Blue River upstream of Tuttle Creek Lake, Tuttle Creek Lake, or the Blue River between the dam and the confluence with the Kansas River. No critical habitat has been identified for the interior least tern.

3.2.4.2 Piping Plover

The piping plover (*Charadrius melodus*) was federally listed as threatened in 1985. The piping plover is a small shorebird about the size of a robin. It has a sandy colored back and white underparts, with a single black neck band, a short stout orange bill and orange legs. For nesting, piping plovers make shallow scrapes in the sand which they line with small pebbles or rocks. The female lays three to four eggs and both parents share incubation duties. The eggs hatch after about 28 days, and the young leave the nest within hours. The chicks can forage for themselves immediately, but remain near their parents for several weeks for protection and temperature control. Depending on food availability, it takes the young from around 10 to 28 days to begin flying.
. The first known breeding record for the piping plover on the Kansas River occurred in 1996 when two pairs of plovers nested on newly created sandbar habitat following high flows on the Kansas River. The new nesting in Kansas on the Kansas River is a southern extension of their breeding range. Success of piping plovers since the initial 1996 nesting has been tenuous. Because much of the flow in the Kansas River has been controlled since the 1950s, sandbar habitat is usually not available for plovers. There are no records to indicate that piping plovers utilize the Tuttle Creek Lake or the Blue River between the dam and the confluence with the Kansas River.

3.2.4.3 Topeka Shiner

The Topeka Shiner (*Notropis topeka*) was federally listed as endangered in 1998. In 2004, the U.S. Fish and Wildlife Service designated critical habitat for the Topeka shiner in Iowa, Minnesota, and Nebraska, while habitat in Kansas, Missouri, and South Dakota was excluded from the designation. The Topeka shiner is a small minnow, less than three inches in total length. It is an overall silvery color, with a well defined dark stripe along its side, and a dark wedge-shaped chevron at the base of the tail fin. Males develop additional reddish coloration in all other fins during the breeding season. They occur primarily in small prairie (or former prairie) streams in pools containing clear, clean water. Most Topeka shiner streams are perennial (flow year-round), but some are small enough to stop flow during the dry summer months. In these circumstances, water levels must be maintained by groundwater seepage for the fish to survive. Topeka shiner streams generally have clean gravel, rock, or sand bottoms. The Topeka shiner is known to inhabit Wildcat creek upstream of the project location. No recent surveys have been performed in the city area of Manhattan.

3.2.4.4 Northern Long-eared Bat

The northern long-eared bat (*Myotis septentrionalis*) (NLEB) is currently proposed to be federally listed as proposed as an endangered species under the Endangered Species Act. The state of Kansas is within the known range of the NLEB. During the summer, NLEBs typically roost singly or in colonies in cavities, underneath bark, crevices, or hollows of both live and dead trees and/or snags. Males and non-reproductive females may also roost in cooler places , like caves or mines. This bat seems opportunistic in selecting roosts, using tree species based on presence of cavities or crevices or presence of peeling bark. It has also been occasionally found roosting in structures like barns and sheds, particularly when suitable tree roosts are unavailable. They forage for insects for insects in upland and lowland woodlots and tree-lined corridors. During winter NLEBs predominantly hibernate in caves and abandoned mine portals.

3.2.4.5 State Listed Species

In addition to those federally listed threatened and endangered species listed above, the State of Kansas maintains a list of threatened and endangered species in Kansas. Included in the planning aid letter from the US Fish and Wildlife Service found in Appendix II are the state listed threatened and endangered species and their critical habitat that are found in Riley and Pottawatomie Counties, Kansas.

3.2.5 Floodplain

The project site consists of the floodplains of the Kansas River and the Big Blue River in addition to the smaller Wildcat Creek. The floodplain in the project area has been impacted over the years due to urban and residential development in Manhattan,

Kansas. Urban development of the floodplain has fill activity, channelization of the drainages, and the development of numerous buildings, parking lots, roads, and utilities. The floodplain has also been altered by the existing Manhattan Levee system constructed in the early 1960's. The levee restricts flow from accessing the floodplain to protect the infrastructure in the downtown Manhattan area. The Dix subdivision is situated just north of the levee system and is outside the protected area. This area is subject to flooding during large events. Flow in the Big Blue River is primarily controlled by releases from the Tuttle Creek Dam several miles upstream of Manhattan. Flow in the Kansas River is largely controlled by releases from the dams located on the major tributaries of the Kansas River. These include Milford, Wilson, and Kanopolis Lakes. Each of these dams are operated as part of the larger Missouri River and Kansas River system and are operated in accordance with the 2006 Master Manual.

3.3 Hazardous, Toxic, and Radioactive Waste (HTRW)

A Phase I (limited) site assessment was conducted in February 2004 in accordance with ASTM Standard E 1527-00 (Standards on Environmental Assessment for Commercial Real Estate) for the areas near and adjacent to the levee.
A search of the available environmental records, revealed five potential areas of concern. Since the 2004 Phase I assessment, one additional site has been identified near the levee.

- Manhattan PWS Wells #14 and #15- Manhattan Industrial Park North of Kretschner
  This site is a CERCLIS (Comprehensive Environmental Response, Compensation and Liability Information System) site. Volatile organic compounds (VOCs) have been detected at the wells intermittently since 1986. These two wells are directly adjacent to the riverward toe of the levee at approximately Station 211 +00 and Station 213+00. A specific site causing contamination in PWS #14 and #15 wells was identified as the Former Quaker Manufacturing, LLC Facility located at 1111 Kretschmer. Investigations were performed and a groundwater plume contaminated with TCE was delineated. The plume extends below the levee from station 215+00 to 218+00. A remedial action is currently ongoing and includes operation of a soil vapor extraction system and injections to enhance anaerobic bioremediation.

- Manhattan PWS Wells #12 and #13- Hayes Dr and North Kretschner Dr
  This site is also a CERCLIS site. VOCs have been detected at the wells intermittently since 1986. These wells are located about 1000 feet landward of the levee, but were included due to the nature of contamination. Similar to the PWS #14 and #15 site, separate upgradient sites were identified to be the cause of contamination of the PWS wells.

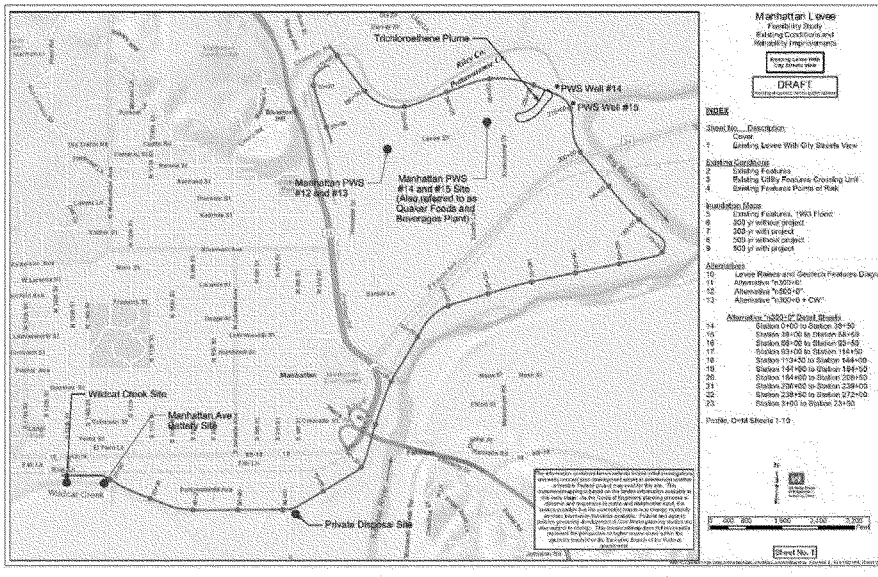
- Wildcat Creek- 705 S 15th
  This site contains one leaking underground storage tank with a status of Active indicating that levels of contamination exist at the site that are greater than

cleanup levels set by the state. The exact location of the tank could not be verified on the reconnaissance trip. However, an approximate location is identified on the map below. It appears the site is located on the creek side of the levee.

- Private Disposal Site
  A privately owned disposal site was identified at approximately levee Station 63+00. It is located at the intersection of Temple Lane and the levee, on the southeast corner. A drainage ditch exists between the levee and the site. The site is wooded and approximately 3 acres in size. Contents of the site include large and small vehicles, trailers, loaded dumpsters, tires, and appliances. Potential soil and groundwater contamination from numerous sources is possible at this site. It has not been identified by Kansas Department of Health and Environment (KDHE) as a contaminated site

- Railroad Tracks
  Railroad tracks exist adjacent to the toe of the landward side of the levee from approximately Station 89+00 to Station 120+00. Potential contamination in the immediate vicinity of the railroad tracks includes creosote from the railroad ties and petroleum products leaking from cars, including greases, hydraulic fluids, brake fluids, and fuel among other things. Since the 2004 Phase I EAS, no additional information has been found to indicate contamination of soil or groundwater along the railroad tracks or spills from rail cars.

- Manhattan Avenue Battery Site
  This site is located west of 15th St, immediately adjacent to the Wildcat Creek side of the levee. The site is a former dumpsite for battery casings discarded during lead reclamation processes. In 2005, lead contaminated soil at the site was excavated and disposed of off-site. The only alternative in this area with proposed levee modifications is alternative N500.



3.4 Cultural Resources

3.4.1 Cultural Resource Laws

Section 106 of the National Historic Preservation Act (NHPA) of 1966 (amended June 17, 1999) requires federal agencies to take into account the effects of their undertakings on historic properties. By definition, historic properties are properties eligible for or listed on the National Register of Historic Places (NRHP). Federal undertakings refer to any federal involvement including funding, permitting, licensing, or approval. Federal agencies are required to define and document the Area of Potential Effect (APE) for undertakings. The APE is defined as the geographic area or areas within which an undertaking may directly or indirectly cause changes in the character or use of historic properties, if such properties exist. For the Manhattan Levee Project the APE includes the area of construction, borrow areas, staging areas, and any temporary access roads (if needed).

In compliance with Section 106 of the National Historic Preservation Act of 1966, as amended, the Corps will coordinate the proposed land acquisition with the Kansas State Historic Preservation Officer and affiliated federally recognized Native American tribes (Tribes).

3.4.2 Cultural Resources Background Review

A literature and background review of the general Manhattan levee project area has been conducted by the District Archeologist. The review area included the proposed construction footprint and the proposed borrow area.. The review consisted of an examination of the NRHP, pertinent archeological documents in the Corps office, and the Kansas State Historical Society's Archeological Inventory (on-line).

The background review found that the majority of the Manhattan Levee project area has not been previously surveyed for cultural resource sites (see attachment). One archeological survey crosses the southern half of the project area. Three archeological sites 14RY380, 382, and 384, are mapped within the previously surveyed area very near the existing levee. All three are late 19th Century sites associated with demolished buildings. The National Register eligibility status of these sites is not reported in site files. Two other archeological sites, 14PO24 and 14PO25, are recorded 0.6 and 0.8 miles east of the northern half of the project area (see attachment). Site 14PO24 is a Historic Kansa Indian village site and 14PO24 is an earlier prehistoric village site. Both sites are considered eligible for listing in the National Register of Historic Places.

3.4.3 Cultural Resource Comments and Future Work

As the majority of the APE has not been previously surveyed and there is a potential for unrecorded archeological sites in the area, project plans will need to be reviewed by the district archeologist and the Kansas State Historic Preservation Officer to determine if archeological field investigations are needed. It is assumed that the current levee footprint is heavily disturbed and unlikely to contain intact historic properties and would likely not require a cultural resources survey. However, borrow areas, haul and access road locations, and other staging areas may require field investigations and need to be reviewed as early as possible to ensure no historic properties would be adversely affected by the project.

3.5 Socioeconomics and Environmental Justice

The Executive Order on Environmental Justice (Executive Order 12898) focuses on social equity issues, particularly any potential disproportionate impacts on minority or low-income groups. No specific geographic areas of minority or low-income groups were identified within the affected area. Looking at the population of Manhattan, the population is 83.5% white compared to 85.0% and 94.6% of Riley and Pottawatomie Counties respectively, compared to 87.4% for the State of Kansas and 78.1% in the U.S. Blacks comprise only 5.5% of the population in Manhattan, 6.6% and 1.3% in Riley and Pottawatomie Counties, compared to 6.1% in Kansas and 13.1% in the U.S. Hispanics account for 5.8% of the population on Manhattan, 6.6% and 1.3% in Riley and Pottawatomie Counties respectively, compared to 10.8% for the state and 16.7% in the U.S. A map of the percentage of minority population within each census block can be found in the Appendix I. The city of Manhattan has a median household income of $36,630 which is lower compared to the state median household income of $49,424,

and $39,257 and $53,430 for Riley and Pottawatomie Counties, respectively. A map of Median incomes by census block groups can be found in Appendix I. Manhattan has a large proportion, 28.8%, of households living below the poverty level compared to the statewide population of 12.4%. This is likely due to the presence of a large university located in Manhattan. The median income by census block groups tend to be lowest in the areas surrounding the university. A large portion of the affected area is commercial and industrial areas without residential households.

The Manhattan levee protects 1,703 residential, 390 commercial, 108 industrial, and 94 public and municipal structures, and more than 30 miles of streets and roads. The estimated total value of investment in the leveed area, including properties and contents, is approximately $1.18 billion. The price level is October 2013 (FY14). Commercial property value, including structures and contents, totals $585.5 million. Industrial value, including structures and contents, totals $129.8 million. Public and municipal buildings are valued at $114.5 million, and residential property value is more than $305.7 million. Streets and roads in the leveed area total almost $41.5 million.

3.6 Recreation

Several Parks and trail systems are located in the vicinity of the Manhattan Levee. Northeast Community Park is a 79 acre park located north of the northern segment of the levee. This park was a joint effort between the City of Manhattan, the Blue Earth Citizens Group, and the Northern Flint Hills Audubon Society. Just over half of the site is in turf grass activities such as ball fields and picnic areas, while the southern half is maintained as a restored native prairie and woodland. The park features the Cecil Best Memorial Birding Trail which connects Northeast Park to the Linear Park Trail. The Linear Park Trail is a combination of paved and crushed limestone trail system that runs along the top of the entire levee system. Access points and trailheads can be found at major road intersections. This trail gets a lot of pedestrian and bicycle use. Other unofficial trails that are running parallel to the levee and are within the riparian vegetation do exist and get used by hikers, bird watchers, bicyclists, and provide access to the Big Blue and Kansas River. The 5 acre Griffith Park that contains athletic fields and the 2.9 acre Sojourner Truth Park that contains picnic shelters, a playground and a butterfly garden are located near the southern portion of the levee system. Southeast Park is located south of Pillsbury Drive between the levee and the Kansas River. The approximately 25 acre Southeast Park is comprised of riparian forest with no developed park facilities. The Kansas and Big Blue Rivers provide water based recreation in the form of boating and fishing. Nearby Tuttle Creek Reservoir provides a variety of water and land based recreation opportunities.

3.7 Noise

Ambient noise along the Manhattan levee system is variable depending on the adjacent land use and proximity to major roadways. Primary sources of noise within the project area are from vehicle traffic as well as commercial/industrial operations. The northern portion of the levee system is bordered on the north by largely parkland, and to

the south by an industrial park. Traffic is light in the area and ambient noise levels are relatively low until you near US Highway 24. The area adjacent the levee near the confluence of the Big Blue and Kansas Rivers is primarily agricultural land and the municipal water treatment plant. This area is also has relatively low ambient noise levels. The area of the levee with the highest ambient noise levels are from about Station 70+00 to 110+00. This section has a high amount of traffic from adjacent US Highway 24 and Fort Riley Boulevard, as well as a cement plant and a busy commercial district. The far south and west portions of the levee are bordered by residential housing and agricultural lands and has some of the lowest ambient noise levels in the project area.

3.8 Land Use (Including Prime Farmland)

In the protected area of the levee, much of the area is in residential or urban industrial use, which includes the main downtown area as well as the Town Center Mall, Mercy Regional Health Center, and numerous other commercial, industrial, governmental, and residential structures. The undeveloped ground consists of maintained grassland and agricultural row crop production. One of the largest undeveloped areas protected by the levee is the area surrounding the sewage treatment plant near the confluence of the Big Blue and Kansas Rivers. That area is primarily in row crop agricultural production with a few small patches of forested area. Riverward of the levee unit, vegetation consists of maintained grassland, areas in agricultural row crop production, and remnants of the wooded riparian corridor along the Big Blue and Kansas Rivers. The top of the levee is utilized as a trail along most of its length.

The Farmland Protection Policy Act (FPPA) is intended to minimize the impact federal programs have on unnecessary and irreversible conversion of farmland to non agricultural uses. For the purpose of FPPA, farmland includes prime farmland, unique farmland, and land of statewide or local importance. Projects are subject to FPPA requirements if they may irreversibly convert farm land to nonagricultural use and are completed by a federal agency or with assistance from a federal agency. The Natural Resource Conservation Service (NRCS) was consulted to determine if any prime or unique farmlands are within the project area. NRCS identified that some areas of prime and/or unique farmland was present in the project area.

4.0 ENVIRONMENTAL CONSEQUENCES (IMPACTS)

4.1 Physical Resources

4.1.1 Geology and Soils

Alternative 1 – No Federal Action: No levee raise, channel widening, or earth disturbing activities would take place under the no action alternative; therefore there would be no effect on the geology or soils.

Plan 2: The plan 2 levee raise would require placement of approximately 25,726 CY of earthen fill. An additional 128,090 CY of earthen fill would be used for placement of underseepage berms. In areas where underseepage berms are placed, the topsoil is typically removed and stock piled, the fill material for the underseepage berm is placed and then the topsoil is spread evenly over the top. This maintains viable topsoil to return the land to agricultural production following construction. The total amount of fill used would be approximately 153,816 CY. An approximately 20 acre borrow area (this consists of a 15 acre primary area, with an additional 5 acres available if needed) has been selected south of the project (see map in appendix I). For this document all evaluation will treat the borrow area as a 20 acre plot. Additional soil disturbance would occur for relocation of utilities and construction of sand drains and relief wells. Approximately 26,400 linear feet of sand drains will be constructed as well as 29 relief wells between 50 to 60 feet deep. The construction contractor would be required to obtain a Section 402 NPDES stormwater permit from Kansas Department of Health and Environment (KDHE), under the Clean Water Act. Best Management Practices (BMPs) would be implemented to minimize material entering into a waterway and to minimize the introduction of fuel, petroleum products, or other deleterious material from entering the waterway. Such measures could include the use of erosion control fences; storing equipment, solid waste, and petroleum products above the ordinary high water mark and away from areas prone to runoff; and requiring that all equipment be clean and free of leaks. To prevent fill from reaching water sources by wind or runoff, fill would be covered, stabilized or mulched, and silt fences would be used as required.

Plan 3 (Recommended Plan): The recommended plan would require the placement of approximately 50,379 CY of earthen fill to raise the levee and an additional 128,090 CY of fill for creation of underseepage berms. The total amount of fill used would be approximately 178,469 CY. An approximately 20 acre borrow area has been identified south of the project area to obtain the needed fill. Additional soil disturbance would occur for relocation of utilities and construction of sand drains and relief wells. Approximately 26,400 linear feet of sand drains will be constructed as well as 29 relief wells between 50 to 60 feet deep. The construction contractor would be required to obtain a Section 402 NPDES stormwater permit from Kansas Department of Health and Environment (KDHE), under the Clean Water Act. Best Management Practices (BMPs) would be implemented to minimize material entering into a waterway and to minimize the introduction of fuel, petroleum products, or other deleterious material from entering the waterway. Such measures could include the use of erosion control fences; storing equipment, solid waste, and petroleum products above the ordinary high water mark and away from areas prone to runoff; and requiring that all equipment be clean and free of leaks. To prevent fill from reaching water sources by wind or runoff, fill would be covered, stabilized or mulched, and silt fences would be used as required.

Plan 4: The levee raise would require the use of approximately 83,965 CY of earthen fill for the raise and approximately 191,053 CY for the placement of underseepage berms. In addition, an extension of a levee along Wildcat creek would require approximately 7,059 CY of earthen fill. The total amount of fill used would be

approximately 282,077 CY. An approximately 20 acre borrow site has been identified south of the project location, however, additional sites may need to be identified to acquire the needed amount of fill. Additional soil disturbance would occur for relocation of utilities and construction of sand drains and relief wells. Approximately 26,400 linear feet of sand drains will be constructed as well as 45 relief wells between 50 to 60 feet deep. The construction contractor would be required to obtain a Section 402 NPDES stormwater permit from Kansas Department of Health and Environment (KDHE), under the Clean Water Act. Best Management Practices (BMPs) would be implemented to minimize material entering into a waterway and to minimize the introduction of fuel, petroleum products, or other deleterious material from entering the waterway. Such measures could include the use of erosion control fences; storing equipment, solid waste, and petroleum products above the ordinary high water mark and away from areas prone to runoff; and requiring that all equipment be clean and free of leaks. To prevent fill from reaching water sources by wind or runoff, fill would be covered, stabilized or mulched, and silt fences would be used as required.

Plan 5: This alternative would have similar impacts and use similar quantities of fill for the levee raise and underseepage berms as the recommended plan. The channel widening would remove approximately 200,000 CY of material from the left descending stream bank of the Big Blue River. This alternative would also involve the expansion of the Highway 24 Bridge and replacement of a new Union Pacific Railroad bridge, both of which would require extensive excavation. Approximately 5,194 tons of 24-inch riprap will be used to armor approximately 1,100 linear feet of the Big Blue River bank to protect against erosion around the structures and other vulnerable areas. In addition to the Clean Water Act Section 404 and 401 authorizations, the construction contractor would be required to obtain a Section 402 NPDES stormwater permit from Kansas Department of Health and Environment (KDHE), under the Clean Water Act. Best Management Practices (BMPs) would be implemented to minimize material entering into a waterway and to minimize the introduction of fuel, petroleum products, or other deleterious material from entering the waterway. Such measures could include the use of erosion control fences; storing equipment, solid waste, and petroleum products above the ordinary high water mark and away from areas prone to runoff; and requiring that all equipment be clean and free of leaks. To prevent fill from reaching water sources by wind or runoff, fill would be covered, stabilized or mulched, and silt fences would be used as required.

4.1.2 Climate

All Alternatives – None of the project alternatives would have more than deminimus impact on climate. However, the U.S. Global Change Research Program expects that there will be large changes in the climate during the life of the project. Average annual temperatures in the area are anticipated to increase. It is anticipated that there will be more large rainfall events and more periods of drought. In this regard, the alternative(s) that have the most resiliency (operate under the widest range of conditions), would have highest chance for success and the least likelihood of failure.

4.1.3 Water Resources and Water Quality

Plan 1 No Federal Action – The no action alternative would not result in any impact to water resources or water quality.

Plans 2, 3 & 4: There is a small chance that during construction water quality might be impacted from runoff. Best Management Practices (BMPs) such as erosion control fences; storing equipment, solid waste, and petroleum products away from areas prone to runoff; and requiring that all equipment be clean and free of leaks. The construction contractor would also be required to obtain a Section 402 NPDES stormwater permit from Kansas Department of Health and Environment (KDHE), under the Clean Water Act (CWA).

Plan 5: This plan would result in impacts similar to those found in plan 3 with the addition of impacts derived from the channel widening activities. Construction of the channel widening would have an impact on turbidity and possibly other water quality parameters at the construction location and downstream during construction. Following construction the turbidity and water quality of the Big Blue River should return to preconstruction levels. The flow patterns within the project site would be altered as the channel widening would create a wider cross section. This would have a minor impact on the channel height and width and the flow pattern of the Big Blue River in this reach. Construction activities with this alternative would occur in a jurisdictional water of the United States and require Section 404 authorization and Section 401 State Water Quality Certification under the CWA. The construction contractor would also be required to obtain a Section 402 NPDES stormwater permit from KDHE, under the CWA.

4.1.4 Air Quality

Plan 1: No Federal Action – Under the no action alternative, there would be minor O&M activities to the existing levees and structures but the impact to air quality would be negligible.

Plans 2-5: With each of these plans there would be minor localized negative impacts to air quality during construction from dust and from emissions from construction equipment. Dust mitigation measures, such as spraying bare soil with water, would be utilized to minimize the impact.

4.2 Biological Resources

4.2.1 Aquatic Habitat (including Fisheries and Wetlands)

Alternative 1 No Federal Action – The no action alternative would not have any activities that would affect aquatic habitat.

Plans 2, 3 & 4: There would be no impact to fish aquatic habitat with construction of any of these plans, including fisheries and wetlands. All construction activity would take place outside the stream channel and/or wetland areas. Since all activity would take place on the existing levee which already limits the floodplain connectivity in the project area, the limited amount of raise would not affect the floodplain connectivity in terms of aquatic habitat.

Plan 5: The channel widening construction activities would have a short term negative impact on aquatic habitat. There would be a disturbance to the physical habitat in the project area as well as an increase in the suspended sediments and turbidity. Some of the more mobile aquatic organisms and fish species will leave the site during construction activities. There may be some loss of the less mobile organisms. Following construction the suspended sediment and turbidity levels would return to pre-construction conditions and it is anticipated that fish and other aquatic species would return to the site. The channel widening would result in a long term increase in aquatic habitat. An additional 19.7 acres of aquatic habitat would be added to the Big Blue River as a direct result of widening the channel. The quality of that habitat could vary depending on the final design of that portion of the stream. It is anticipated that habitat features would be designed in and constructed should this alternative be selected. Construction activities would occur in jurisdictional waters of the United States and require Section 404 authorization and Section 401 State Water Quality Certification under the Clean Water Act before work begins. If this alternative is selected and a more detailed design is drafted, a Section 404 (b)(1) Evaluation Report would be prepared for this action and appropriate mitigation determined for impacts to waters of the U.S. A Section 402 NPDES stormwater permit, as required by the Clean Water Act, would be obtained by the construction contractor prior to the start of construction and BMPs would be implemented.

4.2.2 Terrestrial Habitat

In order to measure impacts to terrestrial habitat, the lateral expansion of the levee footprint from the raise and underseepage berms along with the footprint of the permanent and temporary construction easements. The assumption for this analysis is all habitat within the construction easement would be destroyed or adversely impacted. This is a conservative estimate, as it is likely much of the habitat within the construction easement may be able to be avoided or the impacts minimized, however it will be used here to compare alternatives. ER 1110-2-1150, Engineering and Design for Civil Works Projects, Paragraph 13.6.8 states that the project design shall seek to avoid and minimize adverse environmental impacts and when possible be in concert with the surrounding environment. Temporary construction easements as well as the permanent

easements that are cleared during construction will be planted with native vegetation where possible following construction. During the design phase effort should be made to incorporate where practicable the use of native vegetation and to identify potential ways to enhance or expand existing riparian corridors. All trees at least 50 feet tall and/or greater than 24-inch dbh riverside of the levees should be avoided. These trees are utilized as perching/roosting trees by the bald eagle. Regardless of the action alternative selected, contractors would be required to follow best management practices to avoid the introduction and spread of invasive species.

Plan 1 No Federal Action – The no-action alternative would not result in any ground disturbing activity except for periodic mowing of the levee crown and side slopes to eradicate any woody vegetation growth.

Plan 2: Plan 2 and Plan 3 have very similar footprints and the constructions easements are almost identical. Therefore, their impacts to terrestrial habitat will be the same. See the description for Plan 3 below for description of impacts to terrestrial habitat. This alternative would require approximately 137,000 cubic yards of borrow material which would be obtained from the approximately 20 acre borrow location(s) identified on the map in appendix I. The proposed borrow site is currently in row crop agricultural production. The Migratory Bird Treaty Act (MBTA) prohibits the taking, killing, possession, transportation, and importation of migratory birds and their eggs, parts, and nests. Takings could result from projects in prairies, wetlands, stream and woodland habitats, and those that occur on bridges and other structures if swallow or phoebe nests are present. While the provisions of the MBTA are applicable year round, most migratory bird nesting activity in Kansas occurs during the period of January (owls, and hawks) through August (goldfinches) (USFWS, 2013). Clearing of vegetation should be avoided during this period if possible. If vegetation clearing takes place during the nesting season, then the area to be cleared should be surveyed by a qualified biologist prior to clearing activity.

Plan 3 (Recommended Plan): Impacts to terrestrial habitats come from the lateral expansion of the levee footprint from the levee raise, underseepage berms, and landside toe embankment sand drains. It is also assumed that there will be disturbance to all the areas within the permanent and temporary construction easements. This would result in an impact of 6.23 acres of forested area, 0.67 acres of shrubland area, 17.50 of grassland most of which is mowed turfgrass, and 7.74 acres of cultivated cropland. In some cases these are relatively small isolated patches of impacts, while in other areas the impacts can extend linearly for some distance along a forested area. This would decrease the width of the forested stands which may affect the habitat suitability for species that need larger blocks of habitat. The Migratory Bird Treaty Act (MBTA) prohibits the taking, killing, possession, transportation, and importation of migratory birds and their eggs, parts, and nests. Takings could result from projects in prairies, wetlands, stream and woodland habitats, and those that occur on bridges and other structures if swallow or phoebe nests are present. While the provisions of the MBTA are applicable year round, most migratory bird nesting activity in Kansas occurs during the period of January (owls, and hawks) through August (goldfinches). Clearing

of vegetation should be avoided during this period if possible. If vegetation clearing takes place during the nesting season, then the area to be cleared should be surveyed by a qualified biologist prior to clearing activity. This alternative would require approximately 158,000 cubic yards of borrow material which would be obtained from an approximately 20 acre location(s) identified on the map in appendix I. The proposed borrow location is currently in agricultural row crop production.

Plan 4: Impacts to terrestrial habitats come from the lateral expansion of the levee footprint from the levee raise, underseepage berms, and landside toe embankment sand drains. It is also assumed that there will be disturbance to all the areas within the permanent and temporary construction easements. The footprint of this alternative is similar to Plan 3; however the footprint is expanded slightly to allow for the slightly higher and wider levee raise. Plan 5 would result in greater acreage of impacts to forested area, shrubland, grassland, and cultivated cropland. The Migratory Bird Treaty Act (MBTA) prohibits the taking, killing, possession, transportation, and importation of migratory birds and their eggs, parts, and nests. Takings could result from projects in prairies, wetlands, stream and woodland habitats, and those that occur on bridges and other structures if swallow or phoebe nests are present. While the provisions of the MBTA are applicable year round, most migratory bird nesting activity in Kansas occurs during the period of January (owls, and hawks) through August (goldfinches). Clearing of vegetation should be avoided during this period if possible. If vegetation clearing takes place during the nesting season, then the area to be cleared should be surveyed by a qualified biologist prior to clearing activity. This alternative would require approximately 249,000 cubic yards of borrow material which would be obtained from an approximately 20 acre borrow location identified in appendix I. That area is currently in row crop agricultural production. Due to the amount of fill material needed for this alternative, addition borrow locations may need to be identified to obtain the necessary fill quantities.

Plan 5: Plan 5 would have all the impacts of Plan 3 plus the additional impact related to channel widening activity. It would add an additional 8.6 acres of terrestrial habitat impact almost all of which is riparian forested areas. This would constitute a large portion of the riparian habitat in the area of the channel widening. The Migratory Bird Treaty Act (MBTA) prohibits the taking, killing, possession, transportation, and importation of migratory birds and their eggs, parts, and nests. Takings could result from projects in prairies, wetlands, stream and woodland habitats, and those that occur on bridges and other structures if swallow or phoebe nests are present. While the provisions of the MBTA are applicable year round, most migratory bird nesting activity in Kansas occurs during the period of January (owls, and hawks) through August (goldfinches). Clearing of vegetation should be avoided during this period if possible. If vegetation clearing takes place during the nesting season, then the area to be cleared should be surveyed by a qualified biologist prior to clearing activity. This alternative would require approximately 158,000 cubic yards of borrow material which would come from the identified 20 acre borrow site. If material excavated from the channel can be utilized for the levee raise and underseepage berms then the size of borrow area could potentially decrease.

4.2.3 Wildlife

Plan 1 No Federal Action – Existing management would continue under the no action alternative. There would be some negligible temporary disturbance from maintenance mowing of the levee slope to bird species that like short grass (larks, robins, etc.). Once mowing is complete, birds would be expected to return to utilizing these areas. No other impacts to wildlife are anticipated from this alternative.

Plan 2: There would be both short-term adverse construction-related impacts, as well as long-term impacts to wildlife from loss of habitat from this alternative. These impacts would be similar to the impacts described for Plan 3 below. There would be a direct loss of forested area, shrubland, and grassland habitat, thus resulting in less available habitat for wildlife species. The construction easement areas would be planted with native species where possible following construction.

Plan 3 (Recommended Plan): There would be both short-term construction-related impacts, as well as long-term, minor impacts to wildlife from loss of habitat from this alternative. Noise and ground disturbance from construction activities would cause the more mobile animals to leave the project area. Some of the less mobile fauna would be killed. Following construction some of those mobile fauna that left would be expected to return to the area. The areas along the Big Blue and Kansas Rivers and elsewhere adjacent the levee represent some of the best remaining forested habitats in the urban Manhattan area. The loss of forested, shrubland and grassland habitats would have an adverse impact to animals utilizing those habitats, particularly those that require larger patch size of habitats such as the least flycatcher, American redstart, and red-eyed vireo (Hayden, 1995). A decrease in patch size can lead to increases in nest predation and nest parasitism (Wilcove, 1985; May and Robinson, 1985; Burger, 1988). The construction easement areas would be replanted with native vegetation where possible following construction.

Plan 4: Plan 4 has a slightly larger footprint than the Plan 3, which would lead to an increased amount of impact compared to Plan 3 due to higher wildlife habitat losses (forested, shrubland, and grassland). There would be both short-term construction-related impacts, as well as long-term impacts to wildlife from loss of habitat from this alternative. Noise and ground disturbance from construction activities would cause the more mobile animals to leave the project area. Some of the less mobile fauna would be killed. Following construction some of those mobile fauna that left would be expected to return to the area. Larger portions of patches would be adversely affected than Plan 3, thus leading to greater impact to those species that utilize those corridors/patches. Some of the bird species may be most affected by the decrease in patch size as a few species are sensitive to having large undisturbed blocks of habitat. The construction easement areas would be planted with native vegetation where possible following construction.

Plan 5: This alternative would have all the affects described for Plan 3 but would also have the affects to wildlife related to the channel widening activity. The channel widening would take place along approximately 4,400 feet of the left bank of the Big Blue River. This would result in disturbance to approximately 19.7 acres of the Big Blue River Channel and approximately 8.6 acres of area along the river which is mostly a forested riparian corridor. Many animal species use the riparian corridor as routes for movement. This alternative would remove much of the corridor. This would have an adverse impact on many of the species that utilize this riparian habitat. Those semi-aquatic species such as, raccoons, mink, and river otters would be driven from the area during construction and much of their near-shore feeding/foraging habitat would be altered by the channel widening activities. Eventually, the near shore habitat and forage (invertebrates, freshwater mussels, etc.) would recover, however the lack of riparian corridor vegetation along the river would make it less attractive to these species. Mitigation to offset impacts to waters of the U.S. would be needed should this alternative be chosen for construction.

4.2.4 Threatened and Endangered Species

Plan 1 No Federal Action – Under the no action alternative there would be no impact to any federally listed threatened or endangered species or their critical habitat.

Plan 2: No known federally listed threatened or endangered species or designated critical habitat is present within the project area. The footprint of the alternative would not impact any habitat known to be utilized by the federally listed threatened and endangered species for Riley and Pottawatomie Counties, therefore this alternative would have no affect on threatened and endangered species. If the long-eared bat becomes listed prior to construction, the USFWS will be consulted and potentially a survey conducted to determine the presence or absence of the long-eared bat within the project footprint.

Plan 3 (Recommended Plan): No known federally listed threatened or endangered species or designated critical habitat is present within the project area. The footprint of the alternative would not impact any habitat known to be utilized by the federally listed threatened and endangered species for Riley and Pottawatomie Counties, therefore this alternative would have no affect on threatened and endangered species. If the long-eared bat becomes listed prior to construction, the USFWS will be consulted and potentially a survey conducted to determine the presence or absence of the long-eared bat within the project footprint.

Plan 4: No known threatened or endangered species or designated critical habitat is present within the project area. The footprint of the alternative would not impact any habitat known to be utilized by the federally listed threatened and endangered species for Riley and Pottawatomie Counties, therefore this alternative would have no affect on threatened and endangered species. If the long-eared bat becomes listed prior to construction, the USFWS will be consulted and potentially a

survey conducted to determine the presence or absence of the long-eared bat within the project footprint.

Plan 5: The federally-listed interior least tern and piping plover have been known to nest on the nearby Kansas River. Recent surveys have not found them in or near the project area. It is unlikely that either of these species would be present on the proposed project, however, USFWS should be contacted prior to construction and a cursory survey of the project site conducted to ensure no listed species are present. Plan 5 is not likely to adversely affect any listed species or their critical habitat. If the long-eared bat becomes listed prior to construction, the USFWS will be consulted and potentially a survey conducted to determine the presence or absence of the long-eared bat within the project footprint.

4.2.5 Floodplain

Executive Order 11988 directs federal agencies to avoid to the extent possible the long and short term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development where ever there is a practicable alternative. Due to the nature of this project, there are no feasible alternatives to providing the flood risk reduction without being located within the floodplain.

Plan 1 No Federal Action – The floodplain would remain highly altered due to the development and existing levee system. The levee would become overtopped somewhere between the nominal 1% to 0.5% chance flood event.

Plan 2: This alternative would raise a portion of the levee an average of 0.7 feet and a maximum raise of 1.5 feet. The raise would take place at approximately levee station 200+00 to 272+85. The inside of the levee area would be protected to pass the nominal 0.5% chance flood event profile at which point the levee would overtop and flood the interior area. The maximum the water surface elevation would raise upstream of the levee near the Dix subdivision would be just a few inches.

Plan 3 (Recommended Plan): The recommended plan would have an average raise approximately 1.5 feet with a maximum raise of 3.3 feet. The approximate location of the raise is from levee station 131+00 to 277+53. This alternative would protect the area within the levee to pass the nominal 0.33% chance flood event profile at which point it would overtop and flood the interior. The maximum that the water surface would raise near the Dix subdivision is less than 5 inches. Which would not increase the area of floodplain inundated by very much but would be a slight increase in water depth in the inundated area.

Plan 4: This alternative would have an average raise of approximately 2.1 feet and a maximum of 3.9 feet. In addition there would be an extension of the levee along Wildcat Creek. The levee raise would occur at approximately levee station -8+50 to 72+00 and 101+00 to 277+53. The extension along Wildcat Creek would provide

addition protection at very high flood stages. It would disconnect the creek from its floodplain along its left bank in that area. However the floodplain in that area is almost completely developed so it would have a minor impact to floodplain ecology. In the area upstream of the levee near the Dix subdivision, the maximum water elevation change would be less than one-half foot of rise over the existing levee water surface elevation in that area.

Plan 5: This alternative would have an average levee raise of approximately 1.3 feet with a maximum raise of 2.6 feet. The raise would be located along approximately levee station 131+00 to 277+53. A portion of the Big Blue River Channel would be widened removing area that is currently on the left bank floodplain. This would be a loss of approximately 8.6 acres of riparian floodplain. This alternative would have less of a water surface elevation change upstream in the area of the Dix subdivision than the recommended alternative.

4.3 Hazardous, Toxic, and Radioactive Waste (HTRW)

Plan 1 No Federal Action – There would be no impact to hazardous, toxic, or radioactive wastes.

Plan 2: A sub-surface plume of Trichloroethylene (TCE) is located on the National Guard base and extends under the levee at approximately stations 216+00 to 217+00. The plume is currently being treated with injections of sodium lactate to enhance anaerobic bioremediation of the contaminants. Borrow would be placed on top of the area of the plume in the levee raise. A sand drain would be constructed on the landward side of the levee. The depth of the sand drain would be shallow enough that it would not intersect with the plume and bring contaminants to the surface. Relief wells are proposed from station 64+00 to 97+00 and 110+00 to 120+00. Although no known groundwater contamination has been identified, the potential exists. Due to the urban nature of the area, there is always a small chance of discovering an unknown site during construction. If that occurs all construction in the area would cease until an evaluation is made by a HTRW expert.

Plan 3 (Recommended Plan): As with Plan 2, A sub-surface plume of Trichloroethylene (TCE) is located on the National Guard base and extends under the levee at approximately stations 216+00 to 217+00. The plume is currently being treated with injections of sodium lactate to enhance anaerobic bioremediation of the contaminants. Borrow would be placed on top of the area of the plume in the levee raise. A sand drain would be constructed on the landward side of the levee. The depth of the sand drain would be shallow enough that it would not intersect with the plume and bring contaminants to the surface. Relief wells are proposed from station 64+00 to 97+00 and 110+00 to 120+00. Although no known groundwater contamination has been identified, the potential exists. Due to the urban nature of the area, there is always a small chance of discovering an unknown site during construction. If that occurs all construction in the area would cease until an evaluation is made by a HTRW expert.

Plan 4: This alternative would have similar impacts to Plans 2 & 3; however it has a 1,820 foot extension of the southern levee. The proposed alignment of that extension would go through a private disposal site. Junk yards and industrial areas typically have a higher probability for containing contaminants. The extension would also through or near the Manhattan Avenue Battery Site. If this alternative was chosen a more thorough survey of contaminants would need to be performed to identify any HTRW concerns and possible routing shifts.

Plan 5: This alternative would have similar impacts to plans 2 & 3. There are no known HTRW sites located in the area of the channel widening.

4.4 Cultural Resources

Plan 1 No Federal Action: The no action alternative would have no impacts to cultural resources.

Plan 2: This alternative would have little likelihood of impacting historic properties along the existing levee alignment. However, any borrow areas and associated impact areas (haul roads, storage areas, etc.) would need to be evaluated as to potential to contain historic properties. An archeological survey would be required prior to impact if the borrow or associated areas are found to have the potential for historic properties. All work would be coordinated with the Kansas State Historic Preservation Officer and affiliated Native American Tribes.

Plan 3 (Recommended Plan): This alternative would have little likelihood of impacting historic properties along the existing levee alignment. However, any borrow areas and associated impact areas (haul roads, storage areas, etc.) would need to be evaluated as to potential to contain historic properties. An archeological survey would be required prior to impact if the borrow or associated areas are found to have the potential for historic properties. All work would be coordinated with the Kansas State Historic Preservation Officer and affiliated Native American Tribes.

Plan 4: This alternative would have little likelihood of impacting historic properties along the existing levee alignment. However, any borrow areas and associated impact areas (haul roads, storage areas, etc.) would need to be evaluated as to potential to contain historic properties. An archeological survey would be required prior to impact if the borrow or associated areas are found to have the potential for historic properties. All work would be coordinated with the Kansas State Historic Preservation Officer and affiliated Native American Tribes.

Plan 5: This alternative would have little likelihood of impacting historic properties along the existing levee alignment. The proposed channel widening in this alternative may require the removal of the active Union Pacific railroad bridge in Linear Park that spans the Blue River. The bridge may be eligible for the National Register of Historic Places. Its removal would require coordination with the State Historic Preservation Officer (SHPO) and interested groups. If eligible, mitigation measures would likely be

required. In addition, any required borrow areas and associated impact areas (haul roads, storage areas, etc.) would need to be evaluated as to potential to contain historic properties. An archeological survey would be required prior to impact if the borrow or associated areas are found to have the potential for historic properties. All work would be coordinated with SHPO and affiliated Native American Tribes.

4.5 Socioeconomics and Environmental Justice

The Executive Order on Environmental Justice (Executive Order 12898) focuses on social equity issues, particularly any potential disproportionate impacts on minority or low-income groups. No specific geographic areas of minority or low-income groups were identified within the affected area. None of the alternatives would have an adverse impact on any low-income or minority populations.

Plan 1 No Federal Action – This alternative would result in expected annual damages of $6,745,300 (October 2013 prices). The no action alternative damages for the 1% flood could total $331.7 million, and the 0.2% flood could total $717.7 million. The number of structures affected in a 1% chance flood, given the without project conditions is about 1,700. The number of structures affected in a 0.2% chance flood, given the without project conditions is about 2,200.

Plan 2: Each of the construction alternatives had costs annualized using the FY2014 project interest rate of 3.5% and a 50-year period of analysis. Then net annual benefits were estimated, and a Benefit-Cost Ratio (BCR) was determined. Plan 2 had net annual benefits of $2,082,800 and a BCR of 2.9. This is the second highest BCR of the action alternatives behind only the Recommended Plan.

Plan 3 (Recommended Plan): The recommended alternative had estimated annual net benefits of $2,852,100 and a BCR of 3.5. This alternative had the highest net benefit and BCR of all the action alternatives.

Plan 4: This alternative had estimated annual net benefits of $2,762,700 and a BCR of 2.2, which is the next to lowest of the action alternatives.

Plan 5: This alternative had estimated annual net benefits of $1,393,800 and a BCR of 1.5. This is the lowest BCR of all of the action alternatives.

4.6 Recreation

Plan 1 No Federal Action – There would be no impact to recreation from the no-action alternative.

Plan 2: The linear trail is located on top of the levee for much of the distance of the levee. Linear trail is a multi-purpose trail that receives bicycle and foot traffic from walkers/joggers. During construction portions of the trail would need to be closed to recreational use. This would have a short-term negative impact on recreational use.

Construction activities could be sequenced so only a portion of the trail is closed at a time, minimizing the impact to recreation to just the portion under construction. Following construction activities the trail would be restored to pre-construction condition and recreational activity would resume. This would result in no long-term impacts to recreation.

Plan 3 (Recommended Plan): This plan would result in near identical impacts to recreation as found in Plan 2. Short-term impacts from partial trail closure would occur and last only during construction of a particular levee section. No long term impacts to recreation would occur.

Plan 4: This plan would result in near identical impacts to recreation as found in Plan 2. Short-term impacts from partial trail closure would occur and last only during construction of a particular levee section. No long term impacts to recreation would occur.

Plan 5: This alternative would result in the short-term trail closures similar to the other levee raise alternatives. This alternative likely result in longer period of trail closures near the Highway 24 and Union Pacific Railroad bridges as they undergo alteration and/or replacement. The channel widening activities may have a minor effect on recreational boating during construction and constructions on the bridges.

4.7 Noise

Plan 1 No Federal Action – There would be no impact to noise levels from the no action alternative. Noise levels would remain that of a largely urban commercial and industrial area over most of the project area.

Plan 2: There would be minor noise impacts from construction activities from equipment. The impacts would be local to the project area and short-term in duration. Occurring where the construction activity is currently taking place and would typically be limited to the daylight hours. Noise levels would return to pre-construction levels following construction.

Plan 3 (Recommended Plan): There would be minor noise impacts from construction activities from equipment. The impacts would be local to the project area and short-term in duration. Occurring where the construction activity is currently taking place and would typically be limited to the daylight hours. Noise levels would return to pre-construction levels following construction.

Plan 4: This alternative would have temporary noise impacts similar to alternatives 2 and 3, however the footprint is extends further on both ends of the levee into more residential type areas from the levee extension and Casement Road tie-in. There would be minor noise impacts from construction activities from equipment. The impacts would be local to the project area and short-term in duration. Noise levels would return to pre-construction levels following construction.

Plan 5: This alternative would have the similar impact for the levee raise; however the channel widening and bridge expansion and replacements would have much larger footprints for a longer duration. The area of noise generation with this alternative would extend to the left bank of the Big Blue River. The area of impact on that side of the river is largely agricultural with some commercial businesses nearby. The expansion and replacement of the bridges would require a greater number of construction equipment increasing the generated noise levels. The elevated noise levels would last for a much longer time than the other alternatives, however, they would return to pre-construction levels following completion of construction.

4.8 Land Use (Including Prime Farmland)

The project footprint used for analysis was the actual footprint of the levee raise and the permanent easement. In addition it also includes the temporary construction easement. This provides a conservative estimate as it is likely that not all of the area within the construction easement would be impacted. Much of the impacts that do occur within the construction period would be temporary and where possible the land would return to its previous land use following construction or planted with native vegetation where possible.

Plan 1 No Federal Action – The land use under the no action would remain the same, primarily a heavily developed urban, industrial and residential area.

Plan 2: As this alternative has a very similar footprint to the recommended plan please see the environmental consequences section below for impacts.

Plan 3 (Recommended Plan): The effects on land use for the levee raise alternatives are linear in fashion, paralleling the levee. The total project footprint including the permanent and temporary construction easements is approximately 36.9 acres. This includes about 2.2 acres of barren land, 7.7 acres of cultivated agricultural land, 6.2 acres of forested land, 17.5 acres of grassland most of which is maintained turf, 0.7 acres of grassland, with the remaining footprint consisting of impervious surfaces, and other miscellaneous uses.

Plan 4: This alternative would have a much larger footprint than the Recommended Plan and would therefore have an increase in the land use impact. This alternative also includes the 1,700 foot levee extension of the Kansas River segment which involves placing a new section of levee and easements where there currently is not any. That area is primarily grassland utilized for hay production, and it also traverses through some industrial and residential properties.

Plan 5: This alternative would have the same land use impacts as the recommended plan along the levee. This plan also includes the channel widening that would take approximately 8.6 acres that are currently riparian forest and convert that land into part of the river channel.

5.0 CUMULATIVE IMPACTS

The Council on Environmental Quality Regulations defines cumulative impacts as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time" (CEQ, 1997).

The cumulative impacts addressed in this document consist of the impacts of multiple actions that result in similar effects on the natural resources. The geographical areas of consideration are actions located along the Manhattan Levee and the Big Blue and Kansas Rivers.

Past and current urban and agricultural development in the floodplain have led to implementation of numerous measures to protect these assets. Channelization of streams and rivers, construction of levees, stabilization of banklines, draining and filling of wetlands on the floodplain, and eventually the construction of the major flood control levees and reservoirs have had some adverse cumulative impacts on the ecosystem while minimizing the economic and social effects associated with out of bank flows. Some of these efforts began as early as the first settlers arrived in Kansas, with the vast majority of the major levee and reservoir projects started to be planned and built as a result of the damage from the 1951 flood. Due to the highly erosive nature of the Kansas River most of the channelization efforts have been limited to urban areas or smaller tributaries. Compared to other large mid-western rivers, the Kansas River is relatively un-channelized for large portions of its length. The proposed levee raise would not result in additional channelization features, therefore it wouldn't have an adverse cumulative effect on channelization.

As levees prevent overbank flow into the floodplain to protect infrastructure, it also reduces floodplain storage capacity, and the exchange of nutrients and sediments between the rivers and overbank areas. Most of the major levee systems within the Kansas River basin (Manhattan, Topeka, and Lawrence) were built in the middle of the last century. The affects of these levee systems has been in place for 50 plus years and have changed little over time. No new major levee systems on the Kansas River are planned within the foreseeable future. As the Manhattan levee is an existing levee system only being raised to the approximate original design capacity, it would have almost no change in the cumulative impacts to floodplain storage capacity and nutrient exchange.

Flows in the Kansas River basin are largely influenced by a series of reservoirs. Upstream of the city of Manhattan, the Tuttle Creek reservoir is operated as part of a larger Missouri River/Kansas River system of flood control. Which means releases from the dam may be impacted by events in other parts of the larger Missouri River basin to meet certain minimum flow targets or prevent flooding downstream. A master manual

of the Missouri/Kansas River system along with annual operating plans detail the conditions of operation for each of the dams in the system. The Tuttle Creek Dam controls the flow of the Big Blue River downstream of the dam. The proposed project would not have an adverse cumulative impact to flows during most flow conditions. Only during extremely high flow events equivalent to the nominal 0.33% chance flood event profile or higher would there be a negligible, less than 5 inch, rise in the water surface upstream.

According to the 2010 U.S. Census the population of Manhattan has grown approximately 16.6% from the 2000 Census. Manhattan, Kansas population levels continue to grow leading to increased development. As housing developments in unprotected areas of the floodplains grow and the values of the structures increase there is increasing pressure to build additional flood risk reduction measures.

The recommended plan would bring the level of protection for the existing Manhattan levee system back up near its original design standard. As the recommended plan is largely raising existing levee with only a slight increase in the riverward side increase, the flow within the river(s) would only be affected during extremely large events (greater than the 200-year or 0.5% flood), therefore the recommended plan would have only a minor adverse impact. Therefore, the proposed project would not cause any significant cumulative impacts to the human environment.

6.0 CONCLUSION

The recommended plan would have no impacts to federally-listed threatened or endangered species, or their designated critical habitat, and would not have negative impacts to sites listed, or eligible for inclusion, on the National Register of Historic Places. Minor long-term impacts would occur to the terrestrial habitat and wildlife as a result of removing trees some trees along the right of way. With time, the minor long-term impacts would be reduced as trees become reestablished within the construction easement area. The recommended plan would best meet the purpose and need of the project by providing for increased flood risk reduction with limited impacts to the environment in a cost effective manner. For reasons described in this EA, the Recommended Plan would not result in any significant long-term impacts to the human environment.

7.0 COORDINATION AND COMMENTS

Scoping for the project has included a public workshop held on the evening of April 17, 2013 at the Manhattan Fire Station Located at 2000 Denison Avenue in Manhattan, Kansas. The meeting consisted of an approximately 45 minute presentation on the proposed project and the operation of the Tuttle Creek Dam, and then an open house style forum with a series of stations staffed by Corps of Engineers and City of Manhattan staff. Comment cards were handed out to all participants to receive any comments or feedback on the proposed project. Only one card was returned.

There were also two meetings with the Manhattan City Commission where the meetings were open to the public. The first was held on March 28, 2013 and included a Corps presentation and question and answer session for the purposes of presenting early study findings on existing conditions and offering a series of early alternatives for information and feedback from the Commission and public in attendance. The second Commission meeting was held on January 7, 2014. This meeting was also open to the public. The meeting included a Corps presentation and question and answer session for purposes of offering a tentatively recommended plan for levee improvements and a project implementation schedule for information and feedback from the commission and the public in attendance. Both meetings were held in the Commission Auditorium in City Hall.

The Draft Feasibility Report, Environmental Assessment and Draft Finding of No Significant Impact were released for a thirty (30) day public review starting on June 13, 2014. Notice of Availability was sent to the individuals and organizations on the NWK Regulatory mailing list. The Public Notice as well as a copy of the report and supporting documents were also posted to the NWK internet page, and available at the Manhattan City Hall and the local public library. Comments were received from the Choctaw Nation of Oklahoma, Federal Aviation Administration, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and one private individual. A more detailed description of the public involvement process and the comments can be found in the Public Involvement Appendix of the Feasibility Report/

Extensive coordination with the Manhattan Field Office of the U.S. Fish and Wildlife Service has been performed. A copy of the drat and final Coordination Act reports can be found in Appendix II of this EA.

8.0 AGENCY COMPLIANCE WITH OTHER ENVIRONMENTAL LAWS

Compliance with other environmental laws is listed below.

Federal Polices	Compliance
Archeological Resources Protection Act, 16 U.S.C. 470, et seq.	Not Applicable
Clean Air Act, as amended, 42 U.S. C. 7401-7671g, et seq.	Full Compliance
Clean Water Act (Federal Water Pollution Control Act), 33 U.S.C. 1251, et seq.	Full Compliance
Coastal Zone Management Act, 16 U.S.C. 1451, et seq.	Not Applicable
Endangered Species Act, 16 U.S.C. 1531, et seq.	Full Compliance
Estuary Protection Act, 16 U.S.C. 1221, et seq.	Not Applicable
Federal Water Project Recreation Act, 16 U.S.C. 4601-12, et seq.	Full Compliance
Fish and Wildlife Coordination Act, 16 U.S.C. 661, et seq.	Full Compliance
Land and Water Conservation Fund Act, 16 U.S.C. 4601-4, et seq.	Not Applicable
Marine Protection Research and Sanctuary Act, 33 U.S.C. 1401, et seq.	Not Applicable
Migratory Bird Treaty Act, 16 U.S.C. 703	Full Compliance
National Environmental Policy Act, 42 U.S.C. 4321, et seq.	Full Compliance
National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470a, et seq.	Full Compliance
Rivers and Harbors Act, 33 U.S.C. 403, et seq.	Full Compliance
Watershed Protection and Flood Prevention Act, 16 U.S.C. 1001, et seq.	Full Compliance
Wild and Scenic River Act, 16 U.S.C. 1271, et seq.	Not Applicable
Farmland Protection Policy Act, 7 U.S.C. 4201, et. seq.	Full Compliance
Protection & Enhancement of the Cultural Environment (Executive Order 11593)	Full Compliance
Floodplain Management (Executive Order 11988)	Full Compliance
Protection of Wetlands (Executive Order 11990)	Full Compliance
Environmental Justice (Executive Order 12898)	Full Compliance

NOTES:

a. Full compliance. Having met all requirements of the statute for the current stage of planning (either preauthorization or post authorization).
b. Partial compliance. Not having met some of the requirements that normally are met in the current stage of planning.
c. Noncompliance. Violation of a requirement of the statute.
d. Not applicable. No requirements for the statute required; compliance for the current stage of planning.

9.0 REFERENCES

Collins, Joseph T. 1983. Amphibians & Reptiles in Kansas. The University of Kansas. 397pp.

Council on Environmental Quality (CEQ). 1992. Regulations for Implementing the Procedural Provisions of NEPA, 40 CFR Parts 1500-1508, in accordance with 40 CFR 1507.3.

CEQ. 1997. January, 1997. Considering Cumulative Effects Under the National Environmental Policy Act. Executive Office of the President, Washington, D.C. pp ix-x, 28-29 and 49-57.

Cross, Frank B. and J.T. Collins. 1995. Fishes in Kansas. The University of Kansas. 315pp.

Hayden, T.J., J. Faaborg, and R.L. Clawson. 1985. Estimates of minimum area requirements for Missouri forest birds. Transactions of the Missouri Academy of Science 19:11-22.

May, R.M. and S.K. Robinson. 1985. Population dynamics of avian brood parasitism. American Naturalist 126:475-494.

Thompson, Max C. and C. Ely. 1989. Birds in Kansas, Volume 1. The University of Kansas. 404pp.

USACE. 2002. Final Evaluation Report and Environmental Impact Statement Statement, Tuttle Creek Dam Safety Assurance Program, Big Blue River, Kansas.

Wilcove, D.S. 1985. Nest predation in forest tracts and the decline of migratory songbirds. Ecology 66:1121-1214.

10.0 LIST OF PREPARERS

This EA and FONSI were prepared by Curtis Hoagland, Environmental Resource Specialist, with socioeconomic assistance provided by Ms. Margaret Ryan, Economist, and cultural resource assistance provided by Mr. Timothy Meade, District Archeologist. The address of the preparers is: U.S. Army Corps of Engineers, Kansas City, District; PM-PR, Room 529, 601 E. 12th Street, Kansas City, Missouri 64106.

11.0 APPENDICES

APPENDIX I - PROJECT MAPS

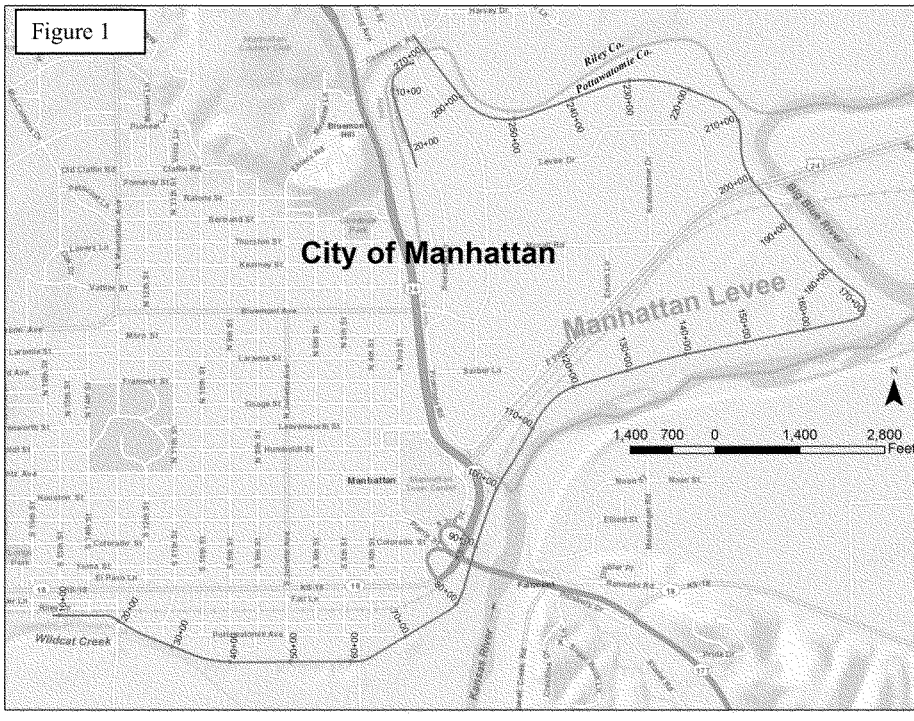
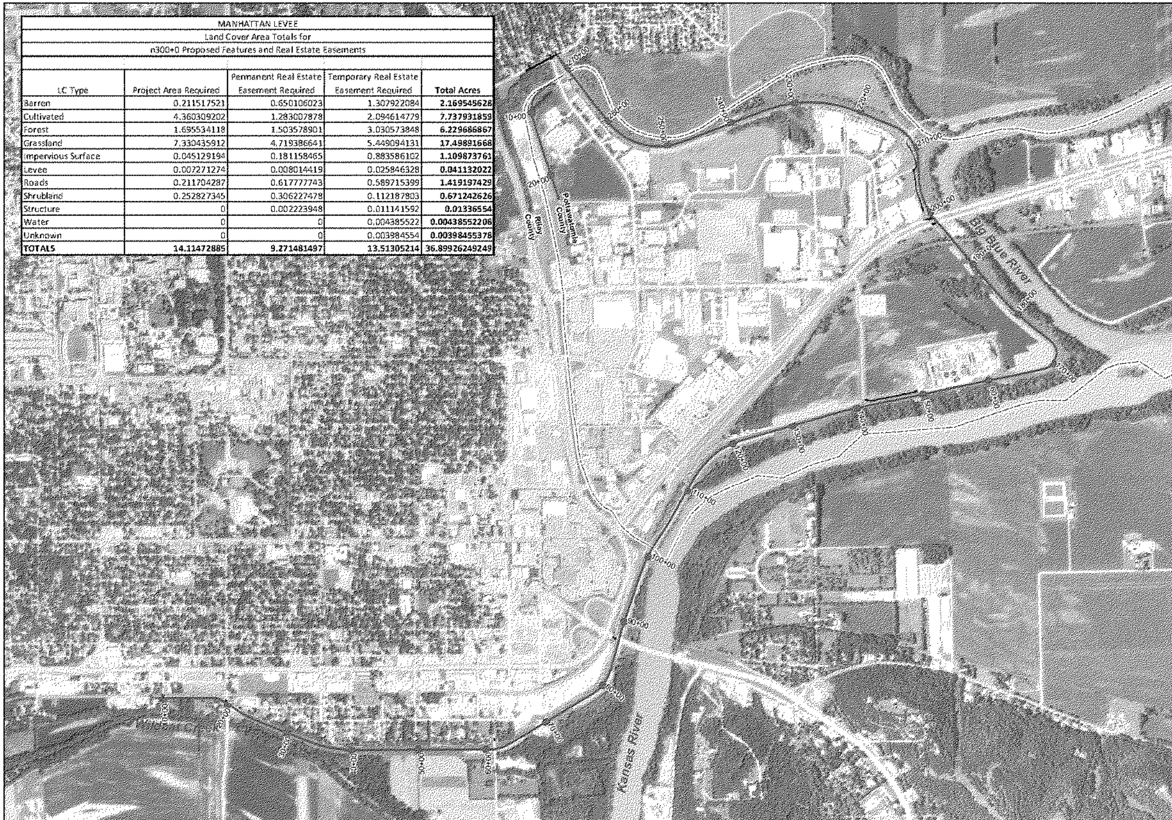


Figure 1
City of Manhattan
Manhattan Levee
Riley Co.
Pottawatomie Co.
Big Blue River
Kansas River
Wildcat Creek
Bluemont Hill
Manhattan
Fairchild
1,400 700 0 1,400 2,800
Feet
N

Tuttle Creek Dam and Reservoir, approximately 5 miles
Manhattan Levee
GI Study
Concept Levee
Reliability Improvements
Percent of Minority Population
DRAFT
Working document, not for public release
Figure 2
Legend
Census Blocks, % Minority, 2010
US Army Corps of Engineers
Kansas City District
Sheet No. x

Manhattan Levee
GI Study
Concept Levee
Reliability Improvements
Median Income by Census Block Groups
DRAFT
Working document, not for public release
Figure 3
Sheet No. x
Tuttle Creek Dam and Reservoir, approximately 5 miles
Fort Riley Military Reservation, approximately 8.5 miles
37999
47323
32019
15000 & 24765
13048
69481
24973
14687
31885
17054
42081
28448
18992
17651
23445 & 28938
53141
41413
46230
50565
Legend
US Army Corps of Engineers
Kansas City District
Photography Date: 2010
Projection: State Plane, Kansas North
Datum: NAD 83
Created by:
U.S. Army Corps of Engineers
Kansas City District, GIS Team
Unauthorized use, correction, addition, and comments for improving this product to:
GIS Coordinator,
U.S. Army Corps of Engineers,
Kansas City District,
601 East 12th, Room 527,
Kansas City, Missouri 64106
Feet
0 300 600 1,200
Topeka
Kansas City
Sabina
Path: K:\projects\cin\Manhattan\levee\arcgis\maps\LeveeModel\LeveeModelBasemap_v93_Envirn_CensusIncome.mxd JJMA 1700 HRS, 11 SEP 2012

MANHATTAN LEVEE				
Land Cover Area Totals for				
n300+0 Proposed Features and Real Estate Easements				
LC Type	Project Area Required	Permanent Real Estate Easement Required	Temporary Real Estate Easement Required	**Total Acres**
Barren	0.211517521	0.650106023	1.307922084	**2.169545628**
Cultivated	4.360309202	1.283007878	2.094614779	**7.737931859**
Forest	1.695534118	1.503578901	3.030573848	**6.229686867**
Grassland	7.330435912	4.719386641	5.449094131	**17.49891668**
Impervious Surface	0.045129194	0.181158465	0.883586102	**1.109873761**
Levee	0.007271274	0.008014419	0.025846328	**0.041132022**
Roads	0.211704287	0.617777743	0.589715399	**1.419197429**
Shrubland	0.252827345	0.306227478	0.112187803	**0.671242626**
Structure	0	0.002223948	0.011141592	**0.01336554**
Water	0	0	0.004385522	**0.00438552208**
Unknown	0	0	0.003984554	**0.00398455378**
TOTALS	**14.11472885**	**9.271481497**	**13.51305214**	**36.89926249249**



Manhattan Levee
Feasibility Study
Existing Conditions and Reliability Improvements

Existing Levee With City Streets View

DRAFT
Working document, not for public release

Figure 4

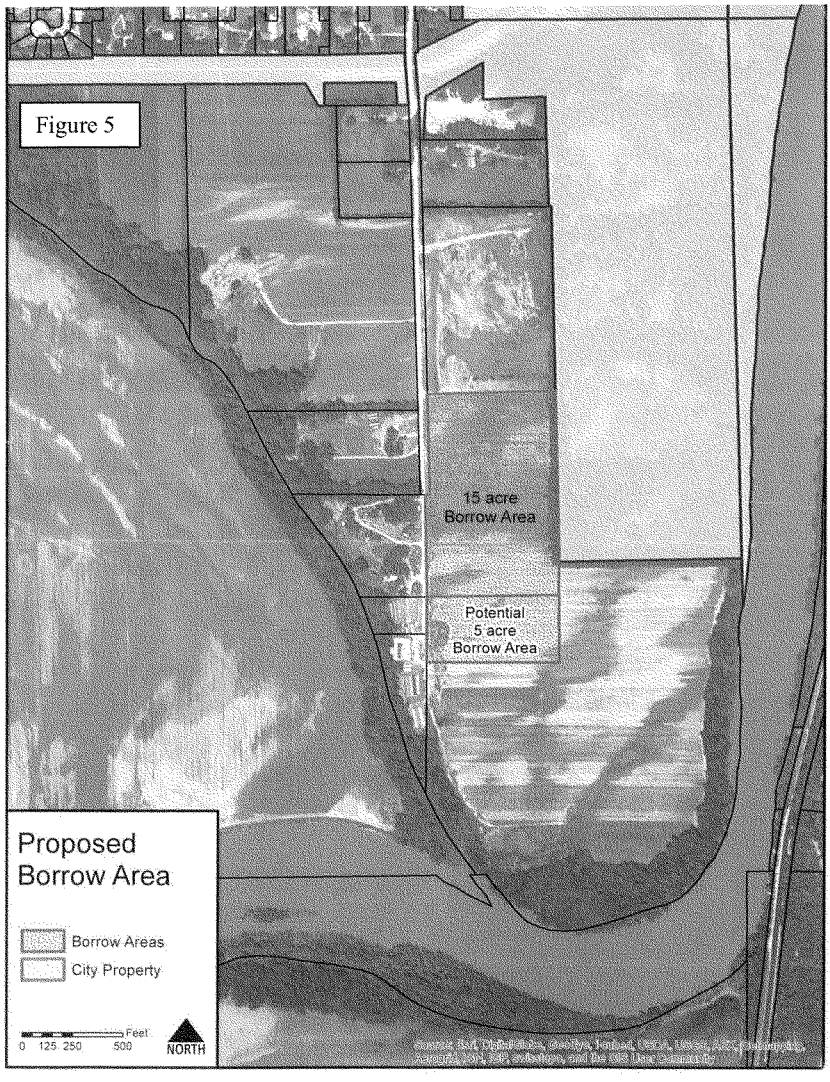


Figure 5
15 acre
Borrow Area
Potential
5 acre
Borrow Area
Proposed
Borrow Area
Borrow Areas
City Property
Feet
0 125 250 500
NORTH

APPENDIX II - AGENCY CORRESPONDENCE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Kansas Ecological Services Field Office
2609 Anderson Avenue
Manhattan, Kansas 66502

September 24, 2013

Curtis Hoagland
PM-PR
US Army Corps of Engineers, Kansas City District
601 East 12th Street
Kansas City, MO 64106

Dear Mr. Hoagland:

The U.S. Fish and Wildlife Service (Service) submits this Planning Aid Letter (PAL) concerning the preliminary alternatives considered for the Section 216 Feasibility Report and Environmental Assessment for proposed improvements to the Manhattan, Kansas Levee located in Riley County, Kansas known as the Manhattan Levee Feasibility Study. The letter focuses on the fish and wildlife resources, needs, opportunities, and impacts associated with this project as they affect fish and wildlife resources.

This PAL has been developed in cooperation with the Kansas Department of Wildlife, Parks, and Tourism and is submitted in accordance with the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) When more definitive plans are developed, we will study the proposal and any alternatives and prepare more detailed comments and recommendations. The Fish and Wildlife Service will provide a draft and final Fish and Wildlife Coordination Act Report after a recommended plan has been selected.

GENERAL DESCRIPTION OF THE PROJECT AREA

The City of Manhattan covers an area of approximately 18.79 square miles and as of the 2010 census, the city population was 52,281. Manhattan is located in the Flint Hills region of Kansas, which consists of continuous rolling hills covered in tall grasses. The current downtown area, the original site of Manhattan, was built on a broad, flat floodplain at the junction of the Kansas and Big Blue rivers. The floodplains of the Big Blue and Kansas River in the study area have been predominantly developed as residential and business areas. Manhattan has faced recurring flooding during times of heavy precipitation. The largest floods in the town's history were in 1903, 1908, 1951 and 1993. In 1993 the emergency flood gates for Tuttle Creek Reservoir were opened, which combined with large outflows from other reservoirs on tributaries to the Kansas River, resulted in an increase in the flood levels in the City of Manhattan.

Tuttle Creek Dam and Reservoir is located on the Big Blue River approximately six miles north of the City of Manhattan or 12.3 miles above its confluence with the Kansas River near river mile 147. Construction of the Dam was initiated 1952 and storage of water in the lake began in 1962. The lake became fully operational for all Congressionally authorized purposes when it reached multipurpose pool in April of 1963. Tuttle Creek Reservoir controls the flow of the Big Blue River downstream of the dam.

The construction of the Manhattan, Kansas Flood Protection Project (Manhattan levee) was initiated in 1961 and the completed project was transferred to the City of Manhattan for operation and maintenance in 1963. The Manhattan levee provides a limited amount of protection to the City of Manhattan from flooding along two major rivers, the Kansas River and the Big Blue River. The Manhattan Levee consists of a primarily earthen levee (5.4 miles), various interior drainage features, pump plants, and levee underseepage controls.

The Big Blue River tieback elevation was originally designed for an 110,000 cfs release from Tuttle Creek Reservoir plus two feet of freeboard. The existing levee withstood the 1993 Flood, with flows of 60,000 cfs on the Big Blue River and peak flows of 100,000 cfs on the Kansas River, but releases from Tuttle Creek Dam created a near overtopping situation at some Big Blue River levee locations. The 1993 event raised concerns that the levee may provide much less than the design level of performance.

The Manhattan Levee is located in Riley and Pottawatomie Counties. For the purpose of the feasibility study the Manhattan levee is described as two major segments:

1. The Big Blue segment extends along the right bank of the Big Blue River from upstream near Casement Road down to the Kansas River confluence.

2. The Kansas River segment starts on high ground on the left bank of Wildcat Creek in the vicinity of 4th Street and then extends along the left bank of the Kansas River to the mouth of the Big Blue River.

Evaluation of Alternatives Considered

The feasibility study includes preliminary engineering, formulation of project alternatives, environmental assessment, economic evaluations, and real estate studies. The Corps has stated that the early alternatives examination show that construction of certain levee reliability improvements and raising the existing Big Blue Levee segment produce solid positive net benefits and offers a good opportunity to pursue a Federal cost-shared project with the Corps.

The feasibility study is exploring four alternatives:

1. N200+0 levee raise from Station 200+00 to 273+00 with an approximate 200-foot extension up Casement Road via a road raise on the Big Blue River Segment. This alternative would raise the levee an average of ¾ foot. A 17-acre borrow area would be required for this alternative.
2. N300+0 levee raise from Station 131+00 to 273+00 with an approximate 450-foot

extension up Casement Road via a road raise on the Big Blue River segment. This alternative would raise the levee an average of 1.5 feet. An approximately 20-acre borrow area would be required for this alternative.

3. N500+0 levee raise from Station 0+00 to 72+00 and from 101+00 to 273+00. This alternative would include a 1700-foot extension along the Kansas River that runs parallel to the railroad to reach high ground on that side, and a 500-foot extension up Casement Road via a road raise on the Big Blue River segment to tie into high ground. This alternative would raise the levee an average of 2 feet. An approximately 65-acre borrow area would be required for this alternative.
4. N300+0 plus channel widening on the Big Blue River. Channel widening would occur north of the confluence of the Big Blue River and Kansas River beginning approximately at River Mile (RM) 0.4 and proceed northeasterly upstream to approximately RM 1.3. The channel widening would affect the U.S. 24 bridge across the Big Blue River.

The Corps has indicated that the N300+0 levee raise alternative appears to be the best candidate for the National Economic Development (NED) plan at this time. This alternative would raise the Big Blue River portion of the levee an average of 1.5 feet with up to a 3.3-foot raise in some locations. The preliminary cost estimate for this alternative is $18 million in 2012 dollars.

Also considered late in the feasibility study was a plan to extend the levee northward to protect additional development in the northern area, including the Dix Addition which sustained considerable damage in the 1993 flood. However, the Corps determined that a northern extension of the levee would be economically unfeasible per Corps guidelines for Federal Civil Works projects. A northern levee extension would add yet another constriction to a river system that has already lost much of its flood plain function to levees. Flood events are important for fish in terms of habitat creation. Building new levees would further reduce flood plain function and processes that create and sustain habitat. New levees would have a potential to impact wetlands and riparian areas.

A draft digital document titled Manhattan Levee Mapbook Alternatives_27MAR2013 depicts a candidate borrow area south of Knox Road and east of the Northeast Park. We determined the geographical coordinates to be 39.1987E, 96.5410 W. Although our land cover database indicates that the majority of the area is primarily cropland, there is a small area of woodland along the southwestern edge. The Northern Flint Hills Audubon Society sponsored Cecil Best Birding Trail and the associated bluebird trail goes through this woodland area.

AQUATIC RESOURCES

The Big Blue River extends approximately nine miles downstream of Tuttle Creek Lake to its confluence with the Kansas River at river mile 147. Both the Kansas River and the Big Blue River in Riley and Pottawatomie Counties are classified as a high priority resource in the Kansas Stream and River Fishery Resource Evaluation (Kansas Fish and Game Commission, 1981). Both rivers support a fish population that is typical of the large turbid rivers. Common species of fish found would likely include common carp, gars, drum, buffaloes, gizzard shad, channel catfish, flathead catfish. white bass, walleye, saugeye and crappie, and wipers.

The levee system includes part of Wildcat Creek. This reach of Wildcat Creek historically contained Topeka shiners (*Notropis topeka*), federally listed as endangered. Although the reach of Wildcat Creek through the City of Manhattan has not been sampled in recent times, upstream reaches on Ft Riley are known to contain healthy populations of Topeka shiners.

Natural processes that create and sustain habitat in the aquatic system are often damaged by flood control projects. These processes include a natural range of variability of flows, channel meandering and flood plain storage, large woody debris recruitment, and sediment routing and transport. Such processes are important to retain or restore because native aquatic species have adapted to them and cannot thrive when they are damaged. Many of these processes have been significantly altered in the Big Blue and Kansas rivers by previous flood control measures including the construction and operation of Tuttle Creek Reservoir, the existing Manhattan Levee system, and the rerouting of the Big Blue River channel, and in Wildcat Creek from development and the removal of the riparian area. We urge the Corps to evaluate and prioritize alternatives, mitigation, and restoration opportunities from a process-based approach that determines whether a proposal will further degrade, maintain, or enhance natural riverine processes. We believe this approach is more likely to result in a preferred alternative that can meet the project objectives and restore habitat conditions for fish and wildlife.

TERRESTRIAL RESOURCES

The floodplains of the Big Blue River and Kansas River in the project area are largely developed, but there is a narrow band of riparian vegetation riverward of the levee unit. This riparian area consists of woody vegetation, native grasses and forbs, and domestic-turf grasses. The dominant trees in these riparian bands would likely include American elm, black walnut, bur oaks, chinkapin oak, eastern cottonwood, hackberry, hawthorn, honey locust, Osage orange, redbud, rough-leaf dogwood, slippery elm, smooth sumac, green ash, and red mulberry. Deciduous shrubs include rough-leaf dogwood, buckbrush, elderberry, fragrant sumac, gooseberry, poison ivy, and the prairie rose. There are areas along the levee that are being invaded by bush honeysuckle which quickly crowds out the native plants. The upland hillsides are occupied by grasses and oak-hickory forest associations with some areas dominated by eastern red cedar.

Mammals in the project area are those typically associated with riparian areas and those that are fairly tolerant of human activity. These would likely include beaver, mink, muskrat, squirrels, opossum, coyote, raccoon, striped skunk, cottontail rabbits, white-tailed deer, red and gray fox, and various species of mice.

The avifauna of the study area includes permanent residents, summer residents, transients, and winter residents. Birds observed in the area by local birdwatchers encompass upland grassland birds, aquatic birds, and woodland birds. These include, but are not limited to, bald eagle, blue-winged teal, turkey vulture, sharp-shinned hawk, red-tailed hawk, American kestrel, green heron, killdeer, yellow-billed cuckoo, yellow-shafted flicker, red-bellied woodpecker, downy woodpecker, eastern kingbird, great crested flycatcher, least flycatcher, eastern wood-pewee,

barn swallow, cliff swallow, blue jay, American crow, black-capped chickadee, tufted titmouse, white-breasted nuthatch, marsh wren, American robin, eastern bluebird, European starling, red-eyed vireo, orange-crowned warbler, yellow warbler, yellow-rumped warbler, American redstart, meadowlark, red-winged blackbird, common grackle, brown-headed cowbird, orchard oriole, northern oriole, northern cardinal, indigo bunting, American goldfinch, Harris' sparrow, chipping sparrow, dark-eyed junco, American tree sparrow, blue-gray gnatcatcher, and rose-breasted grosbeak.. Breeding species observed include: common yellowthroat, song sparrow, red-winged blackbird, American goldfinch, dickcissel, ring-necked pheasant, eastern meadowlark, western kingbird, eastern kingbird, kingfisher, blue heron, white egret, Canada geese, and other waterfowl species. In April of 2009 a group of about 5 whooping cranes were observed in fields adjoining the Kansas River southeast of Manhattan near Zeandale, Kansas (Dan Mulhern, pers. Comm.).

The riparian areas that remain along the Big Blue and Kansas Rivers are among the highest quality habitat in the City of Manhattan. These riparian areas offer the greatest vegetative diversity and degree of interspersion of habitat types, which is important to many wildlife species. Additionally, riparian areas are important for preventing streambank erosion, intercepting sediments and pollutants before entering streams, providing shade, and providing vegetative detritus to streams. Riparian areas provide recreational opportunities through fishing, nature study, and wildlife observation. Because of the extensive development within the floodplain, the habitat value of the remaining areas of native vegetation riverward of the levees is greatly increased. Activities associated with the project should seek to avoid disturbance of the riparian area. If mitigation measures are needed, these could include the expansion of the riparian area and enhancement of the riparian area from the removal of invasive species and the planting of native species to add diversity.

RECREATION

The City of Manhattan maintains Linear Park, a hiking/biking trail which includes the crest of the levee. It is common to see snakes, typically small garter snakes and an occasional ring-neck snake, sunning themselves on the trail or in the riprap on the sides of the levee. Mountain bike trails take off from Linear Park and traverse the woody riparian area riverward of the levee. Linear Park is heavily used by the residents of Manhattan both for recreation and as an alternative transportation route by pedestrians and bicyclists. Trail closings due to construction activity will be a disruption to the user community and would be acutely felt. Trail closings should be kept to a minimum both in length of area and amount of time closed. Mitigation measures should seek to provide an alternative route around the construction areas and preserve the connectivity of the trail.

The City of Manhattan created Northeast Park and Fairmont Park after the flood of 1993. Northeast Park is located northwest of the levee toward the northern extent of the levee and south of Knox Road. Fairmont Park is located on the south side of the Kansas River east of Highway 177.

Both parks are primarily used for open space recreation. In Northeast Park soccer and baseball

occupies areas in the northern part of the park. A small playground has been constructed at the northwest corner. The Northern Flinthills Audubon Society (NFHAS) has developed several features associated with Northeast Park. NFHAS restored and maintains a 28-acre native grass prairie in the southern part of the park. The Cecil Best Birding Trail, which incorporates a bluebird trail, begins close to the levee south of Highway 24 and wanders through a woody area entering the southwest corner of the park close to the native grass area. A wetland swale locally called the "Leander" was developed in a drainage ditch. A hiking/biking trail connects to Linear Trail and surrounds the perimeter of the native prairie area and continues through the Park. The Park has a restroom facility with flush toilets in the northeast corner of the park. In addition, the old Big Blue River channel runs through the southern end of the park.

Several residential properties and a trailer court were bought out after the 1993 flood in the Fairmont Park area. Fairmont Park is used for open space recreation such as soccer and has a few facilities such as a baseball field, frisbee golf course, and off-leash dog areas. Hiking trails along the top of the levee and through the riverward riparian area have been developed and are maintained by local volunteers. A boat ramp has been constructed off Highway 177 on the southwest side of the Kansas River bridge.

CUMULATIVE IMPACT FACTORS

Cumulative impact is defined as the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

The following are events which we know about and believe should be considered in the cumulative impact analysis for this project.

Although the floodway cross section will remain essentially unchanged for all alternatives except the N300+0 plus channel widening, the heightened levees may further constrict flood waters. This may cause flood crests to increase in height (the water has no place to go but up) and floodwaters would be more likely to be impounded upstream. In 1993, the constricted Missouri River floodplain prevented the Kansas River from draining. This caused water to back up in the Kansas River, flooding far into the state of Kansas (White House Interagency Floodplain Management Review Committee, 1994). While the N300+0 alternative would result in levee heights that are near or just below the original design height, other alternatives would result in increased levee heights or new levees. An increase in levee heights and/or new levees may induce downstream levee districts to build their own levees even higher to avoid increased flood damages.

Heavy precipitation events (in approximately 2009) produced a large bank scour on Wildcat Creek which damaged part of the Linear Park trail system in the area locally known as the Pecan Grove. The City of Manhattan conducted a bank stabilization effort. Other areas along Wildcat Creek are experiencing bank failure, notably an area adjacent to the Garden Way Apartment

complex just off west Anderson Street. In 2012 the Natural Resources Conservation Service proposed and then withdrew plans to construct bank armoring along this section. Continued development in the watershed of Wildcat Creek, particularly in the floodplain will increase surface water runoff into Wildcat Creek and promote erosion along the Creek. The increase in water flow and velocities in Wildcat Creek will likely increase downstream flooding and erosion.

There has been some recent discussion from citizens about constructing buildings, such as a new City of Manhattan Park Department building, in Fairmont Park. This would seem to be at odds with the Park providing flood storage capability and the removal of homes from this area to prevent damages from future flooding. Building permanent structures in Fairmont Park would increase the amount of impervious area, decrease the amount of area available to store water, and may increase surface water runoff into the Kansas River resulting in higher water levels.

Levees have constrained the river and isolated the flood plain, greatly reducing flood plain storage of water, sediments, and nutrients. The City of Manhattan has allowed development in areas that previously stored flood water and were flooded in the 1993 floods. The development of these flood prone areas further eliminates flood storage areas that alleviated the effects of flooding. In addition, areas along the Big Blue River in Pottawatomie County have been cleared of much of the riparian vegetation and then lined with riprap and other bank stabilization efforts to alleviate bank erosion to allow development. Because these areas have been developed, increasing the amount of impermeable surfaces in the watershed while eliminating flood prone/flood water storage areas, surface water runoff will increase along with increased flow heights and velocities. As a result, we would expect flooding to occur with less precipitation and the damages associated with the flooding to be greater.

ENDANGERED AND THREATENED SPECIES AND FEDERAL TRUST RESOURCES

Section 7 of the Endangered Species Act, 87 Stat. 884, as amended, requires an agency to ask the Secretary of the Interior, acting through the U.S. Fish and Wildlife Service, whether any listed or proposed endangered species may be present in the area of each Federal construction project. If the project may affect listed species, the Corps of Engineers should initiate formal Section 7 consultation with this office. If there will be no effect, or if the Fish and Wildlife Service concurs in writing there will be beneficial effects, further consultation is not necessary.

The Topeka shiner, federally listed as endangered, is known to inhabit Wildcat Creek. Although the reach of Wildcat Creek through the City has not been surveyed, Topeka shiners are known to inhabit Wildcat Creek on Ft. Riley and on the outskirts of the City of Manhattan.

The interior least tern (*Sterna antillarum*), federally listed as endangered, and the piping plover (*Charadrius melodus*), federally listed as threatened, nest and forage on the Kansas River. Recent surveys have not found them in the project area. However, nesting and foraging sites for both species vary spatially from year to year. Before any construction begins, the Corps should check on the species current status with us. It may be necessary to conduct surveys to determine the location of nesting and foraging sites each breeding season.

Bald eagles are frequently observed flying over both the Big Blue River and the Kansas River and perching in trees along both rivers. Although bald eagles are no longer on the threatened or endangered species list, they are protected by the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. Development in the Manhattan area continues to degrade riparian habitat and destroy trees that the eagles use.

The MBTA prohibits the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests. Takings could result from projects in prairies, wetlands, stream and woodland habitats, and those that occur on bridges and other structures if swallow or phoebe nests are present. While the provisions of MBTA are applicable year-round, most migratory bird nesting activity in Kansas occurs during the period of January (owls, and hawks) through August (goldfinches).

Kansas State Law (K.S.A. 32-504, 32-507: effective May 1, 1981) requires persons undertaking or sponsoring publicly funded or State or Federally Assisted action which is likely to impact endangered or threatened wildlife habitats where they are likely to occur, to obtain a project action permit from the Secretary of the Kansas Department of Wildlife and Parks prior to initiation of such action. In addition to the Federally listed threatened and endangered species, the State lists additional species that may be of concern within the project area. A list of Kansas listed threatened and endangered species and Species in Need of Conservation (SINC) for Riley County is attached to this letter. Please note that the Plains minnow listed as a SINC species on the list is now classified as threatened. The list is subject to change and updated information should be requested from the Environmental Services Section, Kansas Department of Wildlife and Parks, 512 SE 25th Ave., Pratt, KS 67124-8174.

Executive order 13112 Section 2 (3) directs Federal agencies to not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere, and to ensure that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions. We encourage the Corps and local sponsor to perform Hazard Analysis and Critical Control Points (HACCP) planning for invasive species control and to implement best management practices to prevent the transference of invasive species to or from the project site. Tools to perform HACCP planning are available at http://haccp-nrm.org/. HACCP planning focuses attention on critical control points where non-target species can be removed. Documenting risks and methods used to remove non target species gives managers a strategic method to make consistent decisions based on identified risks. Planning builds a logical framework of information to weigh risks for species spread against management benefits.

Invasive species have been identified as a major factor in the decline of native flora and fauna. Human actions are the primary means of invasive species introductions. Prevention of introductions is the first and most cost-effective option for dealing with invasive species. We strongly encourage the inclusion of best management practices for the prevention of invasive species transfer in all project plans such as the following example:

All equipment brought on site will be thoroughly washed to remove dirt, seeds, and plant parts. Any equipment that has been in any body of water within the past 30 days will be thoroughly cleaned with hot water greater 140° F (typically the temperature found at commercial truck washes) and dried for a minimum of five days before being used at this project site. In addition, before transporting equipment from the project site all visible mud, plants and fish/animals will be removed, all water will be eliminated, and the equipment will be thoroughly cleaned. Anything that came in contact with water will be cleaned and dried following the above procedure.

Wetland Information

Small off-channel wetlands are likely to be present in the project area. A jurisdictional wetland determination will be necessary if levee alignments, improvements, or borrow areas directly impact wetlands. The quantity and quality of impacted wetland habitat will determine the amount of compensation necessary to offset project losses. If impacts to wetlands are unavoidable, a wetland mitigation plan should be developed in coordination with the Service, the Environmental Protection Agency, and the Kansas Department of Wildlife, Parks, and Tourism. This plan would be a condition of any Section 404 permit issued for the project. We recommend that all wetland impacts be mitigated regardless of the regulatory nature of the wetland impacted. Minimum replacement ratios for compensatory wetland mitigation should be based on the following guidelines:

U.S. Fish and Wildlife Service, Region 6
Wetland Mitigation Policy Guidance (8/97)
Recommended Minimum Replacement Ratios

Mitigation Type	Ratio	Type of Wetland Being Mitigated
Advance Creation	1.5:1	forested, scrub-shrub
	1:1	emergent
Concurrent Creation	2:1	forested, scrub-shrub
	1.5:1	emergent
Advance Restoration	1.5:1	forested, scrub-shrub
	1:1	emergent
Concurrent Restoration	2:1	forested, scrub-shrub
	1.5:1	emergent
Advance Enhancement	3:1	forested, scrub-shrub
	2:1	emergent
Concurrent Enhancement	4:1	forested, scrub-shrub
	3:1	emergent

Fish and Wildlife Problems, Needs, Opportunities, and Concerns

The Big Blue River and Kansas River have been heavily impacted by previous flood control activities. Both rivers still provide valuable fish and wildlife habitat even in urban settings. However, these habitats have been degraded over the years. Although this importance may be difficult to quantify, it should be taken into consideration when identifying project related opportunities to enhance fish and wildlife resources.

Flood and erosion control have resulted in the loss of opportunity for the river to meander and avulse, natural processes that create habitat such as side channels, oxbows, and wetlands. Bank armoring or channelization in one place tends to transfer erosive energy of flooding downstream. This results in additional bank armoring or flood protection in other locations with a cumulative loss of habitat. Not only is more habitat lost through these actions, but the opportunity for natural processes to create more habitat is progressively eliminated through time.

The levee work would be expected to result in the loss of riparian vegetation. The Corp's own vegetation management standards prescribe tree removal along existing levees. Removal of mature trees, and other native vegetation should be avoided where possible, and if they are removed, should be replaced by establishing 2 acres of native vegetation for every acre impacted with similar native species composition to that which is lost.

The loss of riparian vegetation degrades habitat for fish. Many juvenile fish use the margins of stream channels where, under natural conditions, vegetation and large woody debris create slower velocities and provide cover. Without these refugia, small fish can be flushed prematurely during high flows. Studies comparing fish densities next to hardened versus natural stream banks found that the highest number of fish were found adjacent to natural river banks. Older levees where vegetation had been allowed to grow had more fish than new or recently "maintained" levees, although fewer than natural banks (Peters, R.J. et. al., 1998. Seasonal fish densities near river banks stabilized with various stabilization methods: first year report of the flood technical assistance project, Retrieved on September 20, 2013 from http://www.fws.gov/wafwo/fisheries/Publications/FP125.pdf. See also Rehabilitation of banks and riparian zone, Retrieved September 20, 2013 from http://evidence.environment-agency.gov.uk/FCERM/en/SC060065/MeasuresList/M5/M5T5/M5T5Eff.aspx). A study of fish densities associated with riprap, log jams, and mud banks on the Kansas River concluded that while construction of intermittent riprap may locally increase species richness and diversity in rivers which contain a high proportion of habitat generalists, continuous riprap that constrains natural riverine processes may still be detrimental to riverine ecosystems at larger spatial scales. (White, Katherine, J. Gerken, C. Paukert, and A. Makinster, 2009. Fish community structure in natural and engineered habitats in the Kansas River, Retreived September 20, 2013 from http://web.missouri.edu/~paukertc/reprints/KSR%20rip%20rap%20White.pdf)

Native trees, grasses and forbs, noted for their high wildlife value, could be established along the landward (where feasible) and riverside of the existing levee system. This might help offset future losses due to increased encroachment along the rivers once flood protection is increased. Native vegetation often takes longer to become fully established; however, when established,

stands of native vegetation provide excellent soil binding characteristics, valuable wildlife habitat and requires fewer maintenance costs. The Service, the Kansas Department of Wildlife, Parks, and Tourism, and the Natural Resources Conservation Service offer assistance programs and could work with the City of Manhattan to develop vegetation management plans.

Planting of the floodway to native trees, shrubs, and grasses within the levee system would do much to preserve wildlife habitat in close proximity to the Manhattan urban area. We also encourage the Corps and the City of Manhattan to develop public access to floodway habitats and the Kansas and Big Blue Rivers where appropriate. Opportunities and programs through the Federal Water Project Recreation Act (Public Law 89-72) are available to project sponsors to cost share (75 percent Federal, 25 percent non-Federal) features which enhance fish and wildlife habitat over the existing condition.

The non-native, invasive brome and fescue grasses used on the levee could be replaced with native grasses which would provide a higher habitat value than the non-native grasses. The USDA – Natural Resource Conservation Service's Plants Database (http://plants.usda.gov/java/) lists three species of fescue that are native to Kansas: clustered fescue (*Festuca paradoxa*), nodding fescue (*Festuca subverticillata*), and Rocky Mountain fescue (*Festuca saximontana*). Clustered fescue and nodding fescue have been found in Riley and Pottawatomie Counties while Rocky Mountain fescue has not been found in either county. Other native grasses which might be suitable for use on the levees include buffalo grass (*Bouteloua dactyloides*) and western wheat grass (*Pascopyrum smithii*).

Non structural measures should be incorporated wherever possible because they would have little impact to and in some cases could help restore, natural processes. Nonstructural measures include relocation or removal of structures, improving bank vegetation, land use controls, and flood proofing.

The candidate borrow area should be designed to avoid the woodland area, the Cecil Best Birding Trail and the associated bluebird trail. We recommend a minimum 100-foot buffer be left between the wooded area and the borrow area and be planted to native grass. The buffer area will lessen the disturbance to birds and wildlife in the wooded area and trail users.

If feasible, a shallow wetland created in the borrow area would add an additional component for wildlife habitat in the area, enhancing bird populations as well as amphibians and reptiles. Many floodplain wetlands have likely been destroyed or disturbed in the Manhattan area by development and the creation of the levee system. Creating wetlands where possible would diversify habitat and offset the historical loss of wetlands in the area.

There may be alternatives to using a borrow site to obtain soil to build the levee. The Kansas Water office is currently studying the feasibility of dredging a portion John Redmond Reservoir. The cost of transporting dirt from the dredging may be offset by the cost of containing the dredged material. Another possibility may be to dredge a portion of Tuttle Creek Reservoir and used the dredged material for the levee work.

Thank you for the opportunity to comment on this project. If you have any questions, please contact me or Susan Blackford of my staff at (785) 539-3474.

Sincerely,

Heather Whitlaw
Field Supervisor

cc: KDWP, Pratt, KS (Environmental Services)

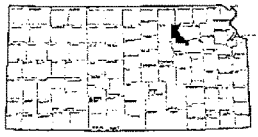
HB/shb

enclosure

enclosure for Manhattan Levee Project PAL
Kansas Department of Wildlife, Parks, and Tourism
Riley County, Kansas Threatended & Endangered Species and Species in Need of Conservation

Updated: 6/1/05

Riley County



Riley County 48 48 kB

THREATENED AND ENDANGERED SPECIES

American Burying Beetle *Nicrophorus americanus* State: END Federal: END Critical Habitat: NO
Bald Eagle *Haliaeetus leucocephalus* State: THR Federal: THR Critical Habitat:YES
Eastern Spotted Skunk *Spilogale putorius* State: THR Federal: NA Critical Habitat: NO
Eskimo Curlew *Numenius borealis* State: END Federal: END Critical Habitat: NO
Least Tern *Sterna antillarum* State: END Federal: END Critical Habitat:YES
Peregrine Falcon *Falco peregrinus* State: END Federal: NA Critical Habitat: NO
Piping Plover *Charadrius melodus* State: THR Federal: THR Critical Habitat:YES
Silver Chub *Macrhybopsis storeriana* State: END Federal: NA Critical Habitat: NO
Snowy Plover *Charadrius alexandrinus* State: THR Federal: NA Critical Habitat: NO
Sturgeon Chub *Macrhybopsis gelida* State: THR Federal: CAN Critical Habitat:YES
Topeka Shiner *Notropis topeka* State: THR Federal: END Critical Habitat:YES
Whooping Crane *Grus americana* State: END Federal: END Critical Habitat: NO

SPECIES IN NEED OF CONSERVATION

Black Rail *Laterallus jamaicensis* State: SNC Federal: NA Critical Habitat: NA
Black Tern *Chlidonias niger* State: SNC Federal: NA Critical Habitat: NA
Bobolink *Dolichonyx oryzivorus* State: SNC Federal: NA Critical Habitat: NA
Eastern Hognose Snake *Heterodon platirhinos* State: SNC Federal: NA Critical Habitat: NA
Franklin's Ground Squirrel *Spermophilus franklini* State: SNC Federal: NA Critical Habitat: NA
Golden Eagle *Aquila chrysaetos* State: SNC Federal: NA Critical Habitat: NA
Henslow's Sparrow *Ammodramus henslowii* State: SNC Federal: NA Critical Habitat: NA
Highfin Carpsucker *Carpiodes velifer* State: SNC Federal: NA Critical Habitat: NA
Long-billed Curlew *Numenius americanus* State: SNC Federal: NA Critical Habitat: NA
Plains Minnow *Hybognathus placitus* State: ~~END~~ Federal: NA Critical Habitat: NA State: THR
Short-eared Owl *Asio flammeus* State: SNC Federal: NA Critical Habitat: NA
Southern Bog Lemming *Synaptomys cooperi* State: SNC Federal: NA Critical Habitat: NA
Timber Rattlesnake *Crotalus horridus* State: SNC Federal: NA Critical Habitat: NA
Western Hognose Snake *Heterodon nasicus* State: SNC Federal: NA Critical Habitat: NA
Whip-poor-will *Caprimulgus vociferus* State: SNC Federal: NA Critical Habitat: NA
Yellow-throated Warbler *Dendroica dominica* State: SNC Federal: NA Critical Habitat: NA

Download PDF

Email Page

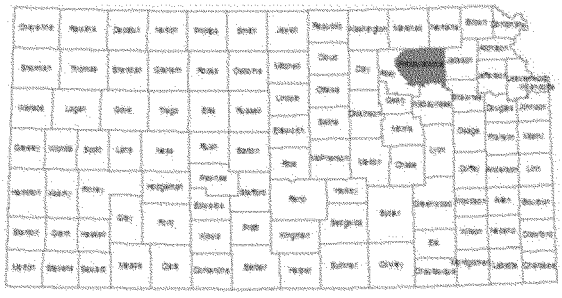
eZ publish™ copyright © 1999-2005 eZ systems as

Kansas Department of Wildlife, Parks and Tourism

Kansas Department of Wildlife, Parks and Tourism

Pottawatomie County

Print This Page | Back to Site



Threatened and Endangered (T&E) Species

PIPING PLOVER *Charadrius melodus*
State: Threatened **Federal:** Threatened **Critical Habitat:** Yes

STURGEON CHUB *Macrhybopsis gelida*
State: Threatened **Federal:** Candidate **Critical Habitat:** Yes

SILVER CHUB *Macrhybopsis storeriana*
State: Endangered **Federal:** N/A **Critical Habitat:** Yes

LEAST TERN *Sterna antillarum*
State: Endangered **Federal:** Endangered **Critical Habitat:** Yes

PLAINS MINNOW *Hybognathus placitus*
State: Threatened **Federal:** N/A **Critical Habitat:** Yes

SHOAL CHUB *Macrhybopsis hyostoma*
State: Threatened **Federal:** N/A **Critical Habitat:** Yes

AMERICAN BURYING BEETLE *Nicrophorus americanus*
State: Endangered **Federal:** Endangered **Critical Habitat:** No

EASTERN SPOTTED SKUNK *Spilogale putorius*
State: Threatened **Federal:** N/A **Critical Habitat:** No

SNOWY PLOVER *Charadrius alexandrinus*
State: Threatened **Federal:** N/A **Critical Habitat:** No

Species In Need of Conservation (SINC)

Southern Bog Lemming *Synaptomys cooperi*
State: SINC **Federal:** N/A **Critical Habitat:** No

Whip-poor-will *Camprimulgus vociferus*
State: SINC **Federal:** N/A **Critical Habitat:** No

Yellow-throated Warbler *Dendroica dominica*
State: SINC **Federal:** N/A **Critical Habitat:** No

Black Tern *Chlidonias niger*

State: SINC **Federal:** N/A **Critical Habitat:** No

Short-eared Owl *Asio flammeus*
State: SINC **Federal:** N/A **Critical Habitat:** No

Franklin's Ground Squirrel *Spermophilus franklinii*
State: SINC **Federal:** N/A **Critical Habitat:** No

Golden Eagle *Aquila chrysaetos*
State: SINC **Federal:** N/A **Critical Habitat:** No

Highfin Carpsucker *Carpiodes velifer*
State: SINC **Federal:** N/A **Critical Habitat:** No

Timber Rattlesnake *Crotalus horridus*
State: SINC **Federal:** N/A **Critical Habitat:** No

Southern Redbelly Dace *Phoxinus erythrogaster*
State: SINC **Federal:** N/A **Critical Habitat:** No

Blue Sucker *Cycleptus elongatus*
State: SINC **Federal:** N/A **Critical Habitat:** No

Eastern Hognose Snake *Heterodon platirhinos*
State: SINC **Federal:** N/A **Critical Habitat:** No

Common Shiner *Luxilus cornutus*
State: SINC **Federal:** N/A **Critical Habitat:** No

Johnny Darter *Etheostoma nigrum*
State: SINC **Federal:** N/A **Critical Habitat:** No

Bobolink *Dolichonyx oryzivorus*
State: SINC **Federal:** N/A **Critical Habitat:** No

Email Page Printable Version

FINAL FISH AND WILDLIFE COORDINATION ACT REPORT FOR THE MANHATTAN, KANSAS MANHATTAN LEVEE FEASIBILITY STUDY

PREPARED FOR THE

The Kansas City District
U.S. Army Corps of Engineers
Kansas City, Missouri

Prepared by

U.S. Fish and Wildlife Service
Kansas Ecological Services Field Office
Manhattan, Kansas
August, 2014

TABLE OF CONTENTS

INTRODUCTION 1
DESCRIPTION OF THE STUDY AREA 3
Terrestrial Resources 4
Aquatic Resources 7
Wetlands 7
Federal Threatened and Endangered Species and Trust Resources 8
Migratory Bird Treaty Act 14
Bald Eagle 14
State Listed Species 15
EVALUATION OF ALTERNATIVES CONSIDERED 16
FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT 18
FISH AND WILDLIFE RESOURCES WITH THE PROJECT 18
WILDLIFE AND HABITAT IMPACTS 19
RECREATION 22
RECOMMENDATIONS 23
LITERATURE CITED 25

LIST OF FIGURES

Figure 1. Project Area

Figure 2. Land Cover Map

Figure 3. NWI Map for Proposed Borrow Area

Figure 4. NWI Map of Southern Portion of Project Area

Figure 5. NWI Map of Middle Portion of Project Area

Figure 6. NWI Map of Northeast Portion of Project Area

EXECUTIVE SUMMARY

The City of Manhattan, Kansas sits at the confluence of the Big Blue River, the Kansas River, and Wildcat Creek. Flow on the Big Blue River is largely controlled by releases from Tuttle Creek Dam, which is approximately six miles north of the City of Manhattan and 12.3 miles above the confluence with the Kansas River. The existing Manhattan Kansas local protection project is primarily comprised of one levee unit and associated appurtenances. The levee unit withstood the Flood of 1993, but some elements of the system were seriously challenged as the flood crested. This event raised a concern that the levee may provide less than the authorized benefits for which it was designed. The US Army Corps of Engineers in cooperation with the local project sponsor (City of Manhattan, Kansas) are conducting a feasibility study to identify alternatives for flood risk reduction on the current Manhattan local protection project.

The Corp's Draft Feasibility Study (DFS) stated that Plan 3 – 0.33% Plan (formerly named the N300+0 levee raise alternative) is the National Economic Development (NED) plan and the recommended plan. This alternative would raise the Big Blue River portion of the levee an average of 1.5 feet with up to a 3.3-foot raise in some locations to the 300-year level of protection (0.33% flood) with zero freeboard. The stationing of the levee raise would be from approximately 131+00 to 273+00 with an approximately 500-foot extension for tie-in along Casement Road to the upper end of the Big Blue River Segment and include a new sandbag gap. The project would also entail the construction of associated infrastructure consisting of gatewells, landside toe embankment sand drains, relief wells, collector ditches, and underseepage berms.

Riparian vegetation is the only resource of significance anticipated to be impacted by the proposed flood control work. Approximately 6.23 acres of forested habitat and 0.67 acre of shrubland habitat would be lost.

RECOMMENDATIONS

1. Riparian and wetland habitats should be avoided to the maximum extent practicable during construction and when selecting borrow sites for the proposed levee improvements. Since channelization, levee construction and floodplain development have already resulted in dramatic loss of riparian and wetland habitats in the Kansas River basin within the project area, the Corps should focus on bare or cropland areas for borrow.

2. The non-native, invasive brome and fescue grasses used on the levee could be replaced with native grasses which would provide a higher habitat value than the non-native grasses. The USDA – Natural Resource Conservation Service's Plants Database (http://plants.usda.gov/java/) lists three species of fescue that are native to Kansas: clustered fescue (*Festuca paradoxa*), nodding fescue (*Festuca subverticillata*), and Rocky Mountain fescue (*Festuca saximontana*). Clustered fescue and nodding fescue

have been found in Riley and Pottawatomie Counties while Rocky Mountain fescue has not been found in either county. Other native grasses which might be suitable for use on the levees include buffalo grass (*Bouteloua dactyloides*) and western wheat grass (*Pascopyrum smithii*).

3. Removal of woodlands and other native vegetation should be avoided where possible. Upland trees within the construction right-of-way should remain undisturbed if possible. If avoidance is not possible a plan to replace those habitat losses should be developed in coordination with the U.S. Fish and Wildlife Service (Service) and the Kansas Department of Wildlife, Parks and Tourism (KDWPT).

4. Bald eagle potential roost and nest sites should be protected and preserved by retaining mature trees and old growth stands, particularly within one-half mile from water. If any project activity appears likely to harass or disturb any bald eagle observed at or near the project area the Service should be notified prior to commencement of the activity, so that an assessment may be made of the potential for adverse impacts.

5. All disturbed areas should be immediately planted with native vegetation following construction to prevent erosion and the establishment of invasive species.

6. Best Management Practices to prevent the transport of invasive species to or from the construction sites should be included as an integral component of the project.

7. Establish native vegetation riverward of levee segments where riparian woodlands are sparse or nonexistent or where invasive species have become established.

8. Runoff from construction areas into streams, rivers and wetlands should be avoided. Inadvertent trampling by workers or machinery in those areas should be prevented.

9. The potential use of borrow sites for wetland and aquatic habitat enhancement and public recreation should be investigated with the project sponsors and borrow site owners.

10. If possible, establish replacement areas prior to the onset of impacts from the project to lessen the impacts to wildlife from habitat loss.

11. Closings of the trails in Linear Park should be kept to a minimum both in length of area and amount of time closed. Alternative route(s) should be provided around the construction areas to preserve the connectivity of the trail.

12. Mark and/or modify all overhead lines incorporating the guidelines found in the following documents:
Avian Protection Plan (APP) Guidelines
(http://www.aplic.org/uploads/files/2634/APPguidelines_final-draft_Aprl2005.pdf);
"Suggested Practices for Avian Protection on Power lines: The State of the Art in 2006"
(http://www.aplic.org/uploads/files/2643/SuggestedPractices2006(LR-2).pdf); and

"Reducing Avian Collisions with Power Lines: the State of the Art in 2012 (Avian Power Line Interaction Committee (APLIC), 2012) (http://www.aplic.org/uploads/files/11218/Reducing_Avian_Collisions_2012watermarkLR.pdf).

INTRODUCTION

This Final Fish and Wildlife Coordination Act Report (FCAR) is submitted pursuant to the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.), and the fiscal year 2013 Scope-of-Work Agreement between the U.S. Fish and Wildlife Service (Service) and the U.S. Army Corps of Engineers, Kansas City District (Corps) for the Manhattan, Kansas Levee Feasibility Study. The FCAR is designed to accompany and is to be incorporated into the Corps' Final Feasibility Study/Environmental Assessment on the proposed project. The Service has previously provided a draft Planning Aid Letter (PAL) dated June 14, 2013, a final PAL dated September 24, 2013, and a Draft Fish and Wildlife Coordination Act Report (DCAR) dated March 2014. The CAR has been prepared in cooperation with the Kansas Department of Parks, Wildlife, and Tourism (KDWPT). A letter of concurrence from KDWPT, if it is forthcoming, will be forwarded to the Kansas City District, Corps of Engineers to include as an appendix to the FCAR.

This study was authorized under authority of Section 205 of the Flood Control Act of 1948, as amended.

The Big Blue River tieback elevation was originally designed for an 110,000 cfs release from Tuttle Creek Reservoir plus two feet of freeboard. The existing levee withstood the 1993 Flood, with flows of 60,000 cfs on the Big Blue River and peak flows of 100,000 cfs on the Kansas River, but releases from Tuttle Creek Dam created a near overtopping situation at some Big Blue River levee locations. The 1993 event raised concerns that the levee may provide much less than the design level of performance.

The Manhattan Levee is located in Riley and Pottawatomie Counties. The Manhattan Levee consists primarily of an earthen levee (5.4 miles), various interior drainage features, pump plants, and levee underseepage controls. For the purpose of the feasibility study the Manhattan levee is described as two major segments (Figure 1):

1. The Big Blue segment extends along the right bank of the Big Blue River from upstream near Casement Road down to the Kansas River confluence.

2. The Kansas River segment starts on high ground on the left bank of Wildcat Creek in the vicinity of 4th Street and then extends along the left bank of the Kansas River to the mouth of the Big Blue River.

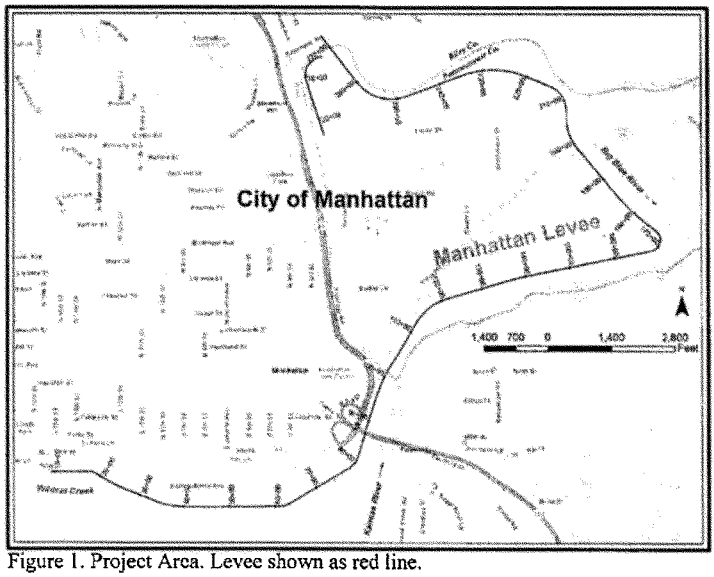


Figure 1. Project Area. Levee shown as red line.

The Corps has indicated that Plan 3 appears to be the best candidate for the National Economic Development (NED) plan and is the recommended plan. This alternative would raise the Big Blue River portion of the levee an average of 1.5 feet with up to a 3.3-foot raise in some locations. The preliminary cost estimate for this alternative is $18 million in 2012 dollars.

The Recommended Plan would raise the existing levee to the 300-year level of protection (0.33% flood) with zero freeboard. The stationing of the levee raise would be from approximately 131+00 to 273+00 with an approximately 450-foot extension up Casement Road (via a road raise) on the Big Blue River Segment that is needed to meet high ground. Gatewells would be replaced at stations 14+78, 62+20, 89+83, 163+00, and 269+50. Landside toe embankment sand drains would be installed at stations 8+00, to 97+00, 110+00 to 137+00, and 165+00 to 269+50. Relief wells and collector ditches would be constructed at stations 64+00 to 97+00, 110+00 to 120+00, and 265+70 to 269+50. Underseepage berms would be constructed at 120+00 to 137+00, and 165+00 to 177+00.

Riparian vegetation is the only resource of significance anticipated to be impacted by the proposed flood control work. The Corps estimates that 6.23 acres of forested habitat and 0.67 acres of shrubland habitat would be lost. Although the amount of forested and shrubland riparian habitat lost may appear to be low, this type of native vegetation represents valuable wildlife habitat. To minimize the long term impact to terrestrial habitat and wildlife the Corps is proposing to plant native vegetation where possible

following construction in the temporary construction easements and the permanent easements that were cleared during construction and to identify potential ways to enhance or expand existing riparian corridors. We support this initiative. Planting of disturbed areas to native vegetation is important to prevent the colonization of these areas by exotic, invasive, and undesirable species (e.g. bush honeysuckle, eastern red cedar, reed canary grass) which would provide little value for wildlife but would provide entry point for invasion into adjacent areas further degrading the remaining wildlife habitat.

The Corps has inspected the levee and project area and has found no wetlands or other Waters of the U.S. that would be impacted by the project.

The levee constitutes a major portion of Linear Park, a trail system for walking, hiking, and bicycling. Off-road bicycling trails take off from Linear Park and traverse the woody riparian area riverward of the levee. Linear Park is heavily used by the residents of Manhattan both for recreation and as an alternative transportation route by pedestrians and bicyclists. Trail closings due to construction activity would be a disruption to the user community and would be acutely felt.

DESCRIPTION OF THE STUDY AREA

The City of Manhattan covers an area of approximately 18.79 square miles and as of the 2010 census, the city population was 52,281. Manhattan is located in the Flint Hills region of Kansas, which consists of continuous rolling hills covered in tall grasses. The current downtown area, the original site of Manhattan, was built on a broad, flat floodplain at the junction of the Kansas and Big Blue rivers. The floodplains of the Big Blue and Kansas River in the study area have been predominantly developed as residential and business areas. Manhattan has faced recurring flooding during times of heavy precipitation. The largest floods in the town's history were in 1903, 1908, 1951 and 1993. In 1993 the emergency flood gates for Tuttle Creek Reservoir were opened, which combined with large outflows from other reservoirs on tributaries to the Kansas River, resulted in an increase in the flood levels in the City of Manhattan.

Tuttle Creek Dam and Reservoir is located on the Big Blue River approximately six miles north of the City of Manhattan or 12.3 miles above its confluence with the Kansas River near river mile 147. Construction of the Dam was initiated 1952 and storage of water in the lake began in 1962. The lake became fully operational for all congressionally authorized purposes when it reached multipurpose pool in April of 1963. Tuttle Creek Reservoir controls the flow of the Big Blue River downstream of the dam.

The construction of the Manhattan, Kansas Flood Protection Project (Manhattan levee) was initiated in 1961 and the completed project was transferred to the City of Manhattan for operation and maintenance in 1963. The Corps states that the Manhattan levee provides a limited amount of protection to the City of Manhattan from flooding along two major rivers, the Kansas River and the Big Blue River.

The levee was built close to the Big Blue and Kansas Rivers constricting their floodplains and limiting the amount of riparian habitat (Figure 3). The areas between the river and levees contain much of the remaining available wildlife habitat in the project area.

The latest proposed borrow area is within a row crop field adjacent to the original levee borrow area which has developed into forested wetland and shrub-scrub wetland as shown on the National Wetland Inventory map.

The soils of the project area typically are classified within the Eudora-Haynie-Sarpy soil series. These are deep, nearly level silt loams, very fine sandy loams, and loamy fine sands on terraces and flood plains. The soils along the Kansas and Big Blue Rivers in the City of Manhattan typically fall into the Eudora series which occurs on the bottom lands along the Kansas and Big Blue Rivers. The soils around Wildcat Creek and south of the K-177 Kansas River Bridge, which includes the proposed borrow area, are of the Haynie soil series which consist of very fine sandy loam. In general the more sandy soils occur on the lowest bottoms next to the river channels and the soils that have higher clay content are on the highest terraces farthest from the channels. Eudora soils are on upper terraces that are rarely flooded. Haynie soils are on the flood plain and are well drained. Sarpy soils are also associated with flood plains and are described as being excessively drained.

Terrestrial Resources

Most of the vegetation in the study area has been greatly impacted by urban development and agricultural land clearing. The major land use adjacent to the project area is urban, with cropland being the second major land use. There are a few small patches of native prairie and woodlands near the project area most notably the restored native prairie and woodland areas in Northeast Park. The project area itself, consisting of the levee and the land between the levee and the banks of the Kansas River, Big Blue River, and Wildcat Creek, is primarily used for recreation. The majority of the grasslands within the project footprint are either mowed turf grass or un-mowed areas that contain a majority of non-native species with a few native grass or forb species scattered within them. Domestic grass is used for landcover on the levee. The area riverward of the levee contains much of the remaining native vegetation and wildlife habitat. There is a narrow linear strip of riparian woodlands along most of the length of the rivers in the project area consisting of native tree species like cottonwood, willow, sycamore, American elm, and maple, along with grasses, shrubs, and herbaceous species (Figure 2). Historically the riparian vegetative community consisted of American elm, bur oak, poplar, sycamore, red-bud, hackberry, and buckeye. Common species of shrubs included poison ivy, greenbrier, gooseberry, and coral berry. Common shrubs vines included Virginia creeper, poison oak, and grapes. Violets and nettles were abundant herbs (Dice, 1923).

The riparian woodland that remains along the two rivers and Wildcat Creek is the highest quality habitat in the project area. It offers the greatest vegetative diversity and degree of interspersion with other habitat types, which is important to many wildlife species providing food and cover for local wildlife, many neotropical migrant birds, and wintering habitat for the bald eagle. Riparian woodlands have been found to support significantly higher abundance and diversity of bird species compared to upland forests (Brinson 1981). The lack of native vegetation is a limiting factor for the populations of these species. Additionally, riparian woodlands are important for preventing streambank erosion; intercepting sediments and pollutants before entering streams; providing shade and leaf detritus to the stream; and providing recreational opportunities through fishing, nature study, and wildlife observation. Linear corridors of habitat, such as that found along the Kansas River, allow animals to disperse throughout their ranges, preventing genetic isolation and allowing the reestablishment of populations in areas where wildlife may have been eliminated in the past.

The Kansas River, Big Blue River and Wildcat Creek also provide important habitat for wildlife. The rivers provide waterfowl and shorebird resting, feeding, and staging areas during migration. In spring and summer, sandbars and islands provide protected feeding and potential nesting sites for Canada geese and shorebirds. Stream banks provide habitat for bank swallows, belted kingfishers, beaver, and muskrat. The remaining areas of native vegetation provide vital habitat for local wildlife and migrating songbirds.

Thompson and Ely (1989) report that 424 bird species have been recorded in Kansas. The state's central location is an important contributing factor to this large species count, containing both eastern deciduous forest and the central grasslands and it is on a major flyway. Kansas is also a wintering area for far-northern birds, as well as a breeding area for typically southern species. Kansas' major rivers funnel in stragglers from the Rocky Mountains. Many migratory songbird species are dependent on woodlands, and especially riparian woodlands, for food, shelter, and rearing of young. As a prairie state, bird species dependent on grasslands are predominant in Kansas. However, as a group, grassland birds are declining at a faster rate than any other group of birds in North America.

Reptiles and amphibians found in Riley County include the collard lizard, ring-neck snake, horned toad, Texas horned lizard, ground skink, tiger salamander, plains spadefoot, great plains toad, Woodhouse's toad, Blanchard's cricket frog, western chorus frog, gray treefrog, plains leopard frog, bullfrog, plains narrowmouth toad, common snapping turtle, ornate box turtle, western painted turtle, midland smooth softshell turtle, western spiny softshell turtle, great plains skink, prairie-lined racerunner, western slender glass lizard, western hognose snake, eastern hognose snake, western worm snake, prairie ringneck snake, western smooth green snake, eastern yellowbelly racer, great plains rat snake, black rat snake, bullsnake, prairie kingsnake, common kingsnake, milk snake, plains black headed snake, flat-headed snake, red-sided garter snake, western plains garter snake, lined snake, Texas brown snake, blotched water snake, diamond-backed water snake, northern water snake, copperhead, timber rattlesnake. Garter snakes and

ringneck snakes are often seen sunning on Linear Trail (Susan Blackford pers. observation).

Aquatic Resources

Ninety-nine species of fish inhabit the Kansas River basin of which at least 19 are probably introduced, non-native species. The distribution and abundance of most species have changed markedly in this century in response to reservoir construction and land use changes. Species found in the Kansas River, Blue River, Wildcat Creek and tributaries in the close proximity to Manhattan include shovelnose sturgeon, paddlefish, longnose gar, shortnose gar, goldeye, American eel, gizzard shad, red shiner, common carp, speckled chub, plains minnow, common shiner, silver chub, emerald shiner, sand shiner, rosyface shiner,Topeka shiner, suckermouth minnow, bluntnose minnow, creek chub, river carpsucker, quillback, white sucker, blue sucker, smallmouth buffalo, bigmouth buffalo, black buffalo, shorthead redhorse, yellow bullhead, blue catfish, channel catfish, slender madtom, stonecat, flathead catfish, misquitofish, white bass, orangespotted sunfish, bluegill, largemouth bass, white crappie, orangethroat darter, sauger, and freshwater drum (Cross and Collins, 1995).

In a 1977 report, published by the Kansas Forestry, Fish and Game Commission (Dowlin, et al, 1977) angler utilization from approximately Junction City to Kansas City was 29,909 angler days per year. With increasing population during the last 20 years within the river corridor from Junction City to Kansas City, recreation and angler days have, no doubt, also increased.

The Kansas River adjacent to Manhattan is likely under-utilized by the resident population. This may be due, in part to a lack of adequate access or development of park lands riverward of the flood control levee system. However, recent efforts have been made to address this issue. Several boat launching facilities and river user access sites have been constructed along the Kansas River in recent years. One access site named the Fairmont Park Boat Ramp, on the south side of the River under the K-177 highway bridge over the Kansas River at River Mile 149.3, was constructed in 2008 near the project area. A long time established boat ramp is located on the Big Blue River near the US 24 bridge. Boating use, including canoes and kayaks, in the Big Blue River and Kansas River adjacent to Manhattan is a popular activity. Fairmont Park on the south side of the Kansas River (downstream from the boat ramp) was established following the 1993 flood and has river access via trails.

Wetlands

The Corps stated in the Draft EA that no wetlands have been identified in the project's footprint area. However, there are wetlands near the project site. The NWI identifies wetlands landward of the levee and in-stream wetlands in the Kansas River (Figures 4, 5 and 6). In addition, the original borrow area used for the initial construction of the Manhattan Levees has developed into wetlands as identified on the NWI (Figure 3). The latest proposed borrow area for this project is located adjacent to the original borrow site.

Federal Threatened and Endangered Species and Trust Resources

Section 7 of the Endangered Species Act, 87 Stat. 884, as amended, requires Federal Agencies to ask the Secretary of the Interior, acting through the U.S. Fish and Wildlife Service, whether any listed or proposed endangered species may be present in the area of each Federal construction project. If the project may affect listed species, the Corps of Engineers should initiate formal Section 7 consultation with this office. If there will be no effect, or if the Fish and Wildlife Service concurs in writing that there will be beneficial effects, further consultation is not necessary.

Species listed under the Endangered Species Act (ESA) for Riley County are the interior least tern (*Sterna antillarum*), listed as endangered; piping plover (*Charadrius melodus*), listed as threatened; and the Topeka shiner (*Notropis topeka*), listed as endangered. The Sprague's pipit (*Anthus spragueii*), is a candidate species. In addition, the northern long-eared bat (*Myotis septentrionalis*) (NLEB) is currently proposed for listing under the Endangered Species Act (ESA) (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*).

Least Tern and Piping Plover: The high flows on the Kansas River in July 1993 and in May 1995 caused many new high elevation sandbars on the Kansas River. This flood-induced habitat was attractive to piping plovers, and least terns. The first documented nesting of least terns and piping plovers was in 1996 and 1997, respectively (Busby 1997). This was the first nesting of piping plover ever recorded in Kansas and the first time least terns were known to nest along the Kansas River. Since 1998, nesting locations of these two bird species have been monitored throughout the breeding season to determine productivity of the species (Boyd 2005).

Our office has worked closely with the Kansas City District Corps of Engineers (Corps) to monitor nesting tern and plover colonies on the Kansas River. We are involved in water release decisions made by the Corps in an attempt to avoid direct take of active nests. Beginning in 1997, the Service's Kansas Field Office staff has conducted boat surveys of the upper Kansas River, searching for tern and plover nesting colonies. Currently, there are no tern and plover nests near the project site. However, suitable

habitat exists in the Kansas River near the Manhattan Levee project area. Even though project activities are not anticipated to directly impact this habitat, construction activities could disturb nesting least terns and piping plovers from noise and human and machine movement. Least terns and piping plovers generally nest between May 1st and August 31st. If construction occurs in areas visible to unvegetated sand bars in the Kansas River during those dates, we recommend that the area be surveyed by a qualified biologist to locate any nesting least terns or piping plovers. If nesting least terns or piping plovers are located, this office should be consulted.

Topeka Shiner: The Topeka shiner historically inhabited Wildcat Creek in the Manhattan area. There have been no recent surveys on Wildcat Creek through the City of Manhattan to document the continued presence of Topeka shiners in this reach. However, surveys have confirmed their presence in Wildcat Creek on Ft. Riley and downstream of Ft. Riley to the west side of Manhattan. Sedimentation and runoff from construction areas into Wildcat Creek should be avoided. Given the current project plans in that no work will be conducted in streams or rivers we have not discussed timing restrictions and other conditions to protect the Topeka shiner. Should that change please contact this office to discuss your plans.

Sprague's Pipit: The Sprague's pipit is a small passerine bird (about the size of a bluebird) of the open grasslands. Although it prefers large tracts of shortgrass prairie for nesting, they seem to be a generalist in their preferences during migration and may occur infrequently in any short grass habitat of any size anywhere in Kansas during migration. It feeds and nests exclusively on the ground. Insects, spiders and some seeds comprise its diet. Spring migration primarily occurs in April and May while fall migration occurs primarily from late September through early November. It is unlikely that they would be found in the project area.

Northern Long-Eared Bat: The northern long-eared bat (NLEB) is currently proposed for listing under the Endangered Species Act (ESA) (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*). The final listing decision for the NLEB is expected in April 2015. At this time, no critical habitat has been proposed for the NLEB. The state of Kansas is within the known range of the NLEB and there are historical sightings from Riley County. During the summer, NLEBs typically roost singly or in colonies in cavities, underneath bark, crevices, or hollows of both live and dead trees and/or snags (typically ≥3 inches dbh). Males and non-reproductive females may also roost in cooler places, like caves and mines. This bat seems opportunistic in selecting roosts, using tree species based on presence of cavities or crevices or presence of peeling bark. It has also been occasionally found roosting in structures like barns and sheds, particularly when suitable tree roosts are unavailable. They forage for insects in upland and lowland woodlots and tree lined corridors. During the winter, NLEBs predominately hibernate in caves and abandoned mine portals. NLEB maternity habitat is defined as suitable summer habitat used by juveniles and reproductive females. NLEB home ranges, consisting of maternity, foraging, roosting, and commuting habitat, typically occur within three miles of a documented capture record or a positive identification of NLEB from properly deployed acoustic devices, or within 1.5 miles of a known suitable roost tree.

(http://www.fws.gov/midwest/endangered/mammals/nlba/pdf/NLEBinterimGuidance6Jan2014.pdf). Additional habitat types may be identified as new information is obtained.

Pursuant to Section 7(a)(4) of the ESA, federal action agencies are required to confer with the Service if their proposed action is likely to jeopardize the continued existence of the NLEB (50 CFR 402.10(a)). Action agencies may also voluntarily confer with the Service if the proposed action may affect a proposed species. Species proposed for listing are not afforded protection under the ESA; however as soon as a listing becomes effective, the prohibition against jeopardizing its continued existence and take applies **regardless of an action's stage of completion.** If the agency retains any discretionary involvement or control over on-the-ground actions that may affect the species after listing, section 7 applies. Therefore, if suitable NLEB habitat is present within the proposed project area, we recommend further coordination with our office to avoid potential project delays should the species be listed. NLEB survey may be necessary depending on the time of tree clearing. Additional information regarding NLEB and conference procedures can be found (http://www.fws.gov/midwest/endangered/mammals/nlba/index.html) http://www.fws.gov/midwest/endangered/mammals/nlba/pdf/NLEBinterimGuidance6Jan2014.pdf.

Migratory Bird Treaty Act

Under the Migratory Bird Treaty Act (MBTA), construction activities in prairies, wetlands, streams, and woodland habitats, including the removal of upland borrow, and those that occur on bridges (e.g., which may affect swallow nests on bridge girders) that would otherwise result in the taking of migratory birds, eggs, young, and/or active nests should be avoided. Although the provisions of the MBTA are applicable year-round, most migratory bird nesting activity in Kansas occurs during the period of April 1 to July 15. However, some migratory birds are known to nest earlier than this (e.g., hawks, owls, and eagles) and some later (e.g., goldfinches). If the proposed project may result in the take of nesting migratory birds, the Service recommends a field survey during the nesting season of the affected habitats and structures to determine the presence of active nests. The location of active nests should be avoided until all young have fledged to avoid a taking under the MBTA. Our office should be contacted immediately for further guidance if a field survey identifies the existence of one or more active bird nests that cannot be avoided temporally or spatially by the planned activities.

Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) which is known to occur in the project area, is protected by the Bald and Golden Eagle Protection Act (Eagle Act) and the Migratory Bird Treaty Act (MBTA). A variety of human activities can potentially impact bald eagles, affecting their ability to forage, nest, roost, breed, or raise young. Bald eagles are frequently observed near or in the project area roosting in trees, loafing on sandbars in the river, and flying along the river corridor. Although nesting occurs nearby (around Tuttle Creek Reservoir, on Ft. Riley, and upstream and downstream of the project site along the

Kansas River), there have been no nests observed in the project area at this time. However, this is subject to change as bald eagles change nesting trees or new pairs establish territories. Bald eagles use large live trees and snags for perches.

The USFWS has developed National Bald Eagle Management Guidelines (http://www.fws.gov/midwest/eagle/pdf/NationalBaldEagleManagementGuidelines.pdf) to advise landowners, land managers, and others who share public and private lands with bald eagles when and under what circumstances the protective provisions of the Eagle Act may apply to their activities. These Guidelines are intended to help people minimize such impacts to bald eagles, particularly where they may constitute "disturbance," which is prohibited by the Eagle Act.

We encourage you to protect and preserve potential roost and nest sites by retaining mature trees and old growth stands, particularly within one-half mile from water. If any project activity appears likely to harass or disturb any bald eagle observed at or near the project area the Service should be notified prior to commencement of the activity, so that an assessment may be made of the potential for adverse impacts.

State Listed Species

Kansas State Law (K.S.A. 32-504, 32-507: effective May 1, 1981) requires persons undertaking or sponsoring publicly funded or State or Federally Assisted action which is likely to impact endangered or threatened wildlife habitat where they are likely to occur, to obtain a project action permit from the Secretary of the Kansas Department of Wildlife, Parks and Tourism (KDWPT) prior to initiation of such action. In addition to the federally-listed threatened and endangered species, the State lists additional species that may be of concern within the project areas.

The KDWPT maintains a list of State listed threatened and endangered species and species in need of conservation (SINC). As these lists are periodically updated, the Corps should contact KDWP directly for the most current information at Environmental Services Section, 512 SE 25th Ave, Pratt KS 67124-8174.

State-listed endangered species in Riley County include American burying beetle (*Nicrophorus americanus*), Eskimo curlew (*Numenius borealis*), least tern (*Sterna antillarum*), peregrine falcon (*Falco peregrinus*), silver chub (*Macrhybopsis storeriana*), and whooping crane (*Grus americana*). KDWPT has designated critical habitat for the least tern.

State listed threatened species in Riley County includes bald eagle (*Haliaeetus leucocephalus*), eastern spotted skunk (*Spilogale putorius*), piping plover (*Charadrius melodus*), plains minnow (*Hybognathus placitus*), snowy plover (*Charadrius alexandrinus*), sturgeon chub (*Macrhybopsis gelida*), and Topeka shiner (*Notropis topeka*). KDWPT has designated critical habitat for the bald eagle, piping plover, sturgeon chub, and Topeka shiner.

SINC species listed for Riley County include the black rail (*laterallus jamaicensis*),black tern (*Chlidonias niger*), bobolink (*Dolichonyx oryzinvorus*), eastern hognose snake (*Heterodon platirhinos*), Franklin's ground squirrel (*Spermophilus franklinii*), golden eagle (*Aquila chrysaetos*), Henslow's sparrow (*Ammodramus henslowii*),highfin carpsucker (*Carpiodes velifer*), long-billed curlew (*Numenius americanus*), , short-eared owl (*Asio flammeus*), southern bog lemming (*Synaptomys cooperi*), southern flying squirrel (*Glaucomys volans*), tadpole madtom (*Noturus gyrinus*), timber rattlesnake (*Crotalus horridus*), western hognose snake (*Heterodon nasicus*), whip-poor-will (*Camprimulgus vociferous*), and yellow-throated warbler (*Dendroica dominica*).

EVALUATION OF ALTERNATIVES CONSIDERED

The feasibility study includes preliminary engineering, formulation of project alternatives, environmental assessment, economic evaluations, and real estate studies. The Corps has stated that the early alternatives examination show that construction of certain levee reliability improvements and raising the existing Big Blue Levee segment produce solid positive net benefits and offers a good opportunity to pursue a Federal cost-shared project with the Corps.

The DFS explored five alternatives:

Plan 1 – No Federal Action Alternative: The No Federal Action option would result in no increase in the current level of flood protection. Structures within the protected zone would continue to be at a higher risk for flooding during large flood events. This plan was previously named the No Federal Plan.

Plan 2 – 0.5% Plan: This alternative would raise the current levee to pass the nominal 0.5% chance flood event profile. The stationing of the raise would be from approximately 200+00 to 272+85 with an approximately 200-foot extension for tie-in along Casement Rd upper end of Big Blue River Segment to include a new sandbag gap. Gatewells would be replaced at stations 14+78, 62+20, 89+83, 163+00, and 269+50. A Landside toe embankment sand drain would be installed along a portion of the Big Blue River levee segment. Relief wells would be constructed at stations 64+00 to 97+00, 110+120+00, and 265+70 to 269+50. Underseepage berms would be constructed at 120+00 to 137+00, and 165+00 to 173+50. This plan was previously named the N200+0.

Plan 3 – 0.33% Plan (Recommended Plan): The Recommended Plan would raise the current levee to pass the nominal 0.33% chance flood event profile. The stationing of the levee raise would be from approximately 131+00 to 277+53 with an approximately 500-foot extension for tie-in along Casement upper end of Big Blue River Segment to include a new sandbag gap. Gatewells would be replaced at stations 14+78, 62+20, 89+83, 163+00, and 269+50. A landside toe embankment sand drain would be installed along a portion of the Big Blue River levee segment. Relief wells would be constructed at stations 64+00 to 97+00, 110+120+00, and 265+70 to 269+50. Underseepage berms

would be constructed at 120+00 to 137+00, and 165+00 to 173+50. This plan was previously named the N300+0.

Plan 4 – 0.2% Plan: This plan would raise the current levee to pass the nominal 0.2% chance flood event profile. The stationing of the raise would be from approximately -8+50 to 72+00 and from 101+00 to 277+53. There would also be an approximately 1700-foot extension for tie-in along Wildcat Creek and Riley Lane upper end of Kansas River levee Segment. An approximately 500-foot extension for tie-in along Casement Rd upper end of Big Blue River Segment to include new sandbag gap. Thirteen gatewells would be replaced, raising of one gatewell, and strengthen one pump station. Underseepage berms would be constructed from stations 120+00 to 137+00, and 165+12 to 173+50. Landside toe embankment sand drain would be constructed along a portion of the Big Blue River Levee Segment. Relief wells would also be installed from stations 18+00 to 23+00, 64+00 to 97+00, 110+00 to 120+00, 190+00 to 210+00, and 265+70 to 272+00. This plan was previously named the N500+0.

Plan 5 – 0.33% + CW: This plan would raise the current levee according to plan 3 with the addition of channel widening (CW). This alternative includes all the features of the Plan 3 levee raise alternative in addition to excavation of approximately 200,000 cubic yards of material along the left descending bank of the Big Blue River. Both the Highway 24 and Union Pacific Railroad Bridges would be expanded and approximately 1,100 linear feet of riprap armoring would be placed around the bridge abutments. This plan was previously named the N300+0 plus channel widening.

Also considered late in the feasibility study was a plan to extend the levee northward to protect additional development in the northern area, including the Dix Addition which sustained considerable damage in the 1993 flood. However, the Corps determined that a northern extension of the levee would be economically unfeasible per Corps guidelines for Federal Civil Works projects. A northern levee extension would add yet another constriction to a river system that has already lost much of its flood plain function to levees. Flood events are important for fish in terms of habitat creation. Building new levees would further reduce flood plain function and processes that create and sustain habitat. New levees would have a potential to impact wetlands and riparian areas.

Plan 1 would not affect wildlife or habitats as there would be no Federal Action and therefore conditions would remain similar to current conditions. Plan 2 and Plan 3 do not differ significantly in impacts to wildlife and habitats. Plan 4 would incur additional losses of riparian woodlands, shrublands, and other vegetation due to the 1700 foot tie-in along Wildcat Creek. Plan 5 would have similar terrestrial impacts to Plan 3 but could incur significant impacts to aquatic habitats due to the channel widening in the Big Blue River. The channel widening would directly alter the pattern, profile, and dimensions in this reach of the Big Blue and would likely instigate physical changes upstream and downstream of the widened reach.

We have no objection to the selection of Alternative Plan 3 as the Recommended Plan and National Economic Development (NED) plan. We believe that this plan will meet the Corp's objectives while having minimal environmental impacts in the project area.

FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT

Much of the land adjacent to the project areas has been converted to urban uses and cropland. The top of the levee is used for Linear Trail, a hiking and bicycling trail. The riparian area between the levee and the Kansas River, Big Blue River, and Wildcat Creek is some of the highest quality habitat remaining in the area of Manhattan, Kansas. Recreation in the form of hiking, bicycling and bird watching are the primary human uses of the riparian area. We do not anticipate any significant change in land use, and therefore impacts to fish and wildlife resources, if the project does not occur.

FISH AND WILDLIFE RESOURCES WITH THE PROJECT

Construction activities would cause temporary, short-term impacts to fish and wildlife from noise, dust, and the presence of workers and machinery. Runoff from construction areas, access roads, staging areas and unprotected fills could degrade water quality inside the levee system. Accidental spills of fuels, lubricants, hydraulic fluids, and other petrochemicals would be harmful to aquatic life. Runoff from construction sites into streams, rivers and wetlands should be avoided. The proximity of the project area to streams, rivers and wetlands is very close in some locations. Inadvertent trampling by workers or machinery in these areas should be prevented.

Grassland strips occurring on and adjacent to the levee and the toe would be temporarily impacted during construction. Impacts would be temporary but would cease to provide habitat to wildlife during project construction and for approximately two to three years after project completion or until the grassland vegetation is well established.

Riparian vegetation is the only resource of significance anticipated to be impacted by the proposed flood control work. The few, remaining areas of native vegetation represent valuable wildlife habitat. Areas of native vegetation should be avoided. Work in the riparian areas area will displace wildlife that currently use the areas due to disturbances from noise, dust, human activity, machinery and destruction of habitat. Depending on construction timing, this displacement could result in serious consequences to wildlife such as loss of reproduction and possible death of individual animals from dispersal from the area, accidents (crossing roads and unknown hazards in new areas), starvation, competition for other areas, etc. There is little refuge habitat in close proximity to the project area for displaced wildlife to move into. Available habitat is presumably at carrying capacity which further reduces the likelihood of wildlife surviving the displacement and intensifies the competition for the limited habitat available. Although the temporal displacement from disturbance may be relatively short, the repercussions

could be long-term. Establishment of replacement areas prior to the onset of project construction would lessen the impacts to wildlife from habitat loss.

Severing travel corridors, whether from physical construction activity or behavioral avoidance of construction activities, could cause wildlife to seek alternative routes or be prevented from moving between habitats. Wildlife travel corridors linking other areas of suitable floodplain upstream and downstream of the project area should be maintained during project construction. If construction will disrupt the entire area from the levee riverward to the streambank or riverbank alternative travel corridors should be established before construction begins on that levee segment especially if wildlife would be compelled to cross a road to alternative areas. This could involve constructing road crossings to assist wildlife in crossing over or under a road, erecting barriers to redirect wildlife to suitable crossing locations, or to encourage wildlife to use a wildlife crossing.

The Corps has not found any wetlands in the project area. The National Wetland Inventory does not identify any wetlands in the project area. However, there are identified wetland areas adjacent to the project area within the Kansas River channel, landward of the levee near the project area, and near the latest proposed borrow area (Figures 3 – 6). Indirect impacts to these wetlands should be avoided.

The Corps has removed from consideration two potential borrow areas due to wetlands and/or historical concerns. The latest proposed borrow area is within a row crop field adjacent to the original levee borrow area. The original levee borrow area has developed into forested wetland and shrub-scrub wetland as shown on the National Wetland Inventory map (Figure 3). The new proposed borrow area should not impact these wetlands so long as erosion and runoff are controlled so they don't enter the adjacent wetlands and equipment is kept out of the wetlands.

WILDLIFE AND HABITAT IMPACTS

The Service has established the Fish and Wildlife Service Mitigation Policy (46 FR: 7644-7663) to be used as guidance in determining resource categories and recommending mitigation. For the purposes of this CAR, the word "mitigation" refers to taking steps to avoid or minimize negative environmental impacts. These steps can include avoiding the impact; rectifying the impact by repairing or restoring the affected environment; reducing the impact; or compensating the impact by replacing or providing substitute resources.

We have determined that most of the wildlife habitat that would be affected by the raising of existing levees consisting of the levee footprint and easements is in Resource Category No. 4 (habitats of medium to low value). This resource is primarily comprised of the domestic, non-native grasses used on the levee. For this category, loss of habitat value should be minimized.

Riparian woodlands are consistent with Resource category No. 2 that is, habitats are of high value that are relatively scarce or becoming scarce on a national or regional basis.

Losses attributed to the project would require in-kind replacement (replacement of habitat value lost with equal habitat values of the same kind of habitat as those eliminated). Another alternative to replace the lost habitat would be to simply replace two acres of in-kind habitat for every acre lost. Further, we recommend that 3 trees be planted to replace every tree lost in acknowledgment that many of those planted trees will not survive to maturity. Replacing two acres for every acre lost would provide space for the replacement trees. The establishment of native vegetation may take years, or even decades for woodlands resulting in long-term temporal loss of habitat. This temporal loss of habitat should be factored into the calculations to determine replacement values. The cost of replacing habitat losses should be included as a project cost. Plans to replace these high value areas should be developed in cooperation with the Service and KDWPT. The plans should include baseline information, site objectives, work plans (design and construction details), success criteria, performance standards, monitoring protocols, long-term management strategies and adaptive management procedures.

We advocate protecting local genotypes by using plant sources that are within 100 miles in latitude and 200 miles in longitude of the planting site. Plants evolve to local conditions (climate, soil, moisture conditions, etc.) and can develop different genetic structure (genotypes) within the same species. Gene pools of remnant plant communities can be altered genetically by the invasion of non-native genotype plant species.

Section 2 of the Fish and Wildlife Coordination Act requires the Service to identify project related opportunities to enhance fish and wildlife. The enhancement recommendations discussed below refer to project related creation of wildlife habitat, over and above that required to replace losses attributable to project construction.

If agreeable to the project sponsors and borrow site owners, borrow sites could be designed and managed to enhance wetland and aquatic habitat, and provide recreational access.

Whenever possible, we recommend upland trees within the construction right-of-way remain undisturbed. While some of the trees may be young now, they are closer to a mature and more valuable stage than newly established trees.

Native trees, grasses and forbs, noted for their high wildlife value, could be established along the landward and river-side base of the existing levee system. Native vegetation often takes longer to become fully established; however when established, stands of native vegetation provide excellent soil binding characteristics, valuable wildlife habitat and require fewer maintenance costs. The Service, the Kansas Department of Wildlife and Parks, and the Natural Resource Conservation Service offer assistance programs and could work with the City of Manhattan to develop vegetation management plans.

Trees at least 50 feet tall and /or 24-inches dbh riverside of the levees should be avoided. Removal of these trees may adversely affect the habitat of the bald eagle.

Vegetation clearing and construction related soil disturbances can cause sediment-laden runoff to enter waterways. To minimize impacts associated with erosion, contractors should employ silt curtains, coffer dams, dikes, straw bales or other suitable erosion control measures adjacent to floodplain water bodies or tributaries affected by the project. Construction related petrochemical spills can also negatively impact fish and wildlife resources. Therefore, measures should be implemented prior to construction to minimize the likelihood of petrochemical spills.

Invasive species have been identified as a major factor in the decline of native flora and fauna and their ecosystems. Invasive species of particular concern in Kansas include the zebra mussel (*Dreissena polymorpha*), Eurasian watermilfoil (*Myriophyllum spicatum*), purple loosestrife (*Lythrum salicaria*), Johnson grass (*Sorghum halepense*), sericea lespedeza (*Lespedeza cuneata*), salt cedar (*Tamarix spp.*), and reed canary grass (*Phalaris arundinacea*). Executive order 13112 Section 2 (3) directs Federal agencies to not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere and to ensure that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions. Proactive measures to prevent the inadvertent spread of exotic and invasive species would appear to satisfy this directive. Therefore we recommend the implementation of the following BMP.

> All equipment brought on site will be thoroughly washed to remove dirt, seeds, and plant parts. Any equipment that has been in any body of water within the past 30 days will be thoroughly cleaned with hot water greater 140° F (typically the temperature found at commercial car washes) and dried for a minimum of five days before being used at this project site. In addition, before transporting equipment from the project site all visible mud, plants and fish/animals will be removed, all water will be eliminated, and the equipment will be thoroughly cleaned. Anything that came in contact with water will be cleaned and dried following the above procedure.

All overhead transmission lines should be modified or marked to reduce the likelihood of bird collisions with the lines or bird electrocutions on the lines. The interactions of migratory birds (e.g. eagles, hawks, owls, waterfowl, waterbirds, and songbirds) may create operational risks, health and safety concerns, and avian injuries or mortalities. The frequency of electrocutions and collisions and the associated outages has been dramatically reduced in areas where efforts have been made to retrofit or replace hazardous poles and mark lines (APLIC 2006 and APLIC 2012). The design and placement of transmission lines and towers can increase or decrease the exposure for bird collisions (APLIC 2012). Early evaluation of risk factors for bird electrocution and collision can reduce the risk potential and may reduce the need for costly modifications later. Since the plans for the levee improvement include moving transmission poles and lines it would be a cost effective time to mark the lines, conduct an avian risk assessment and develop an avian protection plan for the levee project.

RECREATION

The levee constitutes a major portion of Linear Park, a trail system for walking, hiking, and bicycling. Off-road bicycling trails take off from Linear Park and traverse the woody riparian area riverward of the levee. Linear Park is heavily used by the residents of Manhattan both for recreation and as an alternative transportation route by pedestrians and bicyclists. Trail closings due to construction activity would be a disruption to the user community and would be acutely felt. Trail closings should be kept to a minimum both in length of area and amount of time closed. Alternative route(s) around the construction areas should be designed, and constructed if necessary, to preserve the connectivity of the trail.

RECOMMENDATIONS

1. Riparian and wetland habitats should be avoided to the maximum extent practicable during construction and when selecting borrow sites for the proposed levee improvements. Since channelization, levee construction and floodplain development have already resulted in dramatic loss of riparian and wetland habitats in the Kansas River basin within the project area, the Corps should focus on bare or cropland areas for borrow.

2. The non-native, invasive brome and fescue grasses used on the levee could be replaced with native grasses which would provide a higher habitat value than the non-native grasses. The USDA – Natural Resource Conservation Service's Plants Database (http://plants.usda.gov/java/) lists three species of fescue that are native to Kansas: clustered fescue (*Festuca paradoxa*), nodding fescue (*Festuca subverticillata*), and Rocky Mountain fescue (*Festuca saximontana*). Clustered fescue and nodding fescue have been found in Riley and Pottawatomie Counties while Rocky Mountain fescue has not been found in either county. Other native grasses which might be suitable for use on the levees include buffalo grass (*Bouteloua dactyloides*) and western wheat grass (*Pascopyrum smithii*).

3. Removal of woodlands and other native vegetation should be avoided where possible. Upland trees within the construction right-of-way should remain undisturbed if possible. If avoidance is not possible a plan to replace those habitat losses should be developed in coordination with the U.S. Fish and Wildlife Service (Service) and the Kansas Department of Wildlife, Parks and Tourism (KDWPT).

4. Bald eagle potential roost and nest sites should be protected and preserved by retaining mature trees and old growth stands, particularly within one-half mile from water. If any project activity appears likely to harass or disturb any bald eagle observed at or near the project area the Service should be notified prior to commencement of the activity, so that an assessment may be made of the potential for adverse impacts.

5. All disturbed areas should be immediately planted with native vegetation following construction to prevent erosion and the establishment of invasive species.

6. Best Management Practices to prevent the transport of invasive species to or from the construction sites should be included as an integral component of the project.

7. Establish native vegetation riverward of levee segments where riparian woodlands are sparse or nonexistent or where invasive species have become established.

8. Runoff from construction areas into streams, rivers and wetlands should be avoided. Inadvertent trampling by workers or machinery in those areas should be prevented.

9. The potential use of borrow sites for wetland and aquatic habitat enhancement and public recreation should be investigated with the project sponsors and borrow site owners.

10. If possible, establish replacement areas prior to the onset of impacts from the project to lessen the impacts to wildlife from habitat loss.

11. Closings of the trails in Linear Park should be kept to a minimum both in length of area and amount of time closed. Alternative route(s) should be provided around the construction areas to preserve the connectivity of the trail.

12. Mark and/or modify all overhead lines incorporating the guidelines found in the following documents:
Avian Protection Plan (APP) Guidelines
(http://www.aplic.org/uploads/files/2634/APPguidelines_final-draft_Aprl2005.pdf);
"Suggested Practices for Avian Protection on Power lines: The State of the Art in 2006"
(http://www.aplic.org/uploads/files/2643/SuggestedPractices2006(LR-2).pdf); and
"Reducing Avian Collisions with Power Lines: the State of the Art in 2012 (Avian Power Line Interaction Committee (APLLIC), 2012)
(http://www.aplic.org/uploads/files/11218/Reducing_Avian_Collisions_2012watermarkLR.pdf).

LITERATURE CITED

Avian Power Line Interaction Committee (APLIC). 2006. Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006. Edison Electric Institute, APLIC, and the California Energy Commission. Washington, D.C. and Sacramento, CA.

Avian Power Line Interaction Committee (APLIC. 2012. Reducing Avian Collisions with Power Lines: The State of the Art in 2012. Edison Electric Institute and APLIC. Washington D.C.

Brinson, M., B. Swift, R. Plantico, and J. Barclay. 1981. Riparian ecosystems: Their ecology and status. U.S. Fish and Wildlife Service. FWS/OBS-81/17 155pp.

Collins, Joseph T. 1983. Amphibians & Reptiles in Kansas. The University of Kansas. 397pp.

Corps of Engineers, Kansas City District. 1990. Regulatory plan for commercial dredging activities on the Kansas River, Appendix A. Retrieved March 5, 2006 from http://www.nwk.usace.army.mil/Portals/29/docs/regulatory/ksdredging/RegulatoryPlan.pdf

Cross, Frank B. and J.T. Collins. 1995. Fishes in Kansas. The University of Kansas. 315pp.

Dice, Lee R. 1923. Notes on the Communities of the Vertebrates of Riley County, Kansas, with Especial Reference to Amphibians, Reptiles, and Mammals. Ecological Society of America Vol. 4, No1. Jan. 1923. http://www.jstor.org/stable/1929272?seq=1 Retrieved March 3, 2014.

Thompson, Max C. and C. Ely. 1989. Birds in Kansas, Volume 1. The University of Kansas. 404pp.

United States Department of Agriculture, Soil Conservation Service. 1975. Soil Survey, Riley County, Kansas.

United States Fish and Wildlife Service. Mitigation Policy. 1981. Federal Register Vol. 46 (15): 7664-7663. (http://www.fws.gov/habitatconservation/FWS%20Mitigation%20Policy.pdf, Retrieved March 31, 2014)

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Kansas Ecological Services Office
2609 Anderson Avenue
Manhattan, Kansas 66502-2801

August 6, 2014

Curtis Hoagland,
Kansas City District, Corps of Engineers
601 East 12th Street
Kansas City, Missouri 64106-2896

RE: Manhattan, Kansas Levee Feasibility Study Final Coordination Act Report

FWS Tracking # 2014-CPA-0583

Dear Mr. Hoagland:

This Final Fish and Wildlife Coordination Act Report (FCAR) is provided pursuant to the Fiscal Year 2012 Scope of Work (SOW) Agreement for the Section 216 Feasibility Report for Improvements to Flood Damage Reduction Measures Along Manhattan, KS Levee System (Manhattan Levee), between the U.S. Fish and Wildlife Service (Service) and the Kansas City District, Corps of Engineers (Corps). The FCAR fulfills the obligations of the SOW Agreement. This FCAR was prepared in accordance with provisions of the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.) and constitutes the report of the Secretary of the Interior on the project within the meaning of Section 2(b) of this Act.

Cooperation and information utilized in preparation of this report was obtained from the Kansas Department of Wildlife, Parks, and Tourism (KDWPT) and the Corps. The Service solicited comments from KDWPT. Their comments and recommendations have been reflected in the Final Coordination Act Report (FCAR). To date we have not received a letter of concurrence from them. Their concurrence letter, if it is forthcoming, will be sent to you to include as an appendix to the FCAR.

We appreciate the opportunity to discuss impacts to fish and wildlife anticipated by implementation of this project.

Thank you for the opportunity to comment on this project. If you have any questions, please contact me or Susan Blackford of my staff at (785) 539-3474.

Sincerely,

Heather Whitlaw
Field Supervisor

HW/shb

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Kansas Ecological Services Office
2609 Anderson Avenue
Manhattan, Kansas 66502-2801

August 6, 2014

Jason Luginbill,
Kansas Department of Wildlife, Parks, and Tourism
1020 S. Kansas Ave., Suite 200
Topeka, KS 66612-1327

RE: Manhattan, Kansas Levee Feasibility Study Final Coordination Act Report

FWS Tracking # 2014-CPA-0583

Dear Mr. Luginbill:

Enclosed is a copy of the Final Fish and Wildlife Coordination Act Report (FCAR) for the Section 216 Feasibility Report for Improvements to Flood Damage Reduction Measures Along Manhattan, KS Levee System (Manhattan Levee). This FCAR was prepared in accordance with provisions of the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.) and constitutes the report of the Secretary of the Interior on the project within the meaning of Section 2(b) of this Act.

Cooperation and information utilized in preparation of this report was obtained from the Kansas Department of Wildlife, Parks, and Tourism (KDWPT) and the Corps. The Service solicited comments from KDWPT throughout the process and those comments and recommendations have been reflected in the Final Coordination Act Report (FCAR). To date we have not received a letter of concurrence from KDWPT. Your concurrence letter, if it is forthcoming, will be forwarded to the Corps of Engineers to be included as an appendix to the FCAR.

Thank you for your cooperation on this project. If you have any questions, please contact me or Susan Blackford of my staff at (785) 539-3474.

Sincerely,

Heather Whitlaw
Field Supervisor

- 1 -

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Kansas Ecological Services Field Office
2609 Anderson Avenue
Manhattan, Kansas 66502-6172

August 6, 2014

MEMORANDUM

To: Region 6, Chief of Endangered Species

From: Kansas Ecological Field Office Supervisor

Subject: Manhattan, KS Levee Final Coordination Act Report

General Comments

This Final Fish and Wildlife Coordination Act Report (FCAR) is provided pursuant to the Fiscal Year 2012 Scope of Work (SOW) Agreement for the Section 216 Feasibility Report for Improvements to Flood Damage Reduction Measures Along Manhattan, KS Levee System (Manhattan Levee), between the U.S. Fish and Wildlife Service (Service) and the Kansas City District, Corps of Engineers (Corps). The FCAR fulfills the obligations of the SOW Agreement. This FCAR was prepared in accordance with provisions of the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.) and constitutes the report of the Secretary of the Interior on the project within the meaning of Section 2(b) of this Act.

cc: Robert Stewart, USFWS Region 6, Regional Environmental Officer

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Kansas Ecological Services Field Office
2609 Anderson Avenue
Manhattan, Kansas 66502-6172

August 6, 2014

MEMORANDUM

To: USFWS Region 6, Regional Environmental Officer

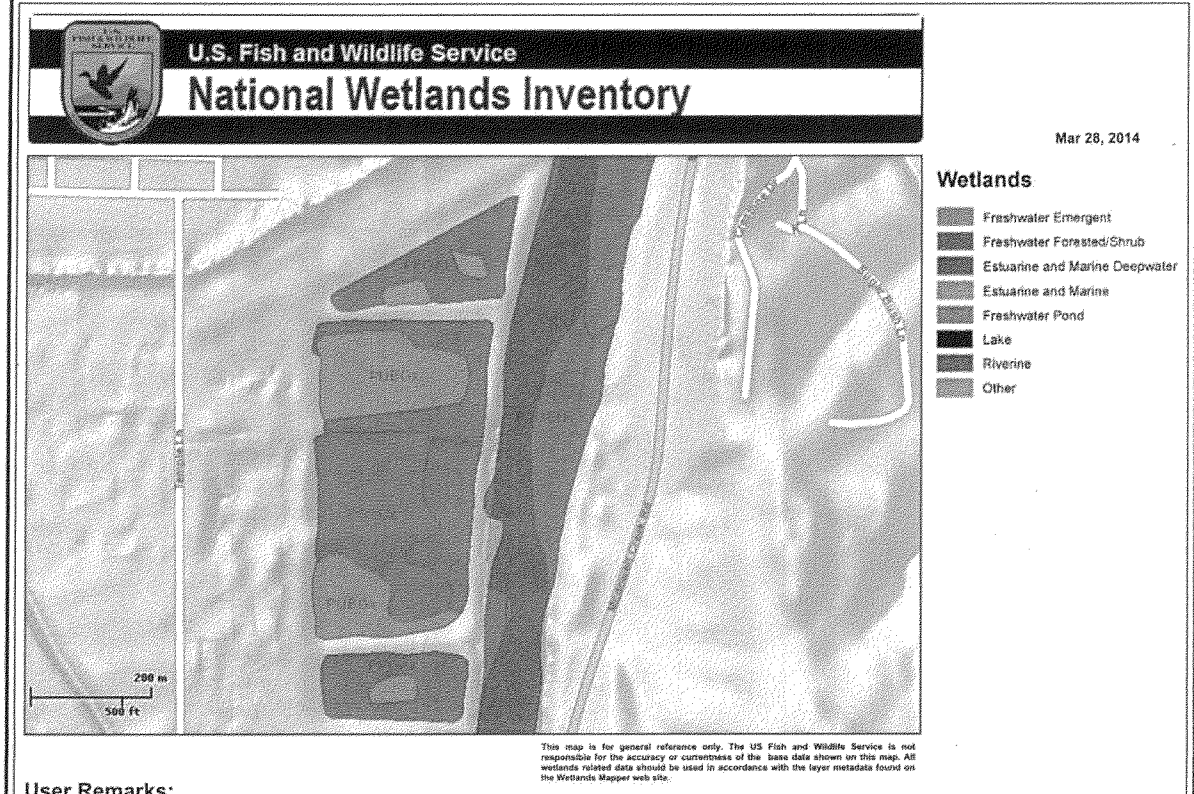
From: Kansas Ecological Field Office Supervisor

Subject: Manhattan, KS Levee Final Coordination Act Report

General Comments

This Final Fish and Wildlife Coordination Act Report (FCAR) is provided pursuant to the Fiscal Year 2012 Scope of Work (SOW) Agreement for the Section 216 Feasibility Report for Improvements to Flood Damage Reduction Measures Along Manhattan, KS Levee System (Manhattan Levee), between the U.S. Fish and Wildlife Service (Service) and the Kansas City District, Corps of Engineers (Corps). The FCAR fulfills the obligations of the SOW Agreement. This FCAR was prepared in accordance with provisions of the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.) and constitutes the report of the Secretary of the Interior on the project within the meaning of Section 2(b) of this Act.

cc: Bridget Fahey, USFWS Region 6, Chief of Endangered Species



User Remarks:

Figure 3. NWI Map of Proposed Borrow Area

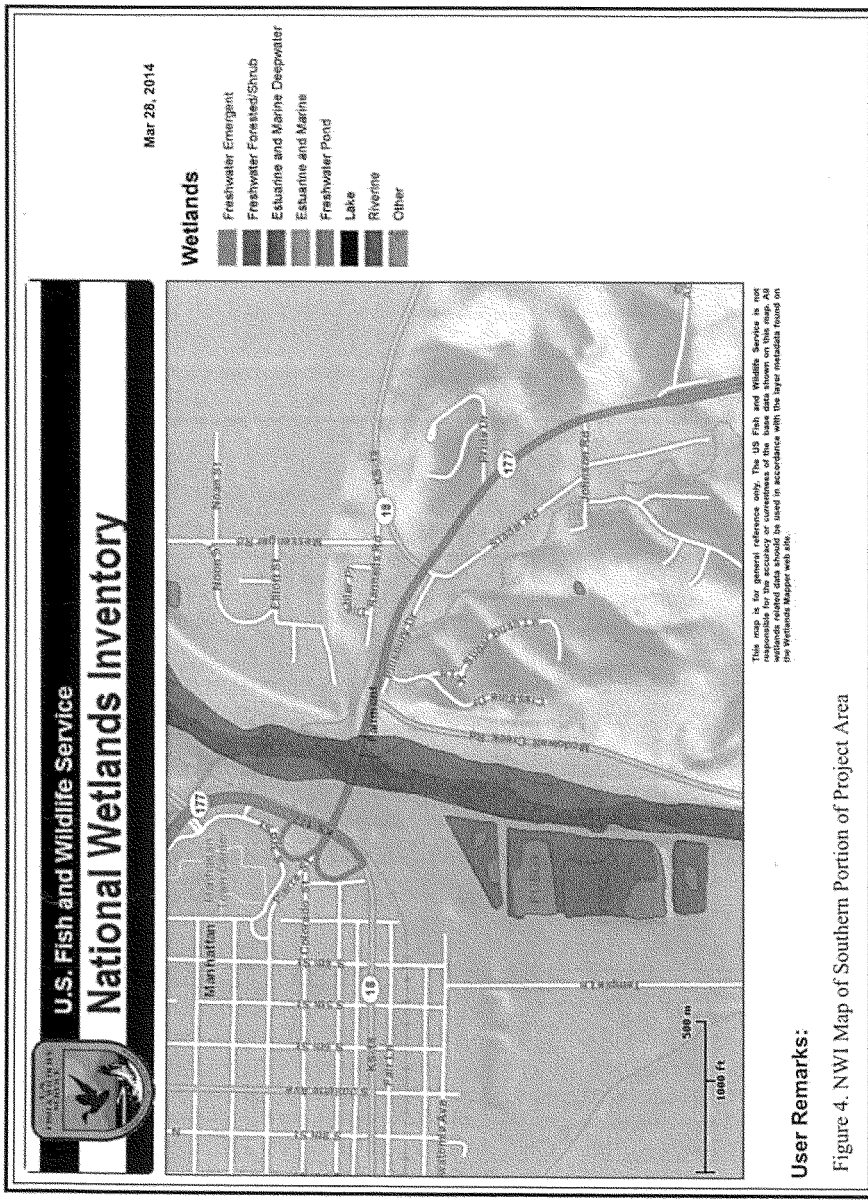
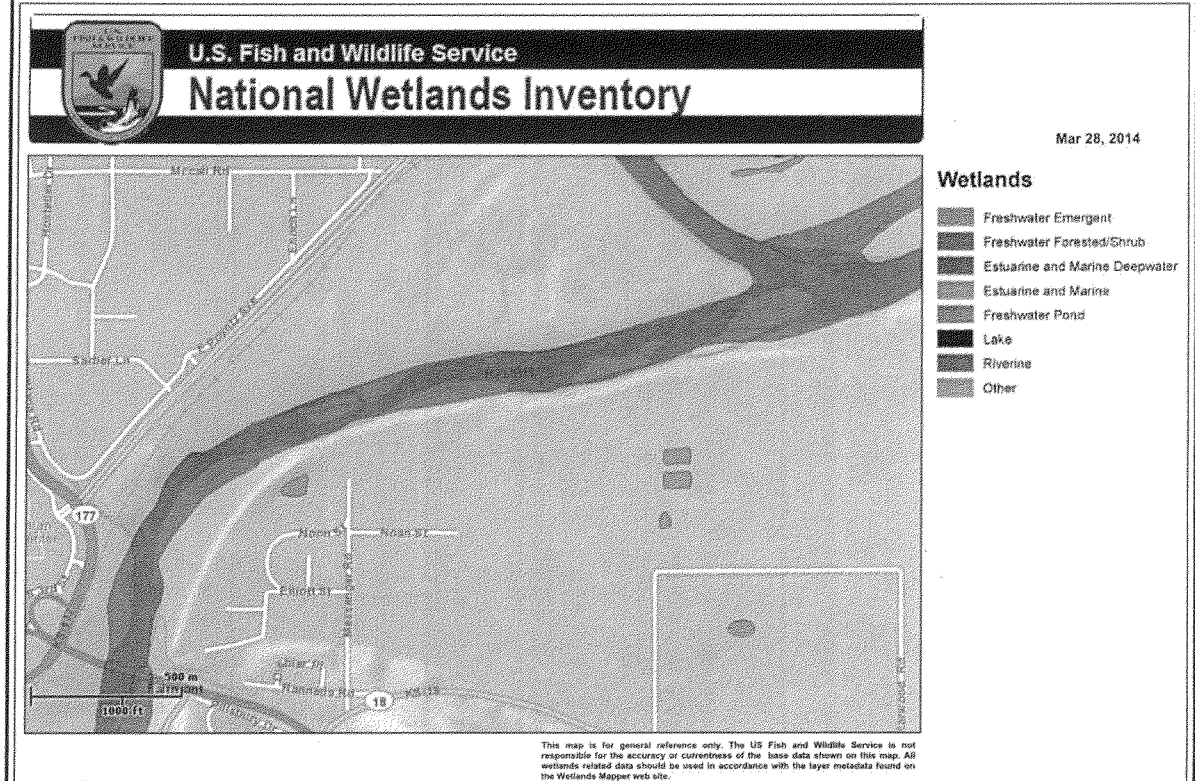


Figure 4. NWI Map of Southern Portion of Project Area

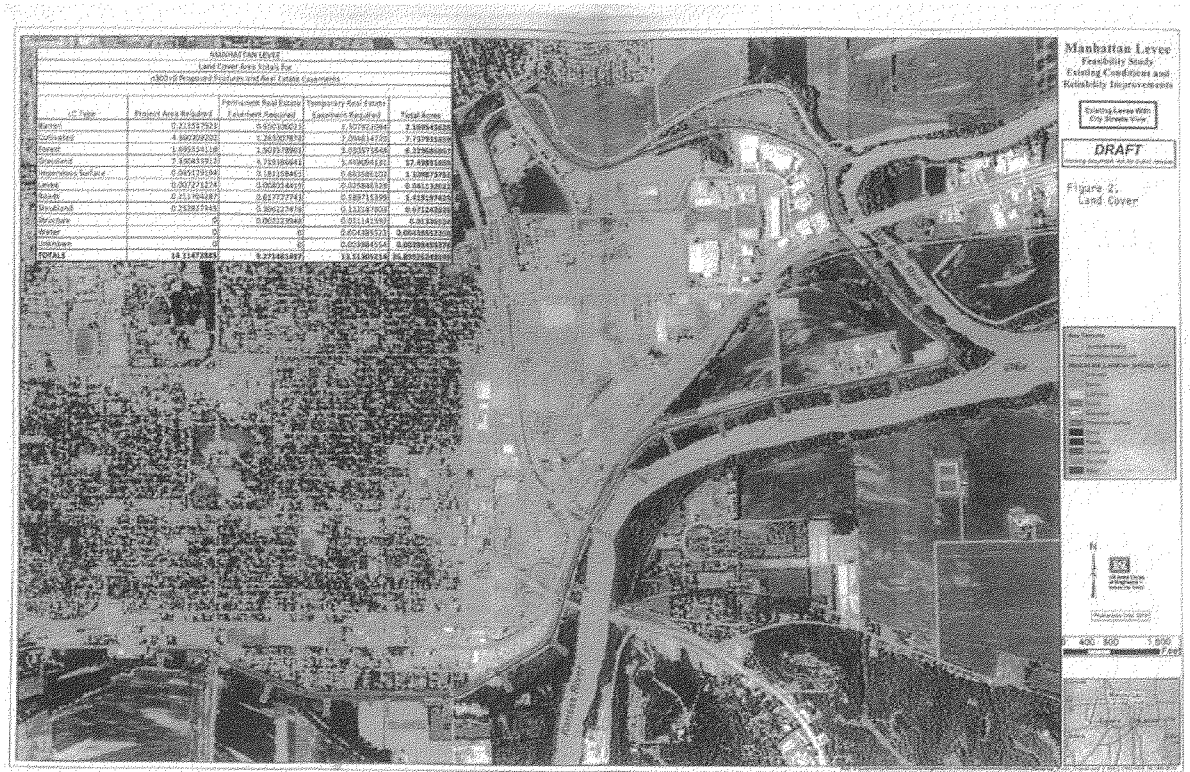


User Remarks:

Figure 5. NWI Map for Middle Portion of Project Area

User Remarks:

Figure 6. NWI Map for Northeast Portion of Project Area



LC Type	Project Area Required	Permanent Real Estate Easement Required	Temporary Real Estate Easement Required	Total Acres
Barren	0.213517521	0.950106023	1.507921594	2.169545628
Cultivated	4.160209202	1.263007878	1.294814735	7.717931815
Forest	1.695534118	1.503178901	3.033571546	6.232684567
Grassland	7.330433913	4.753186641	5.409064151	17.49931605
Impervious Surface	0.045179194	0.181158453	0.683586120	1.109873767
Levee	0.007271274	0.008014417	0.025846328	0.041132019
Roads	0.211704287	0.617727741	0.589715399	1.419197425
Shrubland	0.252817345	0.306227478	0.112147909	0.671242732
Structure	0	0.003123948	0.011141593	0.013265[illegible]
Water	0	0	0.004385521	0.004385521[illegible]
Unknown	0	0	0.003984554	0.003984554[illegible]
TOTALS	14.11472885	9.271461897	13.51305214	36.89025[illegible]

APPENDIX III - CULTURAL RESOURCES

DEPARTMENT OF THE ARMY
KANSAS CITY DISTRICT, CORPS OF ENGINEERS
600 FEDERAL BUILDING
KANSAS CITY, MISSOURI 64106-2896

May 22, 2014

REPLY TO
ATTENTION OF

Environmental Resources Section
Planning Branch

Ms. Jennie A. Chinn
Executive Director, State Historic Preservation Officer
Kansas State Historical Society
6425 S. W. 6th Avenue
Topeka, Kansas 66615-1099

Dear Ms. Chinn:

The U.S. Army Corps of Engineers, Kansas City District (Corps) and the City of Manhattan are partnering on a Section 216 flood risk management project for the levee unit that protects Manhattan. The existing levee unit withstood the flood of 1993, but some elements of the system were seriously challenged as the flood crested. This event raised a concern that the levee may provide less than the authorized benefits for which it was designed. The recommended flood protection would raise the height of the levee within the existing foot print and add a small additional segment. This letter initiates Section 106 coordination for the project.

The city of Manhattan is situated at the confluence of the Big Blue River and the Kansas River. The Big Blue River is on the east side of the downtown area and confluences with the Kansas River on the southeast side of the city. The Manhattan levee unit is located west and north of the confluence of the Big Blue River and the Kansas Rivers, and is approximately 5.48 miles in length (see attachment). The typical levee profile consists of a 10-foot crown width with a typical three horizontal to one vertical embankment slope.

The recommended project plan would raise the existing levee to a 300 year flood event level of protection. The plan would also require an approximate 500 foot long levee segment addition to be located along Casement Road at the upper end of the Big Blue River Segment. Other features would include a new sandbag gap; five gatewells to be placed along the levee, a landside toe embankment to be placed along a segment of the Big Blue River levee segment; five relief wells; and two under seepage berms. The proposed work would require borrow material. The proposed borrow area would be up to 20 acres in size and would be excavated to approximately six feet in depth (see attachment).

A background cultural resource literature review was conducted of the project vicinity. Documents reviewed included the National Register of Historic Places (NRHP); the Kansas State Historical Society's Archeological Inventory (on-line); and various cultural resource reports including the Manhattan Archaeological Survey Phases I and II (Ritterbush 2009). In addition, historic Kansas River channel maps (Dort 1976) were consulted to determine archeological potential for the proposed borrow area.

The background review found that the majority of the Manhattan levee project area has not been previously surveyed for cultural resource sites (see attachments). One archeological survey for a bridge replacement project on K-18/K-177 at the Kansas River bisects the project area. This survey project resulted in the identification and NRHP eligibility testing of six sites, 14RY380- 384 and 365. All six sites were the demolished ruins of historic structures and all were determined not eligible for the NRHP. Two prehistoric archeological sites, 14PO24 and 14PO25, are recorded 0.6 and 0.8 miles east of the northern half of the levee area. Site 14PO24 is an Historic Kansa Indian village site and 14PO24 is an earlier prehistoric village site. Both sites are considered eligible for listing in the NRHP. The NRHP-eligible Bluemont Mound Site (14RY32) and Bluemont Youth Cabin, a WPA structure are both mapped near the north end of the levee. Site 14RY38, the Macy Site, a NRHP eligible multi-component site is mapped east of the Kansas River and approximately a quarter mile southeast of the levee project. No sites are mapped within the vicinity of the proposed borrow area. However, three mound sites (14RY37, 84, and 307) are mapped on the bluff on the east side of the Kansas River. None of the above mentioned sites would be impacted by the proposed construction or borrowing activity.

The majority of the project area is along the existing levee which has been severely disturbed by construction of the levee. The two areas of project disturbance outside of the existing levee footprint are the proposed 500 foot levee segment and the borrow area. Neither has been professionally surveyed for archeological sites. An examination of the proposed borrow area with historic Kansas River channel maps found that the proposed borrow location is situated immediately north of the 1909-1913 Kansas River channel and entirely within an area marked by previous scars (see attachment). The age of the former channels the scars represented is unclear. The borrow areas used for the initial levee construction are located immediately east of the proposed borrow areas.

The proposed borrow area, identified by Ritterbush as the Hunters Island area, was not surveyed during that 2009 investigation, but was given a general archeological evaluation. Ritterbush noted the old meander scars in the area and postulated that given the active nature of the area that surface deposits would likely only be of recent age. She also noted that there could be isolated pockets of deeply buried material especially around former ox bow lakes and edges of the stream valleys. Neither landform is present within the area of the proposed borrow area.

Examination of the proposed levee extension and berm area found that the area is within the residential and commercial Manhattan area and has been disturbed by typical urban development including road construction activity, land clearing, utility installation, and residential development. The disturbance is evident in the attached Google Earth image from 1991. It appears unlikely that any intact unrecorded archeological sites eligible for the NRHP would remain within the project area in the extension area.

In sum, the work on the existing levee alignment and levee extension area would likely have no impact on historic properties because of extensive previous disturbances. As for the proposed borrow area, it is likely that the river channel has crossed the proposed borrow area at some point, but it is unclear when that would have occurred. As such, it is unknown whether NRHP eligible archeological sites could be present in the area.

At this time we are requesting your concurrence and comment on the Corps recommendations below. As the work on the levee alignment and new levee segment and berm is on heavily disturbed areas, project construction would likely have no effect on historic properties. However, because of the uncertainty of the archeological potential of the borrow area, an archeological survey or geoarcheological evaluation of the proposed borrow location appears warranted. As permission to conduct the survey has not been granted and funds for the survey are not yet available at this stage of the study, the survey would be conducted during project design. Also, in the unlikely event that archeological materials are discovered during construction, work in the area of discovery will cease and the discovery investigated by a qualified archeologist. The findings on the discovery would be coordinated with your office and appropriate federally recognized Native American tribes.

Thank you for your consideration in this matter. If you have any questions or have need of further information please contact me at timothy.m.meade@usace.army.mil or at (816) 389-3138.

Sincerely,

Timothy Meade

Timothy Meade
District Archeologist

Enclosures

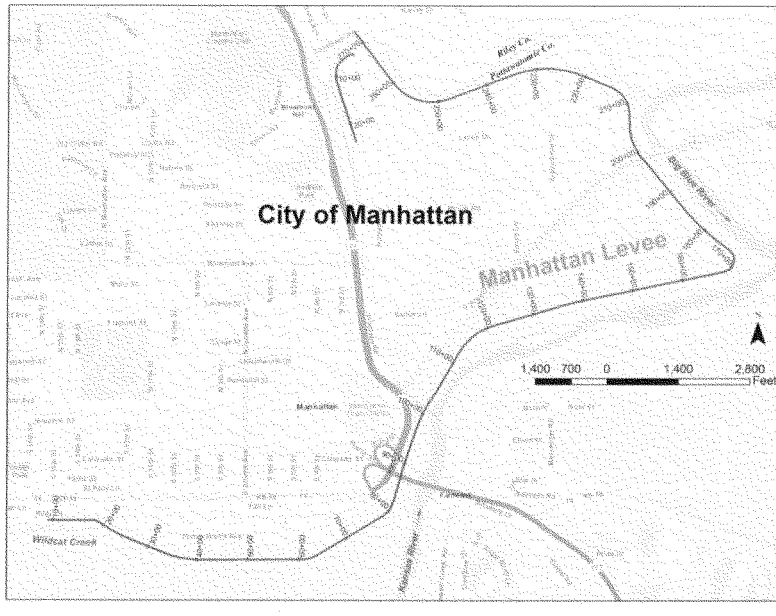
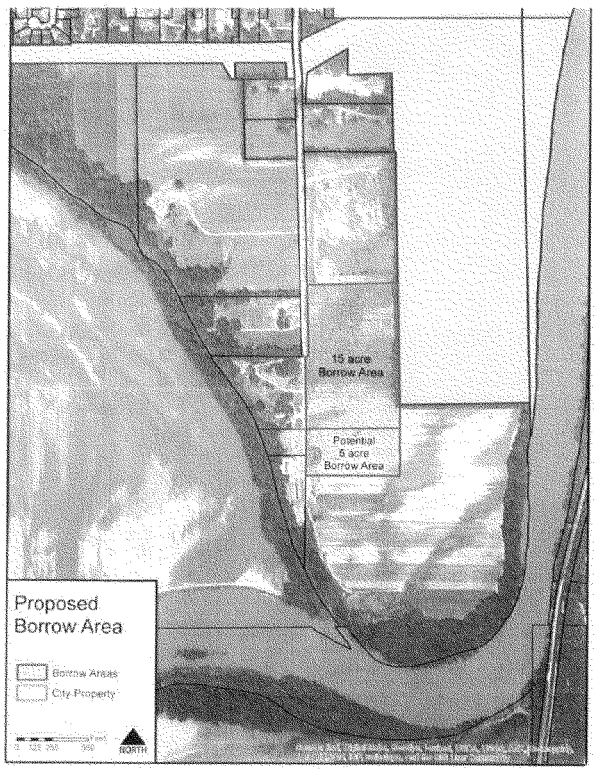


Figure 1. Manhattan levee study area.

Figure. Proposed levee extension and berm area on 1991 Google Earth image depicting disturbances within the project area.

Figure 2. Proposed borrow area.



6425 SW 6th Avenue
Topeka, KS 66615

Kansas

phone: 785-272-8681
fax: 785-272-8682
cultural_resources@kshs.org

Kansas Historical Society

Sam Brownback, Governor
Jennie Chinn, Executive Director

KSR&C No. 14-05-235

May 29, 2014

Timothy Meade
District Archeologist/Tribal Liaison
U.S. Army Corps of Engineers
Kansas City District
600 Federal Building
601 E. 12th Street
Kansas City, Missouri 64106-2896

Via E-Mail

RE: Flood Control Levee Improvements
City of Manhattan
Pottawatomie and Riley Counties

Dear Mr. Meade:

In accordance with 36 CFR 800, the Kansas State Historic Preservation Office has reviewed your letter and attached documentation (dated May 22, 2014) describing plans for improvements to the City of Manhattan's flood control levee system. Given the level of existing disturbance associated with the levee system, our office agrees that archeological survey is not warranted for the actual levee improvements, including the proposed extension along Casement Road. The proposed borrow locality in the Hunter's Island area along the Kansas River at the mouth of Wildcat Creek is, as you noted, a different matter. The area's archeological potential, though not high, cannot be entirely discounted. Our office therefore concurs that archeological survey and/or geoarcheological investigation of the proposed borrow area is an appropriate course of action.

Any changes to the project, which include additional ground disturbing activities, will need to be reviewed by this office prior to beginning construction. If construction work uncovers buried archeological materials, work should cease in the area of the discovery and this office should be notified immediately.

This information is provided at your request to assist you in identifying historic properties, as specified in 36 CFR 800 for Section 106 consultation procedures. If you have questions or need additional information regarding these comments, please contact Tim Weston at 785-272-8681 (ext. 214).

Sincerely,

Jennie Chinn, Executive Director and
State Historic Preservation Officer

Timothy Weston for

Patrick Zollner
Deputy SHPO

US Army Corps
of Engineers
Kansas City District

MANHATTAN LOCAL PROTECTION PROJECT
FEASIBILITY STUDY

MANHATTAN, KANSAS
(Manhattan Levee)

(Section 216 Review of Completed Civil Works)

Economics Appendix

August 2014 Final Feasibility Report

Table of Contents

1.1 INTRODUCTION 1

1.1.1 PURPOSE 1
1.1.2 STUDY GUIDANCE 1
1.1.3 LOCATION 2
1.1.4 FEDERAL PROJECT DESCRIPTION 2
1.1.5 HISTORICAL FLOODING 3

2.1 SOCIOECONOMIC DESCRIPTION 4

2.1.1 POPULATION AND SOCIAL CHARACTERISTICS 4
2.1.2 INVESTMENT 6
2.1.3 ECONOMIC DEVELOPMENT 7

3.1 DAMAGE ANALYSIS DATABASE PREPARATION 10

3.1.1 ANALYSIS YEARS AND PERIOD OF ANALYSIS 10
3.1.2 FUTURE DEVELOPMENT 10
3.1.3 INTEREST RATE AND PRICE LEVEL 10
3.1.4 STUDY REACHES 10
3.1.5 ECONOMIC CATEGORIES FOR STRUCTURE OCCUPANCIES 11
3.1.6 DATA COLLECTION METHODOLOGY 12
3.1.7 DATA COLLECTION 12
3.1.8 MAPPING 13

4.1 DATA AND MODEL DEVELOPMENT 15

4.1.1 PROPERTY INVENTORY 15
4.1.2 ELEVATIONS 15
4.1.3 VALUATION 16
4.1.4 DEPTH-DAMAGE FUNCTIONS 20
4.1.5 HEC-FDA MODEL DEVELOPMENT 22
4.1.6 HYDROLOGIC AND HYDRAULIC DATA 23
4.1.7 GEOTECHNICAL AND STRUCTURAL DATA 24

5.1 EXISTING CONDITIONS DAMAGE ANALYSIS RESULTS 27

5.1.1 MANHATTAN LEVEE EXPECTED ANNUAL DAMAGES 27
5.1.2 MANHATTAN LEVEE PROJECT PERFORMANCE 31

6.1 FUTURE WITHOUT-PROJECT CONDITION 32

7.1 ALTERNATIVES SCREENING 34

7.1.1 OVERVIEW OF EVALUATION PROCEDURES 34
7.1.2 GENERAL DESCRIPTION OF ALTERNATIVES 34
7.1.3 SCREENING BENEFITS DETERMINATION 35
7.1.4 ENGINEERING DATA CONSIDERATIONS 35
7.1.5 SCREENING COST ESTIMATES 36
7.1.6 ALTERNATIVES SCREENING RESULTS 37
7.1.7 COSTS, NET BENEFITS, AND BENEFIT-COST RATIOS 39

8.1 THE NED PLAN 41

8.1.1 DESCRIPTION OF THE NED PLAN 41

8.1.2 Engineering Performance of NED Plan 42
8.1.3 Costs of NED Plan 43
8.1.4 Economic Performance and Justification of NED Plan 43
8.1.4.1 Benefit Cost Ratio and Net Benefits. 43
8.1.4.2 Benefits Breakdown 43
8.1.5 Induced Damages 44

9.1 FUTURE WITH-PROJECT CONDITION SUMMARY 46

9.1.1 NED Effects of NED Plan 46
9.1.2 RED Effects of NED Plan 47
9.1.3 Other Social Effects of NED Plan 47

10.1 RESIDUAL RISK 48

11.1 PLAN FOR ECONOMIC UPDATES 49

12.1 CONCLUSION 51

List of Tables

Table 1: Population and Housing Trends, 2000 to 2010 5
Table 2: Age, Race, Income, and Education Demographics, 2010 6
Table 3: Investment (in $000) FY14 Price Level by Reach and Category 7
Table 4: Investment by Reach and Percentage 7
Table 5: Manhattan, KS Employment by Industry 8
Table 6: Manhattan, KS Micropolitan Statistical Area General Business Patterns, 2010 9
Table 7: HEC-FDA Study Reaches 11
Table 8: Residential Depreciation Scheme by Age and Condition 16
Table 9: Non-Residential Depreciation Scheme by Age and Condition 17
Table 10: Residential Other Value Assignment Summary 18
Table 11: Probability of Failure Curves for Big Blue River Confluence Reach 25
Table 12: Probability of Failure Curves for Big Blue River Reach 2 25
Table 13: Probability of Failure Curves for Kansas River Reach 1 26
Table 14: Probability of Failure Curves for Kansas River Reach 2 26
Table 15: Kansas and Big Blue River HEC-FDA Expected Annual Damages – Existing Condition ($000's) – FY14 Price Level 27
Table 16: Expected Annual Damages by Category and Reach ($000's) 28
Table 17: Percentage of Total Expected Annual Damages by Category and Reach 28
Table 18: Distribution of Damages in the Confluence Reach ($000's) 29
Table 19: Distribution of Damages in the Kansas River Reach ($000's) 30
Table 20: Distribution of Damages in the Big Blue River Reach ($000's) 31
Table 21: HEC-FDA Manhattan Levee Assurance - Existing Condition Overtopping and Levee Failure 32
Table 22: HEC-FDA Manhattan Levee Assurance – Existing Condition Overtopping Only 32
Table 23: Manhattan Levee Future without Project Condition Damages and Assurance FY14 Price Level ($000s) 33
Table 24: Screening Costs Summary ($000's) 37
Table 25: Alternatives Analysis, Equivalent Annual Damages and Damages Reduced, FY Price Level ($000's) 37

Table 26: Alternatives Reliability Analysis 38
Table 27: Manhattan Levee Alternatives Analysis, Screening Alternatives - Benefits and Costs Summary ($000's) 39
Table 28: Engineering Performance Future Without Project Conditions vs. NED Alternative (Plan 3) 42
Table 29: NED Plan Cost Breakdown ($000's) 43
Table 30: Total NED Project Benefits and Costs ($000's) 43
Table 31: NED Plan Benefits Summary ($000's) 44
Table 32: Estimated Induced Damages, Expected Annual Damages ($000's) 45
Table 33: Expected Depths for Infrequent, Large Flood Events at Selected Locations 49
Table 34: NED Plan Breakdown ($000's) 51

List of Figures

Figure 1: Manhattan Levee Reach Delineation 11
Figure 2: City of Manhattan Economic Analysis Area 13
Figure 3: City of Manhattan Economic Analysis Area Parcel Outline 14
Figure 4: City of Manhattan 14
Figure 5: Manhattan Levee Alternatives Array Analysis Cost Optimization Curve 40
Figure 6: Manhattan Potential for Induced Damages, North of the Existing Levee 46

1.1 INTRODUCTION

1.1.1 Purpose

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

1.1.2 Study Guidance

Pertinent guidance governing economic analysis procedures includes:

-Economic and Environmental Principles and Guidelines for Water and Related Resources Implementation Studies (P&G), dated March 1983;

-Engineering Regulation (ER) 1105-2-100, "Planning Guidance Notebook," dated 22 April 2000;

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

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

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

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

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

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

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

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

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

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

1.1.3 Location

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

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

1.1.4 Federal Project Description

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

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

1.1.5 Historical Flooding

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

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

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

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

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

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

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

2.1 SOCIOECONOMIC DESCRIPTION

2.1.1 Population and Social Characteristics

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

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

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

Table 1: Population and Housing Trends, 2000 to 2010

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

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

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

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

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

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

2010 Census and 2010 American Community Survey

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

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

2.1.2 Investment

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

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

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

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

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

Table 4: Investment by Reach and Percentage

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

2.1.3 Economic Development

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

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

Table 5: Manhattan, KS Employment by Industry

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

2010 Economic Census

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

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

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

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

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

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

3.1 DAMAGE ANALYSIS DATABASE PREPARATION

3.1.1 Analysis Years and Period of Analysis

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

3.1.2 Future Development

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

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

3.1.3 Interest Rate and Price Level

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

3.1.4 Study Reaches

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

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

Table 7: HEC-FDA Study Reaches

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

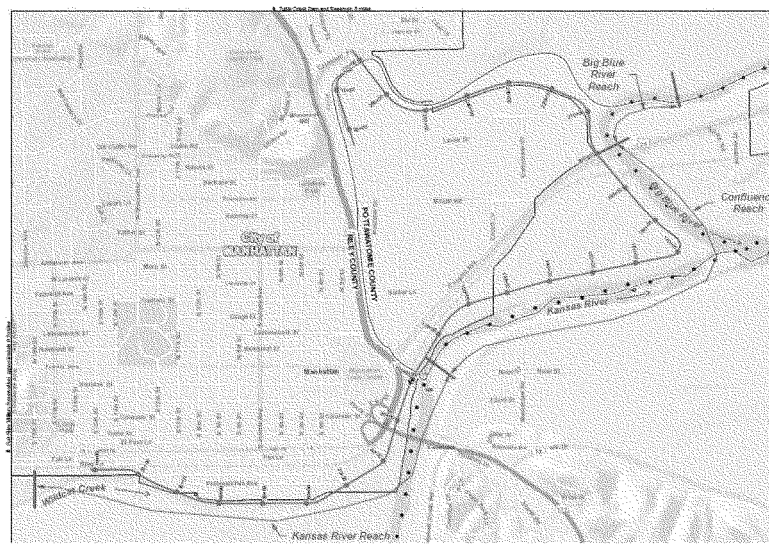


Figure 1: Manhattan Levee Reach Delineation

3.1.5 Economic Categories for Structure Occupancies

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

3.1.6 Data Collection Methodology

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

3.1.7 Data Collection

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

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

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

3.1.8 Mapping

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

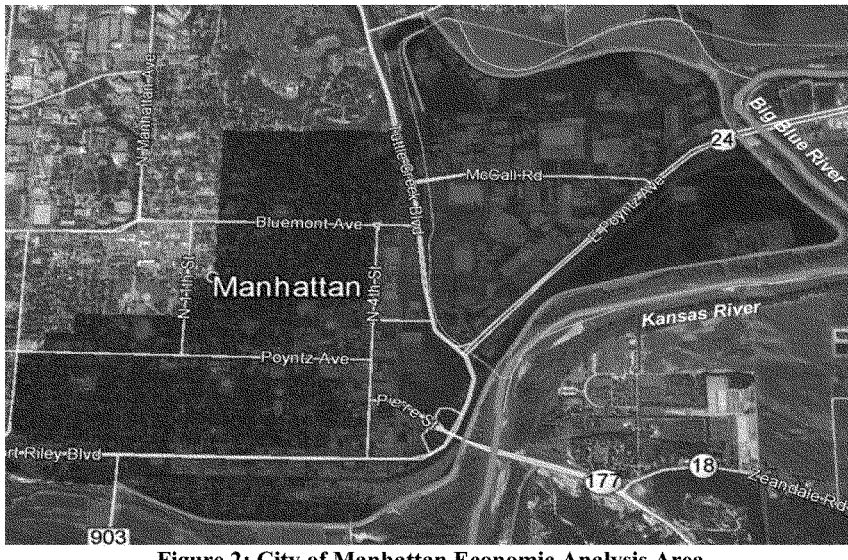


Figure 2: City of Manhattan Economic Analysis Area

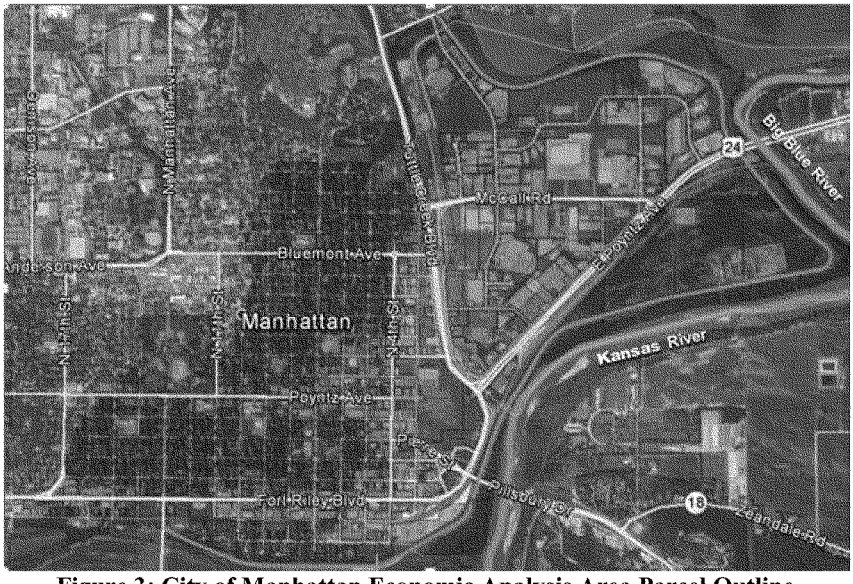


Figure 3: City of Manhattan Economic Analysis Area Parcel Outline

Figure 4: City of Manhattan

4.1 DATA AND MODEL DEVELOPMENT

4.1.1 Property Inventory

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

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

4.1.2 Elevations

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

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

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

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

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

4.1.3 Valuation

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

Table 8: Residential Depreciation Scheme by Age and Condition

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

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

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

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

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

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

Table 10: Residential Other Value Assignment Summary

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

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

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

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

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

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

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

Other costs of flooding such as emergency costs are much more difficult to determine and estimate than physical flood damages. In the Manhattan study area, actual study area historical data about these types of emergency costs are neither readily available nor easily estimated because the last damaging flood event for the area behind the levee was in 1951. As an alternative, several reports were consulted that were published by the Corps pertaining to the 1993 Missouri River basin flood in order to estimate typical emergency costs for a large flood in an urban setting. (The 1993 event was rated as equal to or approximating a 0.2%-chance event in most locations along the Missouri.) These reports included the *1993 Interagency Floodplain*

Management Review Committee Report (Galloway Report); *Impacts of the Great Flood of 1993*, U.S. Army Corps of Engineers Lower Mississippi Valley Division, May 1996; and the *Flood Plain Management Assessment of the Upper Mississippi River and Lower Missouri Rivers and Tributaries,* U. S. Army Corps of Engineers June 1995.

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

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

4.1.4 Depth-Damage Functions

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

As discussed in section 4.1.3 Valuation, residential damages for most homes in this analysis are based on depth-damage percentages released in Economic Guidance Memorandum 04-01, "Generic Depth-Damage Relationships for Residential Structures With Basements," dated 10 October 2003. This EGM summarized data developed by the Institute for Water Resources (IWR) using post-flood residential damage claim records provided by the Federal Emergency Management Agency (FEMA). The functions account for both structural and content damage to homes. Of the seven residential occupancy types selected for this analysis, the IWR functions pertain to six: 1-story with and without basement, 1 1/2-story with and without basement, and 2-story with and without basement. (Note that the 1 1/2 story functions are not included in the

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

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

Some of the functions assume that damage occurs at an elevation of zero. One reason for this is that surface flows do, in fact, damage some items. Examples include finished goods inventories stored on the floor (particularly items such as food or drugs), inventories that are very sensitive to humidity even if not directly touching the water, or equipment with electrical wiring in the floor. Another reason is that depth-damage functions typically are structured in depth increments of a half-foot, if not a foot. If damage occurs with depths of only two or three inches (as it usually would), these depths would more readily round to zero than to one foot or one half foot. Damage percentages paired with an elevation of zero, therefore, might in actuality be accounting for very shallow flows of greater than zero depth.

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

resurfacing and reconstruction costs per mile obtained were divided by the new construction costs per mile to produce the depth-damage percentages.

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

4.1.5 HEC-FDA Model Development

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

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

thousands of theoretical flood events, synthetically extending the period of record to thousands of years and thereby producing results that embody uncertainties in assumptions and the dynamic interaction of variables over time. For each event, the program samples the range of possible values for each variable and determines (a) whether the flood event results in damage, and (b) how much damage occurs. See Appendix H.2.3. of the HEC-FDA Users Manual for further description.

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

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

4.1.6 Hydrologic and Hydraulic Data

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

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

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

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

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

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

4.1.7 Geotechnical and Structural Data

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

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

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

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

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

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

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

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

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

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

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

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

5.1 EXISTING CONDITIONS DAMAGE ANALYSIS RESULTS

5.1.1 Manhattan Levee Expected Annual Damages

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

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

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

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

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

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

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

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

FY14 Price Level

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

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

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

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

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

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

FY14 Price Level

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

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

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

FY14 Price Level

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

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

FY14 Price Level

5.1.2 Manhattan Levee Project Performance

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

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

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

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

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

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

6.1 FUTURE WITHOUT-PROJECT CONDITION

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

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

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

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

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

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

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

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

7.1 ALTERNATIVES SCREENING

7.1.1 Overview of Evaluation Procedures

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

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

7.1.2 General Description of Alternatives

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

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

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

7.1.3 Screening Benefits Determination

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

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

7.1.4 Engineering Data Considerations

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

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

7.1.5 Screening Cost Estimates

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

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

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

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

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

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

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

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

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

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

7.1.6 Alternatives Screening Results

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

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

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

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

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

Table 26: Alternatives Reliability Analysis

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

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

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

7.1.7 Costs, Net Benefits, and Benefit-Cost Ratios

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

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

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

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

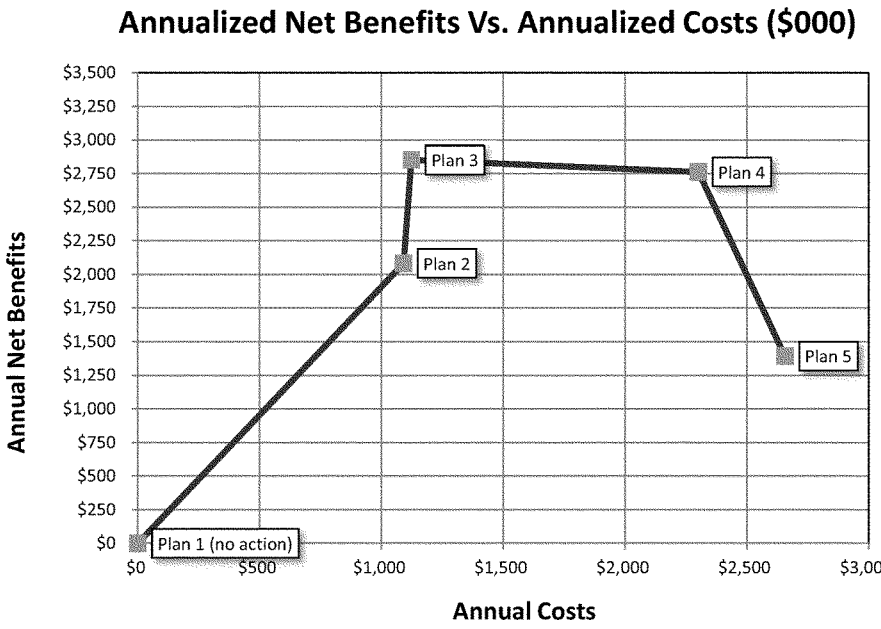


Figure 5: Manhattan Levee Alternatives Array Analysis Cost Optimization Curve

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

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

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

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

8.1 THE NED PLAN

8.1.1 Description of the NED Plan

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

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

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

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

8.1.2 Engineering Performance of NED Plan

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

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

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

8.1.3 Costs of NED Plan

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

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

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

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

8.1.4 Economic Performance and Justification of NED Plan

8.1.4.1 Benefit Cost Ratio and Net Benefits.

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

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

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

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

8.1.4.2 Benefits Breakdown

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

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

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

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

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

8.1.5 Induced Damages

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

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

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

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

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

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

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

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

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

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

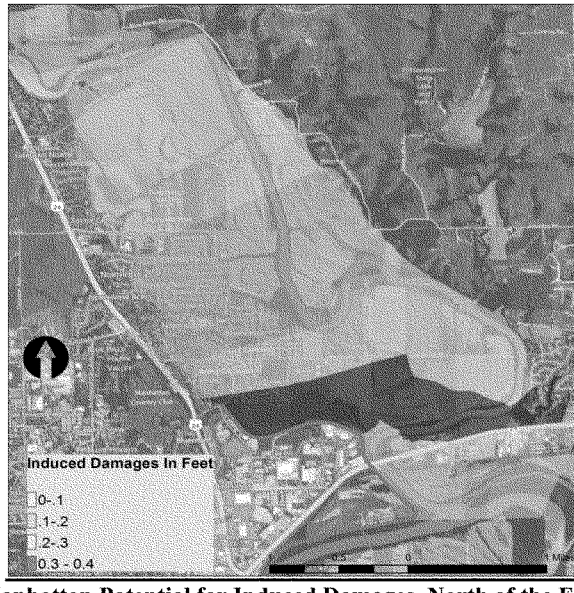


Figure 6: Manhattan Potential for Induced Damages, North of the Existing Levee

9.1 FUTURE WITH-PROJECT CONDITION SUMMARY

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

9.1.1 NED Effects of NED Plan

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

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

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

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

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

9.1.2 RED Effects of NED Plan

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

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

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

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

9.1.3 Other Social Effects of NED Plan

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

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

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

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

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

10.1 RESIDUAL RISK

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

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

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

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

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

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

11.1 PLAN FOR ECONOMIC UPDATES

ER 1105-2-100, para. D-4, requires that feasibility reports include a plan for conducting periodic updates of the project economic justification. Director of Civil Works' Policy Memorandum 12-001 "Methodology for Updating Benefit-to-Cost Ratios (BCR) for Budget Development" dated March 8, 2012 will be used to guide the update process for Manhattan. Economic updates, revisiting estimated damages, benefits, costs, affected population, and residual risk, will be required when the last approved data are more than three years old. (The three-year interval becomes five years once the project receives a construction start.) Updates are not intended to involve major economic analyses or extensive reworking of the feasibility study analysis. They are intended to verify the continuing validity of important assumptions on which the economic justification is founded as well as to convert data to current price levels. It is currently expected that the first economic update would be required in FY 2018. Project economic justification updates will include the following tasks and estimated labor:

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

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

b. Discussions with local leaders and research -- City and/or Chamber of Commerce staff will be consulted to further help identify major changes since approval of the last decision document pertaining to the economic structure inventory and particularly to major non-residential properties. Discussions will encompass verification of continuing operations at major properties, identification of significant changes in operational scale at major businesses and facilities, and identification of significant new development including major new businesses, public facilities, residential developments, and roads and streets. Business operators may also be consulted briefly for general information on operational scale. (12 hours)

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

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

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

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

c. Transportation network -- For roads, streets and railroads, updated average replacement costs per mile, as well as average depreciation factors, will be used to bring depreciated replacement values up to date for each type of road. (2 hours)

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

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

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

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

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

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

Total labor: 92 hours.

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

12.1 CONCLUSION

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

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

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

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

US Army Corps
of Engineers
Kansas City District

MANHATTAN LOCAL PROTECTION PROJECT
FEASIBILITY STUDY
MANHATTAN, KANSAS
(Manhattan Levee)

(Section 216 Review of Completed Civil Works)

Engineering Appendix

August 2014 Final Feasibility Report

VOLUME 1 EXISTING CONDITIONS
ENGINEERING ANALYSIS

VOLUME 1 TABLE OF CONTENTS

PART 1 – INTRODUCTION
1.1 Engineering Appendix Purpose and Context 1-1
1.2 Project Authority 1-1
1.3 Feasibility Study Overview 1-1
1.4 Levee Unit Location and General Description 1-2
1.5 Engineering Documentation 1-3
1.6 Existing Conditions Analysis 1-3
1.7 Future Without Project Conditions Analysis 1-4
1.8 Future Without Project Conditions
– Project Alternatives Overview 1-5
1.9 Plan Evaluation, Comparison and Selection 1-7
1.10 Project Implementation 1-7

PART 2 – HYDROLOGY AND HYDRAULICS
2.1 Site Description 2-1
2.2 Site Background 2-7
2.3 Hydrology 2-14
2.4 Hydraulics 2-33
2.5 Conclusions 2-46
2.6 References 2-49

PART 3 – GEOTECHNICAL
3.1 Introduction 3-1
3.2 Description of Existing Levee Unit 3-1
3.3 Underseepage Analysis 3-4
3.4 Probabilistic Underseepage Analysis Results 3-7
3.5 Slope Stability Analysis 3-8
3.6 Summary 3-13
3.7 References 3-13

PART 4 – STRUCTURAL
4.1 Introduction 4-1
4.2 Engineers 4-1
4.3 Deterministic Criteria 4-2
4.4 Uncertainty Analysis 4-4
4.5 Risk Calculations 4-5
4.6 Structural Material Properties 4-5
4.7 Soil Material Properties 4-6
4.8 Structural Analysis 4-6
4.9 References 4-15

PART 5 – CIVIL

5.1 Introduction 5-1
5.2 Description of Existing Levee Unit 5-1
5.3 Utility Uplift Analysis.....5-1
5.4 Above Ground Utilities and Features 5-6
5.5 Pump Station Assessment.....5-6
5.6 Summary.....5-7
5.7 Items of Consideration for Second Phase.....5-7
5.8 References.....5-9

Detailed drawings and calculations supporting this Appendix are available upon request.

PART 1 – Introduction to Engineering Appendix Volume 1

Table of Contents

1.1 ENGINEERING APP. VOL. 1 PURPOSE AND CONTEXT 1-1

1.2 PROJECT AUTHORITY 1-1
1.2.1 Original Levee Unit Authority 1-1
1.2.2 Feasibility Study Authority 1-1

1.3 FEASABILITY STUDY OVERVIEW 1-1

1.4 LEVEE UNIT LOCATION AND GENERAL DESCRIPTION 1-2

1.5 ENGINEERING DOCUMENTATION 1-3

1.6 EXISITING CONDTIONS ANAYLSIS 1-3

1.7 FUTURE WITHOUT PROJECT CONDTIONS ANAYLSIS 1-4

1.1 ENGINEERING APPENDIX VOLUME 1 PURPOSE AND CONTEXT

This Feasibility Report Engineering Appendix Volume 1 documents the existing conditions engineering analysis and the development of the future without project conditions which support the Manhattan, KS Local Protection Project Feasibility Study. Specifically, this Appendix includes chapters detailing the Hydrology and Hydraulics, Geotechnical, Structural, and Civil Design analyses of the existing project. Information pertaining to the future with project analyses, and the evaluation of the proposed alternatives and project implementation, is found in the Engineering Appendix Volume 2.

1.2 PROJECT AUTHORITY

1.2.1 Original Levee Unit Authority

The Flood Control Act approved 3 September 1954 (Title II, Public Law 780, 83d Cong., 2d Sess., H.R. 9859) authorized the original Manhattan, Kansas, local flood protection project. Construction of the project began on 4 May 1961, and local interests accepted the completed project for operation and maintenance in July 1963.

1.2.2 Feasibility Study Authority

This feasibility study was initiated in 2005 under the authority of **Section 216** of the Flood Control Act of 1970, which allows the Corps to review previously constructed Civil Works projects and make recommendations for improvements. 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."

1.3 FEASIBILITY STUDY OVERVIEW

The existing Manhattan Kansas local protection project is comprised primarily of one levee unit and associated appurtenances and is locally known as the "Manhattan Levee". The U.S. Army Corps of Engineers Kansas City District (CENWK) and the local project sponsor (City of Manhattan, Kansas) are conducting this feasibility study. The Manhattan Levee is located along and near the confluence of the Big Blue and Kansas Rivers and protects a highly-developed area around downtown Manhattan, Kansas from river flooding. This is a single purpose study focusing on flood risk management. The feasibility study will update and verify data on the level of flood risk management provided by the existing project, and as warranted, will develop alternative plans for increasing the reliability of the existing project.

The existing levee withstood the 1993 Flood (60,000 cfs on Big Blue River and peak flows of 100,000 cfs on the Kansas River), but the 60,000 cfs release from Tuttle Creek Dam created a near overtopping situation at some Big Blue River locations along the levee. The 1993 event raised concerns that the levee may provide much less than the design level of performance. The Big Blue River tieback elevation was (originally) designed for a 110,000 cfs release from Tuttle Creek Lake plus 2 feet of freeboard (with 210,000 on Kansas). This potential for overtopping led to a request from the City of Manhattan for Corps assistance to study the problem, determine if the levee may provide less than the authorized benefits for which it was designed, and report out.

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

The main Feasibility Report contains the feasibility investigations, findings, alternative plan evaluation, and the recommended plan for reliability improvements to the existing project. Following approval, the Feasibility Report is accompanied by a Chief of Engineers Report transmittal to Congress. Congressional project authorization (normally provided under a "WRDA" – Water Resources Development Act) is then needed to move forward with any recommended construction project. An Environmental Assessment will accompany the Final Feasibility Report and provide the supporting environmental and NEPA documentation for any recommended Federal action.

1.4 LEVEE UNIT LOCATION AND GENERAL DESCRIPTION

The City of Manhattan is located in central Kansas, and lies at the confluence of the Big Blue River and the Kansas River. The Big Blue River is east of the downtown area and flows into the Kansas River which lies just south and southeast of the city. Both rivers have a history of repeated and sometimes catastrophic flooding. A number of Corps lake projects have provided some regulation of these rivers starting in the mid-twentieth century, resulting in some reduced flooding risks for the city.

The Manhattan levee unit is located generally west and north of the confluence of the Big Blue River and the Kansas Rivers, and is approximately 28,850 feet long. The levee was typically constructed with a 10-foot crown width and three horizontal to one vertical (3H: 1V) embankment slopes. The levee is predominantly an earthen unit -- with a small number of concrete and steel structural components. The land area within the levee unit is almost completely developed and exhibits intense commercial, governmental and light industrial uses accompanied by an residential population located generally along the fringe of the current protection.

The Corps of Engineers Tuttle Creek Lake is situated just to the north of Manhattan with the Big Blue River flowing into and out of Tuttle Creek Lake. Tuttle Creek is a major

lake in the Kansas River basin system of lakes. The system is critical to the Corps' flood risk management mission for both the Kansas and Missouri Rivers.

1.5 ENGINEERING DOCUMENTATION

Study procedures were conducted and the Engineering Appendix content was prepared and arranged in accordance with the engineering guidance described in ER 1105-2-100 Appendix G for feasibility studies. In general, this appendix falls in the category of important supporting documentation for the plan formulation and selection process.

1.6 EXISTING CONDITIONS ANALYSIS

Much of the existing conditions analysis was performed using data and observations from recent high water events (since the original project design), especially the 1993 Flood. Current Corps levee criteria were used. This provided a thoroughly updated engineering analysis of the project. The engineering evaluations, the economic conditions and flood damage analysis, and a summary baseline environmental review of the study area together form a picture of the existing conditions used in the study analysis.

During the existing conditions analysis, the team performed a comprehensive review of the existing hydraulic, geotechnical and structural performance characteristics of the levee unit for various flood conditions. Vol. 1 of the Engineering Appendix (and the accompanying mapbook) contains details of the engineering analysis which supports the identification and quantification of the existing levee risks. Fragility curves were calculated by geotechnical and structural engineers at several locations along the existing levee where vulnerabilities were identified. These separate fragility curves were then translated to "index points", using new hydraulic profiles generated during the study, and combined into a single probability of failure curve for each index point and associated reach.

The Corps HEC-FDA model (a certified economic flood damage analysis program used for Corps feasibility studies) includes the capability for geotechnical and structural failure curve inputs. These failure curves must be considered whenever the levee performance is in doubt, i.e. anytime the levee could fail prior to being overtopped. Including the geotechnical and structural characteristics in HEC-FDA ensures that the economic analysis results are indicative not only of overtopping risks, but also of the risks and potential for damages posed by other major limitations of the existing levee. Once the combined and translated probability of failure curves for each reach are input to the HEC-FDA program, the model uses the probability of failure curves in conjunction with water surface profiles to determine: existing expected annual damages, levee assurance statistics, and other economic-related characteristics of the existing (or any proposed) project and study area. Part 1 Hydrology & Hydraulics (H&H) of Engineering Appendix Vol. 2 contains additional details of the risk translation and use of index points.

A City of Manhattan effort (locally-funded) recently completed the construction of a minimal levee raise for a short segment along the Big Blue River as shown in Figure 1. This small raise addressed a critical low area in levee height and enabled the City to

receive a FEMA 100-year level of protection certification letter early in 2013. The Kansas City District Corps of Engineers reviewed the approved the modification under 33 USC 408 and worked closely with the City to ensure that the H&H modeling used for the design of the raise, and the associated FEMA certification process, was the same as the new modeling generated during this study. This small raise is included in the existing baseline conditions of the levee for this study -- except that this raise does not show on the older O&M Drawings in the mapbook.

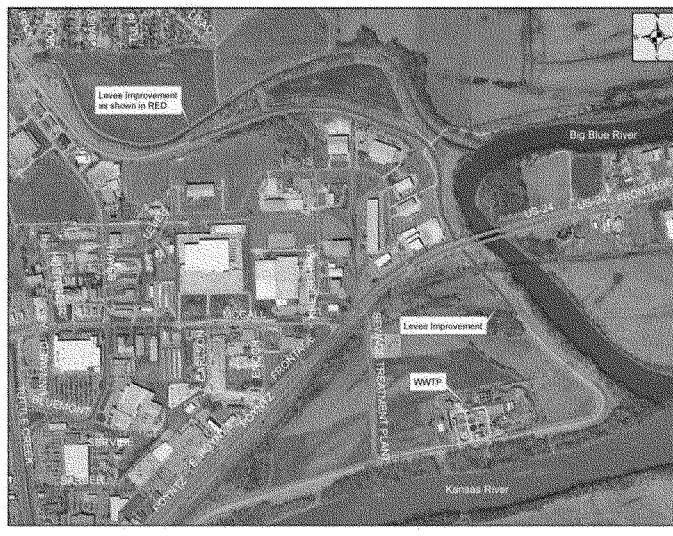


Figure 1
Local FEMA Levee Raise ("Levee Improvement") completed in 2012

1.7 FUTURE WITHOUT PROJECT CONDITIONS ANALYSIS

Establishing a basis for the comparison of project alternatives involves analysis and forecasting of the most likely future without project condition. The future without project condition for this study captures the prevailing future conditions if no major (Federal) action is taken towards solving the Manhattan levee performance problems. The future without project condition is the essentially the same as the "no action" alternative described in the National Environmental Policy Act (NEPA) regulations.

From a hydraulic engineering standpoint, the future without project condition for the study represents the: probable stage-discharge relationship at a selected future time (year 2060) based on the best available current data, the incorporation of any definite projects planned to be completed within the study reach, and any long-term natural river processes that may affect future stages. The future without project conditions analysis includes the following hydraulic characteristics:

- For the purposes of this study, the future without project hydraulic conditions are reasonably expected to be static and consistent with present conditions.
- No projects are planned for the Kansas River or the Big Blue River that will affect the future conditions water surface elevations in the Manhattan area.
- No stage trends are evident in the Big Blue nor Kansas River stretches under study.
- For the flood conditions under study, the operations of Tuttle Creek Lake and Dam, and the upstream Kansas River basin lakes will be consistent with current operational guidelines.

The geotechnical and structural condition of the levee will remain fairly constant over time provided that the City of Manhattan continues to perform adequate operation and maintenance. Based on recent annual inspections of completed works (a joint levee inspection performed by Kansas City District and the City of Manhattan), the City's operation and maintenance support are currently adequate. The City is committed to performing adequate maintenance into the period of feasibility analysis.

In the future, absent a Federal project, the study area will remain exposed to potential flood damages similar to those associated with the existing condition. The potential cost of future flood damages may increase as new development continues to occur within the protected area. Significantly, the land available for development within the City is somewhat constrained by institutional boundaries (Fort Riley and Kansas State University) and physical barriers (the Kansas River and the Big Blue River). Population growth and development within and around the general study area continues resulting in pressure for development of any available tracts of open land. Higher demand leading to re-development and higher values within the protected area might make our future flood damage projections conservative. Any new developments within the protected area that have reliable near-term development schedules are being considered during remaining feasibility efforts.

See the main feasibility report for a more detailed discussion of the future without project condition.

PART 2 – Hydrology and Hydraulics

Table of Contents

2.1 SITE DESCRIPTION 2-1
2.1.1 Study Area 2-1
2.1.2 Manhattan Levee Unit 2-1
2.1.3 Kansas River 2-3
2.1.4 Big Blue River 2-4
2.1.5 Tuttle Creek Lake 2-5

2.2 SITE BACKGROUND 2-6
2.2.1 Flood History 2-6
2.2.2 Flood of 1844 2-7
2.2.3 Flood of 1903 2-7
2.2.4 Flood of 1951 2-8
2.2.5 Flood of 1993 2-11

2.3 HYDROLOGY 2-12
2.3.1 Levee Design Discharges 2-12
2.3.2 General Considerations 2-12
2.3.3 Summary of Studies 2-12
2.3.4 Original Adopted Discharges 2-13
2.3.5 Design Profile for Protected Works 2-13
2.3.6 Model Discharges 2-14
2.3.7 Flow Frequency Analysis 2-14
2.3.8 Big Blue River 2-15
2.3.9 Kansas River Upstream of Big Blue River 2-20
2.3.10 Kansas River Downstream of Big Blue River 2-24
2.3.11 Hydrologic Uncertainty 2-25
2.3.12 Coincident Frequency Analysis 2-28
2.3.13 Hydrologic Period of Record 2014 Sensitivity Analysis 2-31

2.4 HYDRAULICS 2-34
2.4.1 Background 2-34
2.4.2 Model Development 2-34
2.4.3 Cross-Section Data 2-34
2.4.4 Kansas River Cross-Section Data 2-35
2.4.5 Big Blue River Cross-Section Data 2-36
2.4.6 Bridge Data 2-38
2.4.7 Other Geometric Data 2-38
2.4.8 Model Calibration 2-39
2.4.9 Existing Conditions Hydraulic Profiles 2-41
2.4.10 Hydraulic Uncertainty 2-42

2.5 CONCLUSIONS 2-46
2.5.1 River Discharges 2-46
2.5.2 River Stages 2-47

2.6 REFERENCES **2-49**

List of Tables

Table 2-1 Estimated Flow Duration and Mean Flow for USGS Gaging Stations at Fort Riley and Wamego on the Kansas River from Perry et al. 2004 2-4
Table 2-2 Estimated Flow Duration and Mean Flow for USGS Gaging Station on the Big Blue River Near Manhattan from Perry et al. 2004 2-5
Table 2-3 Discharge Capacity at Tuttle Creek Lake 2-6
Table 2-4 Comparison of Maximum Daily Peak Streamflows for Floods of 1844, 1903, 1951, and 1993 at Selected USGE Streamflow-Gaging Stations 2-7
Table 2-5 Monthly Rainfall Leading up to July 1951 Event 2-8
Table 2-6 Natural and Modified Discharges – Vicinity of Manhattan, Kansas 2-13
Table 2-7 Flow Frequency Results for the Big Blue River at Manhattan, Kansas 2-17
Table 2-8 Flow Frequency Results for Kansas River Upstream of Big Blue River 2-21
Table 2-9 Flow Frequency Results for Kansas River Downstream of Big Blue River. 2-25
Table 2-10 Coincident Kansas River Flows for a Big Blue River Flood 2-29
Table 2-11 Coincident Big Blue River Flows for a Kansas River Flood 2-30
Table 2-12 Bridges Included in Manhattan Levee HEC-RAS Model 2-38
Table 2-13 HEC-RAS Model Calibration to 1993 High Water Marks 2-40

Tables of Figures

Figure 1 Manhattan Levee Unit 2-2
Figure 2 Kansas River and Tributaries 2-3
Figure 3 Isohyetal Map of Rainfall in June, 1951 2-9
Figure 4 Isohyetal Map of Rainfall Resulting from Event Spanning July 9th to 12th 2-10
Figure 5 Map of Area Flooded During July 1951 at Manhattan, Kansas from USGS Water Supply Paper 1139 (USGS 1952) 2-11
Figure 6 Big Blue River Flow Frequency 2-18
Figure 7 Big Blue River Annual Peak Flow Relationships, Unregulated Versus Regulated Flows 2-19
Figure 8 Kansas River Upstream of the Big Blue River Confluence Flow Freq 2-22
Figure 9 Kansas River Upstream of the Big Blue River Confluence Annual Peak Flow Relationships, Unregulated Versus Regulated Flows 2-23
Figure 10 Kansas River Downstream of the Big Blue River Confluence Flow Frequency 2-26
Figure 11 Kansas River Downstream of the Big Blue River Confluence Annual Peak Flow Relationships, Unregulated Versus Regulated Flows 2-27
Figure 12 Big Blue River and Kansas River Downstream of the Confluence, Coincidence of Regulated Peaks 2-30

Figure 13 Kansas River Upstream of the Confluence and Kansas River Downstream of the Confluence, Coincidence of Regulated Peaks 2-31
Figure 14 Peak Streamflows Upstream and Downstream of Manhattan, KS 2-32
Figure 15 Graphical Results of Regulated and Unregulated Bulletin 17B POR extension.....2-33
Figure 16 Spatial Extents of Source Data for TIN.....2-35
Figure 17 Kansas River Cross Section Spacing through Study Area.....2-36
Figure 18 Big Blue River Cross Section Spacing through Study Area 2-37
Figure 19 HEC-RAS Model Calibration to the 1993 Flood Event and Check of 1951 Flood Event at the Manhattan Levee.....2-40
Figure 20 HEC-RAS Existing Condition Water Surface Profiles at Manhattan Levee 2-42
Figure 21 Comparison of Rating Curve #28 and Observed Measurements at Wamego Gage on the Kansas River 2-45
Figure 22 Comparison of Rating Curve #56 and Observed Measurements at Manhattan Gage on Big Blue River 2-45
Figure 23 Comparison of Kansas River Flood Profiles to 2005 FEMA FIS Profiles ...2-48
Figure 24 Comparison of Big Blue River Flood Profiles to 2005 FEMA FIS Profiles ..2-48

Acronyms

cfs	cubic feet per second
FEMA	Federal Emergency Management Agency
FIS	flood insurance study
km	kilometer
HEC-DSS	Hydrologic Engineering Center Data Storage System
HEC-RAS	Hydrologic Engineering Center River Analysis System
HEC-SSP	Hydrologic Engineering Center's Statistical Software Package
LP3	log-Pearson Type III
LPS	low point of steel
msl	mean sea level
R.M.	river mile
USACE	U.S. Army Corps of Engineers
USGS	United States Geological Survey

2.1 SITE DESCRIPTION

2.1.1 Study Area

The study area includes that portion of the Kansas River from the confluence with the Big Blue River west to Wildcat Creek, and the Big Blue River from the confluence with the Kansas River north to the outlet of Tuttle Creek Dam. Within this area are the City of Manhattan (primarily urban commercial and residential) and the unincorporated areas of Riley and Pottawatomie Counties (primarily agricultural and low-density residential) surrounding the Big Blue and Kansas River confluence.

The flood plain of the Kansas River in the vicinity of Manhattan is from one-half to one mile wide. Elevations in Manhattan vary from 1,005 feet in the southeast part to 1,040 feet in the northwest part. All elevation references are NAVD88 unless noted otherwise. Wildcat Creek, which is outside of the levee, is south of the city, flows east and enters the Kansas River at River Mile 148.4. The Big Blue River is east of the city and flows southward, entering the Kansas River immediately downstream from Manhattan at River Mile 145.15.

The urban Manhattan floodplain includes a centrally located downtown and commercial area (which includes a major regional shopping mall), neighborhoods generally to the west of the downtown area, and a light industrial area to the east. This area contains more than 1,500 homes and roughly 500 businesses and public facilities.

One bridge crosses the Kansas River in the study reach; the K-18/177 Bridge at Manhattan (R.M. 147.04). Four bridges cross the Big Blue River in the study reach; the two parallel K-24 Bridges (R.M. 0.8), the Union Pacific Railroad Bridge (R.M. 0.7), and the Dyer Road Bridge (R.M. 7.63).

2.1.2 Manhattan Levee Unit

The Manhattan levee unit is located in and around the City of Manhattan, in Riley County Kansas. As show in Figure 1, the levee unit provides flood risk management to Manhattan from floods on the Big Blue and Kansas Rivers. The existing flood risk management measures consist of 28,841 feet of levee, and 4,100 feet of channel improvement for the Kansas River, modification of the Rock Island (now Union Pacific) railroad bridge, six pressure relief wells, and two pumping plants (USACE 2004). Construction of the project was initiated on May 4, 1961 and the completed project was transferred to local interests for operation and maintenance in July 1963.

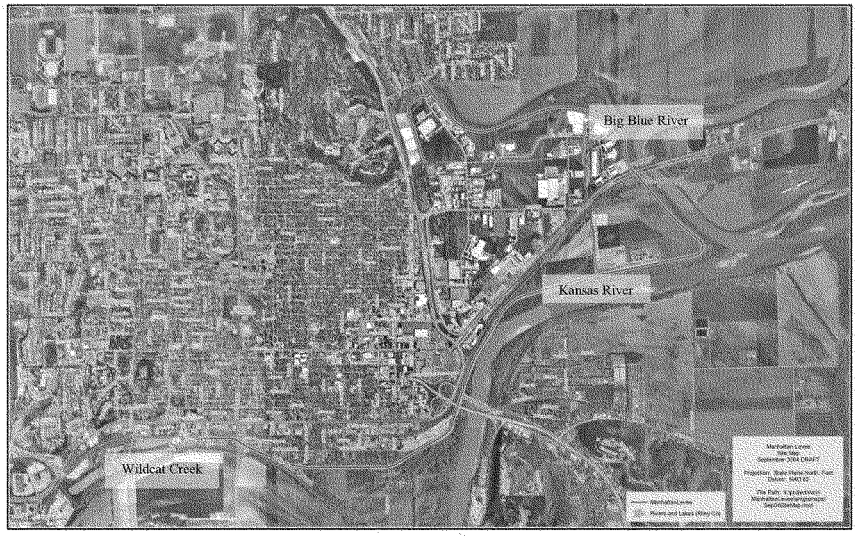


Figure 1. Manhattan Levee Unit

The Manhattan levee unit starts at high ground on the left bank of Wildcat Creek in the vicinity of 15th Street; continues downstream along a pronounced shelf in the river valley to the vicinity of 4th Street; then along the left bank of the Kansas River to the mouth of the Big Blue River where it continues along the right bank to where the Big Blue River turns east; and then along the left bank of the old abandoned Big Blue River channel and across it to high ground. (USACE 1980)

The levee unit was designed to operate with upstream reservoirs such as Tuttle Creek, Milford, Glen Elder, Wilson, and Kanopolis. Tuttle Creek Reservoir controls the Big Blue drainage area upstream of Manhattan. The drainage area above Manhattan on the Kansas River is 45,464 square miles, of which 39,643 square miles are controlled by upstream reservoirs, leaving an uncontrolled drainage area of 5,821 square miles upstream of Manhattan. The Kansas River portion of the project was designed using a balanced overtopping discharge of 335,000 cubic feet per second (cfs). This provided a freeboard of 2 feet above the design discharge (220,000 cfs) at the mouth of the Big Blue River. The Big Blue River tieback was designed using an 110,000 cfs release from Tuttle Creek Reservoir with 2 feet of freeboard. (USACE 1980).

2.1.3 Kansas River

The Kansas River Basin is located in northern Kansas, southern Nebraska, and eastern Colorado. Major tributaries include the Big Blue, the Republican, the Saline, the Solomon, and the Smoky Hill Rivers. Much of the river's watershed is dammed for flood control, but the river is generally free-flowing and has only minor obstructions, including diversion weirs and one low impact hydroelectric dam. The Kansas River is formed by the convergence of the Republican and Smoky Hill Rivers at Junction City, Kansas, about 20 miles upstream from Manhattan (see Figure 2). The river receives discharge from the Big Blue River about 2 miles downstream from Manhattan, where the normal discharge of each river is nearly equal (Perry 1993).

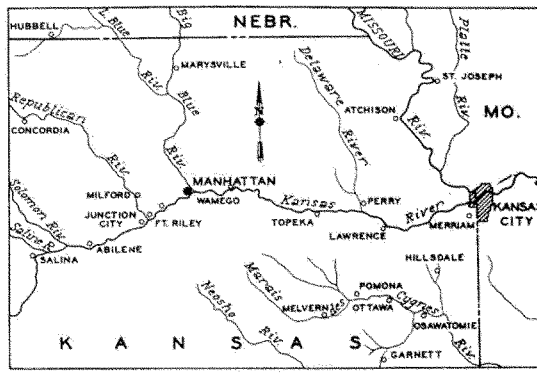


Figure 2. Kansas River and Tributaries

The Kansas River valley averages 2.6 miles (4.2 kilometer [km]) in width, with the widest points being downstream (east) of Manhattan between Wamego and Rossville, Kansas. In the 148-mile stretch between the gaging stations at Fort Riley and Bonner Springs, the river has an average gradient of approximately 2 feet per mile (Fader, 1974). Along this same stretch of the river, the floodplain has a gradient of nearly 2.5 feet per mile. The river follows a sinuous path but primarily flows on the south side of the valley, impinging on the south valley wall at numerous places between Junction City and Lawrence, Kansas (Lawrence et al. 1998). The river approaches the north valley wall at two places between Junction City and Manhattan, Ogden Hill just east of the confluence of the Republican and Smoky Hill Rivers and at Stagg Hill located south of Manhattan.

The average top width of the Kansas River between the confluence of the Smoky Hill and Republican Rivers (R.M. 170) and the Big Blue River is about 480 feet (Simons et al. 1984). Downstream the average top width increases to 740 feet between the Big Blue River confluence and Willard, Kansas (R.M. 100).

The variation in Kansas River discharge is related to climate, season, and location in the drainage basin. The highest discharge occurs in the summer months with the maximum monthly discharge in July. Estimated flow duration and mean flow values for United States Geological Survey (USGS) gaging stations at Fort Riley and Wamego on the Kansas River (from Perry et al. 2004 Table 5 and 6) are summarized in Table 2-1.

Table 2-1. Estimated Flow Duration and Mean Flow for USGS Gaging Stations at Fort Riley and Wamego on the Kansas River from Perry et al. 2004

Gage Station	Stream Name	Estimated flow duration (cfs) for percentage of time flow equaled or exceeded					Mean streamflow 1961 to 2000 (cfs)
		90%	75%	50%	25%	10%	
06879100	Kansas River at Fort Riley, KS	408	637	1,350	3,310	7,450	3,010
06887500	Kansas River at Wamego, KS	846	1,360	2,720	6,340	13,600	5,650

2.1.4 Big Blue River

The Big Blue River basin comprises a total area of 9,628 square miles. Three-fourths of the basin is situated in Nebraska, and the remainder in Kansas. The source of the Big Blue River is near Grand Island, Nebraska. From there, the river flows generally eastward about 50 miles to Ulysses, Nebraska, and then southward over 300 miles to Tuttle Creek Lake (USACE 2004). The Big Blue River valley varies in width from 1,320 feet to nearly 1 mile, with an average of approximately 4,000 feet from Tuttle Creek dam northward to Seward, Nebraska (Weatherly 1994).

The portion of the Big Blue River within the study area (lower Big Blue) extends approximately 12.3 river miles downstream of Tuttle Creek Lake to its confluence with the Kansas River at R.M. 145. Below Tuttle Creek dam the presence of Rocky Ford dam just 1 mile downstream influences the tailwater elevation in the Tuttle Creek stilling basin and in River Pond (USACE 2002). Weatherly (1994) found that significant channel migration on the lower Big Blue occurred in response to flood events and that minimal lateral migration occurred between 1857 and 1989. Further, the channel path stabilized after the 1951 flood and since completion of the Tuttle Creek dam has not undergone significant lateral migration. Estimated flow duration and mean flow values for the USGS gaging station on the Big Blue River near Manhattan (from Perry et al. 2004 Table 5 and 6) are summarized in Table 2-2.

Table 2-2. Estimated Flow Duration and Mean Flow for USGS Gaging Station on the Big Blue River Near Manhattan from Perry et al. 2004

Gage Station	Stream Name	Estimated flow duration (cfs) for percentage of time flow equaled or exceeded					Mean streamflow 1961 to 2000 (cfs)
		90%	75%	50%	25%	10%	
06887000	Big Blue River near Manhattan	178	444	974	2,450	6,500	2,490

A study by Juracek (2001) assessing channel-bed elevation changes downstream from large reservoirs in Kansas found that the channel bed of the Big Blue River down-stream from Tuttle Creek Lake lowered 3.9 feet from 1962 (year of dam completion) to 1997. The channel bed lowered at an average rate of about 0.1 foot/year and showed no indication of slowing as of 1997.

2.1.5 Tuttle Creek Lake

Tuttle Creek Lake is located on the Big Blue River, 12.3 river miles upstream from the confluence of the Big Blue and Kansas Rivers and is 6 miles north of Manhattan. The lake's drainage area is 9,628 square miles. The lake provides flood control, recreation, fish and wildlife conservation, water quality control, and navigation supplementation. When at its multipurpose pool, elevation 1075.44 feet NAVD88, the lake covers about 12,350 acres, extends some 16 miles upstream from the dam, and spreads a mile wide, on average, over that length. At full flood control pool, elevation 1136.44 (NAVD88), the lake swells to cover about 53,700 acres and extends upstream 35 valley miles. (USACE 2004)

Discharges from Tuttle Creek Lake are controlled by the outlet works under both multi-purpose and flood control releases. The emergency spillway will be used under surcharge conditions or when surcharge operations are anticipated. The outlet works include a low flow outlet and a primary outlet works. The low flow outlet is two 24-inch pipes that have a discharge of approximately 100 cfs per pipe at pool elevation 1061.44 feet NAVD88. The primary outlet works consist of four 10 foot by 20 foot gates with one additional emergency gate. These gates control discharges to two 20 foot diameter horseshoe conduits that discharge to a stilling basin and outlet channel. The primary outlet works have a discharge capacity of 31,300 cfs at pool elevation 1075.44 feet and 45,900 cfs at pool elevation 1136.44 feet. The spillway is at a crest elevation of 1116.44 feet NAVD88 and is controlled with eighteen 40 foot by 20 foot tainter gates. The spillway has a maximum discharge of approximately 579,000 cfs at maximum water surface elevation of 1151.84 feet NAVD88. Table 2-3 summarizes the outlet work and spillway discharge capacity for Tuttle Creek Lake even though operational criteria will likely control actual releases from the lake.

Table 2-3. Discharge Capacity at Tuttle Creek Lake

Pool Elevation (NAVD88)	Low Flow Outlet Discharge (cfs)	Primary Outlet Works Discharge (cfs)	Spillway Discharge (cfs)
1030.44	0	0	0
1061.44	200	27,802	0
1075.44	290	31,300	0
1116.44	555	40,898	0
1124.44	606	42,802	50,000
1128.44	632	43,755	100,000
1132.44	658	44,707	150,000
1135.44	677	45,421	200,000
1136.44	684	45,900	233,500
1151.44	781	49,231	579,000

Note: Shaded cells are interpolated values based on flows taken from the Tuttle Creek Operation Manual. Non-shaded cells were taken directly from the manual.

2.2 SITE BACKGROUND

This study was initiated in response to events observed in Manhattan during the July 1993 flood. The Manhattan Kansas levee unit withstood the flood of 1993, but some elements of the system were seriously challenged as releases from Tuttle Creek Dam created a situation with approximately 3.5 feet of freeboard at some locations along the Big Blue River levee segment. Although the design documentation for the Manhattan levee describes a system designed for a significantly higher coincident flow than the July 1993 experience (USACE 2004), this event raised a concern that the levees may be performing below the intended design performance level. The following sections provide a discussion of the flood history of the City of Manhattan, including background information of the 1951 and 1993 flood events.

2.2.1 Flood History

Major floods on the Kansas River are usually caused by a series of short-duration, high-intensity storms following a protracted period of general rains which reduce the infiltration capacity of the soil to a minimum and cause a greater than normal flow in the stream channels. Many of the early floods in the Kansas River Basin are a matter of legend and tradition rather than actual historical record. Early floods affecting the area in the vicinity of Manhattan occurred in 1785, 1826, 1844, 1845, 1851, 1858, 1870, 1881, and 1886, but very little is known concerning these floods (USACE 1959). More recent flood events for which records are available occurred in 1903, 1904, 1908, 1915, 1935, 1941, 1945, 1947, 1948, 1950, 1951, and 1993. The 1844 flood appears to

have produced the maximum stages of record on the Kansas River followed in magnitude by the 1951, 1903, and 1993 stages.

A comparison of the relative flood depths by Juracek et al. (2001) showed that the 1844, 1951, and 1903 flood depths at Ogden, Kansas were about 10, 5.25, and 0.25 feet higher, respectively, than for the 1993 flood. The maximum daily peak streamflows for these four floods for the Kansas River at Ogden, Big Blue River near Manhattan, and Kansas River at Wamego are summarized in Table 2-4. A description of the four largest floods at Manhattan is given in the following subsections.

Table 2-4. Comparison of Maximum Daily Peak Streamflows for Floods of 1844, 1903, 1951 and 1993 at Selected USGS Streamflow-Gaging Stations

USGS Station	Station Name	Maximum daily peak streamflows (cfs) (date)			
		1844	1903	1951	1993
06879500	Kansas River at Ogden[2]	(1)	236,000	298,000	85,000
06887000	Big Blue River near Manhattan[3]	(1)	93,800 (May 31)	93,400 (July 12)	58,800 (July 23)
06887500	Kansas River at Wamego[3]	(1)	280,000 (May 30)	400,000 (July 13)	199,000 (July 26)

[1]Flow was greater than 1951 flood.
[2]From Juracek and others (2001).
[3]From Combs and Perry (2003).

2.2.2 Flood of 1844

A great flood is known to have occurred on the Kansas River in June 1844. Data are not available on the nature, extent, and magnitude of the storm rainfall, and only fragmentary data on flood stages are available. A stage of about 40 feet occurred on the Kansas River at Manhattan (USACE 1959).

2.2.3 Flood of 1903

The second largest flood for which reliable stage records are available occurred during the latter part of May and the first part of June 1903. This flood resulted from extraordinarily heavy rainfall the last five days in May preceded by above-normal rainfall throughout May. The rainfall at Abilene was estimated at 15 inches on May 28. Flood stage was exceeded approximately 16 days at Manhattan (USACE 1959).

2.2.4 Flood of 1951

The maximum flood of record occurred in July 1951 and resulted from the combined effects of well above average rainfall in May and June 1951 and a major event spanning four days (July 9 through 12) of extremely heavy precipitation over the lower portion of the Kansas River Basin. Table 2-5 also includes the average monthly rainfall and the standard deviation for each month.

Table 2-5. Monthly Rainfall Leading up to July 1951 Event

	Rainfall, inches		
	April	May	June
1951	2.8	10.3	11.1
Average	2.9	4.6	5.1
St Dev	1.7	2.7	3.0

An isohyetal map (connecting points having equal amounts of precipitation during a given time period or for a particular storm) for Kansas and western Missouri from the USGS report "Kansas-Missouri Floods of July 1951" (Figure 3) shows that about 40 percent of Kansas received more than 10 inches of rain during June 1951 (USGS 1952). This area included most of the Smokey Hill River Basin and portions of the Republican River Basin. The Big Blue River basin north to the Nebraska border had rainfall in excess of 12 inches, with one area exceeding 14 inches.

The event causing the 1951 flood peaks spanned from July 9th through 12th and occurred in three bursts, with the areas of highest total precipitation receiving nearly one-half of the total amount on July 11 (USGS 1952). The highest precipitation from July 9 through 12 was reported at the weather station in Alta Vista, Kansas 25 miles south of Manhattan. This event followed two months of above normal precipitation over the same area. Near record flows also occurred on the Nebraska headwaters of the Big Blue River during June (USGS 1952).

Figure 4 is an isohyetal map showing rainfall from this event (US Department of the Interior, 1951). This event, combined with the previous months' rainfall, caused the 1951 flooding on the Kansas River. According to the US Weather Bureau's Technical Paper 49, the 1% (1/100) ACE 4-day precipitation for these areas of Kansas range from 7 to 11 inches; therefore, this event alone surpasses a 1% (1/100) ACE event in magnitude of rainfall. Coupled with the effect of the two previous months' above average rainfall, it produced record flooding on the Kansas River.

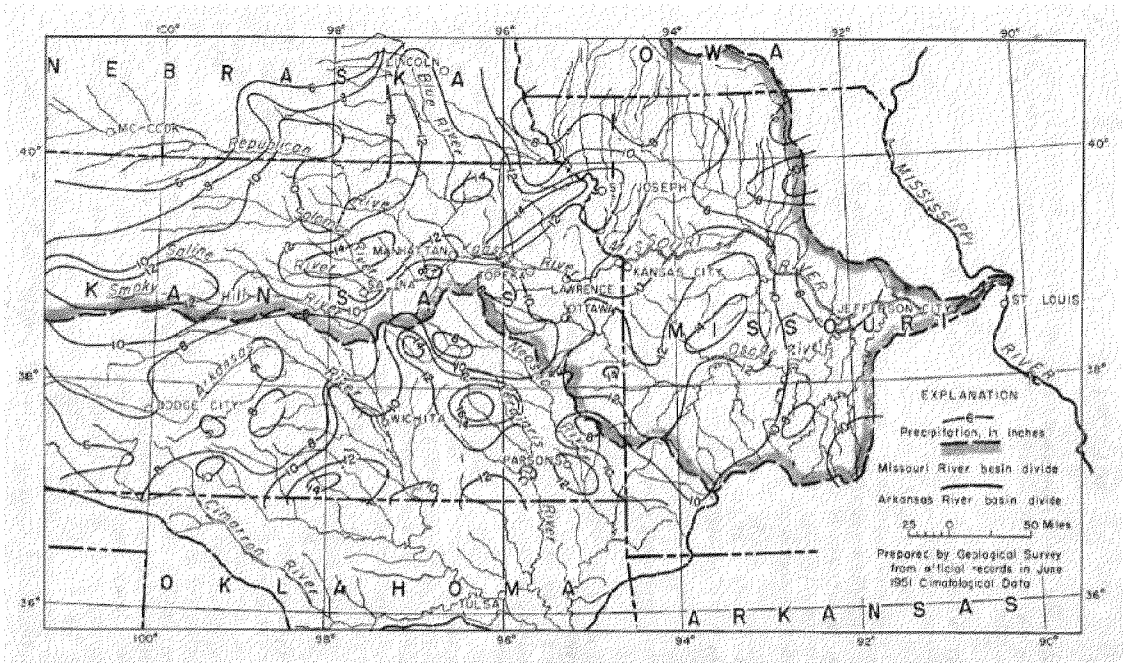


Figure 3. Isohyetal Map of Rainfall in June, 1951
Reference: U.S. Geological Survey (USGS), 1952, Kansas-Missouri floods of July 1951, USGS Water Supply Paper 1139

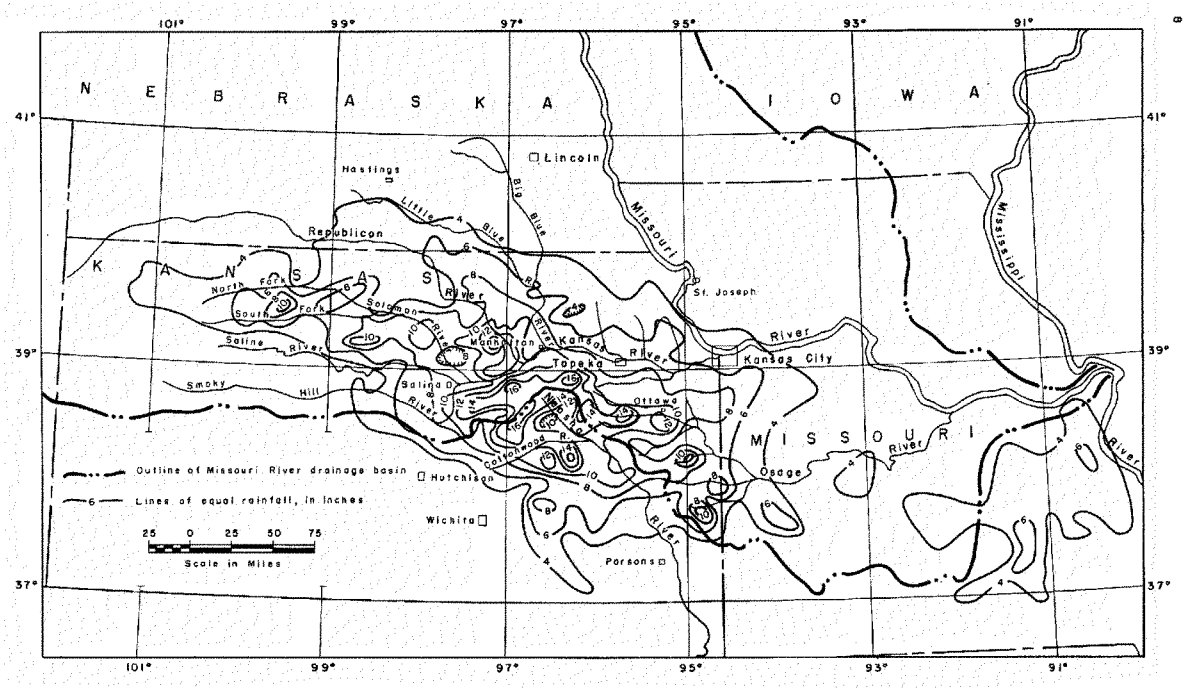


Figure 4. Isohyetal Map of Rainfall Resulting from the Event Spanning July 9th to 12th
Reference: U.S. Department of the Interior – Water Resources Division, Geological Survey Circular 151, October 1951

The Kansas River at Manhattan was above flood stage (17 feet) on June 4, June 7 through 19, and June 22 through July 24, 1951 for a total of 47 days. The maximum gage height of 33.40 feet occurred at 3:00 a.m., July 13, with an estimated discharge of 300,000 cfs in the Kansas River and about 98,000 cfs in the Big Blue River (USACE, Manhattan, Kansas Flood Protection Project Design Memorandum No. 1 - 1959). The USACE reported peak discharge for the Big Blue River near Manhattan in the 1959 report varies approximately 4600 cfs from the USGS peak discharge of 93,400 cfs recorded for the Big Blue River near Manhattan Gage in the 1951 flood.

Fort Riley and Manhattan were the first urban areas to be flooded by the Kansas River. Some of the barracks at Fort Riley were smashed or carried away by the flood. The Kansas River at Manhattan began overflowing on July 11 and was soon spread out from bluff to bluff along the entire valley. The main business district and about 1,600 homes were flooded. Depths of flooding in the main business section ranged from 6 to 8 feet. Swift currents through the parts of Manhattan located nearest the Kansas River demolished some homes and two large industrial buildings (USGS 1952). Figure 5 shows the area flooded during July at Manhattan.

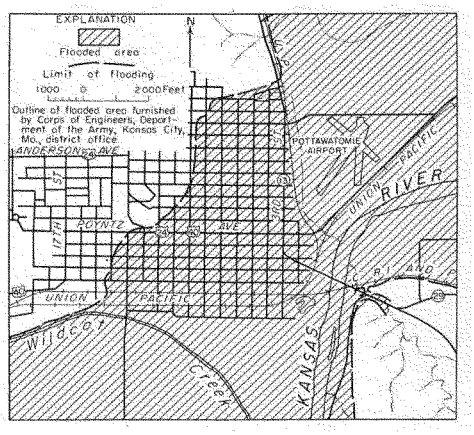


Figure 5. Map of Area Flooded During July 1951 at Manhattan, Kansas from USGS Water Supply Paper 1139 (USGS 1952)

2.2.5 Flood of 1993

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

second wettest period in 104 years of record. July rainfall was 535 percent of the normal (Wahl et al. 1993).

A comparison of observed controlled and simulated uncontrolled daily mean discharge in the Blue River near Manhattan for July 1993 (Perry 1993) indicated that the storage of floodwaters in Tuttle Creek Lake reduced a potentially devastating flood of more than 95,000 cfs on July 5 on the Big Blue River near Manhattan to a much less destructive flood of 60,000 cfs on July 25. The water surface elevation in the Big Blue came within 3 to 4 feet of the top of the Big Blue River section of the Manhattan levee. Perry (1993) concluded that without the reservoir storage, the Big Blue River near Manhattan would have overtopped the Federal levee, and flooding downstream along the Kansas River would have been much more severe. High stages were most noticeable upstream and near the U.S. Hwy 24 and Union Pacific bridge crossings. The levee did not fail, but this incident prompted great concern within the local community about the levee.

2.3 HYDROLOGY

2.3.1 Levee Design Discharges

The original levee design discharges for the Manhattan levee unit as presented in Design Memorandum No. 1, Manhattan, Kansas Flood Protection Project, (USACE 1959) are discussed in the following subsections.

2.3.2 General Considerations

The development of a Standard Project Flood in accordance with the standard procedures at the time of original design was not practical for a stream such as the Kansas River at Manhattan. In establishing the design discharge for the local protection works at Manhattan, consideration was given to (1) confluence condition due to the Kansas and Big Blue Rivers; (2) the effects of existing, authorized and potential reservoirs in the basin above Manhattan; (3) hazards involved in the event of a flood occurrence with peak flows in excess of design discharges; (4) urban development in the areas to be protected; and (5) design discharges recommended in previous studies.

2.3.3 Summary of Studies

The July 1951 flood occurred with an estimated peak discharge of 298,000 cfs at Ogden, upstream of Manhattan, and 400,000 cfs at Wamego, downstream of Manhattan. Detailed studies were made following the July 1951 flood to establish hypothetical flood flows resulting from a transposition of the July 1951 storm center and to evaluate the effects of authorized and potential reservoirs on natural and hypothetical flows. The natural and modified discharges from these studies for Ogden and Wamego, located upstream and downstream from Manhattan, are shown in Table 2-6.

Table 2-6. Actual and Modified Discharges - Vicinity of Manhattan, Kansas (From Design Memorandum No.1)

	Ogden Mile 162.1	Wamego Mile 126.9
July 1951 flood	**(discharge in 1,000 cubic feet per second)**	
Actual discharge	298	400
Modified discharge (modified by existing and authorized reservoirs)	237	251
Modified discharge (modified by existing, authorized and potential reservoirs [a]	227	216
July 1951 transposition flood [b]		
Natural discharge	334	463
Modified discharge (modified by existing and authorized reservoirs)	270	277
Modified discharge (modified by existing, authorized and potential reservoirs) (a)	189	205

(a) Potential reservoirs considered were Sutphen Mills on Chapman Creek, Turkey Creek, Woodbine on Lyons Creek and Humboldt on Clark Creek.

(b) Transposition with storm center moved 40 miles northeast, rotated 25 degrees, counterclockwise, and no adjustment of rainfall amounts.

2.3.4 Original Adopted Discharge

The original design discharge was modified to 220,000 cfs on the Kansas River upstream of the Big Blue River during committee hearings in May 1954 and was authorized by the Flood Control Act approved 2 September 1954 (H.Doc. 642, 81st Cong., 2d sess.). "In reference to Table 3, protection height, based on a design discharge of 220,000 cfs, will provide for the July 1951 flood as modified by existing and authorized reservoirs, with some encroachment on the freeboard. Likewise, such a protection will provide adequate freeboard for a discharge based on the July 1951 transposed flood as modified by existing and authorized reservoirs and a reasonable number of the most effective potential reservoirs on the secondary tributaries of the Kansas River above Manhattan. Therefore, the authorized design discharge was considered adequate and was used in the project plan."

2.3.5 Design Profile for Protected Works

The design profile along the Kansas River was based on backwater computations using the design discharge of 220,000 cfs with assumed "n" values of 0.025 and 0.05 for channel and overbank, respectively, which were verified from

calibration to known profiles of the Kansas River. Design flow is considered to be confined by left bank levees along the Kansas River. The elevation at the tieback along the Blue River was determined by assuming an outflow of approximately 110,000 cfs from Tuttle Creek Dam as resulting from a transposition of the July 9 to 13, 1951 storm above Milford and Tuttle Creek Dams and operation with antecedent storage which would have existed as of July 9. The top of levee profile was adopted which would provide balanced overtopping along the Kansas River for a discharge of 335,000 cfs. The revised top of levee profile provided a freeboard of 2 feet above the design discharge (220,000 cfs) at the mouth of the Big Blue River and approximately 3 feet of freeboard above the design discharge at the contraction due to the bridges over the Kansas River present at the time of design. Freeboard along the Blue River tieback levee was revised to 2 feet.

2.3.6 Model Discharges

River flow rates for both the Kansas and Big Blue Rivers for this evaluation were based on output from the Kansas River UNET model. The Kansas River UNET model was developed by the Kansas City District for unsteady flood routing of the daily flows over the period of 1929 to 2002. The daily flows were evaluated in two scenarios. The Unregulated scenario evaluated a synthetic period of record flows along the Kansas and Big Blue Rivers assuming that no reservoirs were in place within the Kansas River Basin for the entire period of record. The Regulated scenario developed a synthetic record assuming current Kansas River Basin reservoir operations were in place for the entirety of the period of record. This approach was developed using actual USGS daily gage records over the period of record. This is an approach similar to the methods used for the USACE Kansas River Hydrology Report (2002) and the USACE Upper Mississippi River System Flow Frequency Study – Appendix E (2003).

2.3.7 Flow Frequency Analysis

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

A graphical analysis of regulated data (following USACE Engineer Manual 1110-2-1415) for the most frequent flows is appropriate as the reservoirs provide complete regulation of the frequent flow events. A log Pearson type III (LP3) analysis of unregulated data (following USACE Engineer Manual 1110-2-1415 and Bulletin 17B) was conducted to provide an upper bound for the flow frequency analysis and estimate the most extreme events.

In the largest events, reservoirs will make releases for dam safety in lieu of flow regulation and outflows will tend to match unregulated releases. Between these two

flow frequencies there is a transition zone where the reservoir operations begin to release higher flows to maintain the flood control pool and avoid surcharge operations. In this transition zone an analysis relating unregulated flows to regulated flows was conducted and the relationship was used to convert the log Pearson III unregulated flow frequency to regulated discharges.

The recognition and exclusion of outliers played a significant role in this analysis. USACE Engineer Manual 1110-2-1415, Paragraph 3-2g defines an outlier as a data point which departs significantly from the trend of the remaining data. In a flow frequency analysis, an outlier will have a disproportionate effect on the frequency curve, skewing it either too high or too low against the trend of the rest of the data. For both reaches analyzed, low outliers were found. The Kansas River reach analysis also identified a high outlier. These are described in greater detail in the following sections.

2.3.8 Big Blue River

The final results of the Big Blue River flow frequency analysis for regulated conditions are shown in Table 2-7. Refer to Figure 6 for the flow frequency analysis of the Big Blue River below Tuttle Creek Reservoir. The regulated flow data were plotted and analyzed using a graphical analysis as defined in USACE Engineer Manual 1110-2-1415. The regulated data were assigned plotting positions and a curve was fit through the data. The data points above the 5% (1/20) annual chance exceedance event are from the 1993 and 1951 spillway discharge flood events and likely are not adequately assigned a probability based on the short period of record. Thus the graphical analysis of the regulated data was used only for the flow frequency analysis on the Big Blue River for flows up to the 5% (1/20) annual chance exceedance event.

In order to get a longer period of record than would be available at the dam using the Big Blue River at Manhattan, Kansas gage (pre-dam data started in 1950) and water management daily inflow records post dam (closure was in 1959), and to have a consistent data set, actual daily inflow records for Tuttle Creek Dam were not utilized in the computations. Inflow records in this hydrology study were simulated back to 1929 using upstream inflow gages with daily flows routed to Tuttle Creek Dam via Muskinghum-Cunge and the UNET algorithm for accounting for ungaged inflows to produce expected flow volumes at Manhattan, KS. In general, upstream gage streamflows were factored up using percentage comparisons to flow volumes at Manhattan for pre-dam overlapping data periods between streamflow records, where upstream gages appeared to capture over 80% of the streamflow upstream of Manhattan. Therefore, the daily values of the Tuttle Creek inflow records do not exactly match the simulated inflow record for this feasibility study.

The unregulated analysis was conducted using the procedures defined in USACE Engineer Manual 1110-2-1415 and Bulletin 17B. The unregulated flow frequency analysis was conducted using the Hydrologic Engineering Center's Statistical Software Package (HEC-SSP). The output has been included in Attachment A. The statistical analysis of the unregulated record on the Big Blue River did not identify any high outliers but did identify the 1934 annual peak flow as a low outlier. This data point

was removed from the log Pearson III analysis of the annual peak unregulated flows. The analytical analysis of the unregulated data will be the best estimate for the most extreme events as the reservoir operations will call for passing the incoming flows to protect the integrity of the dam.

The transitional zone of the flow frequency analysis was defined as the point where reservoir regulation of flows begins to be reduced by spillway releases at the lower end of the transition zone and the event where regulated flows are equal to unregulated flows at the high end of the transition zone. The flow frequencies of the transition zone and the point at which the reservoir no longer regulates flood flows must be determined using a comparison of regulated flows (reservoir outflows) and unregulated flows (reservoir inflow) data.

Figure 7 displays the comparison of the annual peak daily inflows to the annual peak daily outflows for a given year. It is evident that there is little correlation between the annual peak daily outflow and the annual peak daily inflow. This is evident by examining some of the extreme events seen on the Big Blue River. The unregulated daily peak flow for 1973 is greater than 100,000 cfs yet the regulated peak discharge for 1973 is only approximately 26,000 cfs, while the unregulated daily peak flow in 1993 was approximately 95,000 cfs and the regulated peak discharge was approximately 60,000 cfs.

A reservoir's outflow (regulated discharges) is dictated more by inflow volume as opposed to inflow daily peaks. A sustained inflow period is necessary to raise reservoir elevations to the point of releasing large outflows. This is evident in both the 1993 and 1951 flood events when large rainfall amounts were recorded over an extended period of time as discussed in Section 2.1.3. Figure 7 displays the relationship of the annual peak reservoir outflow to the annual peak average inflow volumes over 15-day, 30-day, 60-day, and 90-day periods. The correlation between inflow volumes and outflow is much better than that of daily inflow peaks. The peak annual 30-day inflow volume provided the best estimator of peak annual outflow as evidenced by the R^2 value for the trendline of the inflow-outflow relationships.

The 30-day average inflow volume was also chosen as it was the shortest average flow duration that provided a good predictor of outflow. Using the shortest period of inflow that provides a good estimation of outflow is preferable as it maintains the most resolution of inflow peaks from year to year without averaging away peaks for smaller events. A polynomial fit of the 30-day average inflow volumes (unregulated flows) and outflow (regulated flows) relationship was developed. A Log Pearson III frequency analysis of the peak annual 30-day average inflows was analyzed for the period of record.

The 30-day average inflow volumes from this frequency analysis were then converted to peak daily outflows using the polynomial fit. This method provided the outflows from the 4% (1/25) annual chance exceedance event to the 0.5% (1/200) annual chance exceedance event. This analysis also identified those reservoir inflow events greater in magnitude than the 0.5% (1/200) annual chance exceedance event

will most likely behave as unregulated and inflow will equal outflow. Thus the unregulated peak daily flow analysis results were used for the events equal to or greater than 0.33% (1/300) annual chance exceedance.

Table 2-7. Flow Frequency Results for the Big Blue River at Manhattan, Kansas

		Section 216 Feasibility Study Results			FEMA(1)
% Annual Chance Exceedance	Return Period	95% Confidence Limit	Frequency Curve	5% Confidence Limit	Estimated Peak Discharge (cfs)
0.133	750	119,400	179,400	269,700	NA
0.2	500	112,000	167,000	248,800	92,100
0.333	300	102,900	151,700	223,500	NA
0.5	200	81,000	115,800	165,400	NA
1	100	52,800	71,600	97,100	49,600
2	50	35,600	46,200	60,000	46,800
4	25	26,200	33,000	41,600	NA
10	10	21,800	27,000	33,500	36,300

1) FEMA. Revised Feb. 4, 2005. Flood Insurance Study Riley County, Kansas & Incorporated Areas.

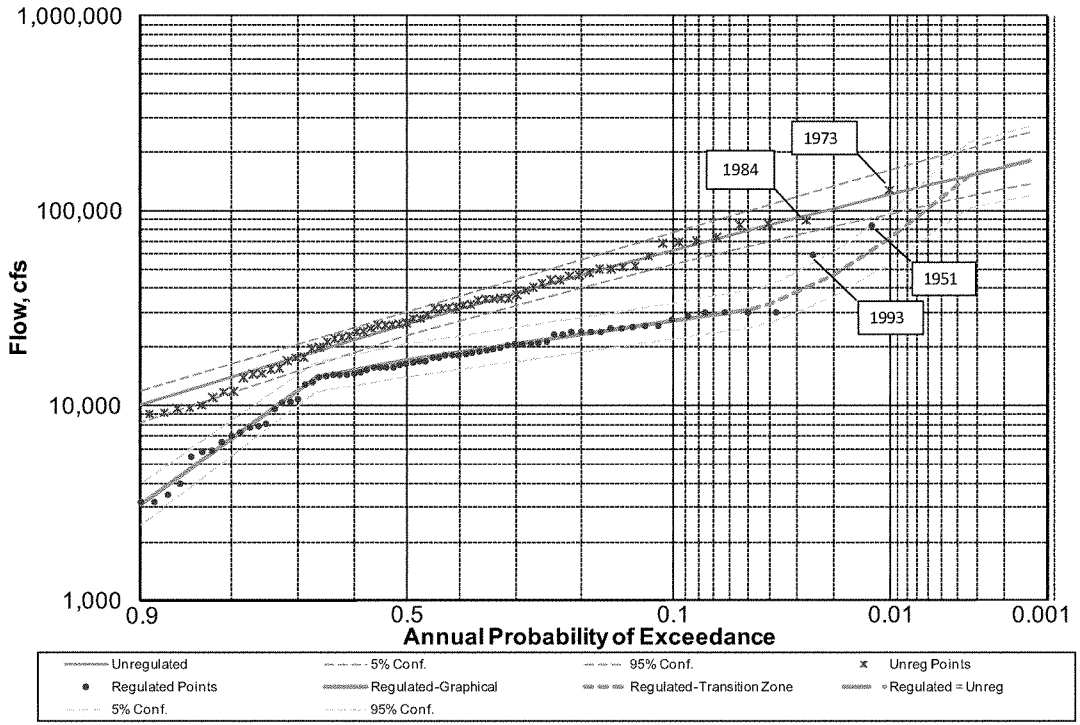


Figure 6. Big Blue River Flow Frequency

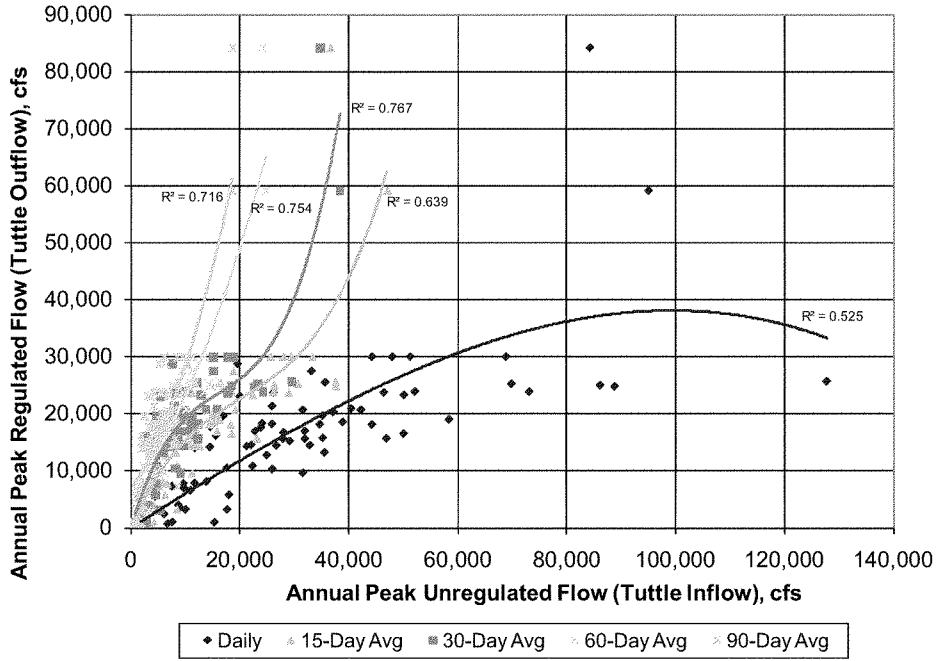


Figure 7. Big Blue River Annual Peak Flow Relationships Unregulated Versus Regulated Flows

2.3.9 Kansas River Upstream of Big Blue River

The final results of the Kansas River upstream of the Big Blue River confluence flow frequency analysis for regulated conditions are shown in Table 2-8. Refer to Figure 8 for the flow frequency analysis of the Kansas River upstream of the Big Blue River Confluence. The regulated flow data were plotted and analyzed using a graphical analysis. The data points above the 5% (1/20) annual chance exceedance event are from the 1993 and 1951 flood events and likely are not adequately assigned a probability based on the short period of record. Thus the graphical analysis of the regulated data was used only for the flow frequency analysis on the Kansas River for flows up to the 5% (1/20) annual chance exceedance event.

The unregulated analysis was conducted similar to the methods used for the Big Blue River. The output has been included in Attachment A. The statistical analysis of the unregulated record on the Kansas River did identify the 1951 peak flow as a high outlier and did not identify any low outliers. The 1951 peak unregulated flow was removed from the systematic record and treated as an historic flood event. The 1903 flood was the last large flood event on the Kansas River prior to the 1951 flood. The 1903 flood is listed as an historic flood event at the USGS Wamego gage on the Kansas River downstream of the confluence.

Thus the relevance of the 1951 flood could be extended to 1903, effectively identifying the 1951 flood event as the largest flood event over 100 years of record. This historic assignment allows for adjusting the log Pearson type III analysis by extending the period of record beyond the systematic record length. The analytical analysis of the unregulated data provides an upper bound for the regulated flow frequency and allows for the estimation of regulated frequency by applying regulation equations to unregulated flow frequencies, as discussed below.

The transitional zone of the flow frequency analysis was defined as the point where reservoir regulation of flows begins to be reduced by spillway releases at the lower end of the transition zone and the event where regulated flows are equal to unregulated flows at the high end of the transition zone. The flow frequencies of the transition zone and the point at which the reservoir no longer regulates flood flows must be determined using a comparison of regulated and unregulated data. Figure 9 displays the comparison of the annual peak daily unregulated flows and the time averaged annual peak unregulated flows to the annual peak daily regulated flows for a given year.

Unlike the Big Blue River flows, the Kansas River unregulated annual peak daily flows are correlated well to the regulated annual peak daily flows. Thus, the relationship between single daily peak flow unregulated and regulated values was used to estimate the regulated peak flows for events greater than the 5% (1/20) annual chance exceedance event. This result is different than the Big Blue River analysis that used annual peak 30-day average unregulated flows, but should be expected.

The Kansas River at Manhattan has significant non-regulated drainage areas and multiple reservoir systems contributing to peak flows. Thus no single reservoir discharge or inflow to a reservoir defines the peak on the Kansas River at Manhattan. Due to the reduced regulation influence on the Kansas River upstream of the confluence as compared to the heavily regulated Big Blue River, a single event that would produce a large unregulated daily peak flow is likely to produce a large regulated daily peak flow as well.

A polynomial fit of the daily peak unregulated flows and daily peak regulated flows was developed. The unregulated log Pearson type III analysis was then converted to the regulated analysis using the polynomial fit. This method provided the outflows from the 4% (1/25) annual chance exceedance event to the 0.133% (1/750) annual chance exceedance event. The unregulated/regulated relationship identified some small benefit of regulation even for the largest events analyzed in this study.

Table 2-8. Flow Frequency Results for Kansas River Upstream of Big Blue River

		Section 216 Feasibility Study Results			FEMA(1)
% Annual Chance Exceedance	Return Period	95% Confidence Limit	Frequency Curve	5% Confidence Limit	Estimated Peak Discharge (cfs)
0.133	750	185,000	277,400	415,900	NA
0.2	500	156,800	229,700	336,500	250,000
0.333	300	127,900	182,200	259,500	NA
0.5	200	108,300	150,800	210,000	NA
1	100	81,700	109,500	146,800	140,000
2	50	61,200	79,000	102,100	105,000
4	25	45,300	56,400	70,300	NA
10	10	27,000	32,000	37,900	46,000

1) FEMA. Revised February 4, 2005. Flood Insurance Study Riley County, Kansas & Incorporated Areas.

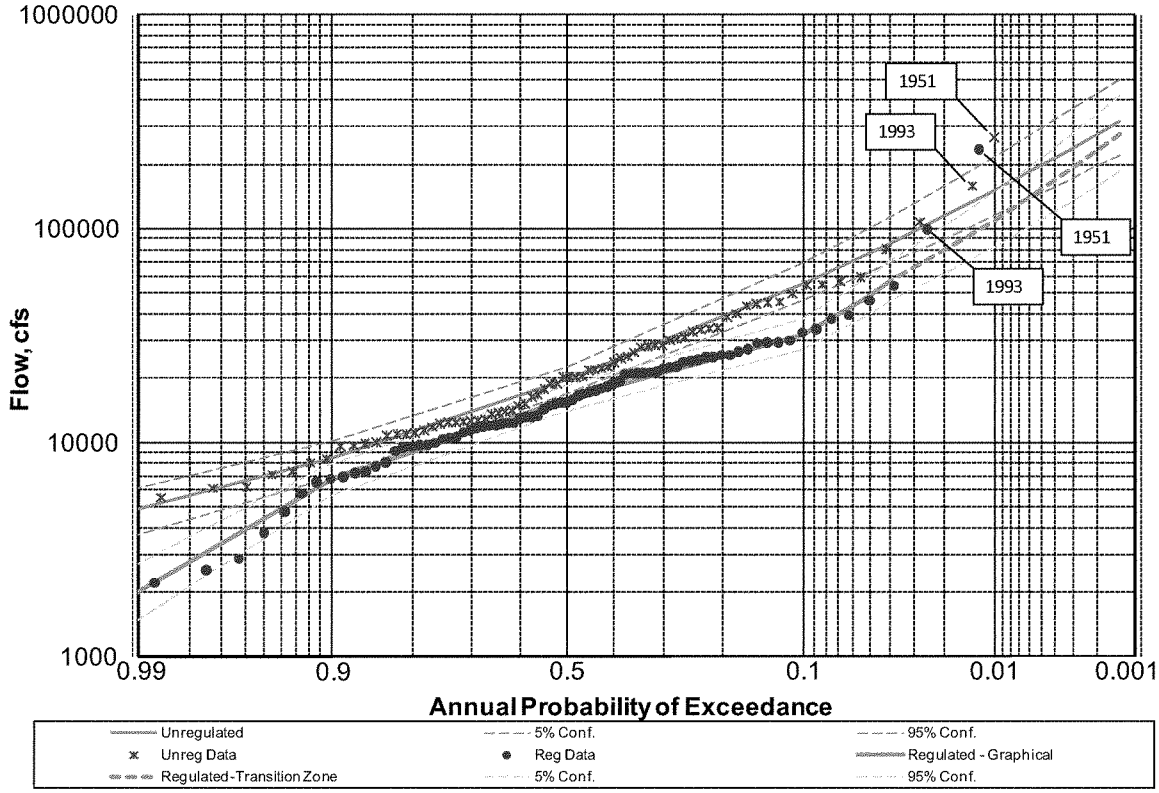


Figure 8. Kansas River Upstream of the Big Blue River Confluence Flow Frequency

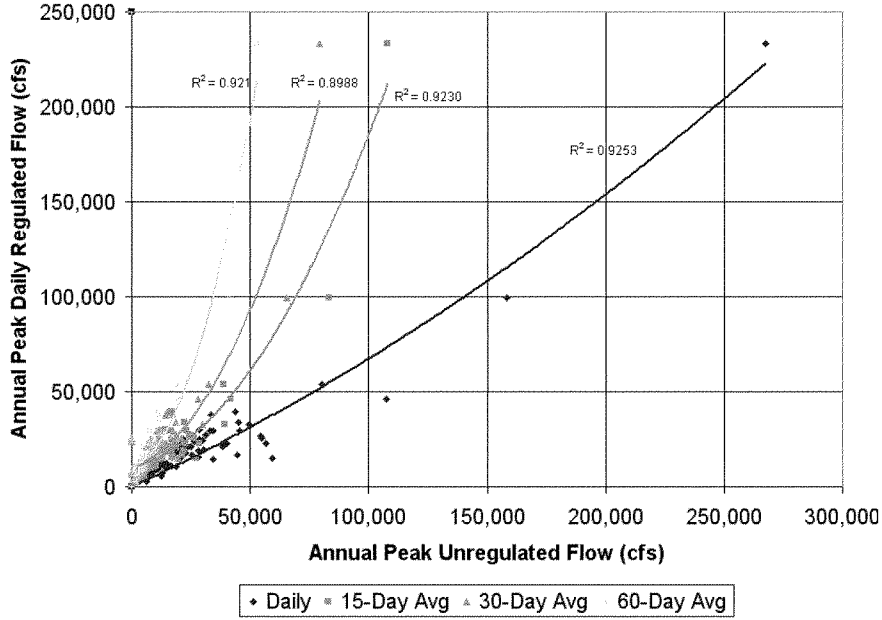


Figure 9. Kansas River Upstream of the Big Blue River Confluence Annual Peak Flow Relationships Unregulated Versus Regulated Flows

2.3.10 Kansas River Downstream of the Big Blue River

The final results of the Kansas River downstream of the Big Blue River Confluence flow frequency analysis for regulated conditions are shown in Table 2-9. Refer to Figure 10 for the flow frequency analysis of the Kansas River downstream of the Big Blue River Confluence. The regulated flow data were plotted and analyzed using a graphical analysis. The graphical analysis of the regulated data was used only for the flow frequency analysis on the Kansas River for flows up to the 5% (1/20) annual chance exceedance event.

The unregulated analysis was conducted similar to the methods used for the Big Blue River and the Kansas River upstream of the confluence. The output has been included in Attachment A. The statistical analysis of the unregulated record on the Kansas River did identify the 1951 peak flow as a high outlier and did not identify any low outliers. The 1951 peak unregulated flow was removed from the systematic record and treated as an historic flood event similar to the Kansas River above the confluence analysis.

The transitional zone of the flow frequency analysis was defined as the point where reservoir regulation of flows begins to be reduced by spillway releases at the lower end of the transition zone and the event where regulated flows are equal to unregulated flows at the high end of the transition zone. The flow frequencies of the transition zone and the point at which the reservoir no longer regulates flood flows must be determined using a comparison of regulated and unregulated data. Figure 11 displays the comparison of the annual peak daily unregulated flows and the time averaged annual peak unregulated flows to the annual peak daily regulated flows for a given year.

The annual peak 15-day average unregulated flows provide a much better correlation to regulated annual peak flows than the annual peak daily flows. The use of the 15-day average unregulated flows is reasonable. Due to the location immediately below the confluence of two major rivers, this is a hybrid between the Kansas River above the Confluence analysis which was governed by the daily peak unregulated flows and the Big Blue River analysis which was governed by the 30-day average unregulated peak flows. Thus, the relationship between unregulated 15-day average peak flows and regulated daily peak flows was used to estimate the regulated peak flows for events greater than the 5% (1/20) annual chance exceedance event. A polynomial fit of the 15-day average unregulated peak flows and daily peak regulated flows was developed. A Log Pearson III frequency analysis of the peak annual 15-day average unregulated flows was analyzed for the period of record. The 15-day average unregulated flows from this frequency analysis were then converted to peak daily regulated flows using the polynomial fit.

This method provided the outflows from the 4% (1/25) annual chance exceedance event to the 0.5% (1/200) annual chance exceedance event. This analysis also identified those events greater in magnitude than the 0.5% (1/200) annual chance exceedance event will most likely behave as unregulated and regulated flows will be equal to unregulated flows. Thus the unregulated peak daily flow analysis results were used for the events equal to or greater than 0.33% (1/300) annual chance exceedance.

Table 2-9. Flow Frequency Results for Kansas River Downstream of Big Blue River

		Section 216 Feasibility Study Results			FEMA(1)
% Annual Chance Exceedance	Return Period	95% Confidence Limit	Frequency Curve	5% Confidence Limit	Estimated Peak Discharge (cfs)
0.133	750	269,700	397200	585,000	NA
0.2	500	248,100	361200	525,700	290,000
0.333	300	222,500	319000	457,400	NA
0.5	200	185,000	258600	361,400	NA
1	100	132,700	177300	236,900	160,000
2	50	94,300	120500	154,000	120,000
4	25	58,000	70000	84,500	NA
10	10	40,100	46800	54,600	56,000

2.3.11 Hydrologic Uncertainty

Hydrologic uncertainties were calculated using the HEC-SSP program. The flow frequency curves, as determined by the methodology in Sections 3.3.1 – 3.3.3 for the three legs of the confluence, were each entered into HEC-SSP as a graphical analysis of data to allow computation of the uncertainty bands about the adopted frequency curve. The methodology employed by the program to calculate uncertainty for graphical analysis is consistent with USACE Technical Letter No. 1110-2-537 *Uncertainty Estimates for Nonanalytic Frequency* Curves (dated 1997). The hydrologic uncertainties for each leg of the confluence have been included in Tables 2-7 through 2-9 and Figures 6, 8, and 10.

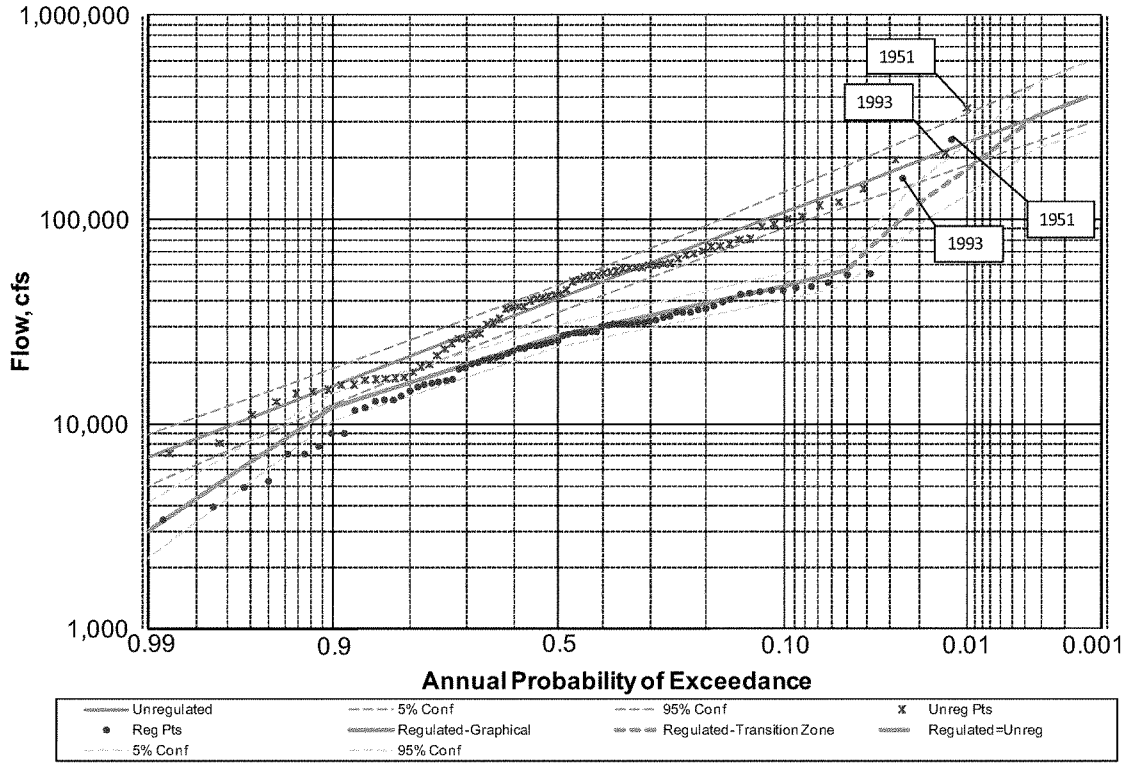


Figure 10. Kansas River Downstream of the Big Blue River Confluence Flow Frequency

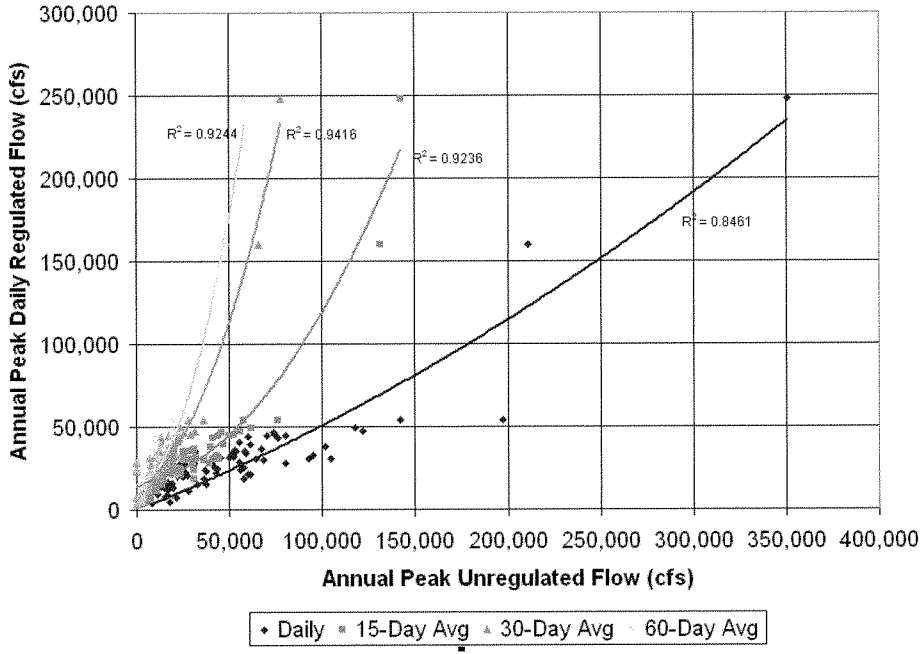


Figure 11. Kansas River Downstream of the Big Blue River Confluence Annual Peak Flow Relationships Unregulated Versus Regulated Flows

2.3.12 Coincident Frequency Analysis

The results of the flow frequency analyses performed in Sections 2.3.8 through 3.3.10 describe the individual frequencies of each of the three legs of the Kansas River and Big Blue River confluence. The individual flow frequency is looking at the historical flow records of each leg of the confluence, disregarding the flow of the remaining two legs of the confluence. However for the hydraulic analysis it is imperative to identify the most likely coincident flow on the remaining legs of the confluence given a flood event on the Big Blue River or the Kansas River.

A review of the records identify that the tributary rivers sometimes respond to a rainfall event that produces a pronounced peak in one hydrograph and only a weak response in the other tributary. At other times, both tributaries respond to the same event, but rarely do both hydrographs peak on the same day. The two largest events for the regulated record of both streams are the peak annual flows of 1993 and 1951. For this study, the streams are being classified as semi-independent. Since each basin has shown the capacity to influence the presence of flooding below the confluence, it has been decided to develop individual relationships between the flow coincidence from each basin and the Kansas River below the confluence.

To develop these relationships between each basin and the Kansas River below the confluence, the peak annual flow from each basin was extracted from the UNET regulated record and plotted with the corresponding flow below the confluence on the same day as the tributary peak flow. Figure 12 displays the plot relating the Big Blue annual peak regulated flows with the corresponding flow below the confluence. A typical method to develop a relationship through this scatter data would be to pass a best fit curve through this data.

However, there is a lot of uncertainty in fitting a curve through this data to predict coincidence out to the 0.133% (1/750) event. It is evident that from the 79 year record that the maximum data point recorded for evaluation is the 1951 event that would represent a recurrence interval between the 1% event and 0.5% event. To provide additional points of reference, for extending the relationship beyond the modeled period of record, the paired flow frequency events from the independent flow frequency analyses for both the Big Blue River and the Kansas River below the confluence were included on the graph. For example, the 0.2% flood event discharge from the Big Blue River was paired with the 0.2% flood event discharge from the lower Kansas River. A best fit curve of the period of record peak annual flow data would lie in line with the paired frequency data.

Thus it was determined that the best predictive relationship between the Big Blue and the Kansas River below the confluence is to utilize the paired flow frequency events. For example, any analysis of the 1% (1/100) annual chance event on the Big Blue River would assume a 1% (1/100) annual chance event on the Kansas River below the confluence. The difference between these two flows would be the coincident flow from Kansas River above the confluence. Table 2-10 shows the most likely coincident Kansas River flows for a Big Blue River flood event.

Table 2-10. Coincident Kansas River Flows for a Big Blue River Flood

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

Figure 13 displays the plot relating the Kansas River annual peak regulated flows with the corresponding flow below the confluence. The same method used in the Big Blue River coincidence analysis was utilized for the Kansas River above the confluence analysis. The Kansas River above the confluence peak flows plotted against the flow in the Kansas River below the confluence on the same day was in general agreement with the paired frequency data except for the 1951 data point. The 1951 data point indicates that for the peak regulated discharge seen above the confluence on the Kansas River (233,500 cfs), the flow below the confluence on the same day was only 248,100 cfs.

This indicates that a large event on the Kansas River above the confluence may have a reduced contribution from the Big Blue River. A best fit curve for this data lies below the paired data. The best fit curve equation was used to estimate the Kansas River Flows below the confluence for a given flow on the Kansas River above the confluence. The difference between these two flows would be the coincident flow from the Big Blue River. Table 2-11 shows the most likely coincident Big Blue River flows for a Kansas River flood event. The coincident frequency analysis results were used in the hydraulic analysis of the existing conditions as described in Section 2.3 of this report.

Table 2-11. Coincident Big Blue River Flows for a Kansas River Flood

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

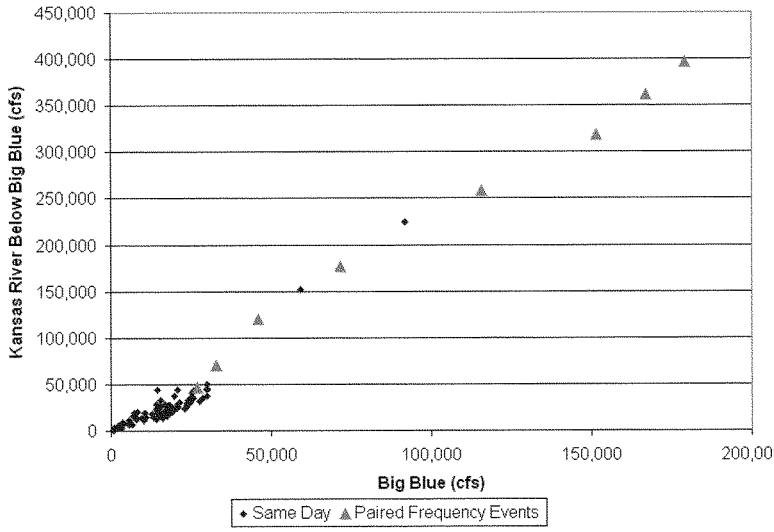


Figure 12. Big Blue River and Kansas River Downstream of the Confluence Coincidence of Regulated Peaks

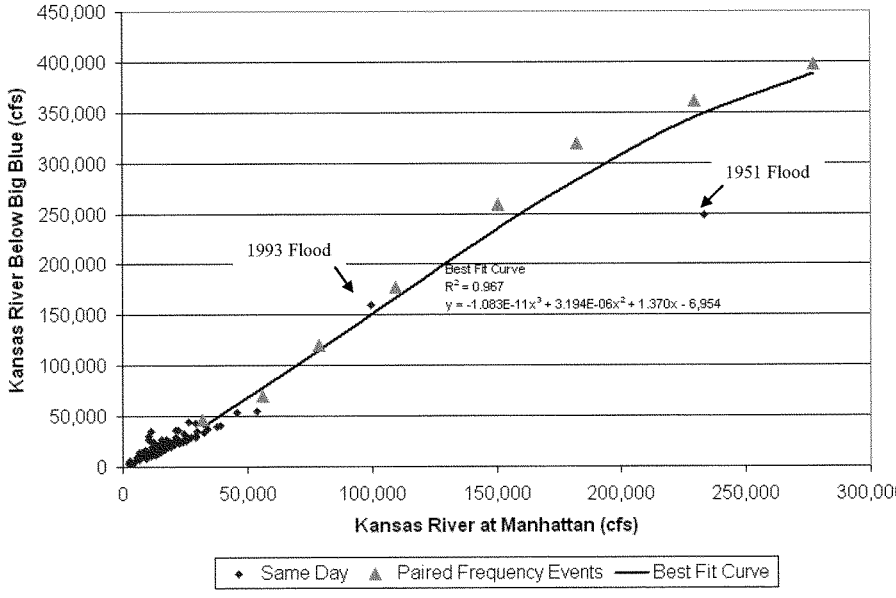


Figure 13. Kansas River Upstream of the Confluence and Kansas River Downstream of the Confluence Coincidence of Regulated Peaks

2.3.13 Hydrologic Period of Record 2014 Sensitivity Analysis

Twelve years of hydrologic data have been observed since the 2002 Kansas Hydrology Study was published. The additional data was evaluated to determine its potential impact to the accuracy of the 2002 hydrologic analysis. Sensitivity analysis was focused on the Big Blue River hydrology as this segment has the lowest existing conditions levee elevations. Figure 14 shows the peak streamflow data recorded by the USGS with the extended 12 years of data on the Big Blue River and the Kansas River. As seen in the figures, no major flood events have occurred since the study's Period of Record (POR) of 1929-2001 was evaluated.

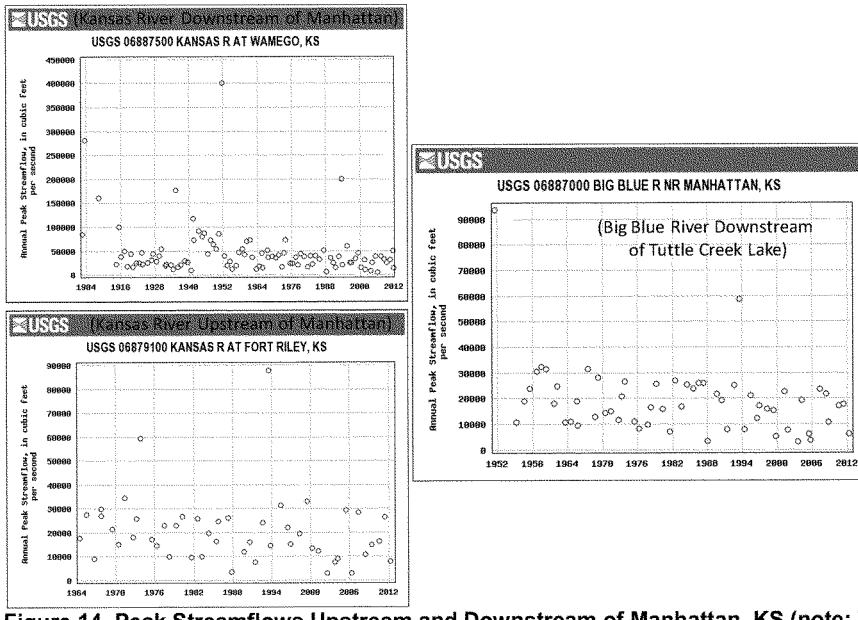


Figure 14. Peak Streamflows Upstream and Downstream of Manhattan, KS (note: Tuttle Creek Reservoir Closed in 1959)

The original study utilized hydrologic routings including reservoir simulations, ungaged inflow simulations along with volumetric statistics to develop a consistent unregulated dataset and convert the data to a consistent regulated dataset and adopted flow frequencies. A simplified approach was adopted to perform the sensitivity analysis. The addition of the unregulated POR on the Big Blue River was estimated with the computed daily inflows to Tuttle Creek Lake from the database maintained by the Kansas City District Water Management section. The 2002-2013 annual peak daily inflows were multiplied by a 10 percent peaking factor to estimate instantaneous unregulated peak streamflows. This extended dataset was incorporated with the original POR into a Bulletin 17B analysis with HEC-SSP software. The regulated peak streamflows at the USGS gage on the Big Blue River were also added to the original POR to evaluate a regulated Bulletin 17B analysis to visualize how the regulated frequency curve may shift with the additional data. Both analyses are presented in figure 15.

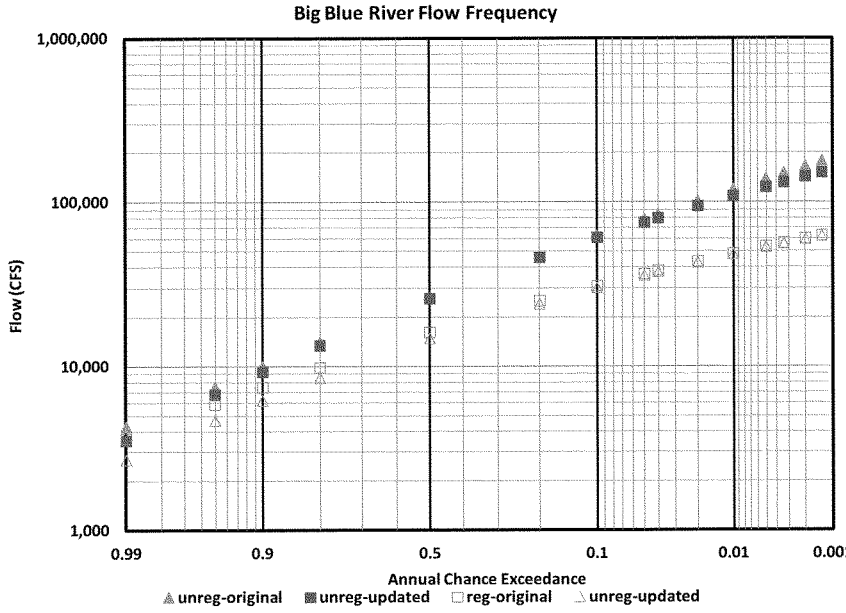


Figure 15. Graphical Results of Regulated and Unregulated Bulletin 17B POR extension

The impact of the POR extension to the hydrologic analysis included a reduction of the 0.33% flow frequency estimate by about 13% in the unregulated data analysis and a much smaller downward impact was observed in the regulated analysis. Regulated data showed a potential larger downward shift for events smaller than a 0.5 ACE. In review of Figure 6, the most likely scenario with the additional data, given that no major events occurred, would be a shift of the 1993 and 1951 data points originally treated as outliers closer to the adopted regulated frequency curve.

Though unregulated peaks do not directly translate to regulated peaks which are required for this study, they provide the apparent largest (downward) change to the hydrology and were considered for a hydraulic sensitivity analysis. After reducing 0.33% event flows by 12.8 percent from 151,700 cfs to 134,124 cfs in the hydraulic model along the Big Blue River based on the shift of the unregulated peak data, the 0.33% event profile was reduced by a maximum of 0.4-feet in the vicinity of the levee system on the Big Blue River. This reduction was considered minimal and did not warrant a major re-design for the study.

2.4 HYDRAULICS

2.4.1 Background

At the peak of the 1993 event, the Big Blue River downstream of Tuttle Creek Lake had flows of approximately 58,800 cfs, and the Kansas River had flows of approximately 100,000 cfs upstream of the Big Blue River. The water surface elevation in the Big Blue came within 3 to 4 feet of the top of the Big Blue River section of the Manhattan levee. These stages were higher than expected based on the previous modeling at the time of design. The concern associated with proximity of the 1993 event to the top of levee at Manhattan prompted this feasibility analysis. The hydraulic analysis of the water surface profiles for multiple frequency events will be critical to the findings of the feasibility study.

2.4.2 Model Development

The basis of the hydraulic analysis was the development of an existing conditions HEC-RAS model. HEC-RAS, version 4.1, as developed by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, was used in this analysis. The model was calibrated to the flood event of 1993 from measured highwater marks and known discharges. The model was further verified with 1951 flood event data. Once the model was calibrated, a series of steady flow water surface profiles were created based on the flood discharges previously discussed in Section 2.3.

2.4.3 Cross-Section Data

In order to create a georeferenced data set for use in the HEC-RAS model, HEC-GeoRAS, an ArcGIS interface containing a set of functions used to process geospatial data, was used. HEC-GeoRAS requires a Triangulated Irregular Network (TIN), or digital representation of the earth's surface, to acquire elevation data. The TIN was created using a total of four sources; Western Air Maps spots and breaks from an aerial photo collection flown in 2001, 2006 LIDAR mapping acquired from Riley County, USGS Seamless 10 meter DEM data, and a field survey completed in July 2006. A map outlining the extents of each data set is shown in Figure 16. The cross sections cut from the TIN were modified manually within HEC-RAS to ensure that the channel cross sections and immediate overbank areas agreed with the field survey conducted in July 2006. The top of levee elevations came from the National Levee Database Top of Levee survey conducted in 2007.

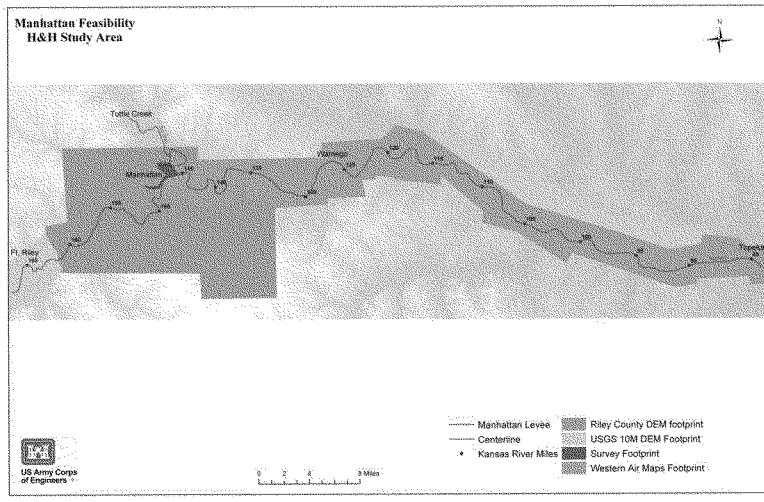


Figure 16. Spatial Extents of Source Data for TIN

River mileages were established for the Big Blue and Kansas Rivers by digitizing a centerline within HEC-GeoRAS with the aid of aerial photography acquired in 2005. River miles were established from the flow line created.

2.4.4 Kansas River Cross-Section Data

The study utilized cross-sections spaced approximately 3-5 miles apart from Topeka (RM 85.7) to Wamego (RM 126.64). The boundary conditions used the Rating Curve at the Topeka Gage (USGS Gage 06889000). The length of the model allowed for the water surface impacts from the boundary condition assumption to be calmed before reaching the study area. Cross-sections were located approximately 1 mile apart on the Kansas River from the Wamego Gage (USGS 06887500) near RM 126.64 to the confluence of the Big Blue River at RM 145.15. There are 12 cross sections on the Kansas River adjacent to the Manhattan Levee, for an average spacing of approximately 0.25 miles (Figure 17). Upstream of the Manhattan Levee the cross section spacing varies from 2 to 3 miles up to the Fort Riley Gage 06879100 location at RM 166.48.

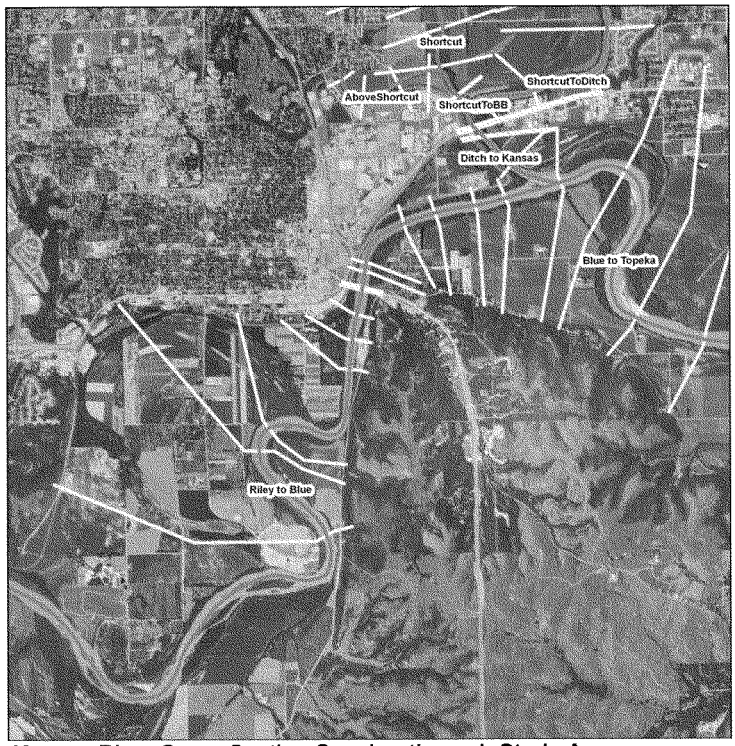


Figure 17. Kansas River Cross Section Spacing through Study Area

2.4.5 Big Blue River Cross-Section Data

The Big Blue River cross sections were also cut from the TIN and in-channel elevation data was used below the river's water surface. The elevation data extracted from the TIN in this reach was developed with 2006 LIDAR based DEMs. These two sources were used to refine the cross-sections on this segment. Degradation ranges used to analyze and track changes in the channel below Tuttle Creek dam are periodically surveyed during Dam Safety Inspections. Station and elevation data from 3 degradation ranges surveyed in 2005 were adapted for some of the model's in-channel data. The field survey from 2006 was also used where available on the Big Blue River. The cross-section layout for the Big Blue River is more complex than the Kansas River segment particularly with the horseshoe bend immediately upstream of the Manhattan Levee.

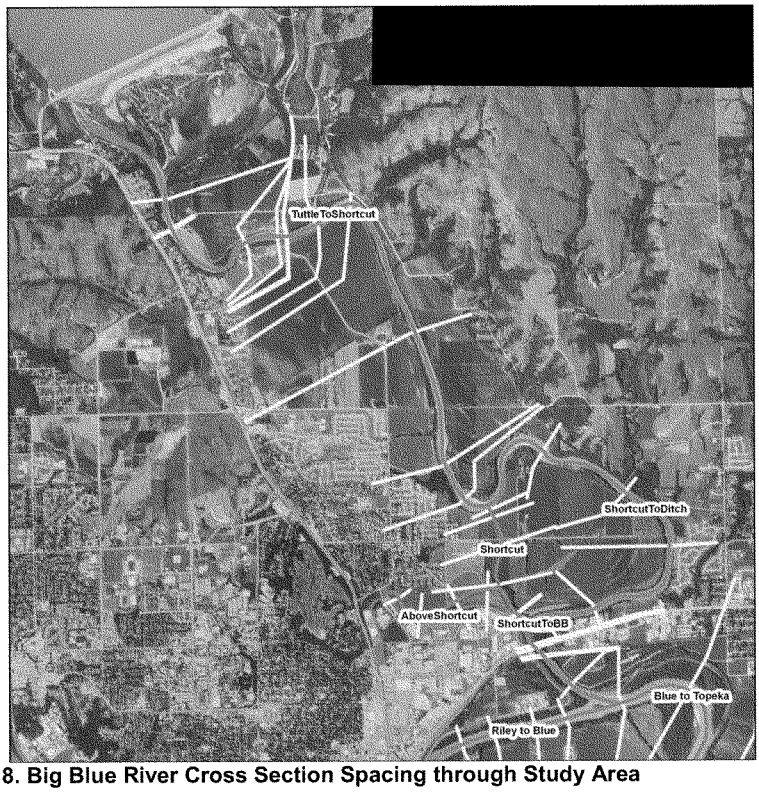


Figure 18. Big Blue River Cross Section Spacing through Study Area

As seen in Figure 18, there are two river reaches in addition to the mainstem that were added to the Big Blue River segment. The drainage ditch shown on the figure just north of the levee was included to better model the water surface on the tieback portion of the levee. Similarly, a shortcut was added at the upstream end of the horseshoe bend extending down to the drainage ditch.

This segment was added to the model after reviewing aerial photographs taken during the 1993 flood. From the photos it is evident that the Big Blue River, during a large flood event, begins spilling into the overbank at this location forming a secondary channel that ties into the drainage ditch and eventually meets back at the main Big Blue River channel.

The Big Blue River shortcut was modeled as a junction on each end of the shortcut and Split Flow Optimization was utilized from within HEC-RAS to balance the flows through the shortcut and around the horseshoe bend on the Big Blue River. For the profiles modeled in the Feasibility study, the 10% (1/10) and 4% (1/25) annual chance events did not produce

shortcut flows while all flows from the 2% (1/50) annual chance event and larger did utilize the shortcut.

2.4.6 Bridge Data

Bridges within the area of Manhattan Kansas were included in the model. A summary of bridges modeled in this study is included in Table 2-12.

Table 2-12. Bridges Included in Manhattan Levee HEC-RAS Model

Bridge	Location	Data Source	Cross-sections
K-18/177	Kansas River	KDOT/HNTB	147.06, 147.03
Union Pacific Railroad	Big Blue River	USACE	0.71, 0.70
U.S.- 24 Eastbound	Big Blue River	KDOT/USACE	0.80, 0.79
U.S.- 24 Westbound	Big Blue River	KDOT/USACE	0.82, 0.81
Dyer Road	Big Blue River	City of Manhattan	7.64, 7.62

The original levee design included the C.R.I.&P. (Chicago Rock Island and Pacific) Railroad bridge over the Kansas River near levee station 83+24 and the State Highway 13 Bridge at levee station 89+40. This railroad bridge has been removed since the construction of the levee. The existing Highway 18/177 Bridge over the Kansas River has replaced the Highway 13 bridge present at the time of original design.

Data for most of the bridges in Table 2-12 were compiled from drawings obtained from the Kansas Department of Transportation along with supplemental survey data collected by the Corps of Engineers survey crew during the course of the levee survey. Data for the bridge at Dyer Road was adapted from the City of Manhattan's Big Blue Predictive Model.

2.4.7 Other Geometric Data

The Manning's n-values used throughout the model were initially assigned based on aerial photography and engineering judgment. The n-values were then modified slightly to calibrate to the known 1993 water surface profile. In the vicinity of the Manhattan Levee, the n-values along the Kansas River channel were typically 0.030, as compared to the original design n-value of 0.025. The overbank n-values along the Kansas River ranged, due to vegetation and land use, from 0.060 to 0.130 for heavily forested areas, as compared to the original design n-value of 0.050. The Big Blue River channel n-values were typically 0.035, as compared to the original design n-value of 0.025, with the overbanks ranging similar to those of the Kansas River. These updated n-values resulted in updated hydraulic profiles that supersede the original design profiles. Ineffective flow areas were entered into the HEC-RAS model to account for areas of quiescent water that do not contribute to the discharge calculations.

Contraction and expansion coefficients were entered into the model according to the guidance distributed by HEC (HEC-RAS 2010). These parameters account for losses

associated with flows expanding and contracting across the flood plain. For areas with gradual transitions between cross sections, contraction and expansion coefficients were set at 0.1 and 0.3, respectively. In the vicinity of bridges, contraction and expansion coefficients were increased to 0.3 and 0.5, respectively. However, due to the close proximity of the bridges adjacent to the levee on the Blue River and the assumption that flow would not fully expand and contract between the bridges, contraction and expansion coefficients were set at 0.1 and 0.3 for the cross sections between these bridges. Contraction and expansion coefficients were increased to 0.3 and 0.5 at the cross section upstream of the westbound Highway 24 Bridge and the cross section downstream of the railroad bridge.

The top of levee elevations used in the model are from the National Levee Database top of levee survey completed in 2007. The interior protected area was modeled as ineffective and not allowed to provide conveyance for flood events large enough to produce overtopping of the levee. This assumption was made based on the uncertainty of levee breach locations and sizes in an overtopping event.

2.4.8 Model Calibration

The HEC-RAS model was calibrated to high water marks recorded during the 1993 flood event. High water marks (HWM) along both the Kansas River and Big Blue River were recorded at each of the freeboard gages along the Manhattan Levee. The freeboard gage measurements came from hourly field recordings from July 25 through July 27, 1993. The model was also calibrated to HWM's recorded by the City of Manhattan at the intersections of Beck Street and Casement Road and also the intersection of Parker Drive and Casement Road.

The Manning's n-values and ineffective flow areas were adjusted to provide the best matching profile in HEC-RAS to the 1993 HWM's (Figure 19 and Table 2-13). It should be noted that the geometric data for the existing Highway 18/177 bridge of the Kansas River was used in the 1993 calibration. The Highway 13 bridge geometry, present at the time of the 1993 flood, was not available for inclusion in the model.

The flows used for the 1993 event calibration were 58,800 cfs in the Big Blue River at Manhattan and 100,000 cfs in the Kansas River at Manhattan. The Big Blue River flow was recorded at the USGS Manhattan Gage. The Kansas River flow was taken from the UNET Regulated flow modeling for the 1993 flood event.

Table 2-13. HEC-RAS Model Calibration to 1993 High Water Marks

	River Mile	Manhattan Levee Station (ft)	1993 HWM Elev (NAVD88 ft)	1993 HEC-RAS Elev (NAVD88 ft)	Delta (ft)
Kansas River	147.51	62+20	1018.5	1018.3	-0.2
	147.15	81+25	1017.3	1016.8	-0.5
	147.01	89+83	1015.9	1016.4	0.5
	146.76	101+26	1015.8	1015.5	-0.3
	146.44	120+00	1014.2	1014.5	0.3
	146.06	140+00	1013.7	1013.4	-0.3
	145.67	163+00	1012.4	1012.4	0.0
Blue River	0.40	175+00	1011.9	1012.0	0.1
	1.00	211+00	1013.6	1013.3	-0.3
Ditch	N/A	234+00	1014.7	1013.9	-0.8
	N/A	269+50	1014.3	1015.2	0.9
Blue River	4.64	N/A	1017.6	1016.9	-0.7
	7.63	N/A	1022.0	1021.9	-0.1

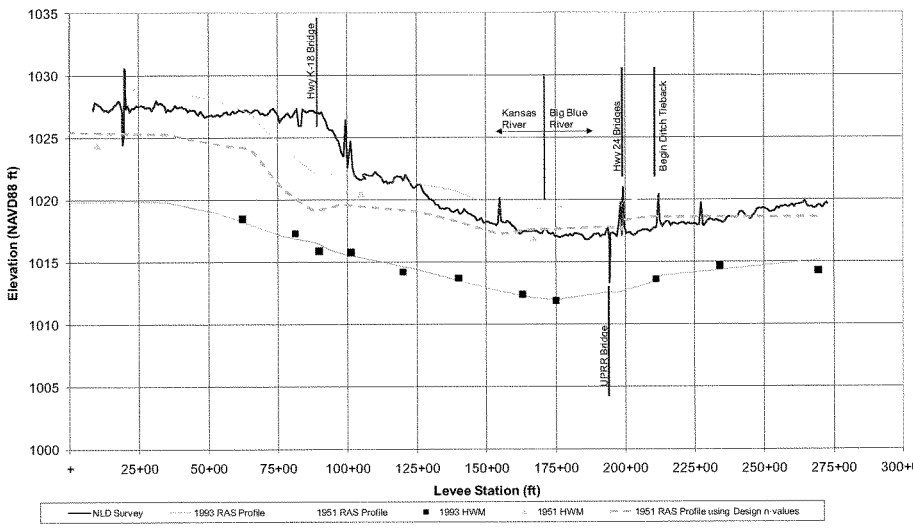


Figure 19. HEC-RAS Model Calibration to the 1993 Flood Event and Check of 1951 Flood Event at the Manhattan Levee

The 1951 flood profile was also modeled to compare the current model to the flood of record profiles. High water marks taken from the Manhattan Gage and Manhattan Levee Design Memorandum were used as comparison points (Figure 19). The 1951 flows were taken from USGS records. This Kansas River flow of 298,000 cfs recorded at the Ogden Gage was taken from the USGS Fact Sheet 041-01, *The 1951 Floods in Kansas Revisited*. The Big Blue River flow of 93,400 cfs was recorded at the USGS Manhattan Gage. The 1951 flood event was modeled with the Manhattan Levee removed from the Existing Conditions model because the levee was not present at the time of the 1951 flood. At the USGS Manhattan Big Blue River gage, the modeled stage matched the 1951 high water mark within 1 foot. The 1951 event was not used for calibration but for a check of the validity of the model for extreme flood events.

The current HEC-RAS model profile is above the 1951 high water marks in all locations, ranging from 2.4 feet above at the downstream end of the levee to 4.5 feet above at the upstream end of the unit. It is expected that the existing conditions model would over estimate the 1951 water surface elevations. The hydraulic analysis in Design Memorandum 1-A, dated 1960, the design Manning's n-values used were 0.025 for the channel and 0.050 for the overbank areas throughout the study reach.

This would indicate that at the time of the 1951 flood event the overbanks and channel were mostly free of woody vegetation. The overbanks along the Kansas River adjacent to and opposite of the Manhattan Levee are now covered with mature tree growth, resulting in a much higher Manning's n-values for the existing conditions. This additional roughness causes the existing conditions model to gradually diverge from the 1951 high water marks from downstream to upstream along the study area.

Figure 19 displays the 1951 water surface profile using current geometry and the original design n-values. The 1951 water surface profile computed using design n-values is within 0.9-feet of the Kansas River high water marks along the Manhattan Levee reach. This would indicate that the changed channel and overbank conditions since the 1951 flood have contributed to increased water surface profiles. Thus, the model seems to provide reasonable results when checking 1951 high water marks to the HEC-RAS estimate of the 1951 flood using existing conditions geometry and n-values.

2.4.9 Existing Conditions Hydraulic Profiles

Once the model was calibrated, existing conditions water surface profiles were generated for the 10% (1/10), 4% (1/25), 2% (1/50), 1% (1/100), 0.5% (1/200), 0.33% (1/300), 0.2% (1/500), and 0.133% (1/750) chance of exceedance flood events. The starting water surface elevations for each of the profiles were calculated using the rating curve at Topeka.

Two scenarios were investigated for each flood event profile. First, a Big Blue River controlled flood was modeled where the Big Blue River was experiencing flooding as analyzed in Section 3.3.1. The coincident flow on the Kansas River for each flood

event would be as determined in the Coincident Frequency Analysis discussed in section 3.3.5 and tabulated in Table 2-10.

The second scenario is a Kansas River controlled flood where the Kansas River was experiencing flooding as analyzed in Section 3.3.2. The coincident flow on the Big Blue River for each flood event would be as determined in the Coincident Frequency Analysis discussed in section 3.3.5 and tabulated in Table 2-11. The results of each of these two scenarios were compared at each cross-section, with the higher water surface elevation being selected as the controlling elevation for a given frequency event. This approach ensures that the range of flow distributions are accounted for and the most critical scenario is evaluated at the confluence. Figure 20 displays the Existing Conditions hydraulic profiles for the studied events plotted against the top of levee elevation. Figure 20 also includes the existing condition profile for the original Manhattan Levee design flows of 220,000 cfs and 110,000 cfs on the Kansas River and Big Blue River, respectively. Attachment B contains the HEC-RAS output for the study reach. Refer to Section 2.5 for conclusions based on this analysis.

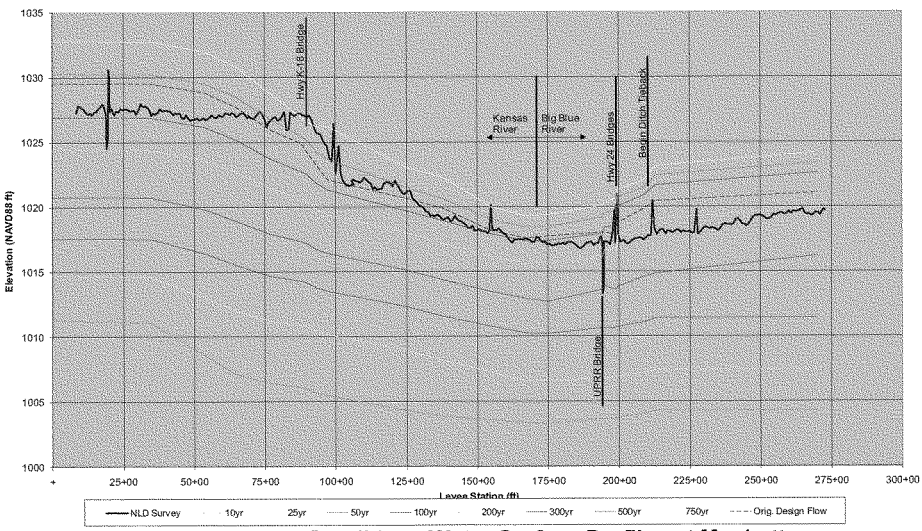


Figure 20. HEC-RAS Existing Conditions Water Surface Profiles at Manhattan Levee

2.4.10 Hydraulic Uncertainty

Uncertainties in computed water surface profiles are a result of imperfect knowledge and lack of appropriate data. Uncertainties in stage result from a number of physical factors such as bed forms, debris and other obstructions, channel scour or deposition, sediment transport, and waves. In hydraulic modeling, other factors such as

hydraulic roughness variation with season, inexact geometry and loss coefficients, and error in setting high-water marks result in errors in computed water surface elevations. Estimating these uncertainties in stage is based on sensitivity analyses, analytical studies of gage readings, and interpretation of the success of model adjustments following traditional procedures presented in USACE Engineering Manual (EM) No. 1110-2-1619 (EM 1996).

Stage uncertainty is expressed in the Risk Based Analysis as a standard deviation (in feet). To obtain a total standard deviation the formula below was applied.

$$\text{Total Standard Deviation} = \text{SQRT}\left((S_{natural})^2 + (S_{model})^2\right)$$

where
$S_{natural}$ = standard deviation based on historical data and gage readings
S_{model} = standard deviation based on mapping detail and reliability of estimating Manning's n values

$S_{natural}$, is calculated by comparing observed data with the latest rating curve at the gage in the project reach. There were no gages available within the project reach, so the Wamego gage was chosen to represent the Kansas River and the Manhattan gage was chosen to represent the Big Blue River. To avoid potential problems due to shifts in the rating curve over time, only observed data going back to 1990 were used. Figure 21 shows this observed data compared to the current rating curve at the Wamego Gage on the Kansas River. Figure 22 shows this observed data compared to the current rating curve at the Manhattan Gage on the Big Blue River. Only data for bank full discharges and greater were analyzed. The formula below is used to calculate $S_{natural}$.

$$S_{natural} = \text{SQRT}\left((\Sigma(X-M)^2)/(N-1)\right)$$

where
X = stage corresponding to measured Q
M = best fit curve estimate of stage corresponding to Q
N = number of stage-discharge observations in the range being analyzed

The standard deviation based on historical data and gage readings, $S_{natural}$, was computed as 0.4 feet at the Wamego Gage and 1.1 feet at the Manhattan Gage. The Wamego Gage standard deviation was applied to the computed water surface elevations on the Kansas River both above and below the confluence. The Manhattan Gage standard deviation was applied to the computed water surface elevations on the Big Blue River.

The second component in quantifying standard deviation is S_{model}. S_{model} is obtained by estimating the confidence in the cross-section data from topographic mapping efforts and in estimating the reliability of the Manning's n-value. Table 5-2 in EM 1110-2-1619 quantifies a S_{model}, based on these two factors. A standard deviation

of 0.7 foot was chosen since the cross-sections were based on current aerial mapping (refer to Figure 16) and the Manning's n-values were assumed to be "fairly" reliable. It is noted that the most upstream portion of the model was based on larger scale DEM terrain data as opposed to aerial mapping, but since these areas are not the primary focus of this study the standard deviation in the study area was used throughout.

Once $S_{natural}$ and S_{model} are known, a total standard deviation can be computed. Following traditional procedures presented in EM 1110-2-1619, a total standard deviation of 0.8 feet was computed for the Kansas River and a total standard deviation of 1.3 feet was computed for the Big Blue River. It is recommended that the calculated total standard deviations be increased to 1.0 feet and 1.5 feet for use in risk analysis for the Kansas River and Big Blue River, respectively. These recommended increases account for the fact that the hydraulic uncertainties were calculated for USGS gage locations that were near to, but not immediately within the Manhattan Levee study area.

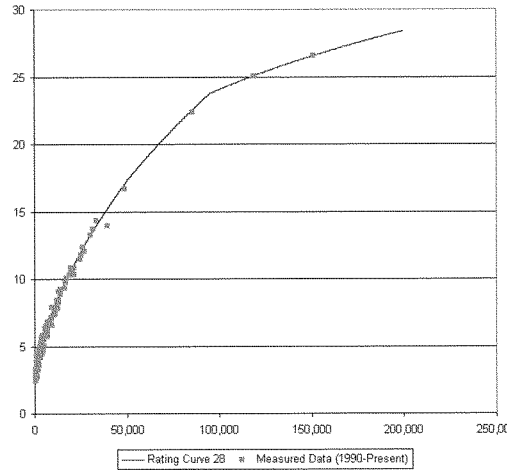


Figure 21. Comparison of Rating Curve #28 and Observed Measurements at Wamego Gage on the Kansas River

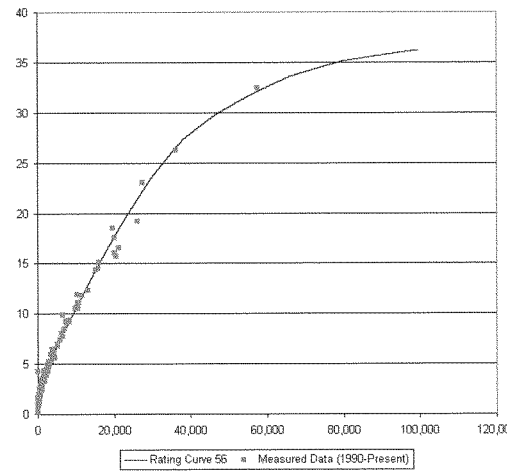


Figure 22. Comparison of Rating Curve #56 and Observed Measurements at Manhattan Gage on Big Blue River

2.5 CONCLUSIONS

2.5.1 River Discharges

This evaluation uses output from a calibrated UNET model of the Kansas River and Big Blue River near Manhattan Kansas. The UNET model, a one-dimensional unsteady river model, was run for a period of record that spanned from Water Year 1929 to Water Year 2002. Between years 2002-2012, no significantly large discharges occurred that would affect the flood flow frequency results less remote than the 10% (1/10) annual chance exceedance event. The UNET model output included simulated daily peak discharges for the period of record under two conditions:

1) Synthetic natural period of record (Unregulated)

2) Synthetic regulated period of record (Regulated)

The simulated discharge results for both rivers were used to develop the maximum yearly discharge over the period of record. The maximum yearly discharges were then used to develop the flow frequency relations for both the unregulated and regulated discharges. Tables 2-7 and 2-8 summarize the regulated discharge results compared to existing FEMA FIS discharges for the Kansas River and Big Blue River, respectively.

For the Kansas River, the flow frequency results indicate that:

1) The 1% (1/100) exceedance event was significantly less than the FEMA FIS 1% (1/100) discharge.

2) The 0.2% (1/500) exceedance event the flow frequency results were less than the FEMA FIS 0.2% (1/500) discharge.

3) The peak flow for the 1993 event on the Kansas River at Manhattan (~100,000 cfs) is estimated as a 1.3% (1/75) exceedance event.

For the Big Blue River, the flow frequency results indicate that:

1) The 1% (1/100) exceedance event was significantly higher than the FEMA FIS 1% (1/100) discharge.

2) The 0.2% (1/500) exceedance event was significantly higher than the FEMA FIS 0.2% (1/500) discharge.

3) The 1993 event on the Big Blue River (59,500 cfs) is estimated as a 1.5% (1/67) exceedance event.

2.5.2 River Stages

The calibrated HEC-RAS model of the Kansas River and Big Blue River near Manhattan, Kansas was used to model existing conditions water surface profiles. The model results displayed in Figure 20 indicate that in the existing conditions without freeboard considerations:

1) The Kansas River portion of the Manhattan Levee is approximately at the 0.33% (1/300) exceedance event.

2) The Big Blue River portion of the levee is overtopped between the 1% (1/100) and 0.5% (1/200) exceedance event.

3) The Manhattan Levee unit is overtopped by the original design flow event.

Figures 23 and 24 show the stage frequency water surface profiles compared to the 2005 FEMA FIS profiles for the 10% (1/10), 2% (1/50), 1% (1/100), and 0.2% (1/500) exceedance events without freeboard considerations. The comparison of the existing conditions HEC-RAS model and the 2005 FEMA FIS profiles reveals that for the Kansas River:

1) The profile for the 1% (1/100) exceedance event is approximately 3 feet higher than the FIS 1% (1/100) profile near the confluence.

2) The profile for the 1% (1/100) exceedance event reduces to only 1 foot above the FIS profile from river mile 146.5 to the upstream end of the levee unit.

The comparison of the existing conditions HEC-RAS model and the 2005 FEMA FIS profiles reveals that for the Big Blue River:

1) The profile for the 1% (1/100) exceedance event ranges from 3 to 4 feet higher than the FIS 1% (1/100) profile adjacent to the Manhattan Levee.

2) The profile for the 1% (1/100) exceedance event spreads from 4 feet higher than the FIS profile at the upstream end of the Manhattan Levee to approximately 6.5 feet above the FIS profile at Hackberry Avenue.

3) Upstream of Hackberry Avenue the 1% (1/100) exceedance event profile is approximately 5 to 6 feet above the published FIS 1% (1/100) profile.

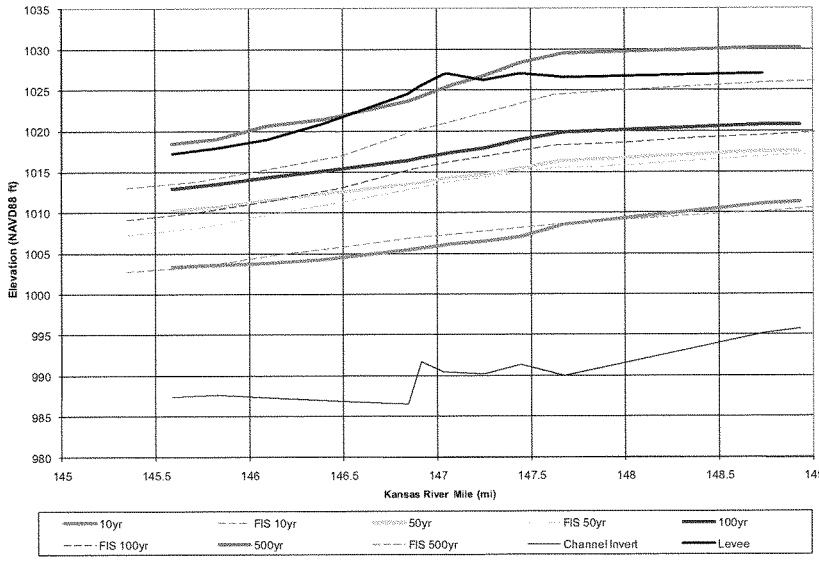


Figure 23. Comparison of Kansas River Flood Profiles to 2005 FEMA FIS Profiles

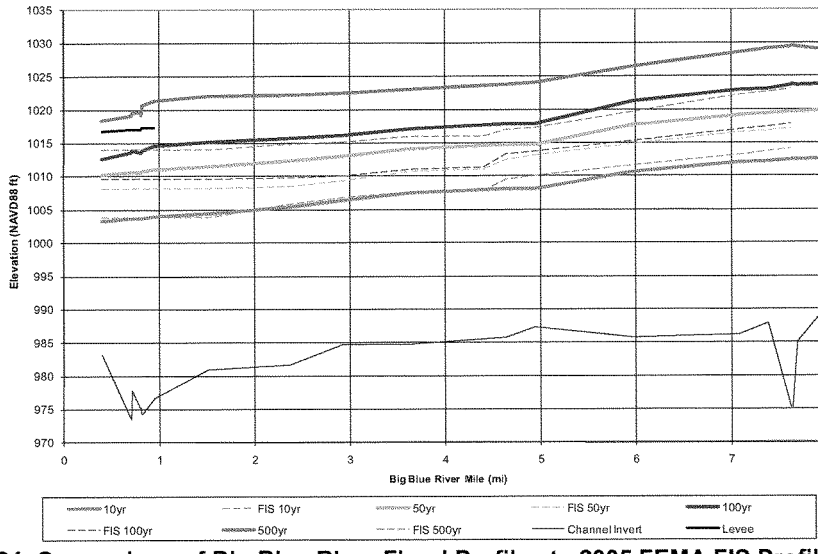


Figure 24. Comparison of Big Blue River Flood Profiles to 2005 FEMA FIS Profiles

2.6 REFERENCES

Combs, L.J. and Perry, C.A., 2003, The 1903 and 1993 Floods in Kansas—The Effects of Changing Times and Technology, U.S. Geological Survey Fact Sheet 019–03, March 2003.

Fader, S. W., 1974, Ground water in the Kansas River valley, Junction City to Kansas City, Kansas: Kansas Geological Survey, Bulletin 206, pt. 2, 12 p.

FEMA, Flood Insurance Study for Riley County, Kansas, and Incorporated Areas, Revised February 4 2005.

Juracek, K.E., Perry, C.A., and Putnam, J.E., 2001, The 1951 floods in Kansas revisited: U.S. Geological Survey Fact Sheet 041–01, May 2001.

Juracek, Kyle E., 2001, Channel-bed elevation changes downstream from large reservoirs in Kansas: U.S. Geological Survey Water-Resources Investigations Report 01-4205, 24 p.

Lawrence, L. B., Grisafe D. A, McCauley, J. R., Ohlmacher,G. C., Quinodoz, H. A. M, and Nelson, K. A., 1998, The Kansas River Corridor--Its Geologic Setting, Land Use, Economic Geology, and Hydrology, Kansas Geological Survey Open-file Report 98-2, January 1998.

Perry, Charles A., 1993, Effects of Reservoirs on Flood Discharges in the Kansas and the Missouri, USGS Circular 1120-E, 28 p.

Perry, C.A., Wolock, D.M., and Artman, J.C., 2004, Estimates of flow duration, mean flow, and peak-discharge frequency values for Kansas stream locations: U.S. Geological Survey Scientific Investigations Report 2004–5033.

Simons, Li, and Associates, 1984, Analysis of channel degradation and bank erosion in the lower Kansas River: MRD Sediment Series Report No. 35, for the US Army Corps of Engineers, Kansas City District, Kansas City, Missouri.

U.S. Army Corps of Engineers (USACE), 2004, Reconnaissance Study for Manhattan Kansas Local Flood Protection Project (City of Manhattan Kansas Levee), Section 905(b) Analysis, 29 September.

U.S. Department of the Interior – Water Resources Division, Geological Survey Circular 151, October 1951.

U.S. Geological Survey (USGS), 1952, Kansas-Missouri floods of July 1951, USGS Water Supply Paper 1139.

USACE, 1959, Design Memorandum No. 1, Manhattan, Kansas Flood Protection Project, August 1959.

USACE, 1980, Operation and Maintenance Manual, Manhattan, Kansas Flood Protection Project, June 1980.

USACE, 2002, Environmental Impact Statement Tuttle Creek Dam Safety Assurance Program Big Blue River, Kansas, July 2002.

USACE, 2004, Manhattan KS Levee System – Expanded Reconnaissance Study – Supporting Hydrology.

Hydrologic Engineering Center (HEC) (2010). "River Analysis System Version 4.1.0 User Manual", US Army Corps of Engineers, Davis CA.

Wahl, K.L., Vining, K.C., and Wiche, G.J., 1993, Precipitation in the upper Mississippi River Basin, January 1 through July 31, 1993: U.S. Geological Survey Circular 1120–B.
Weatherly, Jeffrey J., 1994,"Historical Channel Adjustments of the Lower Big Blue River Below Tuttle Creek Reservoir, Manhattan, Kansas, 1857-1991" (major professor: Dr. Charles W. Martin). May, 1994.

PART 3 – Geotechnical

Table of Contents

3.1 INTRODUCTION 3-1

3.2 DESCRIPTION OF EXISTING LEVEE UNIT 3-1
3.2.1 Levee Description 3-1
3.2.2 Historical Flood Events 3-2
3.2.3 Regional Geology 3-2
3.2.4 Site Geology 3-3
3.2.5 Subsurface Conditions 3-3

3.3 UNDERSEEPAGE ANALYSIS 3-4
3.3.1 Methodology 3-4
3.3.2 Deterministic Analysis 3-5
3.3.3 Probabilistic Analysis 3-5

3.4 PROBABILISTICUNDERSEEPAGE ANALYSIS RESULTS 3-7

3.5 SLOPE STABILITY ANALYSIS 3-8
3.5.1 Probabilistic Slope Stability Analysis 3-9
3.5.2 Probabilistic Stability Results 3-10

3.6 SUMMARY 3-13

3.7 REFERENCES 3-13

List of Tables

Table 3-1 Permeability Ratios for Blanket Material Based on Material Type 3-4
Table 3-2 Observations of Seepage Conditions during 1952 Flooding on the Missouri River 3-6
Table 3-3 Underseepage Parameters Coefficients of Variation (COV) 3-7
Table 3-4 Underseepage Reliability Results 3-8
Table 3-5 Material Properties for Slope Stability Analyses 3-10
Table 3-6 Steady State Slope Stability Analysis Results 3-12
Table 3-7 Transient Seepage Analysis Results, 1993 Flood, and Tuttle Creek Emergency Release 3-12

3.1 INTRODUCTION

This Appendix presents the results of geotechnical evaluation of the Manhattan levee in Manhattan, Kansas. The purpose of the geotechnical evaluation was to determine the reliability of the existing Manhattan levee unit for economic modeling. The evaluations were performed in general accordance with the USACE Engineering Technical Letter (ETL) 1110-2-556 "Risk-Based Analysis in Geotechnical Engineering for Support of Planning Studies." The results of the analyses are only intended for use in economic modeling. This is the first phase of the feasibility study where the existing condition of the levee unit is documented. The second phase of the feasibility study will evaluate ways to improve levee reliability with respect to all failure modes.

The evaluation started with a thorough review of Record Drawings, design memorandums, O&M Manuals, and recent investigations for levee accreditation. From the document review, the subsurface conditions and levee geometry were established. All elevations used in the geotechnical feasibility study are NGVD 1929 to be consistent with historical levee documents.

Geotechnical evaluation of the Manhattan levee consisted of underseepage and slope stability analysis for steady state flood conditions because they are the most likely controlling failure modes. Initial analyses were typically performed deterministically to identify critical areas of the levee. Final analyses were performed probabilistically to develop probability of failure relations with river elevation. The geotechnical probability of failure relations, or hazard curves, will be combined with other failure modes (structural, hydrologic, etc) for economic modeling.

The AE firm CDM was contracted by the Corps to define impending failure as it relates to the Manhattan levee and perform probability of failure analysis at critical levee reaches identified by the different failure modes. This study refines the work initiated by CDM using new subsurface information from borings drilled along the Manhattan levee alignment by AMEC as part of FEMA levee accreditation.

3.2 DESCRIPTION OF EXISTING LEVEE UNIT

3.2.1 Levee Description

The Manhattan levee is located west and north of the confluence of the Big Blue River and the Kansas River in Manhattan, Kansas. The levee consists of protection along Wildcat Creek, the Kansas River, and the Big Blue River. A plan view of the levee system is shown in **Appendix A.1**. The levee embankment begins at 8+50 and ends at station 272+85. The levee starts north of Wildcat Creek and is roughly aligned with 15th Street in Manhattan, Kansas. The levee follows the alignment of Wildcat Creek from Station 8+50 to Station 35+00, where it begins to parallel Pottawatomie Avenue to station 60+00. The levee alignment then turns to the northeast and turns north at 80+00 to align with the Kansas River. The alignment with the Kansas River continues to the confluence with the Big Blue River at approximately Station 173+00.

From the confluence, the levee turns towards the northwest, aligning with the Big Blue River until Station 209+00, where it turns further to the west and splits off from the Big Blue River. The levee continues in a west-northwest direction and aligns parallel to an existing drainage channel to its end at Station 272+85.

The Manhattan levee is approximately 28,850 feet long. The levee was typically constructed with a 10-foot crown width and three horizontal to one vertical (3H: 1V) embankment slopes. The embankment is a zoned embankment. The landside portion consists of a large "random fill" section. The random fill was obtained from channel improvement excavations and other local borrow areas. The random fill ranges from silty sands to lean clays. The riverside section is a minimum 3-foot-thick "impervious fill" section that is assumed to consist of locally available low-permeability lean and/or fat clays. The minimum Factor of Safety (FS) used in the original design for underseepage and stability was 1.1 (with water at top of levee) and 1.5 (with 3 ft of freeboard), respectively. Underseepage control was provided where needed by underseepage berms and relief wells. Six relief wells were originally installed at the Poyntz Avenue pump station inlet ditch. However, only 4 relief wells currently exist along the inlet ditch. On the other hand, stability berms were constructed in five levee reaches. Stability berms were placed in the following reaches: 1) between Station 77+00 and 81+25, 2) between Station 112+50 to 140+00, 3) between Station 160+50 and 179+00, 4) between Station 194+20 and 269+80, and 5) between Station 269+80 and 272+00.

The original design water surface for the Manhattan levee is 3 feet below the levee crest.

3.2.2 Historical Flood Events

The City of Manhattan has a long history of floods during periods of heavy sustained precipitation. The largest recorded floods occurred in 1844, 1903, 1908, 1951, and 1993. The great flood of 1951 and the Federal Flood Control Act of 1954 led to the construction of the Manhattan Levee in the 1960s. The largest recorded flood since levee construction is the 1993 flood. How the levee performed, from a geotechnical perspective is not well documented for the 1993 flood. There have been verbal accounts from memory by the sponsor indicating seepage and pin boils were present between stations 130+00 and 150+00. Aerial photography from the 1993 flood also indicates water ponded on the landside of the levee in the Kansas River-Big Blue River confluence. It is assumed that at least a portion of this is seepage water. Generally speaking, the 1993 flood performance is not documented well enough to provide much information that could be used to calibrate any analyses for this study.

3.2.3 Regional Geology

Almost all of Kansas was under a shallow inland sea during its geologic history. Therefore, most of the rock found in the state was formed in a sedimentary environment with near-horizontal bedding. The topography rises from east to west, exposing or approaching the older rock members including the Pennsylvanian and Mississippian

age deposits. The rock exposed at the surface in the Manhattan area is of Permian Age, with younger Jurassic and Cretaceous age rocks outcropping further to the west.

Toward the end of the Cretaceous times, the uplift of the Rocky Mountains raised the region containing Kansas above sea level. The Tertiary geologic period followed, depositing vast amounts of sand and gravel from surface water runoff, and from river and stream deposits. Alluvial, glacial and dune deposits are the youngest deposits in the region. They overlie the rock and are located near the western boundary of the state. **Figure 1** in **Appendix A.1** presents a generalized topographic and profile views of regional geology across Kansas and the general location of the Manhattan Levee project in Riley County. A detailed description of soil stratum in Riley County is located in **Figure 2** in **Appendix A.1**.

3.2.4 Site Geology

The city of Manhattan within Riley County is located on an outcrop of the Permian formation in a physiographic province referred to as the Flint Hills region. Unlike many of the formations in Kansas, the Manhattan area does not contain layers of sandstone because it was far from the shore of the inland seas that created the sandstone sediments. The Manhattan area is typical of the overall geology of Kansas consisting primarily of alternating layers of limestone (deposited in relatively shallow water) and shale typically deposited in deep water. Shale has weathered to form lean and fat clays in much of Kansas. However, flood plain alluvial deposits dominate the Manhattan, Kansas area.

3.2.5 Subsurface Conditions

The subsurface conditions for the Manhattan levee were mainly derived from historical borings logs from the Record Drawings and Design Memorandum No. 1. Historical boring logs from original design were supplemented by borings drilled by AMEC in 2011. AMEC is performing levee accreditation for the City of Manhattan. The AMEC borings were transferred to the plan/profile sheets containing historical boring logs. Based on all available boring logs, the foundation soils were delineated into two main layers – a natural blanket overlying a sand aquifer - along the levee alignment. Blanket materials consist of silts, sandy clays, lean clays, and fat clay (from Station 269+50 to 272+00). The blanket thickness ranges from 8 to 24 feet. The blanket bottom elevation is shown on the plan/profile sheets included in **Appendix A.1**. The sand aquifer consists of sands and gravels, generally grading coarser with depth. The aquifer thickness ranges from 24 feet to 47 feet. Below the sand aquifer is shale bedrock. Material strength parameters for the embankment and foundation soils were estimated based on information in Design Memorandum (DM) No. 1 and laboratory testing performed by AMEC on samples collected from their 2011 field exploration program for levee accreditation.

3.3 UNDERSEEPAGE ANALYSIS

Underseepage in the levee unit was first analyzed deterministically with water elevation at the crest of the levee to identify critical reaches. Levee reaches were determined based on levee geometry, blanket thickness, blanket material, and river entrance conditions. Critical levee sections were selected if the hydraulic gradient factor of safety is less than or equal to a minimum factor of safety of 1.1. For each of critical levee segment, the probability of failure as a function of water elevation was evaluated to generate the economic hazard curve.

3.3.1 Methodology

Underseepage analyses were performed in general accordance with Engineering Manual (EM) EM 1110-2-1913 – Levee Design and Construction. Local Kansas City District 1) uses permeability ratios instead of blanket and aquifer permeability (**Table 3-1**), 2) assumes an infinite landside blanket (Case 7 in EM 1110-2-1913), and 3) does not transform the blanket but uses a representative permeability ratio for existing materials. This Kansas City practice is based on the findings made at a 1962 Missouri River Division Conference held in Omaha, Nebraska. The conference findings are based on experience during the flood event in 1952 along the Missouri River.

Table 3-1. Permeability Ratios for Blanket Material Based on Material Type

Blanket Material	Assumed Permeability Ratio
SM	100
ML	200-400
ML-CL	400
CL	400-600
CH	800-1000

The analysis methods in EM 1110-2-1913 were modified near the Kansas River-Big Blue River confluence to take into account the sharp levee alignment change. The confluence zone was analyzed using the Intersection Angle Method discussed in **Appendix A.5**. The procedure is considered adequate for feasibility study use, but should be verified with 2-D seepage analysis during design phases.

The relief wells in the Poyntz Avenue pump station inlet ditch were analyzed in general accordance with EM 1110-2-1914 (Design, Construction, and Maintenance of Relief Wells).

As seen in **Figure 5-3** in EM 1110-2-1914, variations from EM 1110-2-1914 used in the analysis are:

1. The excess head is calculated by subtracting the drawdown from the hydraulic grade line assuming no wells. This was done because the procedure outlined in **Figure 5-3** assumes an impervious blanket. However, a semi-pervious blanket was assumed for the underseepage calculations.

2. An efficiency reduction factor of 70% was applied to the expected well flows based on pump tests of the wells provided by the City of Manhattan. This was done to account for the reduction in efficiency with time of the relief wells. An efficiency factor of 0.8 is typically used in the design of new wells as suggested in EM 1110-2-1914 "Design Construction and Maintenance of Relief Wells."

3.3.2 Deterministic Analysis

To identify critical underseepage reaches, a deterministic underseepage analysis was performed along the entire levee unit with water at the levee crest. For underseepage analysis the levee was divided into reaches of similar protection height, blanket thickness, blanket composition, seepage entrance conditions, location of relief wells, and river confluence effects. The factor of safety with respect to hydraulic gradient through the natural blanket was calculated for each of these reaches at the levee landside toe or landside ditch (if present). Calculations were performed assuming landside ditches were full and empty for thoroughness. **Tables 1** through **3** in **Appendix A.2** tabulate the calculations of factor of safety with respect to hydraulic gradient for the entire Manhattan levee unit.

Based on the results of the deterministic analysis, five critical reaches were identified for probabilistic underseepage analysis. These areas are Station 40+00 to 60+00 (deep landside ditch), 73+00 to 82+00, 101+70 (Poyntz pump station inlet ditch), 104+65 to 137+00, and 165+12 to 176+63 (Kansas-Big Blue confluence). Probabilistic analysis and results are discussed below.

3.3.3 Probabilistic Analysis

In probabilistic analysis, when the excess head at the landside levee toe is greater than zero and the blanket is thicker than one-fourth the levee height, the probability of failure can be calculated using the Taylor Series method described in ETL 1110-2-556. The exit gradient (i) was assumed to be log-normally distributed with probabilistic logarithmic moments: expected mean, E[ln i], and standard deviation, $\sigma_{\ln i}$. The limit state for underseepage failure would then be the natural log of the failure gradient (ln [i_f]) with the boundaries for the probability of failure being:

$$P_f = P(\ln i > \ln i_f) \qquad \text{Equation 2-1}$$

The probability of the ln[i] being greater than the ln[i_f] is determined by using the standard normalized variate (z), which is also analogous to the reliability index β The standard normalized variate is calculated as:

$$z = \beta \frac{\ln i_f - E[\ln i]}{\sigma_{\ln i}} = \frac{\ln\left[\frac{i_f * \sqrt{1+COV[i]^2}}{E[i]}\right]}{\sqrt{\ln(1+COV[i]^2)}}$$ Equation 2-2

Where, *E*[i] is the expected value (mean) of the hydraulic gradient and *COV [i]* is the coefficient of variation of the hydraulic gradient.

The underseepage failure limit state, or the actual conditions indicative of an underseepage failure, are highly speculative. The underseepage analysis included in ETL 1110-2-556 (Risk-Based Analysis in Geotechnical Engineering for Support of Planning Studies) uses a threshold value of gradient factor of safety of 1.0 to define failure. A gradient factor of safety of 1.0 reflects a condition where floatation of particles theoretically begins and undesirable seepage and boils can first physically occur, however it is not necessarily a condition indicative of having certain levee failure. Observations during the Flood of 1952 on the Missouri River are shown in **Table 3-2**. The table shows the relation between observed field performance and calculated factors of safety. From the observations it can be seen that somewhere between a factor of safety of 0.55 and 0.80, undesirable seepage reaches a point where a failure could occur without outside intervention (flood fighting). In an effort to define a condition more representative of actual levee underseepage failure for this study, a gradient safety factor of 0.70 was utilized as a threshold value for when certain levee failure is likely to occur without heroic flood flight efforts. The chosen threshold value of gradient factor of safety of 0.70 falls within the "transition" zone in **Table 3-2** between tolerable seepage and objectionable seepage. In the probabilistic underseepage analyses a failure gradient (i_f) was calculated as:

$$i_f = \frac{i_c}{FS} = \frac{0.84}{0.70} = 1.23$$ Equation 2-3

where i_c is the critical gradient and *FS* is the gradient safety factor.

Table 3-2. Observations of Seepage Conditions during 1952 Flooding on the Missouri River

Computed Safety Factor at Flood Crest	Seepage Conditions During Flood Crest
Less than 0.55	Objectionable seepage: major flood fight; boils requiring sandbagging
0.55 to 0.80	Transition zone
Greater than 0.80	Tolerable seepage: distributed seepage, pin boils

Five random variables were used in the probabilistic analysis: blanket thickness, permeability ratio, aquifer thickness, entrance distance, and critical gradient (blanket unit weight). The Coefficients of Variation (COV) for the five parameters are as shown in **Table 3-3**.

Table 3-3. Underseepage Parameters Coefficients of Variation (COV)

Parameter	COV[3]
Blanket thickness[1]	25
Permeability ratio[4]	40
Aquifer thickness[1]	15
Critical gradient[2]	15
River entrance length[4]	50

[1]COV based on Engineering Judgment.
[2]COV based on COV for unit weight in ETL 1110-2-556.
[3]COV is defined as the ratio of standard deviation and expected value.
[4]COV based on ETL 1110-2-556.

Underseepage analyses was performed using the expected values of the random variables and plus and minus one standard deviations at different river levels. Using the log-normal distribution and the limit state function for underseepage, a probability of failure was developed for varying river elevations at each critical reach.

3.4 PROBABILISTIC UNDERSEEPAGE ANALYSIS RESULTS

The deterministic underseepage analysis characterized the whole levee unit based on blanket thickness, levee geometry, river entrance distance, presence of landside levee toe ditch and relief wells, and river confluence. Furthermore, locations with landside levee toe ditch were analyzed for two scenarios: ditch empty and full. Critical levee segments were determined relative to the minimum Factor of Safety (FS) of 1.1 used in the original design. Levee reaches with calculated piping FS less than or equal to 1.1 were identified as critical.

At the critical sections identified from deterministic analysis, the probability of failure was calculated for river elevations between the levee crest and where the probability of failure is zero. A summary of the results with water at the levee crest and with three feet of freeboard for the critical reaches are shown in **Table 3-4**. Of the five problem areas in **Table 3-4**, the deficiency at Station 101+70 is the responsibility of City of Manhattan. This is because four of the existing wells are operating below 80% efficiency (operation and maintenance issue) and two relief wells from the original design are missing due to modification of the Rhode Island/UPRR tracks without Corps approval. **Appendix A-3** contains results of the reliability analysis and the Probability of Failure (PoF) versus water elevation curves.

Table 3-4. Underseepage Reliability Results

Reach Stationing		Water at Levee Crest		Water 3 ft below Crest		
From	To	Calculated Minimum FS	PoF (%)	Calculated Minimum FS	PoF (%)	Remarks
40+00[2]	64+00	0.6	71	0.7	55	Landside ditch considered to be empty in analysis
40+00	64+00	3.2	3.3	5.0	0.9	Landside ditch considered to be full in analysis
73+00	82+00	1.1	7	1.3	1.6	
101+70[1]		0.54	86	0.62	66	Ponding elevation in ditch assumed to be 997 ft (O&M Manual)
104+65	137+00	0.8	36	1.5	18	
165+12	176+63	0.9	32	1.1	12	Confluence area

FS = Factor of Safety (FS = $i/[i_f = 1.23]$)
PoF = Probability of Failure
[1]Four relief wells located along landside ponding area. Two relief wells are missing from original design due to unapproved removal during expansion of Rock Island/UPRR tracks expansion about 30 years ago. Fix is responsibility of City of Manhattan.
[2]Fragility curve used in economics.

3.5 SLOPE STABILITY ANALYSIS

Slope stability analyses were performed in general accordance with EM 1110-2-1902 "Slope Stability." Stability analysis was only performed for the landside slope under steady state seepage conditions. All analysis was performed with the Geostudio Slope/w software program using Spencer's Method.

The embankment was assumed to be homogenous and impervious, even though it is comprised of impervious and random zones. This was done to simplify the analysis and because the random material is mostly comprised of impervious material based on AMEC borings through the centerline. The steady state piezometric surface through the levee section was assumed linear between the water surface-riverside slope intersection and the landside toe. Foundation seepage conditions were modeled in Geostudio Seep/W for use in Slope/w stability analysis. Boundary conditions were changed in the Seep/W model until the excess foundation pressures at the levee toe matched the results of the deterministic underseepage analysis performed using EM 11102-1913 "Design and Construction of Levees" methodology. This ensured pore pressures in the foundation blanket and sand during flood events are adequately modeled.

Critical sections for slope stability analysis were chosen using engineering judgment after considering underseepage analysis results, levee height, foundation materials, and other levee features. Slope stability was analyzed for five levee sections:

1) Deep landward inlet ditch at Poyntz Avenue pump station (Station 97+00 to 102+30)
2) Tallest embankment without stability berm (Station 94+00 top 97+00)
3) Levee segment with highest underseepage gradient (Station 113+50 to 130+00)
4) Levee section at the Kansas-Big Blue River confluence (Station 165+12 to 176+63)
5) Levee reach with weak fat clay blanket material (Station 245+00 to 265+70)

3.5.1 Probabilistic Slope Stability Analysis

Material parameters for slope stability were estimated from Design Memorandum No. 1 and geotechnical laboratory testing performed by AMEC on samples from their 2011 levee accreditation exploration of the Manhattan levee. The properties are considered mean, or expected, values and should only be used for probabilistic analysis. The values shown are likely larger than those typically used for design, and may result in unconservative designs. For probabilistic slope stability analysis, the expected material properties were assumed to vary according to a log-normal distribution. Coefficients of variation (COV) for each parameter were established based on engineering judgment and published values. A summary of the soil parameters used is shown in **Table 3-5**. Mean parameters with COV are used for probabilistic analysis for existing conditions. The seepage conditions were not a variable in the slope stability probabilistic analysis.

A threshold value of stability factor of safety of 1.0 to define a slope failure is by definition the critical state. To quantify the probability of failure, the frequency of FS < 1.0 is calculated using Slope/w with parameter variability. In a Log-normal distribution, the probability of failure is the area in FS distribution between FS = 0 and FS = 1.0. The GeoStudio software SLOPE/W implements this procedure using the Monte Carlo technique by using the uncertainty in soil parameters to evaluate the slope stability probability of failure. At a given water surface elevation, the analysis was iterated 10,000 times using Monte Carlo simulation to quantify the probability of failure. Slope/w results give the expected factor of safety and probability of failure.

Table 3-5. Material Properties for Slope Stability Analyses

Material	Mean Friction Angle (deg.)	Coefficient of Variation (COV)	Moist unit weight (pcf)	Coefficient of Variation (COV)
Probabilistic Analysis				
Embankment	32[1]	15.63[4]	115[3]	7.5[4]
Blanket (ML/CL)	32[1]	15.63[4]	115[3]	7.5[4]
Blanket (CH)	19[2]	15.63[4]	115[3]	7.5[4]
Sand (Foundation)	32[1]	15.63[4]	120[3]	7.5[4]
Design Analysis				
Embankment	26.5	N/A	115[3]	N/A
Blanket (ML/CL)	26.5	N/A	115[3]	N/A
Blanket (CH)	17	N/A	115[3]	N/A
Sand (Foundation)	30	N/A	120[3]	N/A

[1]Based on summary of AMEC 2011 exploration laboratory direct shear testing for levee accreditation (See Appendix A.5)
[2]Based on Design Memorandum (DM No. 1): Flood Protection Project, Kansas River Basin, Manhattan, Kansas, August 1959
[3]Assumed unit weights
[4]In accordance with ETL 1110-2-561: Reliability Analysis and Risk Assessment For Seepage and Slope Stability Failure Modes For Embankment Dams
N/A = Not Applicable

The slope stability analyses assumed the failure surface should be of significant magnitude to remove a major portion of the levee allowing the interior of the levee unit to flood. Utilizing the slope stability program Slope/W, failure was forced to originate at the water surface-riverside slope intersection. Using this constraint, the failure would be of significant magnitude to inundate the levee interior instead of assuming a progressive slope failure from the landward levee toe.

3.5.2 Probabilistic Stability Results

A summary of results with water at the levee crest and with 3ft of free board are shown in **Table 3-6**. With water at the levee crest, the mean FS is significantly lower than the minimum FS stated in the Design Memorandum (FS = 1.5) and EM 1110-2-1913 (FS = 1.4). However, with 3 ft of freeboard the mean FS meets or exceeds the Design Memorandum (DM) minimum FS at all critical segments except between station 113+50 to 130+00 and station 165+12 to 176+63, FS of 1.3 and 1.4, respectively. The DM indicates the steady state stability analyses were performed with three feet of freeboard during design. Subsequently, results with water 3 ft below the crest are a better comparison with the DM and also indicate failure is very unlikely under the original design assumptions. Similarly, the mean FS meets or exceeds the EM 1110-2-1913 minimum FS at all critical reaches except between Station 165+12 and 176+63. However, since mean strengths were used the reaches may not meet criteria with design strengths because design strengths are normally lower than mean strengths.

One of the more significant assumptions for the reliability analysis is the development of a steady state seepage condition that is used in the analysis. The steady state seepage condition takes time to develop and does not occur instantaneously. If the steady state does not occur, then the stability analysis is

conservative and overstates the probability of failure. A transient analysis was completed to better assess the likelihood of a fully developed steady state condition occurring.

The time required to reach steady state was analyzed using GeoStudio software SEEP/W by performing transient seep analysis. The initial water table was assumed at the base of the embankment since slope stability failure is initiated by a driving hydraulic head above the riverside toe. An average permeability of 3.3×10^{-6} ft/sec (Holtz and Kovacs) was assumed representative of the entire embankment material. Summary of the transient seep analysis results with water at the levee crest and 3 ft below the crest is shown in **Table 3-7**. Typical slope stability and transient seep analysis outputs for the critical levee sections are found in **Appendix A.4**. A typical release from Tuttle Creek Dam may last 60 days. Flooding duration on the Kansas River, since it is largely unregulated by reservoirs, is expected to be approximately 15 days.

As seen in **Table 3-7**, the flood duration required to saturate the embankment when the levee is loaded to the crest and with 3 ft of freeboard is generally greater than the expected flood duration from either flood source. The shortest time for saturating the embankment (Station 245+00 to 265+70) at top of levee and with 3 ft freeboard was calculated to be 36 and 45 days, respectively. However, there are many uncertainties that make this analysis approximate. These uncertainties include rainfall impact, wave overwash for river levels approaching top of levee, the assumed permeabilities, simplification of embankment zoning, and the unknown character of the random fill zone which could vary significantly along the levee alignment because of the specification that allowed a wide variety of acceptable soils.

It is unlikely that steady state seepage conditions will develop for a top of levee loading on the Big Blue River or the Kansas River reach. Steady state seepage developing at lower river elevations, however, is possible. However, the risk associated with steady state seepage at lower river elevations is not significant.

The slope stability probabilistic results were not used for economic modeling since the likelihood of developing steady state conditions is relatively remote for river levels where the calculated risk is high. Additionally, underseepage seems to dominate the levee reliability. However, the slope stability reliability concerns under steady state condition will be considered for improvements during design of proposed raises to meet USACE stability criteria for this failure mode. Embankment drainage can easily be incorporated into areas of proposed levee raises to ensure USACE stability criteria is met. However, areas outside proposed raise areas will be more closely evaluated to determine design loading durations and anticipated seepage conditions for stability analysis in design. If areas outside proposed raises do not meet criteria, but do not pose considerable risk to the project, they will be documented and not remediated in the design phase.

Table 3-6. Steady State Slope Stability Analysis Results

Station		Toe Pressure Head (ft)	Blanket Thickness (ft)	River Water Elevation (ft)	Water at Levee Crest		Water 3ft below Crest	
From	To				Mean Factor of Safety (FS)	Probability of Failure (%)[1]	Mean Factor of Safety (FS)	Probability of Failure (%)[1]
94+00	97+00	11.8	20	1025.8	0.99	53.0	1.53	0.2
97+00[2]	102+30	8.9	28	1021.5	1.28	0.5	2.02	0.1
97+00[3]	102+30	6.6	28	1021.5	1.17	1.1	1.55	0.2
113+50	130+00	8.3	8	1021.0	0.66	100.0	1.30	0.3
165+12	176+63	13.4	14	1016.0	0.44	100.0	1.40	0.2
245+00	265+70	4.3	15	1016.5	1.02	33.7	1.82	0.2

[1]Probability of failure corresponds to ratio of the number of FS less than unity divided by the total number of Monte Carlo iterations
[2]Failure surface between riverside slope and landward toe of levee
[3]Failure surface between riverside slope and landward ditch toe

Table 3-7. Transient Seepage analysis results, 1993 Flood, and Tuttle Creek Emergency Release

Station		1993 Flood[1]	Tuttle Creek Emergency Release[2]	Water at Levee Crest	Water 3 ft below Levee Crest
From	To	Max Water Elevation Duration (days)	Release Duration (days)	Saturation Duration (days)[3]	Saturation Duration (days)[3]
94+00	97+00	11	N/A	88	106
97+00	102+30	11	N/A	36	64
113+50	130+00	11	N/A	128	150
165+12	176+63	11	60	87	125
245+00	265+70	11	60	26	45

[1]Duration of maximum water elevation during 1993 flood event corresponding approximately 3 ft freeboard (greater than 50-year and less than 100-year return period).
[2]Duration of Tuttle Creek Emergency release corresponding to roughly 4 ft freeboard (greater than 500-year-return period).
[3]Duration to saturate levee embankment.

3.6 SUMMARY

The geotechnical existing conditions analysis was performed to identify the critical sections from a geotechnical perspective and determine their probability of failure for economic modeling. The probabilistic analyses performed for this study were modeled with guidance given in ETL 1110-2-556 "Risk-Based Analysis in Geotechnical Engineering for Support of Planning Studies" (28 May 1999). The two failure modes considered at various river stages were underseepage and landside slope stability under steady state seepage condition.

3.7 REFERENCES

U.S. Army Corps of Engineers. 2006 Feasibility Underseepage Analysis Study, Kansas City District

U.S. Army Corps of Engineers. EM 1110-2-1913: Design and Construction of Levees, 30 April 2000US Army Corps of Engineers. Operation and Maintenance Manual: Flood Protection Project, Kansas River Basin, Manhattan, Kansas, August 1963

U.S. Army Corps of Engineers. Construction Plans for Levees and Appurtenances: Flood Protection Project, Kansas River, Manhattan, Kansas, February 1961
US Army Corps of Engineers. EM 1110-2-1913: Design and Construction of Levees, 30 April 2000

U.S. Army Corps of Engineers. EM 1110-2-1902: Slope Stability, 31 Oct 2003

U.S. Army Corps of Engineers. ER 1110-2-1942: Inspection, Monitoring and Maintenance of Relief Wells, 25 September 1998US Army Corps of Engineers. Design Memorandum (DM No. 1): Flood Protection Project, Kansas River, Manhattan, Kansas, August 1959

3.7.1.1 SEEP/W Software Version 7.15. GEO-SLOPE International Ltd, Calgary, Alberta, Canada. www.geo-slope.com

3.7.1.2 SLOPE/W Software Version 7.15. GEO-SLOPE International Ltd, Calgary, Alberta, Canada. www.geo-slope.com

3.7.1.3 Ang, A., and Tang, W., (1975), Probability Concepts in Engineering Planning and Design (Vol. I). New York: John Wiley & Sons, Inc.

3.7.1.4 Baecher, G. B., & J. J. Christian (2000), "Uncertainty, Probability, and Geotechnical Data," paper presented at Performance Confirmation of Constructed Geotechnical Facilities, ASCE, Amherst, MA; April 9-12.

3.7.1.5 Holtz, D. Robert and Kovacs, D. William (1981), An Introduction to Geotechnical Engineering: Prentice-Hall Civil Engineering and Engineering Mechanics Series.

3.7.1.6 Hunt, R. E., (1986), Geotechnical Engineering Analysis and Evaluation, New York: McGraw-Hill Book Company.

3.7.1.7 Wolff, T. F., (1985), "Analysis and Design of Embankment Dam Slopes: A Probabilistic Approach", Doctoral Dissertation presented to Purdue University, West Lafayette, IND.

PART 4 – Structures

Table of Contents

4.1 INTRODUCTION 4-1

4.2 ENGINEERS 4-1
4.2.1 Team Leader 4-1
4.2.2 Manhattan Avenue Pump Station 20+13 4-1
4.2.3 Poyntz Avenue Pump Station 101+26 4-1
4.2.4 Old By-Pass 98+80 4-1
4.2.5 Gatewells 4-1
4.2.6 Former Closure Structure Station 83+24 4-2

4.3 DETERMINISTIC CRITERIA 4-2
4.3.1 Assumptions 4-2
4.3.2 Stability Requirements 4-3
4.3.3 Strength Requirements 4-3

4.4 UNCERTAINTY ANALYSIS 4-4

4.5 RISK CALCULATIONS 4-5
4.5.1 Strength 4-5
4.5.2 Stability 4-5
4.5.3 Structural Failure 4-5

4.6 STRUCTURAL MATERIAL PROPERTIES 4-5

4.7 SOIL MATERIAL PROPERTIES 4-6

4.8 STRUCTURAL ANALYSIS 4-6
4.8.1 Manhattan Avenue Pump Station 4-7
4.8.2 Poyntz Avenue Pump Station 4-8
4.8.3 Old By-Pass Pump Station 4-9
4.8.4 Gatewells 4-10
4.8.5 Former Closure Structure Station 4-11

4.9 REFERENCES 4-15

4.1 INTRODUCTION

The structural Flood Risk Management features of the Manhattan Levee Unit analyzed as part of this study consist of pump stations and gatewells. The structural analysis involved an assessment of the existing condition of the structures based on available construction plans, detailed engineering analysis, and engineering judgment. The method of analysis began with a deterministic analysis of critical components (without any load or resistant factors) to establish an expected Factor of Safety (FS). The analysis does not consider any defects, or incremental or secondary load effects, that may have been caused by previous floods.

Components of these structures were analyzed, without factors of safety and with consistent assumptions, in order to evaluate the relative risk and consequences for economic and risk-informed decision-making purposes. Risk and Reliability studies do not replace Load and Resistance Factored Design (LRFD) analysis, nor do such studies confirm that the structure and its components satisfy any design criteria, past or present. The studies simply provide information about the possible performance of the structure for the loads under consideration. The results of the study are provided to the decision-maker to aid in making a risk-informed decision. In this feasibility study, these results were input into the HEC-FDA model to develop the overall levee unit failure probability.

4.2 DETERMINISTIC CRITERIA (EXISTING CONDITIONS)

A series of screening criteria are used to determine if a probabilistic analysis is necessary for a given structure. Summarized below are the assumptions used to analyze structural components as well as the strength and stability criterion from the current design standards. If the analysis shows the existing structural component meets the below criteria, it is assumed reliable and a 99.8% reliability is assigned. If the structural component does meet the criteria, a reliability analysis is performed.

4.2.1 Assumptions

The following lists major assumptions in the feasibility study.

i. Some structural components were not analyzed. Only components judged to be critical based upon engineering experience were analyzed for feasibility.
ii. The pump station components were analyzed based on dimensions, quantities, and conditions represented by record drawings. Deviations from plans cannot be verified per scope and budget. This is a consistent assumption for relative risk and reliability assessment for levee feasibility studies.
iii. Parts of the components being analyzed that were not evaluated with this analysis include, but may not be limited to, minimum rebar embedment lengths, structure capacity at rebar cutoff locations, etc
iv. Any parts of the components that may have been damaged during a flood were repaired to minimum USACE criteria.
v. Construction practices are considered good, and all specifications noted on

plans satisfied.

vi. Materials, such as reinforcing bar, are in good condition.

vii. Soil is adequately compacted and fill type and strength parameters supplied by Geotechnical Section is correct.

viii. Concrete compression zone is without voids.

ix. Other assumptions were made for the uncertainty and risk analysis.

4.2.2 Stability Requirements

Structural stability criterion can be seen in Table 4-1. It is based on Engineering Manual (EM) 1110-2-2100 Stability Analysis of Concrete Structures, dated 1 December 2005. The structures in this study are being analyzed for extreme loading conditions.

Table 4-1. Required Factors of Safety for Flotation

Load Condition Category	Return Period	Factor of Safety
Usual	10 years	1.3
Unusual	300 years	1.2
Extreme	Top of Levee	1.1

4.2.3 Strength Requirements

Typical Strength reduction factors and load factors were not used in the analysis of these structures. Load factors and reduced strengths are used in design, but are not applicable to a probability of failure analysis. If an existing structure has a calculated factor of safety of less than 1.0 (Capacity/Demand), then it implies failure of that structure.

Factors for new design: For new structures designed with the Strength Design Method, loads are increased by multiplying service loads by appropriate load factors and nominal strengths are decreased by corresponding strength reduction factors. Load factors required by EM 1110-2-2104, Strength Design for Reinforced –Concrete Hydraulic Structures include a dead and live load factor (LF) of 1.7 and a hydraulic load factor (HF) of 1.3.

Combining these gives a total load factor (TF) of 2.21. The strength reduction factor for flexure (ϕ), the typical controlling failure mechanism, is 0.90. Dividing the load factor by the strength reduction factor gives an overall factor of safety of about 2.45 for a new design.

Factor for existing structures: A high enough Factor of Safety (FS) in the strength analysis will provide 99.8% reliability because any variance in coefficients is too low to overcome the safety factor. There is a limit where the FS is still above 1, yet the probability of failure (POF) will begin to increase due to statistical possibilities presented by the coefficient of variance. To prevent unnecessary POF analyses, it is desirable to determine this FS threshold. Two reasons are given to set this FS threshold at 1.5.

First, it is possible to calculate the maximum range of FS based upon the coefficients of variation used in the analysis. This is performed by likening the analysis to measurement and instrumentation. Coefficients of Variation (COV) are then treated like uncertainty of a measurement (FS) based upon the mean values. For a system with N^{th} order of uncertainty, a 95% confidence estimate of total uncertainty can be computed by the square root of the sum of the squares of each coefficient of variation.

Considering the Coefficient of Variation for concrete compressive strength, steel yield strength, unit weight of soil, seepage pressures, and the angle of internal friction yields a probable maximum range in FS of +/- .28. Failure is not attained until FS < 1. Therefore, by this method, the FS should not reduce the POF unless the FS is near or below 1.28. A FS threshold of 1.5 would guarantee capturing any change to the POF.

A second reason why a threshold FS of 1.5 is sufficient is based upon historical results. Historical results have shown that for a POF analysis with FS above 1.3, the reliability results were still the maximum (99.8% Reliability). Historical analyses have also shown that POF results didn't vary appreciably unless the FS was lower than 1.2. This was largely because the Standard Variation used in analysis was small compared to 0.5, and there were only two variables in the majority of the analyses. Currently, six variables are considered to substantially contribute to changes in FS. The additional variables also have small variations when compared to 0.5. Using FS threshold of 1.5 has been shown reliable, theoretically and historically.

4.3 UNCERTAINTY ANALYSIS

For structural features not meeting deterministic strength and stability criteria, a risk and uncertainty analysis was performed. The method adopted for calculating a probability of failure is that outlined for geotechnical engineering in "Factors of Safety and Reliability in Geotechnical Engineering", by J. Michael Duncan, published in the Journal of Geotechnical and Geoenvironmental Engineering, April 2000. The use of this method provides consistency between the structural and geotechnical analyses.

To produce a probability of failure curve, the critical section of each feature not meeting criteria was analyzed (factor of safety determined) using mean material strengths and/or mean soil properties. Next, the parameters were varied to plus and minus one standard deviation from the mean one at a time and the factor of safety was recomputed. The reliability index equation from EM 1110-2-547 was used to determine the reliability of the feature not meeting the factor of safety. Assuming the feature started as 100% reliable, the probability of failure was determined by subtracting the reliability from the starting reliability. A 2% probability of failure was used as an appropriate non-failure threshold. If a probability of failure greater than 2% resulted, then the water elevation was lowered in 1-foot increments and the feature was reanalyzed until the probability of failure obtained was less than 2%.

The methods used are appropriate when data is normally distributed, when parameters display a linear relationship, and when degradation over time is not a

consideration. Because of the limited availability of data and with no information to suggest otherwise, an assumption of normal distributions for input data is reasonable and consistent with guidance provided in Engineering Technical Letter (ETL) 1110-2-547 (paragraph B-6.c). Examples of degradation over time would include scour around piles, reactive concrete, sliding movement, and deteriorating drainage systems that affect uplift. All available historic data, site inspections, and engineering judgment do not show time dependent deterioration of structures to be a concern for these Manhattan pump stations.

4.4 RISK CALCULATIONS

4.4.1 Strength

For strength calculations, uncertainty is measured by applying a mean and standard deviation to concrete compressive strength, steel yield strength, unit weight of soil, effective depth, the angle of internal friction, and seepage. The selected mean and normal standard deviation are based on engineering judgment and information published in both "Reliability Based Design in Civil Engineering" by Milton E. Harr, and ETL 1110-2-556.

4.4.2 Stability

For stability calculations, uncertainty is considered by applying a mean and standard deviation to the soil unit weight, shear strength, and varying seepage pressures based on values provided by the geotechnical engineers. The uncertainty inherent in determining the soil parameters provides a means to find a probability of failure. From experience on the Missouri River Levee Project L-142 Criteria Study (KCD-COE), it was determined through analysis that the unit weight and the soil shear strength have a noticeable effect on a floodwall's factor of safety. Varying the concrete density has only a minor effect on the factor of safety.

4.4.3 Structural Failure

Failure is defined as the capacity to demand ratio (factor of safety) less than 1.0, or in other words when the demand (loads) exceed the capacity (structural or geotechnical).

4.5 STRUCTURAL MATERIAL PROPERTIES

For the screening portion of the Manhattan Pump Stations Feasibility Study the following structural properties were used. The American Concrete Institute recommended the use of a 3,000 psi concrete strength around the 1940's through 1960's, the typical timeframe of construction for the Manhattan Avenue pump station structure. The new Poyntz Avenue pump station was constructed in 2002 and a value of 4,000 psi concrete strength was used based on the As-Built drawings, Sheet S1.

Knowing the time period of construction (~1940's – 1960's) and based upon the Portland Cement Association's pamphlet Engineered Concrete Structures, 1997, an assumed reinforcing steel design yield strength, Fy, of 40 ksi is used for the Manhattan

Avenue pump station structure. The newer Poyntz Avenue pump station was designed with Grade 60 ksi reinforcing, based on the As-Built drawings, Sheet S1.

Based on FEMA 310, the mean strength (or expected strength) for Risk and Uncertainty calculations shall be taken as 125% of the design strength. For reinforced concrete structures Harr suggests a 14% coefficient of variation.

i. Concrete Strength Variation (14%)
1. 1940's-1950's: $\mu - \sigma = 3225$, $\mu = 3750$, $\mu + \sigma = 4275$ (3000 psi min)
2. 1900's-1920's: $\mu - \sigma = 2150$, $\mu = 2500$, $\mu + \sigma = 2850$ (2000 psi min)

ii. Steel Strength Variation (14%)
1. 1940's-1950's: $\mu - \sigma = 43$, $\mu = 50$, $\mu + \sigma = 57$ (40 ksi min)
2. 1900's-1920's: $\mu - \sigma = 35.5$, $\mu = 41.25$, $\mu + \sigma = 47.0$ (33 ksi min)

4.6 SOIL MATERIAL PROPERTIES

The soil properties used to compute loads on structures for the Manhattan Pump Stations Feasibility Study are located in the geotechnical portion of the report. The values posted were obtained from the *Manhattan Levee Feasibility Study,* dated August 2006, in consultation with the geotechnical team members. These simplified values, shown in Table 4-2, were generalized conservatively for use in typical structural calculations.

Table 4-2. Soil Properties

Pump Station	Friction Angle (°)	Soil Unit Weight (lb/ft^3)
Manhattan Avenue 20+13	17	115
Poyntz Avenue 101+26	17	115
Old By-Pass 98+80	17	115
Gatewells 14+78, 34+62, 62+20, 81+25, 89+83, 98+80, 99+15, 105+05, 163+00, 234+00 269+50	17	120
Former Stop Log Gap	26	115

4.7 STRUCTURAL ANALYSIS

The structural evaluation of pump stations focused on floatation stability along with foundation wall and floor strengths. The potential for pump station uplift was computed according to EM 1110-2-2100, Stability Analysis of Concrete Structures taking into consideration site specific hydraulic grade lines supplied by Geotechnical project team members. Foundation wall and floor capacities were calculated using MathCAD worksheets. The CASE project program CORTCUL was used for analyzing the concrete walls on the reinforced concrete box for the Poyntz Avenue Pump Station.

For pump stations not meeting strength and floatation factors of safety, reliability calculations were performed.

4.7.1 Manhattan Avenue Pump Station

General: The Record "as-built" drawings dated August 1963 show that this pump station was constructed around February of 1961. It is located near the Tieback Levee portion of the Manhattan Kansas Levee System. The entire pump plant sits on an area of approximately 10.5 ft by 22 ft. A 72" Reinforced Concrete Pipe (RCP) extends to the face of the North and South Wet Well Walls. The West wall is bumped out (approximately 4 ft by 8 ft high) to go around the above mentioned RCP. The soil elevation is approximately the same around all four sides of the pump station.

Summary of the Analysis of Foundation Walls and Floor Strengths, and Uplift: Assumptions were made in analysis. It was also assumed that the water was at the top of the levee. It was determined after looking at the difference in the size and reinforcement of the walls, that the North and South Walls directly underneath the pump house (Wall 1: North and South Long Walls) could be analyzed as if they were identical.

The North and South Short Walls (Wall 3 or the walls that house the trash rack and sluice gate) could also be analyzed as if they were identical because of the size of the walls and the reinforcement. The East Wall (Wall 2) would be analyzed separately from the West Wall (Wall 4). Wall 4 is the bottom portion of the West Wall. The top portion of the west wall mimics Wall 2. The center wall will not be analyzed as a part of this feasibility report.

The walls were analyzed with applied soil, water and thrust loads. A plate analysis was done to determine the moment reaction coefficients for walls 1, 2, and 3. These moment reactions are for two-way bending and therefore, both horizontal and vertical steel must be checked. The moment reactions were used to determine the moment applied to the wall. A RAM Elements Model was used to determine the moments for Wall 4. These moments were compared to the wall and steel capacities and a factor of safety was computed based on the ratio of strength design wall capacity divided by computed wall moments.

After completing the plate analysis and the RAM Model, and putting the results into the spreadsheet to reanalyze, all of the walls met the factors of safety required for moment and for shear. The uplift forces on this structure were also calculated, and the results can be found in Table 4-3 below. It was determined that the pump station does meet the factor of safety requirements for uplift. The base slab of the pump station was also checked and found to be adequate.

Corrective measures will NOT be required for this pump plant because all the Factors of safety for strength were greater than 1.5 and the uplift factor of safety was greater than 1.1. Detailed calculations are available upon request.

4.7.2 Poyntz Avenue Pump Station

General: The exiting pump station is a fairly new structure that was built in approximately 2002 to replace the original pump station. The new pump station is located to the south of the old station and has a main interior space with plan dimensions of 16' x 16'. Drilled piers form two sides of the pump station and were used as form work during construction and probably used as form work to shore and dewater the area. The thicknesses of the drilled piers were neglected in the thickness of the pump station walls.

A unique aspect of this pump station is that the soil elevation varies depending on which wall is being analyzed. The soil elevation on the east side of the pump station (levee side) was raised up during construction and is higher than the soil elevation on other pump station walls. This causes the hydraulic grade line to be lower than the soil elevation on the east wall but higher than the soil elevation of the remaining walls.

Summary of the Analysis of Foundation Walls and Floor Strengths, and Uplift: Moment coefficients were taken from Plate tables (per Moody, 1963) to determine the wall moments in each direction. These moments are for two-way bending and therefore, both horizontal steel and vertical steel must be checked. These moments were compared to the wall and steel capacities and a factor of safety was computed based on the ratio of strength design wall capacity divided by computed wall moments. All factors of safety are greater than 1.5, and therefore 99.8% reliability is assigned. Uplift on the new pump station was also checked.

Even though the new pump station is doweled into and connected to the existing box conduit at several locations, uplift was checked for the new pump station separately based on the minimal dowels and connections. The uplift factor of safety was found to be greater than the required 1.1 factor of safety. The slab of the pump station was also checked and found to be adequate. Corrective measures will NOT be required for this pump plant because all the Factors of safety for strength were greater than 1.5 and the uplift factor of safety was greater than 1.1. Calculations are available upon request.

Summary of Reinforced Concrete Box Conduit Analysis: The reinforced concrete box conduit was analyzed with CORTCUL, a CASE program designed by the US Army Corps of Engineers. The conduit dimensions, steel reinforcement, concrete and reinforcement strength, reinforcement cover, soil data, elevations of the conduit and ground water, etc. were input into the program. Based on the age of the structure, concrete strength is assumed to be 3000 psi and the steel yield strength is assumed to 40,000 psi.

The conduit is analyzed at its worst case scenario, which is directly below the levee. The amount of soil and potential water over the conduit is at its greatest. The conduit is analyzed with no water in the conduit. A point load on the levee due to a vehicle load of 32 kip axle weight based on the design truck per ASHTO was also

assumed.

The program CORTCUL analyzes the four wall members of the conduit in bending, axial, and shear. The output gives factors of safety analyzed at each end and the centerline of each wall. All factors of safety for the conduit are greater than 1.5 and are therefore adequate for this feasibility study.

4.7.3 Old By-Pass Pump Station Sta. 98+80

General: Construction of this pump station is unknown and is presumed to be completed by the City of Manhattan, KS (City) prior to the construction of the current Federal levees in the early 1960's. The Old-By-Pass Pump Station was originally used by the City to pump effluent into the Kansas River from a now abandoned sewage treatment plant. The pump station is currently used as a back-up to the New Poyntz Ave pump station located at Sta. 101+26 just directly to the north-east which is fed by the nearby drainage canal via gravity flow.

A 24" CIP extends from the Old-By-Pass pump station through the levee. On 5/9/2011 AMEC, an A/E contracted by the City to conduct levee certification, conducted a video inspection of the 24" CIP. The video inspection was only able to see from the outlet to the levee. At the levee, the pipe makes a sharp bend upward towards a valve box at the top of levee. The pipe from the levee to the pump station was not inspected as the only way to inspect would be to cut a hole into pipe or disassemble pipe in pump station. According to the Manhattan Periodic Inspection Report #3, the pipe was rated as unacceptable because it was not completely inspected.

Summary of the Analysis of Foundation Walls and Floor Strengths, and Uplift: Old By-Pass was analyzed similarly to Manhattan and Poyntz pump station. It should be noted that reinforcing bar sizes, and wall and slab thicknesses are based on the use of ground penetrating radar and leaves some uncertainty. Moments are for two-way bending and both horizontal and vertical steel must be checked.

All factors of safety are greater than 1.5, and therefore 99.8% reliability is applied. Uplift on the pump station was also checked. The uplift factor of safety was found to be inadequate for water to top of levee (0.87). Per the criteria mentioned above in Section 4.3, a probability of failure (POF) was conducted to determine the reliability of the structure by varying the pressures on the base of the structure.

The POF curve was determined by calculating the POF due to uplift with water at 1022.6' (top of levee), 1015.5' (50 year event), and 1008' (no water on levee) see Figure 4.1 below. Calculations are available upon request.

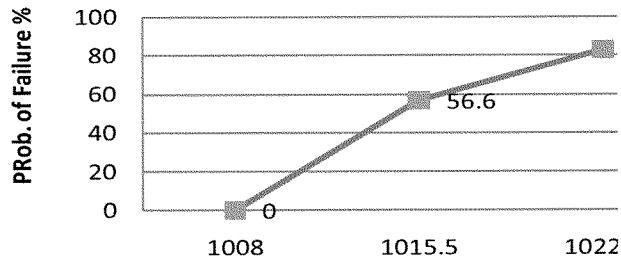


Figure 4.1 Probability of Failure

Considering the unknowns and the estimated risks associated with this pump station and because this is a back-up pump station to the new Poyntz Avenue pump station, it is recommended that water within the Old-By-Pass pump station be maintained at 5'-10" during pumping operations. 5'-10" is the amount of water needed to achieve an uplift factor of safety of 1.1 required by USACE criteria. The Old-By-Pass Pump Station is not part of the Federal project; however since it falls within the levee critical zone, the Sponsor has been made aware of the possible deficiency, and recommendations have been made to address in separate official correspondence.

4.7.4 Gatewells

General: The eleven Manhattan Flood Protection gatewells were analyzed with water to top of levee (worst case) only to determine their reliability for strength and uplift. The results of this analysis are shown in Table 4-6.

Summary of the Analysis of Foundation Walls and Floor Strengths, and Uplift: Five of the eleven gatewells showed inadequate Factors of Safety (1.5 or less) for strength at the walls, except for the Sta. 62+20 gatewell. Upon first failing to meet the deterministic criteria, Sta. 62+20 was considered 100% reliable after conducting a probability of failure analysis. However, considering the age of the structure and based on engineering judgment, it was determined for feasibility purposes that this structure should be assumed to be fully replaced. Per the criteria mentioned above in Section 4.3, a probability of failure (POF) analysis was conducted to determine the reliability of the structure by varying the pressures on the gatewell as a function of dropping the water surface elevation on the structure from top of levee (TOL), 3-feet, and 6-feet down, respectively. See results in Table 4-6. The POF graph(s) below Table 4-6 will be used by economics for assessing economic impact. There were no concerns with uplift on the structures.

Alternatives to improve structural reliability include strengthening walls with W-sections and bracing or adding to the concrete thickness of the walls. Full pipe

replacements will be made for Sta. 269+50 and 163+00 since these pipes will be subject to induced loading caused by the raise on the Big Blue levee segment. The remainder of the pipes on the Kansas River segment will remain in place except for the first approximately 10-feet upstream and downstream of the gatewell replacements.

4.7.5 Former Closure Structure

General: A field visit was conducted on December 18, 2010, in order to obtain measurements of the stop log gap since no as-built drawings were available as mentioned above. An excavator provided by the City of Manhattan was used to excavate at two locations (1) riverside (RS) from the centerline of the stoplog gap and (2) next to the right RS abutment facing landside.

It was impractical to excavate on the landside (LS) as the excavator would not have enough clearance on top of levee to excavate and would compromise fully compacted and settled in-situ soils. Once riverside footing was exposed, measurements were taken. The RS footing width is 5.5' from stem wall and the heel depth exposed to 3' (did not go all the way down).

After the excavations and further research in ED-DS archives, a design computation from September 1961 was found showing the concrete sill and adjacent abutment/floodwall design. The verifiable dimensions matched the measurements and the other dimensions from the computations were assumed to be correct.

Summary of the Analysis: The structure was analyzed for sliding, overturning, and strength at the abutments. The structure is **ADEQUATE** for sliding and overturning with moist soil conditions. However, the stop-log abutments are **NOT ADEQUATE** for strength as a result of the loading being reversed since its original design. The 3-#4's at the landside face of the abutment (now in tension) were not designed to retain land side soil. A recommendation was made for the Sponsor to place USACE approved select levee fill material (equivalent to landside) on the riverside to further enhance the structural stability of the structure and off-set soil loading on landside. In 2012, the Sponsor added the approved fill on the landside of wall as recommended.

Table 4-3. Pump Stations analyzed with water at top of levee

Station	Station Name	Uplift Factor of Safety (> 1.1 Req'd)	Water Req'd to meet 1.1 Uplift Factor of Safety (ft)	Water Available (ft)	Comments
20+13	Manhattan Avenue	1.24 (Wet) 1.13 (Dry)	0	3.09	**No Corrective Measures Necessary**
101+26	Poyntz Avenue	1.18 (Wet) 1.10 (Dry)	0.28	3.18	**No Corrective Measures Necessary**
98+80	Old By-Pass	0.87 (Wet) 0.78 (Dry)	5.8	3	Verification prior to or during PED that no heel exists. IF heel exist then uplift FS will improve. If no heel present then corrective measures will be necessary. Measures may consist of rock or helical anchors, adding a concrete heel, etc.

Table 4-4. Pump Stations Moment Factor of Safety (> 1.5 Req'd)

Station	Station Name	Wall 1	Wall 2	Wall 3	Wall 4	Base Slab	Comments
20+13	Manhattan Avenue	1.52	2.13	1.73	2.24	1.59	**No Corrective Measures Necessary**
101+26	Poyntz Avenue	1.79	2.23	1.82	N/A	2.12	**No Corrective Measures Necessary**
98+80	Old By-Pass	2.46	4.62	N/A	N/A	1.70	**No Corrective Measures Necessary**

Table 4-5. Pump Stations Shear Factor of Safety (> 1.5 Req'd)

Station	Station Name	Wall 1	Wall 2	Wall 3	Wall 4	Base Slab	Comments
20+13	Manhattan Avenue	1.73	2.70	3.35	2.41	4.67	No Corrective Measures Necessary
101+26	Poyntz Avenue	2.49	3.06	2.62	N/A	2.12	No Corrective Measures Necessary
98+80	Old By-Pass	2.89	2.38	N/A	N/A	2.25	No Corrective Measures Necessary

Table 4-6. Gatewells Existing Conditions Analyzed with Water TOL					
Station	Uplift Factor of Safety HGL (>1.1 Req'd)	Controlling Strength Factor of Safety (>1.5 Req'd)	Controlling Structural Mechanism	Assigned Reliability (%)	Comment
14+78	1.2	0.97	Mid-Span Wall Bending	94.8	Wall AD mid-span bending ,shear, and base slab fail to meet the minimum Factor of Safety of 1.5 required per our guidance. Consider strengthening walls and slab of gatewell
34+62	1.5	2.5			
62+20	1.7	1.3	End Span Wall Bending	100	Wal 1 negative end span moment meets relibaility after conducting POF and varying concrete and steel strengths. Based on engineering judgement assume full replacement.
81+25	1.8	2.2			
89+83	1.3	1.1	End Span Bending	97.21	Consider strengthening walls of gatewell. Nearly meets criteria.
98+80	1.5	4.4			
99+15	1.4	2.8			
105+05	1.5	2.3			
163+00	1.6	0.95	Mid-Span Bending	62.1	Wall AD mid-span bending , fails to meet the minimum Factor of Safety of 1.5 required per our guidance. Consider strengthening walls of gatewell
234+00	2.2	2.8			
269+50	1.6	0.76	Mid-Span Bending	0	Wall AD fails to meet criteria and is recommended to strengthen walls in PED.

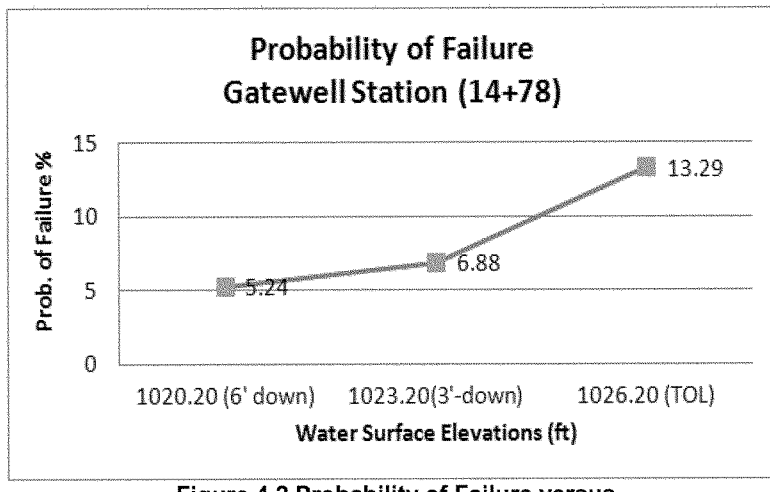


Figure 4.2 Probability of Failure versus Water Surface Elevation for Economics (Sta. 14+78)

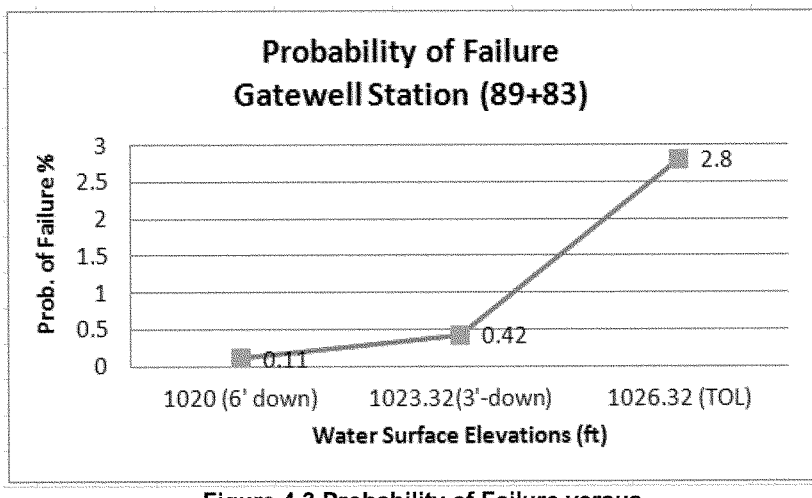


Figure 4.3 Probability of Failure versus Water Surface Elevation for Economics (Sta. 89+83)

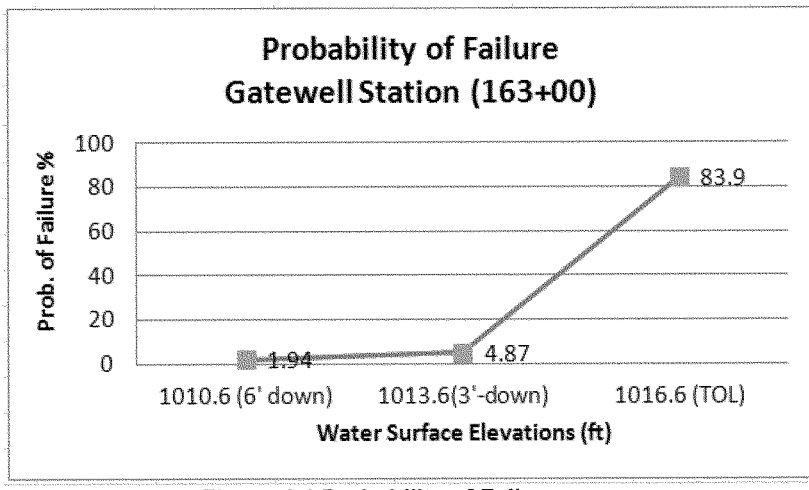


Figure 4.4 Probability of Failure versus Water Surface Elevation for Economics (Sta. 163+00)

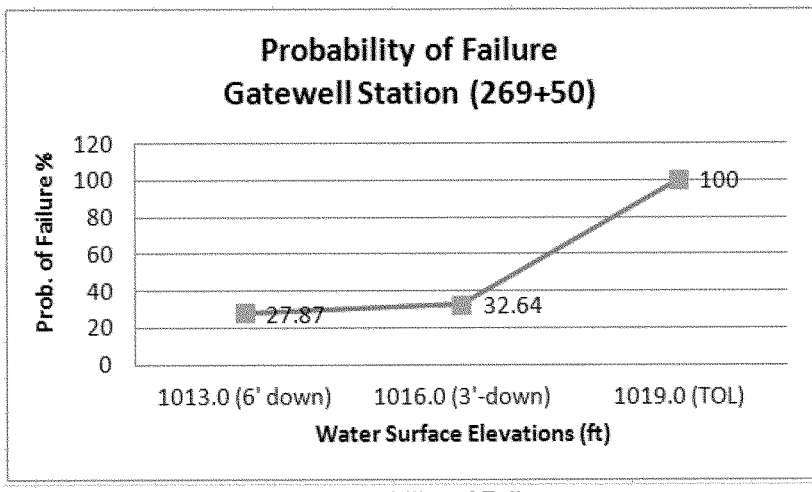


Figure 4.5 Probability of Failure versus Water Surface Elevation for Economics (Sta. 269+50)

4.8 REFERENCES

ACI 318-08

EM 1110-2-2104, DESIGN FOR REINFORCED CONCRETE HYDRAULIC STRUCTURES

EM 1110-2-2100, STABILITY ANALYSIS OF CONCRETE STRUCTURES

POYNTZ AVE PUMP STATION AS-BUILT DRAWINGS DATED JAN. 2003

O & M MANUAL FLOOD PROTECTION PROJECT, MANHATTAN, KANSAS RECORD DRAWINGS (1965)

ENGINEERING MONOGRAPHS NO. 27, MOMENT & REACTIONS FOR RECTANGULAR PLATES BY W.T. MOODY, REVISED JULY 1963

RELIABILITY-BASED DESIGN IN CIVIL ENGINEERING BY MILTON E. HARR, DOVER PUBLICATIONS INC. 1996

ENGINEERING TECHNICAL LETTER (ETL) 1110-2-556, APPENDIX B, PAGE 30

PART 5 – Civil

Table of Contents

5.1 INTRODUCTION **5-1**

5.2 DESCRIPTION OF EXISTING LEVEE UNIT **5-1**
5.2.1 Levee Description 5-1

5.3 UTILITY UPLIFT ANALYSIS **5-1**
5.3.1 Methodology 5-1
5.3.2 Results 5-3
5.3.2.1 Utilities Crossing the Levee 5-3
5.3.2.2 Utilities in the Critical Zone 5-4

5.4 ABOVE GROUND UTILITIES AND FEATURES **5-6**

5.5 PUMP STATION ASSESSMENT **5-6**

5.6 SUMMARY **5-7**

5.7 ITEMS OF CONSIDERATION FOR ALTERNATIVES **5-7**
5.7.1 Vicinity of Station 110+00 to 150+00 5-8
5.7.2 Vicinity of Station 255+00 5-8
5.7.3 Other Utilities 5-8
5.7.4 Borrow Quantities and Source of Materials 5-8

5.8 REFERENCES **5-9**

5.1 INTRODUCTION

This document presents results of civil / utilities evaluation of the Manhattan levee in Manhattan, Kansas to include utility uplift and limited hydraulic assessment of pump stations under existing conditions.

This is the first phase of the feasibility study where the existing condition of the levee unit is documented. The second phase of the feasibility study considers alternatives to improve levee reliability with respect to all failure modes, including improvement of the factor of safety of utilities constructed as part of the Federal project found to be deficient, and is presented in Volume 2.

5.2 DESCRIPTION OF EXISTING LEVEE UNIT

5.2.1 Levee Description

The Manhattan levee protects the City of Manhattan, Kansas from high water along Wildcat Creek, the Kansas River, and the Big Blue River. The levee is approximately 5-½ miles long and generally has a 10-foot wide crown and three horizontal to one vertical side slopes. Construction of the levee was completed in the early 1960s. The levee was designed with freeboard, e.g. the original design water surface for the Manhattan levee is 3 feet below the levee crest. Note that, while the original design included 3 feet of freeboard, this analysis considers water to the top of the existing levee.

5.3 UTILITY UPLIFT ANALYSIS

Uplift is the force acting on buried structures (e.g. utility lines) due to excess hydrostatic pressure during times of high river stage. Excessive uplift forces can literally "float" a structure or utility out of the ground, causing a situation that is difficult to flood-fight. Since excessive pressures could occur at any location along the levee, all utilities crossing the levee or within the critical zone (300 feet riverward to 500 feet landward of the levee) were inventoried and analyzed. .

5.3.1 Methodology

A variety of information sources were considered. Riley County supplied GIS data sets for water and sewer lines during the reconnaissance phase. This information, along with information obtained from discussions with Kansas Gas Service representatives, was used for the utilities analysis. Selected operational and maintenance manual (O&MM) drawings for the Manhattan levee were also reviewed and used for utility information.

Utilities were broken into two groups; buried utilities analyzed for uplift, and above ground utilities which may pose clearance problems for proposed construction. Buried utilities analyzed for uplift were further broken into two groups; those that cross the levee and those located in the critical zone.

The geotechnical data used for uplift analysis was provided by district geotechnical engineers, and was the same data used for seepage and stability computations.

In cases where pipe materials are unknown, steel is assumed for gas lines; ductile iron for other pressurized lines (e.g. water and sewage force main), and reinforced concrete for gravity sewer lines.

Depths of utilities used in the analysis are to the invert. Actual reported or surveyed depths were used when available. When actual depths were not available, sanitary and storm sewers up to 30 inches diameter were estimated to be 10 feet deep. Depths for 36 inch and larger sewers were estimated at 15 feet. Depths for pressurized lines (water, gas, sewage force main) were estimated to provide approximately 4 feet of cover, e.g. analysis depth for 6 inch water would be 4-1/2 feet; analysis depth for 30 inch water would be 6-1/2 feet.

Wall thickness was neglected for relatively thin materials, including ductile iron, steel, and vitrified clay. Wall thickness for reinforced concrete utilities was estimated as the nominal diameter in feet, plus one inch, e.g. for a 4 foot diameter reinforced concrete pipe (RCP) the wall thickness would be estimated at 4+1 = 5 inches, resulting in an outside diameter for analysis of 48+5+5 = 58 inches.

Representative unit weights for various pipe materials were taken from a variety of sources. American Society for Testing and Materials (ASTM) C76 "Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe" was used to estimate weight per lineal foot, assuming wall type "B". ASTM C700 "Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated" was used to estimate weight of clay pipe. Steel pipe weights were estimated for schedule 40 pipe. Cast and ductile iron pipe weights were estimated for the lowest pressure of class readily available in a particular size, e.g. class 150 for 30 inch diameter.

While the original design included 3 feet of freeboard, the head pressures used in the uplift calculations are based upon water to the top of the existing levee, as well as subsurface information as determined by Kansas City District geotechnical engineers. In some cases, head pressures for a given range vary due to the existence of landside ditches. In these cases, the most conservative values (e.g. highest excess head pressures) were used in the utility uplift calculations. Structures in the area formed by the ponding levee were not analyzed since they are outside of the critical zone of the primary levee system.

With the above information in hand, each utility was analyzed for uplift according to Kansas City District Geotechnical Design and Dam Safety Section guidance for uplift. A "spot check" comparison was made per EM 1110-2-2100: Stability Analysis of Concrete Structures with results generally consistent, with the EM being slightly more conservative (e.g. producing a slightly lower factor of safety).

The analysis was conducted in three steps, with the first step considering buried pipes subject to uplift forces, and neglecting similar hydrostatic forces acting down on the pipe. This was a "screening level" analysis intended to identify areas where due diligence would dictate a closer look at utilities. The second step looked at those utilities identified as potentially problematic in step 1, but considered all of the hydrostatic forces acting on the pipe, including those forces acting downward. The third step considered manholes associated with the utilities. Unlike buried pipes, manholes would not experience downward-acting hydrostatic forces since they would typically extend to or above the ground surface. In other words, if potential utility problems are identified in an area, they would likely be most serious at manholes.

5.3.2 Results

Screening level analysis was performed on all utilities crossing or in the critical zone of the levee. Utilities considered to be questionable or problematic based on screening level analysis are discussed below. In each case, a factor of safety of 1.1 (corresponding with the extreme loading condition for flotation per EM 1110-2-2100) or greater is considered to be acceptable under existing conditions.

5.3.2.1 Utilities Crossing the Levee

Station 62+20, ID 11xng

This drainage structure is a 48-inch RCP. At the line of protection the structure invert is 20 feet below grade. Screening level uplift analysis shows this line to have acceptable factors of safety when full; unacceptable when empty. Further detailed analysis, considering all of the hydrostatic forces acting on the pipe, results in acceptable factors of safety at all locations. Analysis of the gatewell structure is presented in the structural portion of the existing conditions document.

Station 81+25, ID 12xng

This drainage structure is a 24-inch RCP. At the line of protection the structure invert is 22 feet below grade. Screening level uplift analysis shows this line to have an unacceptable factor of safety, near the landside levee toe. Further detailed analysis, considering all of the hydrostatic forces acting on the pipe, results in acceptable factors of safety at all locations. Analysis of the gatewell structure is presented in the structural portion of the existing conditions document.

Station 163+00, ID 18xng

This drainage structure is an 84-inch RCP. At the line of protection the structure invert is 20 feet below grade. Screening level uplift analysis shows this line to have acceptable factors of safety when full; unacceptable when empty. Further detailed

analysis, considering all of the hydrostatic forces acting on the pipe, results in acceptable factors of safety at all locations. Analysis of the gatewell structure is presented in the structural portion of the existing conditions document.

Station 234+00, ID 21xng

This drainage structure is an 84-inch RCP. At the line of protection the structure invert is 16 feet below grade. Screening level uplift analysis shows this line to have acceptable factors of safety when full; unacceptable when empty. Further detailed analysis, considering all of the hydrostatic forces acting on the pipe, results in acceptable factors of safety at all locations. Analysis of the gatewell structure is presented in the structural portion of the existing conditions document.

Station 269+50, ID 22xng

This drainage structure is a 72-inch RCP. At the line of protection the structure invert is 21 feet below grade. While this pipe would likely be full during a high water event due to uncontrolled seepage and impeded drainage, screening level uplift analysis shows an unacceptable factor of safety, near the landside levee toe. Further detailed analysis, considering all of the hydrostatic forces acting on the pipe, results in acceptable factors of safety at all locations. Analysis of the gatewell structure is presented in the structural portion of the existing conditions document.

5.3.2.2 Utilities in the Critical Zone

Station 35+00 – 45+00, ID 5cz, 6-inch Water within 220 feet of levee

Screening level uplift analysis shows this water line to have unacceptable factors of safety only when empty, and only for a portion of its length (Station 40+00 to 45+00) due to unusually high residual head pressures. Further detailed analysis, considering all of the hydrostatic forces acting on the pipe, results in acceptable factors of safety at all locations.

Station 70+00 – 100+00, ID 12cz, 24-inch Water within 125 feet of levee

Uplift analysis shows this water line to have unacceptable factors of safety only when empty, and only for a portion of its length (Station 73+00 to 87+00 and 94+00 to 97+00) due to unusually high residual head pressures. Further detailed analysis, considering all of the hydrostatic forces acting on the pipe, results in acceptable factors of safety at all locations.

Station 110+00 – 115+00, ID 17cz, 42-inch Sewer within 110 feet of levee

Uplift analysis shows this sanitary sewer line to have unacceptable factors of safety at some locations when empty, and also at some locations when full. Further detailed analysis, considering all of the hydrostatic forces acting on the pipe, results in acceptable factors of safety at all locations *on the pipe*. Further detailed analysis of the manholes, assuming 6 foot diameter typical precast structures, results in unacceptable factors of safety.

While these manhole structures are not part of the Federal project and therefore not used in economic calculations for levee evaluations, they do present a potential means of failure under conditions of high water and corresponding high excess head. The Sponsor should further evaluate these structures and consider means of reducing excess head pressures, adding weight, or anchoring the structures.

Station 112+00 – 114+00, ID 21cz, 10-inch Sewer within 200 feet of levee

Uplift analysis shows this sanitary sewer line to have unacceptable factors of safety at some locations (Station 113+00 – 114+00) when empty. Closer examination shows that the sewer is farther from the levee (approx. 300 feet) within this area of exceptionally high residual head. At that greater distance, the factor of safety is acceptable.

Station 115+00, ID 22cz, 36-inch Sewer within 110 feet of levee

Uplift analysis shows this sanitary sewer line to have unacceptable factors of safety when empty or filled. Further detailed analysis, considering all of the hydrostatic forces acting on the pipe, results in acceptable factors of safety at all locations *on the pipe*. Further detailed analysis of the manholes, assuming 6 foot diameter typical precast structures, results in unacceptable factors of safety.

While these manhole structures are not part of the Federal project and therefore not used in economic calculations for levee evaluations, they do present a potential means of failure under conditions of high water and corresponding high excess head. The Sponsor should further evaluate these structures and consider means of reducing excess head pressures, adding weight, or anchoring the structures.

Station 115+00 – 151+00, ID 23cz, 54-inch Sewer within 50 feet of levee

Screening level uplift analysis shows this sanitary sewer line to have unacceptable factors of safety at some locations when empty, and also at some locations when full. Further detailed analysis, considering all of the hydrostatic forces acting on the pipe, results in acceptable factors of safety at all locations *on the pipe*. Further detailed analysis of the manholes, assuming 8 foot diameter typical precast structures, results in unacceptable factors of safety.

While these manhole structures are not part of the Federal project and therefore not used in economic calculations for levee evaluations, the do present a potential means of failure under conditions of high water and corresponding high excess head. The Sponsor should further evaluate these structures and consider means of reducing excess head pressures, adding weight, or anchoring the structures.

Station 194+00 – 200+00, ID 26cz, 16-inch Water within 0 feet of levee

Uplift analysis shows this water line to have unacceptable factors of safety only when empty. Further detailed analysis, considering all of the hydrostatic forces acting on the pipe, results in acceptable factors of safety at all locations.

Station 200+00 – 213+00, ID 28cz, 20-inch Water within 0 feet of levee

Uplift analysis shows this water line to have unacceptable factors of safety only when empty. Further detailed analysis, considering all of the hydrostatic forces acting on the pipe, results in acceptable factors of safety at all locations.

Station 255+00 – 272+00, ID 34cz, 36-inch Sewer within 175 feet of levee

Uplift analysis shows this sanitary sewer line to have unacceptable factors of safety when empty within a limited range (Station 265+70 – 269+50). Since this is a main line, it would be expected to contain water at all times, with the depth of water varying with the time of day. With the pipe half full, analysis still results in an unacceptable factor of safety. Further detailed analysis, considering all of the hydrostatic forces acting on the pipe, results in acceptable factors of safety at all locations *on the pipe*. Further detailed analysis of the manholes, assuming 6 foot diameter typical precast structures, results in unacceptable factors of safety.

While these manhole structures are not part of the Federal project and therefore not used in economic calculations for levee evaluations, they do present a potential means of failure under conditions of high water and corresponding high excess head. The Sponsor should further evaluate these structures and consider means of reducing excess head pressures, adding weight, or anchoring the structures.

Station 255+00 – 272+00, ID 36cz, 12-inch Water within 125 feet of levee

Uplift analysis shows this water line to have unacceptable factors of safety only when empty, due to unusually high residual head pressures. Further detailed analysis, considering all of the hydrostatic forces acting on the pipe, results in acceptable factors of safety.

5.4 ABOVE GROUND UTILITIES AND FEATURES

Above ground features such as bridges and overhead utilities will be considered with regard to prospective levee raises, and how those levee raises might affect clearance. Since potential levee raises are very small, slight reductions in clearance are not expected to be problematic.

5.5 PUMP STATION ASSESSMENT

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

Information on the Manhattan Avenue Pump Plant was obtained from 1961 record drawings and the operations & maintenance manual. This station was designed to handle interior drainage and limited relief well flow. Since interior drainage is a local

responsibility and several of the relief wells have been abandoned, this station was not analyzed for hydraulic capacity. Capacity requirements for any proposed improvements which would result in concentrated seepage flow (e.g. relief wells) to these stations should be addressed in future conditions analysis. Structural evaluation of the Manhattan Avenue Pump Station is provided in Part 4 Structures.

Information on the original Poyntz Avenue Pump station was obtained from 1961 record drawings. Local interests demolished the original Poyntz Avenue station and constructed a new / larger station in 2003. Record drawings dated January 2003 were provided by the local Sponsor. Since this station handles only interior drainage, which is a local responsibility, the hydraulic capacity of this station was not analyzed. Structural evaluation of the Poyntz Avenue Pump Station is provided in Part 4 Structures.

No detailed information such as as-built drawings or pump curves was found on the Old Bypass Pump Station. This facility was reportedly constructed by the City of Manhattan prior to construction of the Federal levee in the early 1960s and originally used to pump effluent into Kansas River from a now abandoned sewage treatment plant. While this plant is not part of the Federal system, it is currently used as a backup to the new Poyntz Avenue station during high rainfall events concurrent with high river stages. Since this station handles only interior drainage, which is a local responsibility, the hydraulic capacity of this station was not analyzed. Structural evaluation of the Old Bypass Pump Station is provided in Part 4 Structures.

5.6 SUMMARY

The civil / utilities existing conditions analysis was performed to identify utilities that could pose a risk of failure during high water events, to broadly assess the hydraulic capacity of existing pump stations as they relate to levee features, and to identify above ground utilities or bridges that could affect implementation of future improvements (e.g. a levee raise). Several utilities raise concern, as noted in the following section.

5.7 ITEMS OF CONSIDERATION FOR ALTERNATIVES TO IMPROVE RELIABILITY OF UTILITIES FOR RESISTING UPLIFT AND PROPOSED LEVEE

As the study moved into alternatives examination, it became necessary to determine what improvements would be required to address the deficiencies noted under existing conditions and to support potential levee raises averaging 1.5 feet with some levee segments needing up to a three foot raise depending, on location and existing topography. These potential improvements would likely include the levee raise, berms and / or relief wells, improvements to existing structures, and incidental utility relocations and other associated work items.

5.7.1 Vicinity of Station 110+00 to 150+00, ID 17cz, 22cz, 23cz

This area is characterized by an interceptor sewer transitioning from 42-inch to 54-inch as it picks up flow from a 36-inch trunk, in an area where the Kansas River is particularly close to the levee, and excess heads are high under extreme flooding conditions. The manhole with the most uplift force under extreme conditions would require approximately 75,000 pounds of downward force to prevent flotation. This downward force could be provided by anchors, heel extensions, or simply by adding weight. For purposes of estimating potential costs, a 20 foot diameter x 3 foot thick concrete ring is assumed for each of eleven manholes in this area. If a berm were to be proposed in this area, these manholes would also need to be raised accordingly.

5.7.2 Vicinity of Station 255+00 – 272+00, ID 34CZ

This sewer is located in an area where excess heads under conditions of high river stage could cause unacceptable uplift forces on manholes. These manholes will not experience the same level of uplift as those discussed above, however for purposes of estimating potential costs, a 20 foot diameter x 3 foot thick concrete ring is assumed for each of three manholes in this area.

5.7.3 Other Utilities

Thirty power poles from Station 104+00 to 140+00 may need to be raised to accommodate any proposed berms in this area.

An 8-inch diameter gas line at Station 227+00 would need to be raised to accommodate any proposed levee raise in this area.

A 36-inch diameter water line at Station 232+28 would need to be raised to accommodate any proposed levee raise in this area.

5.7.4 Borrow Quantities and Source of Material

Borrow quantities and potential sources of material are discussed in Volume 2 of the Engineering Appendix.

5.8 REFERENCES

US Army Corps of Engineers. Operation and Maintenance Manual: Flood Protection Project, Kansas River Basin, Manhattan, Kansas, revised June 1980

Kansas City District Geotechnical Design and Dam Safety Section Guidance for Uplift, January 2003, http://www.nwk.usace.army.mil/geotech/pdf/uplift.pdf

US Army Corps of Engineers, EM 1110-2-2100: Stability Analysis of Concrete Structures

US Army Corps of Engineers. Construction Plans for Levees and Appurtenances: Flood Protection Project, Kansas River, Manhattan, Kansas, February 1961

US Army Corps of Engineers. EM 1110-2-1913: Design and Construction of Levees, 30 April 2000

American Society for Testing and Materials (ASTM). C76: Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe

American Society for Testing and Materials (ASTM). C700: Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated

Flood Protection Project Manhattan, Kansas, Supplemental Design Memorandum No. 1-C (1960) was used in the development of Paragraphs; Design Storm.

Riley County GIS website http://gis.rileycountyks.gov/

US Army Corps
of Engineers
Kansas City District

MANHATTAN LOCAL PROTECTION PROJECT
FEASIBILITY STUDY
MANHATTAN, KANSAS
(Manhattan Levee)

(Section 216 Review of Completed Civil Works)

Engineering Appendix

August 2014 Final Feasibility Report

VOLUME 2 ALTERNATIVES ENGINEERING

VOLUME 2 TABLE OF CONTENTS

PART 1 – INTRODUCTION
1.1 Engineering App. Vol. 2 Purpose and Context 1-1
1.2 Engineering Documentation 1-1
1.3 Future Project Conditions – Project Alternatives Overview 1-1
1.4 Plan Evaluation, Comparison, and Selection 1-2
1.5 Environmental Impacts and Engineering 1-3
1.6 Project Implementation 1-5

PART 2 – HYDROLOGY AND HYDAULICS ENGINEERING
2.1 Background 2-1
2.2 Hydraulic Analysis of Alternative Components 2-1
2.3 Inundation Mapping 2-6
2.4 Levee Modeling Approach 2-11
2.5 Fragility Curve Analysis 2-13
2.6 Future Without Project Conditions (Baseline) 2-15
2.7 Climate Change Considerations 2-17
2.8 Flood Stage Forecasting During Gatewell Construction 2-19
2.9 Upstream Reservoir Operation Modification Alternatives 2-25
2.10 References 2-33
2.11 Enclosures 2-35

PART 3 – GEOTECHNICAL ENGINEERING
3.1 Introduction 3-1
3.2 Underseepage Analysis Methodology and Criteria 3-1
3.3 Slope Stability Analysis Methodology and Criteria 3-3
3.4 0.50% and 0.33% Chance of Exceedance Levee Raise 3-5
3.5 0.20% Chance of Exceedance Levee Raise 3-5
3.6 Underseepage Control 3-6
3.7 Slope Stability Control 3-8
3.8 Expected Settlement of Design Features 3-8
3.9 Recommendations for PED Phase 3-9

PART 4 – STRUCTURAL ENGINEERING
4.1 Background 4-1
4.2 References 4-1
4.3 Stuctural Features for Alternative Plans 4-1
4.4 Structural Feature Overview 4-4
4.5 Enclosures 4-7

PART 5 – CIVIL ENGINEERING

5.1 Introduction 5-1
5.2 Utility Uplift Anaylsis 5-1
5.3 Above Ground Utilities and Features 5-1
5.4 Pump Station Assessment 5-1
5.5 Road Raises 5-2
5.6 Items of Consideration to Improve Reliablity 5-2
5.7 Alternative Plans 5-4
5.8 Summary Of Survey Work 5-4
5.9 References 5-5

PART 1 – Introduction to Engineering Appendix Volume 2

Table of Contents

1.1 ENGINEERING APP. VOL. 2 PURPOSE AND CONTEXT 1-1

1.2 ENGINEERING DOCUMENTATION 1-1

1.3 FUTURE WITH PROJECT CONDITIONS – PROJECT ALTERNATIVES OVERVIEW 1-1

1.4 PLAN EVALUATION, COMPARISON AND SELECTION.....1-2

1.5 ENVIRONMENTAL IMPACTS AND ENGINEERING 1-3

1.6 PROJECT IMPLEMENTATION.....1-5

1.1 ENGINEERING APPENDIX VOLUME 2 PURPOSE AND CONTEXT

This Feasibility Report Engineering Appendix Volume 2 documents the engineering analysis and the development of the alternatives evaluated during the Manhattan, KS Local Protection Project Feasibility Study. Specifically, this Appendix includes chapters detailing the Hydrolgy and Hydraulics, Geotechnical, Structural, and Civil Design analyses of each of the proposed study alternatives. Information pertaining to the existing project conditions and future without project analyses, including discussions of project and study authority and location, are found in the Engineering Appendix Volume 1.

1.2 ENGINEERING DOCUMENTATION

Study procedures were conducted and the Engineering Appendix content was prepared and arranged in accordance with the engineering guidance described in ER 1105-2-100 Appendix G for feasibility studies. In general, this appendix falls in the category of important supporting documentation for the plan formulation and selection process.

1.3 FUTURE WITH PROJECT CONDITIONS - PROJECT ALTERNATIVES OVERVIEW

The initial future with project studies involved generating preliminary concepts and measures for levee reliability improvement, along with a reasonable set of early alternative plans using the findings from the existing conditions analysis. Potential nonstructural and structural solutions to flooding problems were evaluated using the latest hydrology and hydraulics modeling and the results were analyzed ("future with project" results). In the case of the existing Manhattan project, levee raises provided the most net benefits among the various potential solutions. This was followed by various sponsor and public discussions, alternatives screening, and various in-progress-reviews and refinement of the most promising solutions. See the main feasibility report for a more detailed discussion of the plan formulation and alternatives development and comparison process and details of the construction components making up the final array of alternatives summarized in the list below.

FINAL ARRAY OF ALTERNATIVES

1) Plan 1 -- No Federal Action

2) Plan 2 -- raising the current level of protection to pass the nominal 0.5% annual chance flood event with accompanying geotechnical and structural reliability improvements

3) Plan 3 -- raising the current level of protection to pass the nominal 0.33% annual chance flood event with accompanying geotechnical and structural reliability improvements

4) Plan 4 -- raising the current level of protection to pass the nominal 0.2% annual chance flood event with accompanying geotechnical and structural reliability improvements

5) Plan 5 -- raising the current level of protection with channel widening (CW) and bridge modifications on the Big Blue River for increased flood conveyance so as to pass the nominal 0.33% annual chance flood event with accompanying geotechnical and structural reliability improvements.

The alternatives are mapped and displayed in the accompanying Mapbook. Especially see sheet No. 10 in the Mapbook for a good comparison of the length/location of alternative levee raises and geotechnical features involved with each alternative.

Depending on the specific requirements of the alternative plan under development, appropriate engineering measures (consistent with the latest Corps design and safety guidance) were considered for:

- improved structural feature strength and stability,
- levee underseepage control,
- pump station performance and interior drainage characteristics,
- reliability against levee overtopping.

Certain engineering measures outside the immediate raised levee area are necessary so as to provide a levee unit meeting the Corps' current design criteria and factors of safety -- such as improved levee foundation, strengthened structural elements, and increased underseepage control.

The total project cost estimates for the final array of alternative plans roughly range between $20 million to $52 million (in 2014 dollars).

1.4 PLAN EVALUATION, COMPARISON AND SELECTION

The evaluation and comparison of the various alternative plans is described in the main Feasibility Report. The actual plan selection process is undertaken as one of the final steps in the planning process, and is performed in conjunction with sponsor input and HQUSACE reviews and approval. The selected plan is held to stringent standards. The plan must be technically viable, economically feasible and environmentally acceptable – all in accordance with governing agency regulations and associated Federal statutes.

All of the plans were evaluated and indicated positive net economic benefits and benefit to cost ratios, as described in the Feasibility Report. Based on the evaluation and comparison of the alternatives, the Plan 3, based on the nominal 0.33% annual chance flood event, is the National Economic Development Plan (NED) Plan and is the Recommended Plan.

1.5 ENVIRONMENTAL IMPACTS AND ENGINEERING

ER 1110-2-1150, Engineering and Design for Civil Works Projects, Paragraph 13.6.8 states that the project design shall seek to avoid and minimize adverse environmental impacts and when possible be in concert with the surrounding environment. Review and selection of the engineering measures and alternatives discussed in this appendix performance included a determination of their potential environmental impacts and a consideration of environmental engineering features that may be included in the design.

Details of the environmental impacts associated with each proposed alternative are discussed in the Environmental Assessment (EA) prepared in conjunction with this Feasibility Report. Section 4.0 of the EA presents a description of each plan's potential impact to soils, water quality, air quality, aquatic and terrestrial habitats, wildlife, threatened and endangered species, HTRW, and social and cultural resources. The proposed project would have none to minor adverse impacts to each of the resource categories, most impacts being short-term in nature (e.g. dust or noise from construction equipment). The project also would have no impacts to Federally listed threatened or endangered species or their designated critical habitat. As no wetlands or waters of the US are impacted, no Section 404 or 401 permitting will be necessary. The contractor would be required to obtain a land disturbance permit and develop the Stormwater Pollution Prevention Plan.

Potential impacts to terrestrial habitat and the need for environmental mitigation associated with each alternative were studied and coordinated with applicable resource agencies. The initial assumption for this impact analysis and alternative comparison was that all habitat within the construction easement would be destroyed or adversely impacted. This is a conservative estimate, as it is likely much of the habitat within the construction easement may be able to be avoided or the impacts minimized. Temporary construction easements as well as the permanent easements that are cleared during construction will be planted with native vegetation where possible following construction. During the design phase effort will be made to incorporate where practicable the use of native vegetation and to identify potential ways to enhance or expand existing riparian corridors. All trees at least 50 feet tall and/or greater than 24-inch dbh riverside of the levees should be avoided. These trees are potentially utilized as perching/roosting trees by the Bald Eagle. The contractor will be required to follow best management practices to avoid the introduction and spread of invasive species.

As presented in Section 4.2.2 of the EA, the Recommended Plan impacts to terrestrial habitats come from the lateral expansion of the levee footprint from the levee raise, underseepage berms, and landside toe embankment sand drains. It is also assumed that there will be disturbance to all the areas within the permanent and temporary construction easements. This would result in an impact of 6.23 acres of forested area, 0.67 acres of shrubland area, 17.50 of grassland most of which is mowed turfgrass, and 7.74 acres of cultivated cropland. In some cases these are

relatively small isolated patches of impacts, while in other areas the impacts can extend linearly for some distance along a forested area. This would decrease the width of the forested stands which may affect the habitat suitability for species that need larger blocks of habitat. With time, the minor impacts would be reduced as trees become reestablished within the construction easement area.

In accordance with the Migratory Bird Treaty Act clearing of vegetation should be avoided during the migratory bird nesting season, which in Kansas occurs during the period of January (owls, and hawks) through August (goldfinches). If vegetation clearing takes place during the nesting season, then the area to be cleared should be surveyed by a qualified biologist prior to clearing activity. Design and construction planning will take these requirements into consideration.

The primary materials required for construction of the recommended plan is earthen soil for the levee raise and underseepage berms. Approximately 158,000 cubic yards of borrow material which would be obtained from an approximately 20 acre location(s) identified on the map in Appendix I of the EA. The proposed borrow location is currently in agricultural row crop production. There is no other environmentally renewable material option available. There is not expected to be any spoil or other refuse from project construction and operation that can be put to beneficial reuse.

Implementation of the recommended plan will be generally limited to the already disturbed existing levee project location, maintaining the current ecological continuity in the project with the surrounding area and region. The existing project easement is already maintained by the non-Federal sponsor in accordance with USACE operations and maintenance guidelines to be free of excessive vegetation. There are little to no opportunities to design additional environmental attributes into the recommended plan within the existing project area. Future operations and management of the project following plan implementation will be essentially the same as current operations which already minimize environmental impact and energy consumption. No opportunities have been identified for enhancing environmentally beneficial operations or energy savings.

The study of alternative and determination of the recommended plan has identified no other indirect environmental costs or benefits and has considered the environmental sensitivity of the study area to project modification. All future project design and implementation phases will continue to adhere to all required environmental compliance measures and requirements.

The Recommended Plan has been determined to best meet the purpose and need of the project by providing for increased flood risk management with limited impacts to the environment in a cost effective manner. The Recommended Plan does not result in any significant long-term impacts to the human environment.

1.6 PROJECT IMPLEMENTATION

A 5-year construction phase beginning in 2018 is planned -- subject to authorization and availability of construction funding. The technical scope and magnitude of the project would be best served by a three construction contract package arrangement for the work item groups as shown below.

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

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

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

Significant complications arise with alternative plans which involve: 1) Big Blue River bridge modifications (either the Hwy 24 Bridge and/or the Union Pacific Railroad Bridge); 2) any work on the east side of the Big Blue River -- such as channel widening. Such work will likely require more construction contracts, and carefully sequenced construction phasing given the various Federal and State agencies involved in modifying any major transportation features. The project risks also increase – and new safety risks arise due to the need for maintaining vehicular traffic safety during bridge modifications.

During any modification of the existing levee, the construction contractor must maintain (at least) the current flood protection performance level of the existing levee features. Emergency response plans for the construction period must be coordinated and prepared, reviewed by the Corps, and then monitored and executed properly were any adverse flood conditions to occur. The Corps of Engineers Kansas City Area Construction Office is assigned to oversee any construction resulting from this study.

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

According to Federal law, the sponsor is responsible, with Corps guidance, to undertake (pay for) the required real estate actions. The overall project schedule anticipates timely real estate actions, and the sponsor is aware of their responsibilities in this regard. Real estate actions and acquisition required for the project construction will begin prior to the first construction contract award. The Manhattan levee has

relatively few utilities requiring relocation. The Corps evaluates the compensable or non-compensable nature of the various utility relocations, in conjunction with the sponsor. The Corps then assigns relocation costs when the utility ownership and real estate rights information is adequate for a compensability determination. Utility relocation design details are developed during the design phase.

It is difficult to predict the exact timing of the project funding allocations or whether such allocations will be forthcoming for construction. However, the schedule does assume reasonable periods for the design and construction process from the standpoint of Corps capabilities.

US Army Corps
of Engineers
Kansas City District

Part 2
Hydrology and Hydraulics

Alternatives Engineering
Manhattan, KS

August 2014

Table of Contents

2 Hydrology & Hydraulics 2-1
2-1. Background 2-1
2-2. Hydraulic Analysis of Alternative Components 2-1
2-2.1. Channel Widening and Levee Raises 2-1
2-2.2. Levee Raises 2-3
2-2.3. Considered but Screened Out Northern Levee 2-6
2-3. Inundation Mapping 2-7
2-3.1. Existing Conditions Mapping 2-7
2-3.2. Future Conditions Mapping and Induced Damages 2-8
2-3.3. Leveed Area 2-9
2-3.4. Anticipated Changes in the FEMA Regulated Flood Plain 2-10
2-4. Levee Modeling Approach 2-12
2-5. Fragility Curve Analysis 2-14
2-6. Future Without Project Conditions (Baseline) 2-16
2-7. Climate Change Considerations 2-18
2-8. Flood Stage Forecasting During Gatewell Construction 2-20
2-8.1. Kansas River Forecasting 2-21
2-8.2. Big Blue River Forecasting In Normal Conditions 2-22
2-8.3. Big Blue River Forecasting In Surcharge Conditions at Tuttle Creek Lake. 2-24
2-9. Upstream Reservoir Operation Modification Alternatives 2-26
2-9.1. Background 2-26
2-9.2. Tuttle Creek Lake Alternatives for Consideration 2-29
2-9.3. Multi-purpose and Flood Control Pool Reallocation Alternative 2-30
2-9.4. Phased Release Schedule Modification 2-31
2-9.5. Recommendation 2-34
2-10. References 2-34
2-11. Enclosures 2-36
2-11.1. Enclosure 1: Existing Conditions Inundation Maps 2-36
2-11.2. Enclosure 2: Fragility Curve Combinations 2-41

List of Tables

Table 1: Levee Raises and Lengths to Existing Levee for Alternatives Array 2-3
Table 2: Alternative Design Discharges for Levee Heights 2-4
Table 3: Gatewell Replacements 2-21
Table 4: Regulating Discharges on the Kansas River from Phased Releases 2-33

Table of Figures

Figure 1: Concept rendering of channel widening under 24-HWY Westbound 2-2
Figure 2: Hydraulic profiles of Plan 3, Plan 5, and existing conditions 0.33% (1/300) ACE floods 2-3
Figure 3: Plan 2 Levee Raise Hydraulic Profile 2-5

Figure 4: Plan 4 Levee Raise Hydraulic Profile 2-6
Figure 5: Profile of Screened Out New Northern Levee 2-7
Figure 6: Inundation Extents of the EC 1% ACE flood 2-8
Figure 7: Modeled induced damages of the Plan 3 alternative 2-9
Figure 8: Hydraulic profiles at existing conditions 2-10
Figure 9: Estimated Changes to the 1% (1/100) ACE Flood Plain on the Big Blue River 2-11
Figure 10: HEC-RAS cross section extensions and additions with LIDAR imagery in background 2-13
Figure 11: Plan of HEC-RAS Geometry with conveyance area boundaries 2-14
Figure 12: Levee Profile with Fragility Curves, Index Points, and Expected Overtopping Locations 2-16
Figure 13: Stage Trends on the Kansas River at Wamego, Kansas 2-18
Figure 14: First order trend detection on annual maximum daily inflows into Tuttle Creek Lake. A negative slope is determined to be statistically significant at the p<0.05 level. . 2-19
Figure 15: First order trend detection on annual three-day maximum daily inflows into Tuttle Creek Lake. A negative slope is determined to be statistically significant at the p<0.05 level. 2-20
Figure 16: 1993 Flood Hydrograph on the Kansas River at Fort Riley, Kansas 2-22
Figure 17: 1993 Flood Hydrograph and on the Big Blue River at Manhattan, Kansas Overlaid with Tuttle Creek Inflow and Pool Level 2-23
Figure 18: Levee Overtopping Height During the 0.33% (1/300) ACE Flood 2-25
Figure 19: Leveed Area Storage Volume and Area versus Interior Elevation Curves 2-25
Figure 20: Flood control projects upstream of the Manhattan, KS Federal Levee 2-27
Figure 21: Tuttle Creek Lake Storage Allocations 2-28
Figure 22: Large Inflows to Tuttle Creek Lake from 1960-1985 2-29
Figure 23: Large Inflows to Tuttle Creek Lake from 1986-2013 2-29
Figure 24: 1993 Flood Hydrographs and Tuttle Creek Pool Conditions 2-32
Figure 25: Seasonal Guidelines for Phase Determination (WCM, Plate 37) 2-33
Figure 26: Inundation map of the EC 4% (1/25) ACE flood 2-36
Figure 27: Inundation map of the EC 2% (1/50) ACE flood 2-36
Figure 28: 1993 Flood Calibrated Results at EC 2-37
Figure 29: Orthography of the 1993 flood 2-37
Figure 30: Inundation map of the EC 1% (1/100) ACE flood 2-38
Figure 31: Inundation map of the EC 0.5% (1/200) ACE flood 2-38
Figure 32: Inundation map of the EC 0.33% (1/300) ACE flood 2-39
Figure 33: Inundation map of the EC 0.2% (1/500) ACE flood 2-39
Figure 34: Inundation map of the EC 0.13% (1/750) ACE flood 2-40
Figure 35: Cumulative Probability Plot at Index Point 0.95 on Big Blue River 2-41
Figure 36: Cumulative Probability Plot at Index Point 0.82 on Big Blue River 2-42
Figure 37: Cumulative Probability Plot at Index Point 146.84 on Kansas River 2-43
Figure 38: Cumulative Probability Plot at Index Point 147.67 on Kansas River 2-44

2 Hydrology & Hydraulics

2-1. Background

The Existing Conditions (EC) Hydraulics and Hydrology (H&H) Appendix of the Manhattan Levees Feasibility Study was complete in May of 2011. Since that report's completion, significant work has been accomplished to develop a Future Conditions (FC) alternatives analysis, inundation maps, hydraulic model improvements, and levee performance risk data for the economics analysis. The purpose of this report is to document the work that has been completed since the completion of the EC H&H appendix.

2-2. Hydraulic Analysis of Alternative Components

The alternatives analysis for the Manhattan Feasibility study was based on the calibrated existing conditions hydraulic model that is documented in the Hydraulics and Hydrology Existing Conditions Engineering Appendix.

2-2.1. Channel Widening and Levee Raises

Channel widening was evaluated for the alternatives Plan 5, and Early Formulation Plan B, which are described in Table 1 below. Approximately 1,200 feet of channel was widened on the Big Blue River to maintain a 250 feet wide bottom width with channel banks cut back to 2:1 horizontal:vertical slopes. Figure 1 below is a concept rendering of this alternative at the 24 Highway Westbound bridge. This analysis required adding a span to each bridge to increase conveyance area below the 24 Highway and Railroad bridges. An area-end method quantity was computed with the Channel Modification Tool in HEC-RAS to develop the quantities for costs associated with this alternative. This tool develops volumes by calculating changes in cross sectional area and estimates volume with the reach lengths between cross sections.

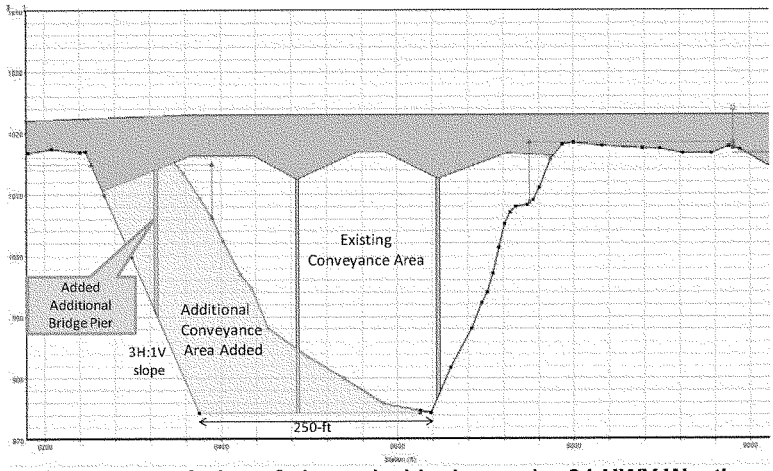


Figure 1: Concept rendering of channel widening under 24-HWY Westbound

The results of the channel widening in the hydraulic model are shown below in Figure 2. On the Big Blue River and Drainage Ditch segments of the levee, channel widening lowers the hydraulic profile of the 0.33% (1/300) Annual Chance Exceedance (ACE) by about 0.4 feet from the existing conditions profile and it is about 0.6 feet below the Plan 3 alternative profile. Closer to the confluence, the effects of channel widening raise the 0.33% (1/300) ACE flood profile above existing conditions by about 0.5 feet due to the increased channel conveyance around the 24 Highway and railroad Bridges. This additional conveyance, which previously backed water up behind the bridges, induces a backwater effect closer to the mouth of the Big Blue River. Additional considerations for channel widening in other alternatives were not pursued because of the minimal improvements channel widening makes to the hydraulic performance of the levee as well as the high costs incurred from modifying the three bridges that cross the Big Blue River.

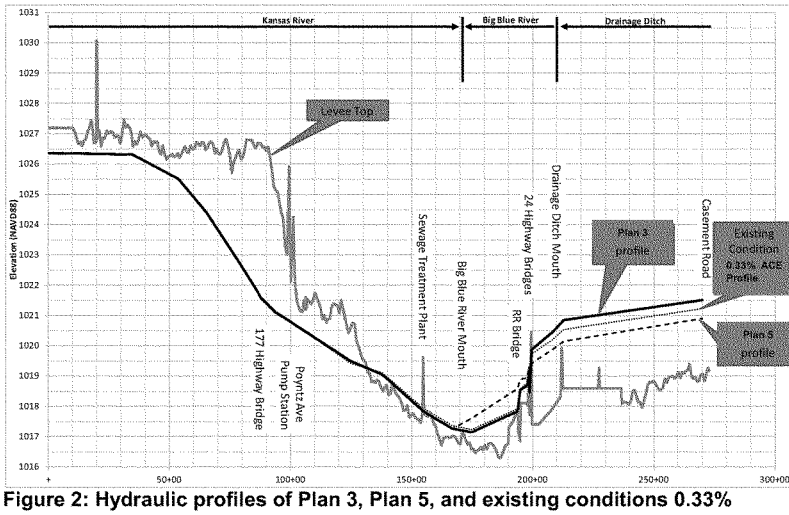


Figure 2: Hydraulic profiles of Plan 3, Plan 5, and existing conditions 0.33% (1/300) ACE floods

2-2.2. Levee Raises

Levee raises described in Table 1 were hydraulically evaluated for alternatives Plan 2, Plan 3, Plan 4, Plan 5, as well as Early Formulation Plans A and B,. Each raise includes the height above the corresponding existing top of levee that is required to account for the hydraulic impacts of raising the levee. However, the Plan 5 levee raise has the same discharge level of protection as the Plan 3 alternative profile shown in Figure 2 with an additional levee raise (about 0.5 feet) between the mouth of the Big Blue River and the bridges that cross the Big Blue River. Due to the complexity of the Big Blue River and the drainage ditch, a conservative approach was used to estimate the hydraulic profile at the upstream terminus of the levee, at approximate station 273+00. The energy grade line from the shortcut on the Big Blue River at river station 1838.18 in the hydraulic model was used to assign the profile elevation at approximate station 273+00 to appropriately account for the limitations of the one-dimensional hydraulic analysis in this reach. Table 1 shows the resulting levee raises for each of these alternatives.

Table 1: Levee Raises and Lengths to Existing Levee for Alternatives Array

Alternative	Description	Average Raise (ft)	Maximum Raise (ft)	Approximate Levee Raise Locations (stations)
Plan 1	No Federal Action	--	--	--

Plan 2	0.5% ACE Levee Raise	0.7	1.5	200+00 to 273+00*
Plan 3	0.33% ACE Levee Raise	1.5	3.3	131+00 to 273+00*
Plan 4	0.2% ACE Levee Raise	2.1	3.9	0+00 to 72+00 and 101+00 to 273+00*
Plan 5	0.33% ACE Levee Raise with channel widening	1.3	2.6	131+00 to 273+00*
Early Formulation Plan A	0.33% ACE Levee Raise with northern levee	1.5	3.3	131+00 to 273+00*
Early Formulation Plan B	0.33% ACE Levee Raise with northern levee and channel widening	1.5	3.9	131+00 to 273+00*

*Station 273+00 is approximate because there will be an extension to high ground for each alternative from the current levee terminus.

Hydraulic effects of levee raises along the existing levee were calculated. Nominal levee raises were estimated for the 0.5% (1/200) ACE, 0.33% (1/300) ACE, and the 0.2% (1/500) ACE floods. These raises were developed with the levee tool in the HEC-RAS geometry. The maximum increases to these three hydraulic profiles ranged from 0.2-0.6 feet. Discharges used to select top of levee heights for each alternative are shown in Table 2.

Table 2: Alternative Design Discharges for Levee Heights

Alternative	Big Blue River Flood*		Kansas River Flood*	
	Big Blue River	Kansas River	Big Blue River	Kansas River
Plan 2	115,800	142,800	84,400	150,800
Plan 3	151,700	167,300	101,000	182,200
Plan 4	167,000	194,200	115,400	229,700
Plan 5	151,700	167,300	101,000	182,200
*Levee height selection based on maximum water surface elevation resulting from these two floods				

Levee raise quantities were computed using the area end method for cost development of these alternatives. The Manhattan Levee Unit operation and maintenance manual was used to estimate the levee toe elevations, which were used for quantity calculations.

2-2.2.1. Plan 2

A levee raise for the 0.4% (1/200) ACE flood level of protection was considered along the existing alignment of the Manhattan Federal Levee Unit. Figure 3 shows the hydraulic profile of the existing conditions .4% and the hydraulic profile of the Plan 2 levee raise. This raise requires about 7,300 feet of levee between Stations 200+00 to 273+00, with a 200-feet extension up Casement Road (via a road raise) on the Big Blue River segment that is needed to meet high ground.

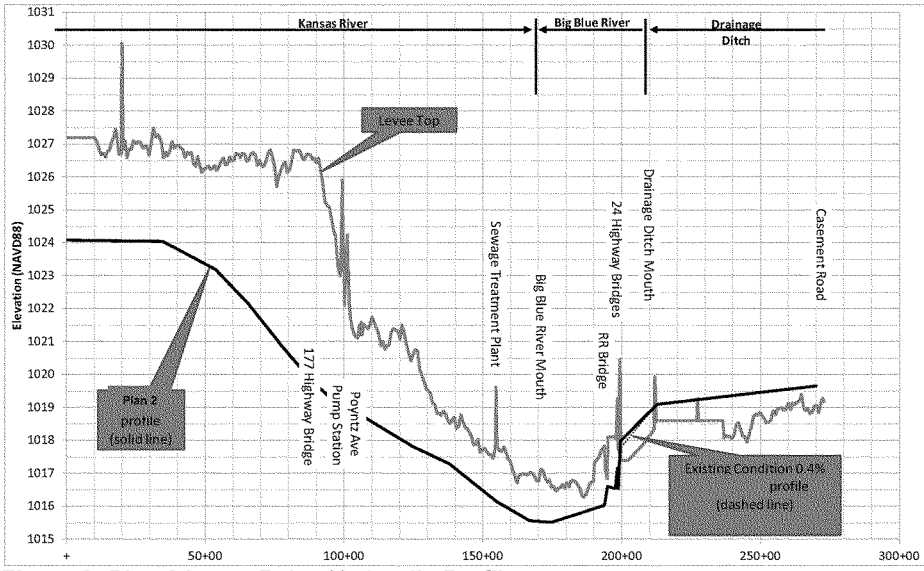


Figure 3: Plan 2 Levee Raise Hydraulic Profile

2-2.2.2. Plan 3

A levee raise for the 0.33% (1/300) ACE flood level of protection was considered along the existing alignment of the Manhattan Federal Levee Unit. Figure 2 shows the hydraulic profile of the existing conditions .33% (1/300) ACE and the hydraulic profile of the Plan 3 levee raise. This raise requires about 14,200 feet of levee between Stations 131+00 to 273+00 with a levee extension to high ground in the viscinity of Casement Road on the Big Blue River segment.

2-2.2.3. Plan 4

A levee raise for the 0.2% (1/500) ACE flood level of protection was considered along the existing alignment of the Manhattan Federal Levee Unit. This raise requires about 24,400 feet of levee from Stations 0+00 to 72+00 and from Stations 101+00 to 273+00. There will also be a 1,700ft extension along the Kansas River segment that runs parallel to the railroad to reach high ground with a levee extension to high ground in the viscinity of Casement Road on the Big Blue River segment. Figure 4 shows the hydraulic profile of the existing conditions 0.2% (1/500) ACE and the hydraulic profile of the Plan 4 levee raise.

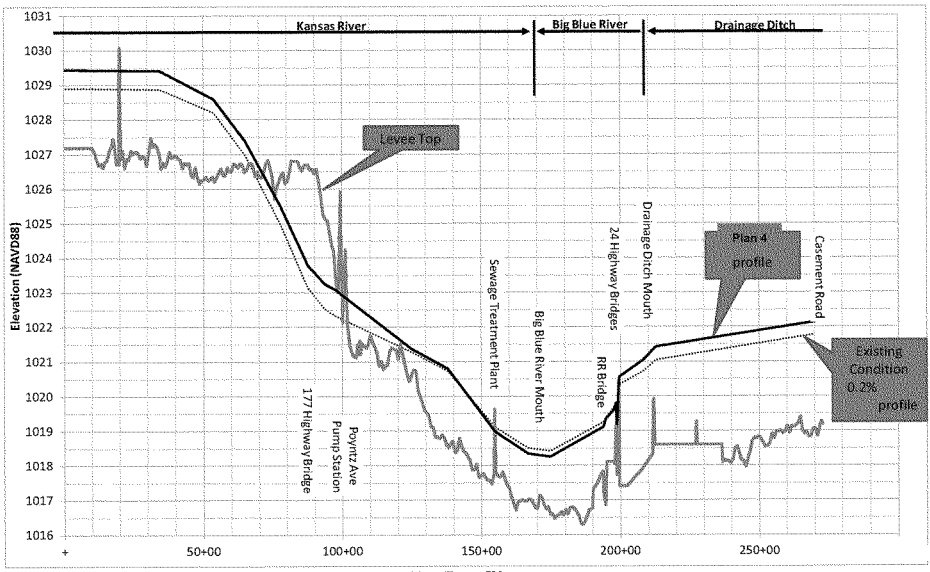


Figure 4: Plan 4 Levee Raise Hydraulic Profile

2-2.3. Considered but Screened Out Northern Levee

A new northern levee was considered and screened out for the alternatives Early Formulation Plans A and B. A preliminary 3.3 mile alignment was developed and the levee was hydraulically evaluated for cost development. The average levee height is 7.9 feet with a maximum height of 30.5 feet.

The hydraulics of a new levee were computed by modeling a levee in HEC-RAS with the levee tool in the model's geometry. The concept-level new northern levee (NNL) is on the right bank of the Big Blue River upstream of the existing Federal levee. The levee height was designed to the energy grade line of a 0.3% (1/300) ACE flood level of protection based on the future condition hydraulic profile computed in this HEC-RAS simulation.

Compacted fill quantities for the NNL were developed with the average end area method for cost development of the alternative. Quantities were based on the hydraulic model's output and the existing ground surface elevations along the levee's alignment, both of which are shown in Figure 5 below. Locations were also identified where structures would likely be required for interior drainage. Calculations assumed no topographic variation perpendicular to the levee's alignment. Other assumptions include a 10-feet wide top width with 3:1 horizontal to vertical side slopes. The existing ground surface elevations along the preliminary alignment were extracted from the 2006 LiDAR elevation dataset. The energy grade line was used to design levee heights to

account for the stages that would be observed in the overbank conveyance area where channel velocities are significantly less than those in the channel.

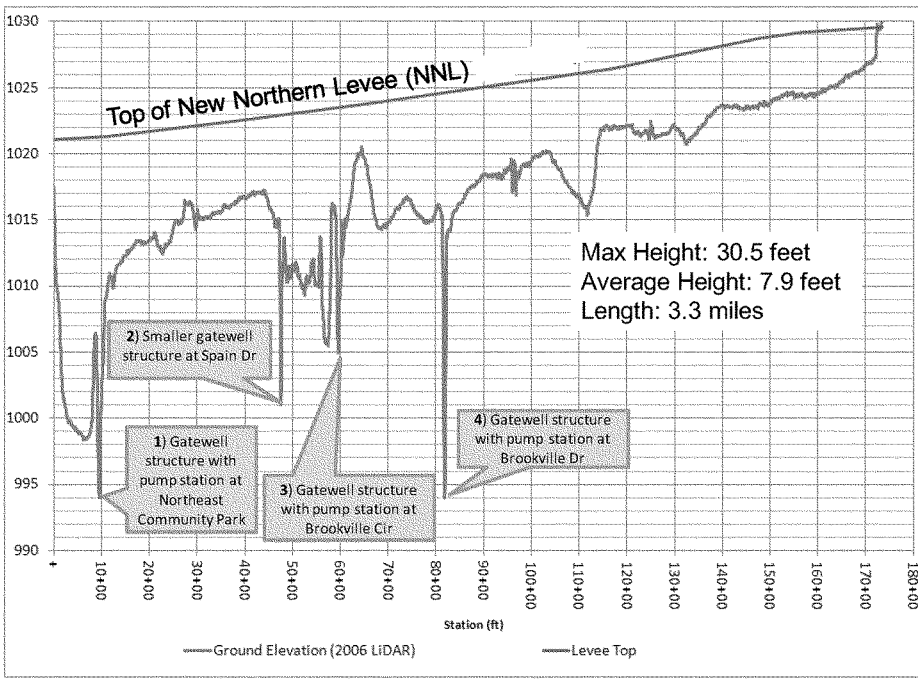


Figure 5: Profile of Screened Out New Northern Levee

2-3. Inundation Mapping

2-3.1. Existing Conditions Mapping

Inundation mapping was developed in the protected area of the Manhattan Levee unit as well as the unprotected areas near to the levee unit. Since the levee is near the confluence of the Big Blue River and the Kansas River, a blended inundation mapping approach was used to account for coincident flooding risk. For example, two simulations were made for the 1% (1/100) annual chance exceedance (ACE) flood to simulate both a Kansas River controlled flood and a Big Blue River controlled flood. Inundation maps were produced for the two scenarios and then blended to show the maximum inundation area produced by either river's control flood. Figure 6 shows the results of the 1% (1/100) ACE flood. Existing Conditions inundation maps were developed with similar methods for several flood events including the 4% (1/25) ACE, 2% (1/50) ACE, 1% (1/100) ACE, 0.5% (1/200) ACE, 0.33% (1/300) ACE, 0.2% (1/500) ACE, 0.13% (1/750) ACE events as well as the calibrated flood event of July, 1993. Enclosure 1 includes figures of the results of these other mapped flood events.

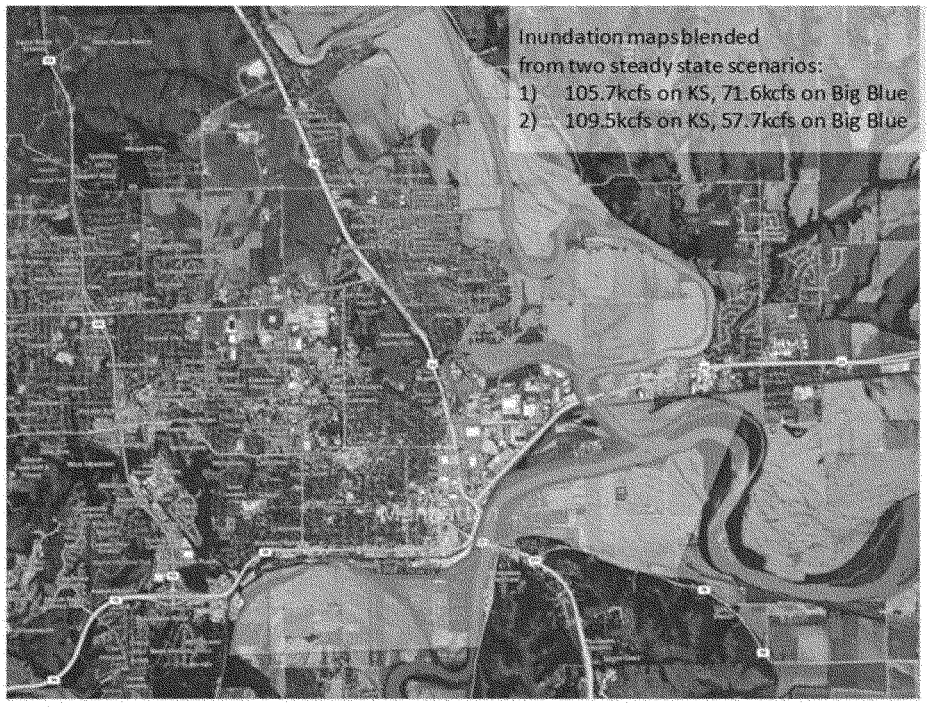


Figure 6: Inundation Extents of the EC 1% ACE flood

2-3.2. Future Conditions Mapping and Induced Damages

Detailed FC inundation maps shown in the mapbook section were developed with HEC-RAS Ras-Mapper Software. Each alternative has very small differences from the EC inundation maps except for the leveed area, which will have less inundation upon implementation of the preferred alternative. Since the recommended plan (Plan 3) alternative is a levee raise with no other hydraulic modifications to the channel or bridges, the EC inundation maps will accurately depict FC inundation maps at and below the existing level of protection, which is about 1 foot below the 0.5% (1/200) ACE flood and about 3 feet above the 1% (1/100) ACE flood.

North of the existing levee in Manhattan, there is a large area of residential development within the existing FEMA 0.2% (1/500) ACE floodplain, currently unprotected by any kind of structural flood protection project. Hydraulic analysis determined that the area north of the existing levee would likely experience slightly raised water surface profiles, if the current levee is raised. With the Plan 3 alternative, the greatest change in water surface elevation in this area would be less than 5 inches, which does not appear to significantly increase the inundated area, but rather increase

flood depths. This increase of 4.8 inches also occurs in an area that is largely undeveloped land. The bulk of the developed residential area would actually experience an estimated 1-2 inch increase in profile under the Plan 3 alternative as shown in Figure 7. The economic analysis appendix includes the economic effects of induced damages of each alternative. If the preferred alternative is a levee raise, induced damages are not expected below the EC level of protection because the hydraulic response during floods below the EC level of protection should not change.

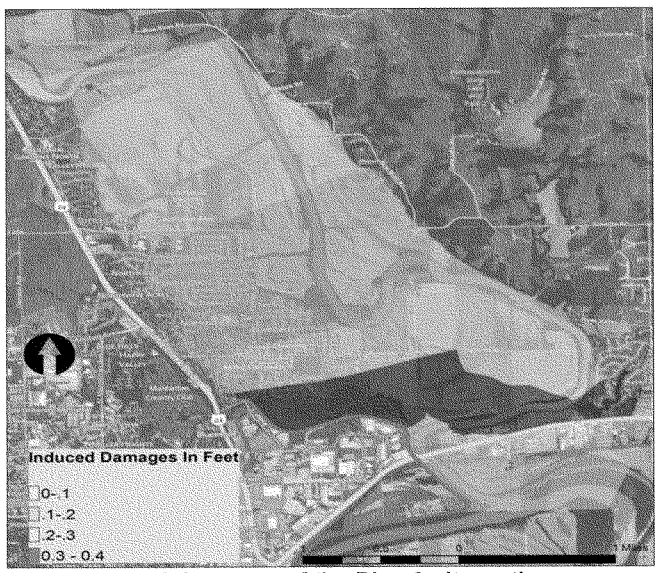


Figure 7: Modeled induced damages of the Plan 3 alternative

2-3.3. Leveed Area

Inundated areas were estimated behind the levee for modeled floods that overtop the levee. This was conducted with hydraulic model output, engineering judgment and high definition LiDAR elevation imagery in the protected area. HEC-RAS version 4.1 steady modeling was used to develop the Manhattan Feasibility hydraulic analysis and this model is based on steady-state calculations that do not account for volume and hydrologic routing if the levee is overtopped.

A modified backwater approach was combined with a "bathtub effect" approximation to develop inundation areas behind the levee. The RAS Mapper module of HEC-RAS version 4.1 was first used to estimate the inundated area behind the levee based on the hydraulic profiles shown in Figure 8. Then the inundated area was modified to include all areas in the leveed area below the maximum water surface elevation on the Big Blue River, which is near the levee's terminus at Casement Road. Contours based on LiDAR imagery were developed and traced with ArcGIS software to

modify the modeled inundated area. Figures in Enclosure 1 show the inundation areas behind the levee in flooding events that overtop the levee.

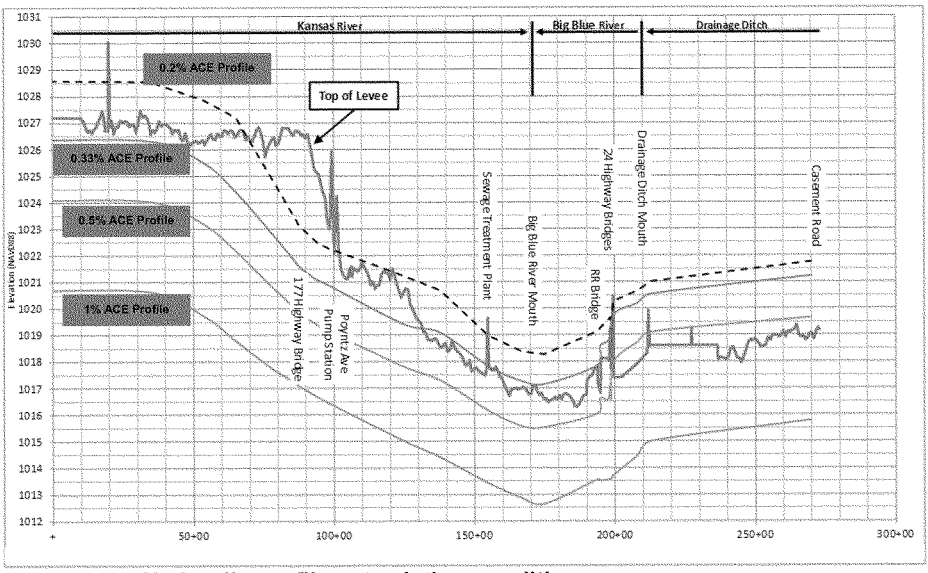


Figure 8: Hydraulic profiles at existing conditions

2-3.4. Anticipated Changes in the FEMA Regulated Flood Plain

The existing FEMA published Flood Insurance Rate Maps (FIRM) were developed in 1981 with legacy hydrologic information dating back to the 1960s. Updated hydrology used in the EC Feasibility hydraulic model incorporated over 40 years of additional hydrologic information about the basin than that used during the old FEMA flood insurance study. This analysis produced results that significantly changed the 1% (1/100) ACE flood on the Big Blue River, which are most substantial in the unleveed area north of the existing levee shown in Figure 9. Along the Big Blue River in Riley County, up to 317 structures are estimated to be added to the 1% ACE flood plain. This analysis is based on a calculation with ESRI software and 2010 census data, although this is only a preliminary estimate and revisions to the FIRM will be finalized by FEMA. It is important to recognize that Pottowatomie County is defined as unincorporated on the left bank, which is why there are not more boundaries on the left bank shown in Figure 9.

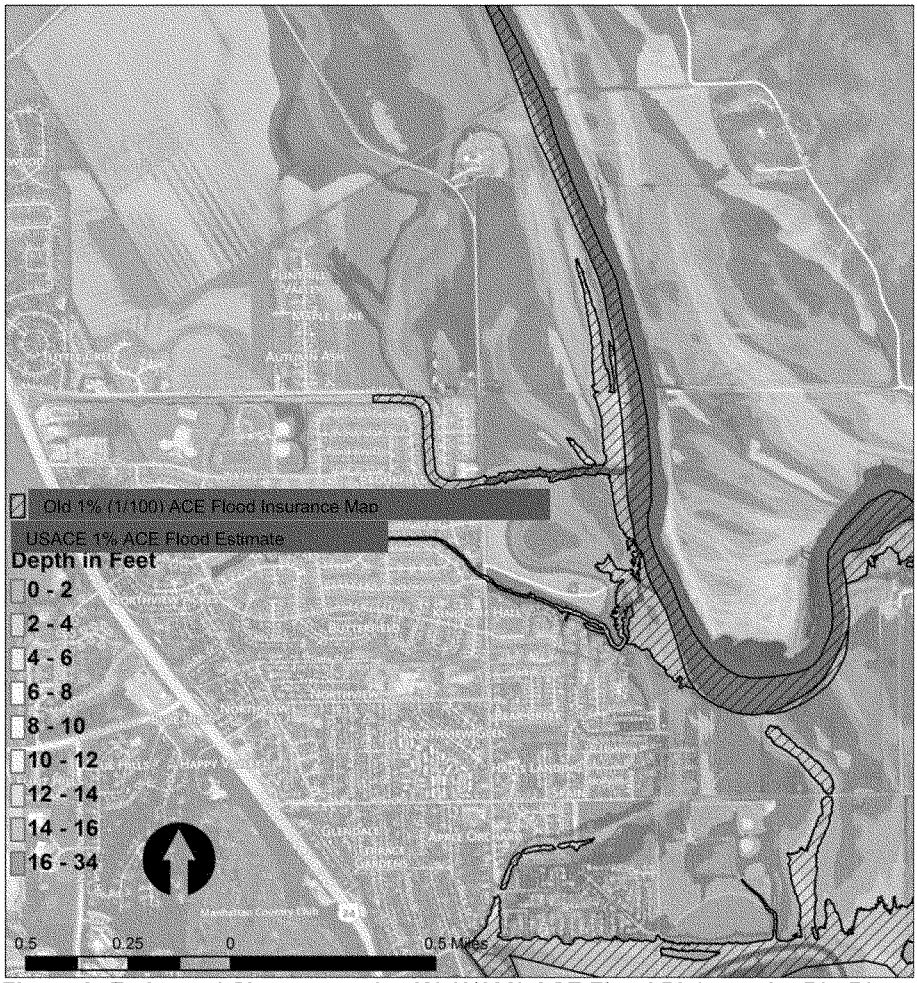


Figure 9: Estimated Changes to the 1% (1/100) ACE Flood Plain on the Big Blue River

2-4. Levee Modeling Approach

After developing the set of alternatives, updates were made to the existing conditions hydraulic model to allow better comparision of these alternatives and to improve inundation mapping at extreme events. Cross sections were extended across the leveed area to the bluff with permanent ineffective flow areas placed in the leveed area at an expected exit elevation at a low elevation point in levee near the confluence to account for the additional conveyance in each extended cross section. This exercise reduced the stages of simulated floods near the levee that exceeded the 0.5% (1/200) ACE flood.

Changes in the existing conditions hydraulic model were made to improve accuracy of flood inundation in the levee's protected area and to develop a way to evaluate induced damages caused by a preliminary levee raise. Figure 10 shows a plan of the previous existing conditions cross section locations with cross section extensions as dashed lines.

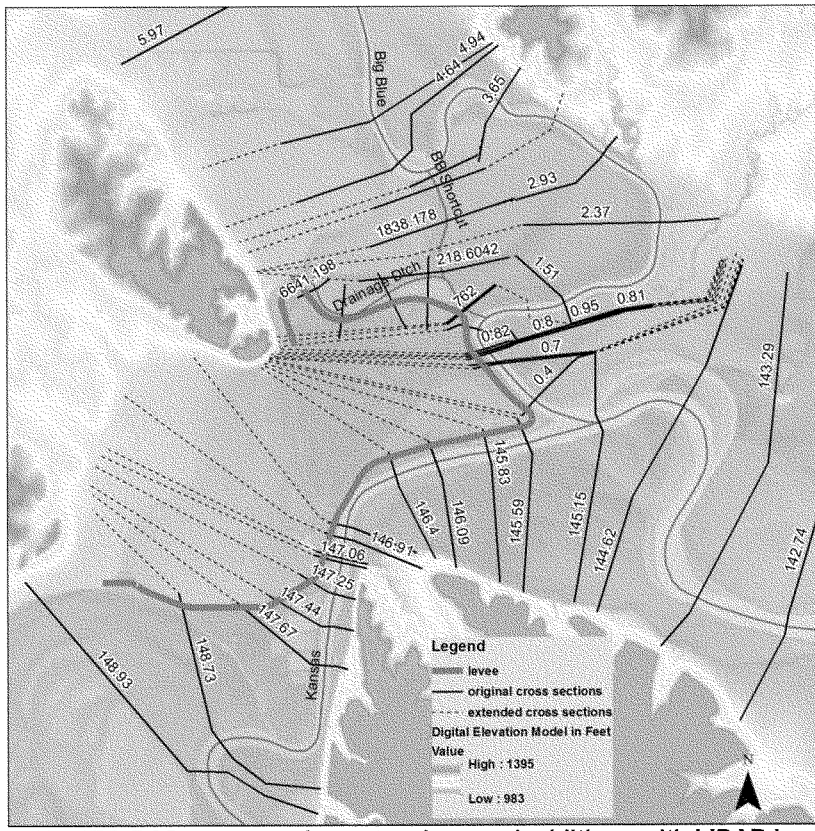


Figure 10: HEC-RAS cross section extensions and additions with LIDAR imagery in background

High ground in the leveed area on the Kansas River and Big Blue River does not occur perpendicular to the direction of flow near the confluence of the Kansas and Big Blue Rivers. This issue affects the one-dimensional assumption in HEC-RAS that cross sections are located along a river run perpendicular to the river centerline and flowpaths. The violation of this assumption in the model over-accounts conveyance area near the confluence. In these instances, permanent ineffective flow areas were applied in the leveed area at the edge of each affected cross section. Figure 11 illustrates this decision.

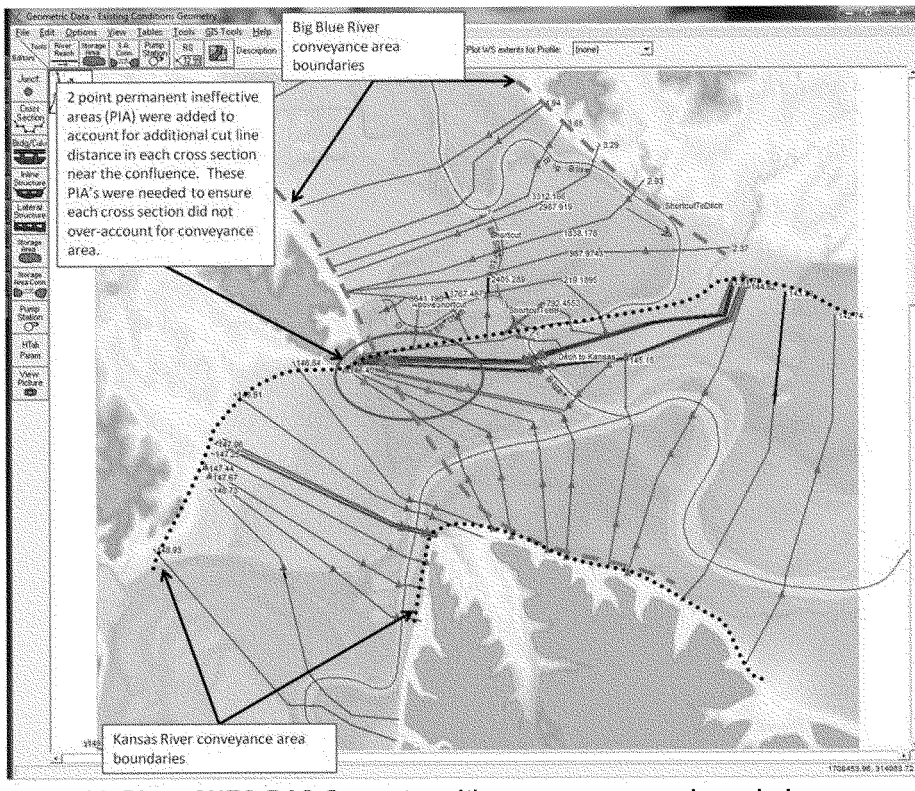


Figure 11: Plan of HEC-RAS Geometry with conveyance area boundaries

The methodology to choose where to add the permanent ineffective areas in the leveed area involved identifying cut lines that are longer than the distance approximately perpendicular with the conveyance area boundaries shown in Figure 11. The difference from the conveyance area boundaries and cross section length was measured and permanent ineffective areas in the leveed area were placed at that measured distance.

The existing condition model was updated with the results of this analysis to use as a baseline from which future condition alternative analyses were conducted.

2-5. Fragility Curve Analysis

Structural and geotechnical fragility curves were developed at several locations along the levee where vulnerabilities exist in the existing levee as shown on Figure 12 below. Green lines show underseepage fragility curve locations, black squares represent structural fragility curve locations, blue lines represent index point locations,

and the top of levee is shown in red. These fragility curves were translated to economic index points and cumulated for the economic analysis.

Slope stability fragility curves were not included in the study because they added unrealistically high probabilities of failure. The assumption of steady state phreatic surface gradients through the levee that would lead to slope stability failure require several weeks of saturation with water surfaces at the levee top for several months. Historical records suggest a relatively short flood durations on the Big Blue River. In July 1993, the flood of record since the levee's construction, exceeded the bank full discharge of 35,000 cfs for 16 days at the USGS gage 06887000 located on Casement Road.

The methodology to combine fragility curves involved translation of each fragility curve along the existing condition hydraulic profiles to the economic index points shown in Figure 12. Fragility curves were translated to index points on the Kansas River to two index points at river mile 146.84 and 147.67 and on the Big Blue River to two index points at river miles 0.95 and 0.82. Curves originating from the Kansas River were only translated to index points on the Kansas River while curves originating from the Big Blue were only assigned to index points on the Big Blue River. In an exception at the confluence of an underseepage fragility curve between stations 165+12 to 173+63, the curve was assigned to both Big Blue River and Kansas River index points. The four index points are cross sections in the Feasibility hydraulic model. The cumulative probability was then computed with the translated fragility curves at each index point. At each index point, probabilities of failure were combined with the cumulative probability equation known as the Unimodal Bounds Theorem (USBR 2011) in Equation 1. Independent fragility curves required interpolation of probability between calculated ordinates in order to calculate cumulative probability with other fragility curves at the same elevation.

$$P_{cumulative\ at\ elev\ i} = 1 - (1 - P_{1\ at\ elev\ i}) \times (1 - P_{2\ at\ elev\ i}) \times (1 - P_{3\ at\ elev\ i}) \times \ldots \times (1 - P_{n\ at\ elev\ i}) \quad \text{(Eq 1)}$$

The resulting cumulative probability of failure versus elevation curves are shown in Enclosure 2. The economic analysis then input the cumulative fragility curve to the Hydrologic Engineering Center Flood Damages Analysis (HEC-FDA) computer program model.

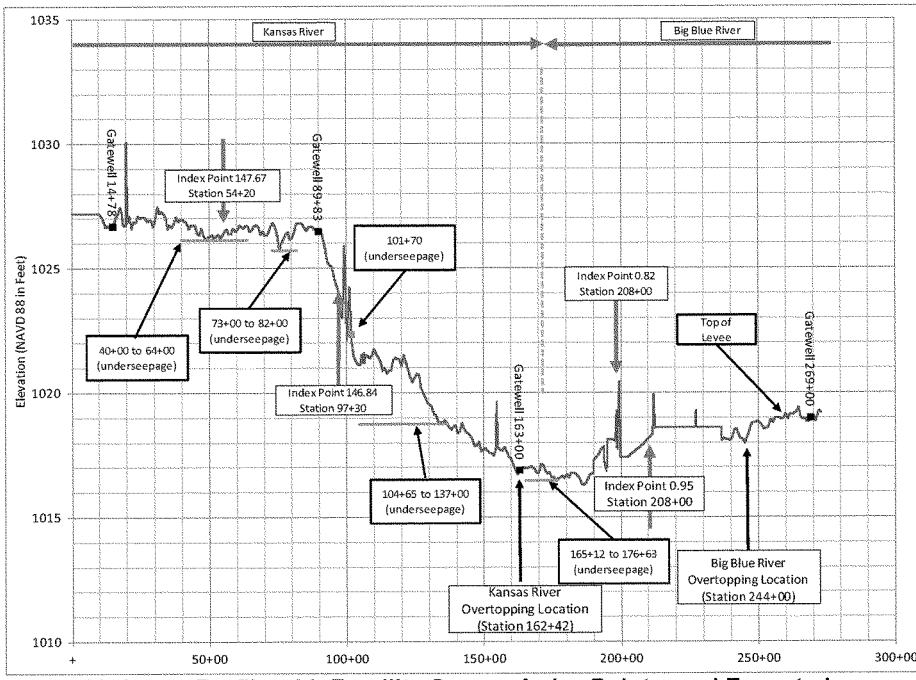


Figure 12: Levee Profile with Fragility Curves, Index Points, and Expected Overtopping Locations

2-6. Future Without Project Conditions (Baseline)

Overbank and in-channel vegetation in the floodway near the levee system is not expected to significantly change in future conditions. The community has been progressive in mapping flood risks along its streams and is currently working to develop floodplain management plans with engagement of local governments through the Corps Silver Jackets Program. Accordingly, any new hydraulic flow obstructions or conditions in the floodway such as buildings and woody vegetation are assumed to either be minimal or to not cause a raise of the hydraulic profiles along the levee. An analysis was conducted that assumed heavy forested overbanks along the left bank of the Big Blue River in the proximity of the levee, which resulted in a raise of the 0.33% ACE profile by a maximum of 0.8ft. Although no plans are currently known to exist, future changes to the existing highway and railroad bridges or highway causeways in the floodplain should be identified as a risk to the levee in the floodplain management plan and treated with caution.

The Manhattan levee system was originally designed for vegetation along the overbanks to be represented by an n-value of 0.05, which is typical of scattered brush and mature field crops. A maintenance measure of the original design was for the

removal of wild growth and drift deposits in the floodway. Currently, the overbank n-values assigned in the existing conditions hydraulic model range from 0.04, reflective of row-crop fields, to 0.13 to represent heavy stands of timber. An in-channel n-value of 0.035 was used in the existing conditions hydraulic model instead of the original design channel n-value of 0.025. Areas difficult or infeasible for the levee district to maintain due to land ownership and right of way, including areas across the river from the levee, appear to have already grown into dense forest as reflected in the existing conditions model. Areas of the floodplain near and downstream of the levee system with active agricultural fields are expected to continue to be maintained in crop production.

The future conditions without project represents the probable stage-discharge relationship at a selected future date based on the best available current data, the incorporation of any definite projects planned to be completed within the study reach, and any long term natural river processes that may affect future stages. For the purposes of this study, the future conditions have been defined as conditions reasonably expected to be present in 2060. A critical assumption in the future conditions analysis is that hydrologic conditions along the Kansas River and the Big Blue River are relatively static and that flows used in the existing conditions study will be used in the future conditions analysis. Several factors exist that may influence future condition hydrologic conditions on the Big Blue River and include urbanization in Manhattan, Kansas as well as any unforeseen modification to regulation manual for the Tuttle Creek Reservoir. The future hydrologic conditions on the Kansas River will not likely change significantly due to its watershed's large size and the regulation it experiences from several reservoirs upstream of Manhattan, Kansas. Additional information on expected hydrologic trends can be found in section 1.7, Climate Change Considerations.

The Kansas River has been subject to many natural processes that have affected river stages for both low and high frequency flood events. These long-term changes in the stage-discharge relationship of the river are referred to as stage trends. Since the period of record is small at the Kansas River gage at Manhattan (USGS 06879820), the Wamego river gage, which is approximately 19 river miles downstream of Manhattan, was used for this analysis. The stage trends on the Kansas River at Wamego, Kansas are shown on Figure 13 for annual peak flows between 1914 and 2008 that range from 5,000 cfs to 400,000 cfs.

The period of record used in Figure 13 includes instantaneous annual peak discharges from 1914 to 2008. Unregulated discharges were recorded at the Wamego gage from 1914 until Tuttle Creek Dam was constructed in 1963. When discharge is less than 73,000 cfs the stage trend decreases about 1.6 feet between 1914-1950 and 1951-2008. The higher flow data series (greater than 73,000 cfs) generally reflect data collected during the floods of 1935, 1951, and 1993. These floods are the only floods in recent history to produce significantly higher discharges than other flooding events in the period of record and there is not enough evidence to suggest a stage trend occurs at large discharges. Because there is insufficient evidence of stage trend at high discharges, significant hydraulic uncertainty exists when predicting the future rating curve for the gage in Wamego, Kansas.

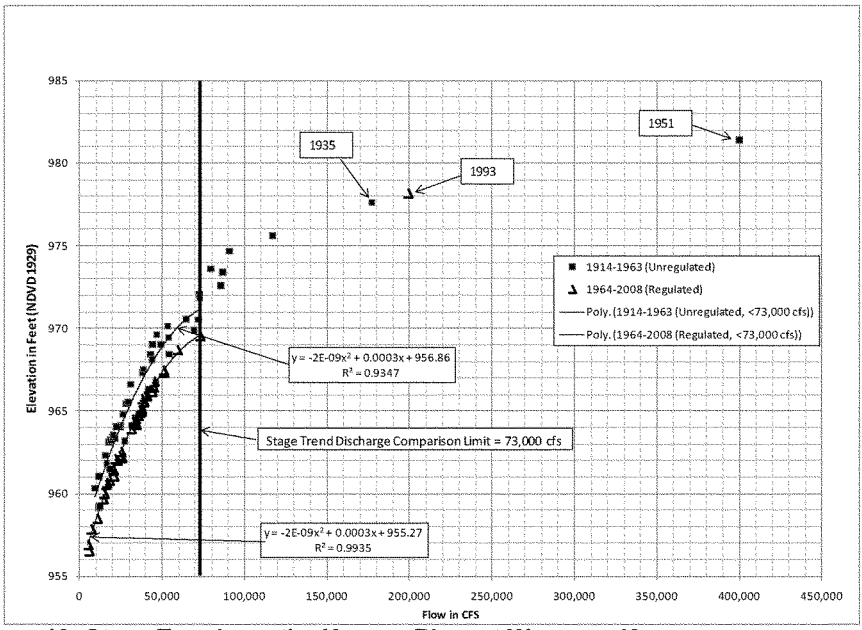


Figure 13: Stage Trends on the Kansas River at Wamego, Kansas

Therefore, based on available information, evaluation of trends in climate, stage trends, and expected floodplain management, the existing conditions model was assumed to be adequately representative of the future without project conditions.

2-7. Climate Change Considerations

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

A model of future conditions for the central plains of the United States was created by the NOAA National Environmental Satellite, Data and Information Service in a report issued in January 2013. This report is an assessment of Climate Trends and Scenarios into the next 50 to 100 years. The report cites that over the past period of record for the region of northeast Kansas, both temperature and precipitation has trended above normal, especially over the last 50 years. To account for climate change in the meteorological conditions of northeast Kansas, the future forecast of conditions in the region takes into consideration the past temperature and precipitation records, and then considers future modeled conditions in the area through 2070. According to the

NESDIS report, a warming trend of about 3-5 degrees F and a precipitation trend very slighty toward wetter conditions can be expected through the next 50 years although significant uncertainty is expected with these estimates.

Huntington (2006) notes that a proportionality has been observed in recent meteorological models between temperature and precipitation where precipitation increases by about 4.3% per degree Kelvin. In an effort to evaluate the hydraulic effects of this relationship during the 0.33% ACE event in 50 years, it was considered that in the worst case scenario, flood discharges may increase by no more than 15% if temperatures increase by 3-5 degrees F (1.7-2.8 degrees K). The analysis also assumes that all additional precipitation becomes direct runoff. When these flows were hydraulically modeled at the levee, the 0.33% event profile raised by an average of 1.0 feet and a maximum of 1.8ft.

An additional local level analysis was performed to do a first order detection of any changes in floods that have been occurring over the observed record period. For the period of record from 22 July 1959 through 21 January 2010 daily observations of discharge for inflow into Tuttle Creek Lake were analyzed in two ways. The first was to identify the annual maximum daily discharge from the record and perform a linear regression on the data to determine if there was a statistically significant slope (Figure 14). The second was to identify the largest annual three-day maximum discharge and perform a linear regression on the data to determine if there was a statistically significant slope (Figure 15). Both analyses resulted in a relatively small but statistically significant trend towards smaller annual maximum daily discharges as well as annual maximum three-day average discharges.

Impacts associated with changes in flood frequencies to the project are directly related to whether the floods would be increasing or decreasing. Increases in flood magnitudes may increase the benefits of the proposed project in that there would be greater benefit achieved by reducing overall flood risk. However, increases in flood magnitudes would both alter the project performance in terms of whether it is satisfying the 1% Conditional Non-exceedance Probability or chosen performance criteria, as well as increase maintenance costs or repairs associated with potentially more frequent overtopping events then were originally assumed. Decreases in flood magnitudes may decrease assumed project benefits as the project would not be protecting against the greater floods assumed during the study. However, project costs in terms of maintenance or repairs may be reduced as the project will not be subjected to the level of floods assumed during this study.

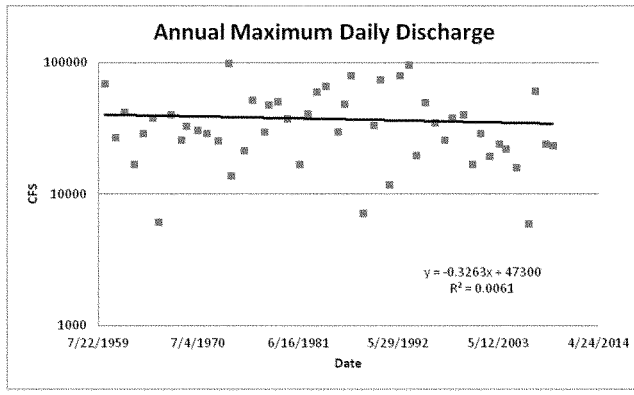


Figure 14: First order trend detection on annual maximum daily inflows into Tuttle Creek Lake. A negative slope is determined to be statistically significant at the p<0.05 level.

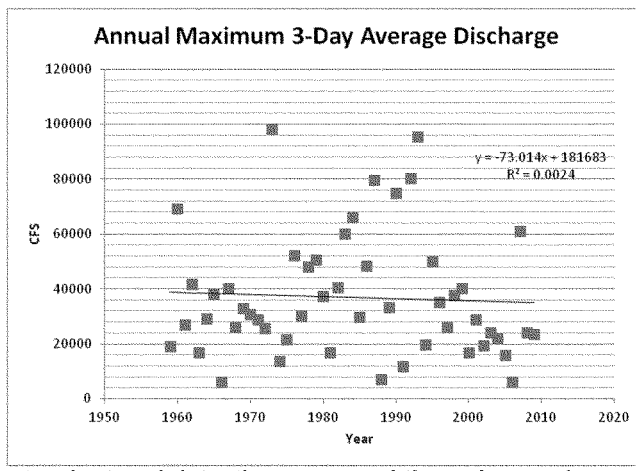


Figure 15: First order trend detection on annual three-day maximum daily inflows into Tuttle Creek Lake. A negative slope is determined to be statistically significant at the p<0.05 level.

The objective of the hydrologic analysis conducted for the USACE Manhattan Feasibility Study is to update estimates for frequency flooding events, which were last investigated with a period of record that ended in the 1960s. Since that time, flooding events have occurred that include 1993, the flood of record since significant flood control projects have been operational in the basin. This new hydrologic information has contributed to improved estimates for extreme flood flow frequencies. As time progresses and additional flood events occur, these estimates may need future updates. It is expected that climate change in the next 50 years may increase

frequency flows over the study basin, but these increases are being treated in this evaluation to be retained within the bands of uncertainty in the Existing Condition Feasibility hydrologic analysis.

2-8. Flood Stage Forecasting During Gatewell Construction

The levee will require emergency closure structures (ECS) to adequately protect against flooding during gatewell replacement construction because of openings in the levee during construction. The probability of occurrence of an extreme flood during construction is expected to be very low because of the relatively short time of vulnerability during the gatewell replacements. However, from a hydrologic perspective, there is a remote but highly consequential risk that a large flood may occur during construction. If earthen materials with riverside erosion protection are immediately available at the construction site, an emergency closure structure (ECS) of the levee will require about twelve hours to meet a level of protection equal to a 1% (1/100) ACE flood. Table 1 shows the required ECS height at each gatewell that will be replaced.

Table 3: Gatewell Replacements

Gatewell Station	**269+50**	**163+00**	**89+83**	**62+20**	**14+78**
Levee Segment	Big Blue	Kansas	Kansas	Kansas	Kansas
Levee Toe*	995.9	1002.9	1007.1	1008.0	1011.8
1% (1/100) ACE Elevation	1015.8	1013.0	1016.9	1019.0	1020.6
Levee Top**	1018.9	1016.9	1026.4	1026.6	1026.8
Emergency Closure Structure Height (ft)	19.9	10.2	9.8	11.0	8.8
Adjacent Levee Height (ft)	23.1	14.1	19.3	18.6	15.0

*Levee toe based on O&M drawings existing elevation centerline at centerline of levee and conversion to NAVD88 vertical datum with CorpsCon 6.1
**Levee top based on National Levee Database data and 2012 FEMA certification levee raise as-built data

2-8.1. Kansas River Forecasting

The Kansas River hydrologic response to rainfall is expected to be slow because the Kansas river basin at Manhattan, Kansas is significantly regulated and very large (45,288 square miles). The upstream portion of the basin that is regulated with flood control projects of Manhattan is about 39,740 square miles, or about 88 percent of the basin. Evidence of basin response during the 1993 flood at Fort Riley USGS 06879100 gauge on the Kansas River is shown in Figure 16. Discharge is not measured at the Manhattan gauging station but the observed discharge at the Fort Riley gauge is shown in Figure 16 to provide a glimpse of the hydrologic behavior nearby in the basin.

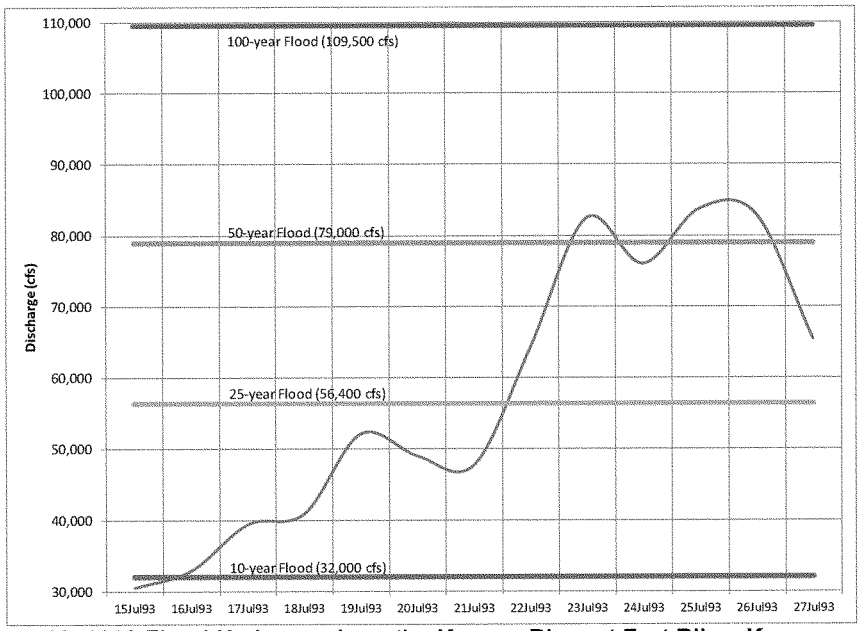


Figure 16: 1993 Flood Hydrograph on the Kansas River at Fort Riley, Kansas

The National Weather Service's Advanced Hydrologic Prediction Service (NWS AHPS) forecasts are available on the Kansas River both at Manhattan and Fort Riley, which is about 17.5 river miles upstream of Manhattan. Hydraulic analysis indicates the average channel velocity between Fort Riley and Manhattan is about 4.5 miles per hour during flooding conditions. In these conditions, the arrival time for flood waters from Fort Riley to Manhattan is about 4 hours. Local runoff area between Fort Riley and Manhattan is about 418 square miles, which is about 1 percent of the total basin area at Manhattan.

The NWS AHPS forecasts at Fort Riley and Manhattan, which are 3-4 days in advance, would provide enough time to build ECSs at gatewells under construction. The construction schedule should only allow one gatewell to be under construction at a time so multiple ECSs would not have to be made at the same time in the event of a flood. On the Kansas segment of the levee, the decision to stop construction and build a ECS to prepare the levee for flood protection would be made when the NWS AHPS forecast reaches flood stage either at Fort Riley or Manhattan.

2-8.2. Big Blue River Forecasting In Normal Conditions

The Big Blue River hydrologic response to rainfall is expected to be very predictable in normal flood control operations because of the levee's close proximity of Tuttle Creek Lake, which heavily regulates discharges on the Big Blue River at

Manhattan. On the Big Blue River, 3-5 day pool level forecasts at Tuttle Creek Lake are available from the Kansas City District Water Management Section that would provide enough time to construct ECS. The decision to construct ECSs should be made when the Tuttle Creek Lake pool elevation is forecasted to reach elevation 1125, which is the elevation at which the critical level of surveillance for Tuttle Creek Dam is underway. This is an appropriate threshold to seal the levee for active flood protection because there are 11 feet of remaining flood control pool, which is necessary for additional construction time if unfavorable wet conditions inhibit rapid closure material placement. At elevation 1136, when surcharge operations begin to govern the release schedule, much less time for downstream readiness will be available and the ECSs will already be sealed before that scenario occurs.

The hydrologic response during the 1993 flood at Manhattan on the Big Blue River is shown in Figure 17. Tuttle Creek Lake entered surcharge operations during the 1993 flood event, which led to unprecedented discharges on the Big Blue River. If an event similar to the 1993 flood occurs again during gatewell replacement construction, it is assumed that the ECSs would be constructed before surcharge operations at the lake occurred.

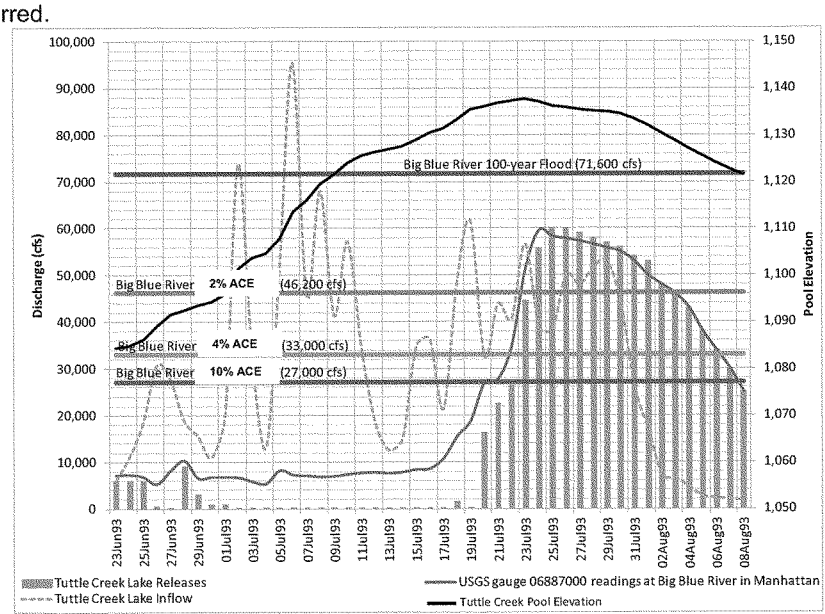


Figure 17: 1993 Flood Hydrograph and on the Big Blue River at Manhattan, Kansas Overlaid with Tuttle Creek Inflow and Pool Level

2-8.3. Big Blue River Forecasting In Surcharge Conditions at Tuttle Creek Lake

2-8.3.1. Background

Risk warning time at Manhattan, Kansas is largely dependent on releases from Tuttle Creek Lake, which is the upstream flood control project on the Big Blue River. The time for discharge releases from Tuttle Creek Lake to travel to Manhattan, Kansas is about 1-2 hours because the dam is less than 10 river miles from Manhattan. Releases that would cause significant downstream damages will occur in surcharge operations. These releases are primarily dependant on inflow amounts into the lake because there is no available space in the flood control pool to detain inflow. Surcharge releases are based on the last 1 or 2 hour inflow calculation, whichever is greater, and the gates are set to that release amount. The gates are set at that point or go higher if inflow increases based on the subsequent 1-2 hour inflow forecast computed hourly during the surcharge release period. Due to the relatively short time that is available to forecast inflows to the lake and the short travel time for water to travel from Tuttle Creek Dam to Manhattan, the actual risk warning time to residents within the leveed area is limited. In summary, risk warning time was estimated to be approximately six hours between the time at which Tuttle Creek Lake personnel are aware of upcoming spillway releases that resemble the 0.33% (1/300) ACE flood on the Big Blue River and the time at which the leveed area is completely inundated. Accordingly, egress readiness will be of particular importance if entering into surcharge operations.

2-8.3.2. Leveed Area Inundation Timing

Existing conditions hydraulic modeling of the 0.33% (1/300) ACE flood indicates there will be about 7,300 feet of levee (between stations 200+00 and 273+00) on the Big Blue River levee segment that will overtop by a representative height of 2.5 feet. In the most conservative case, the leveed area would be inundated by the 0.33% (1/300) ACE flood up to about elevation 1021.5. Figure 18 shows the overtopping height along the levee in the event of a 0.33% (1/300) ACE flood. The total volume landside of the levee that could be filled with water up to elevation 1021.5 was determined using ESRI GIS software and 2010 Light Detection And Ranging (LiDAR) elevations. Figure 19 shows the leveed area storage volume and inundated acreage as elevation increases.

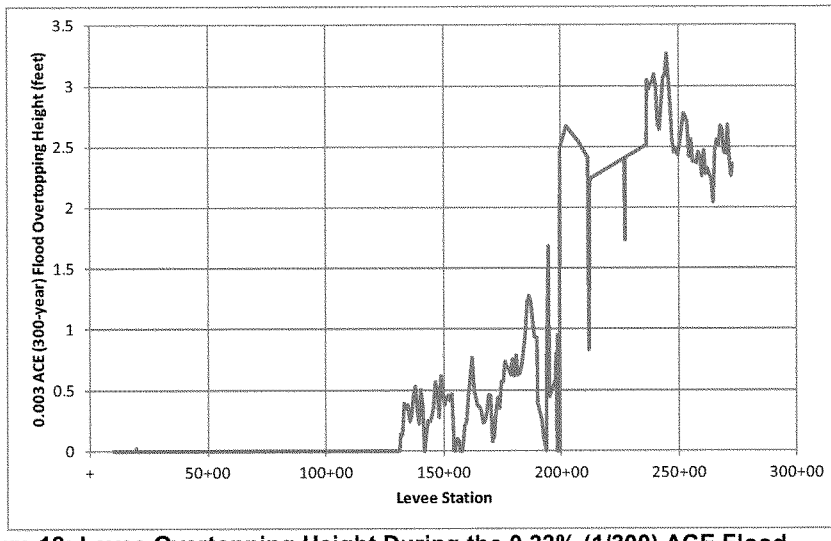


Figure 18: Levee Overtopping Height During the 0.33% (1/300) ACE Flood

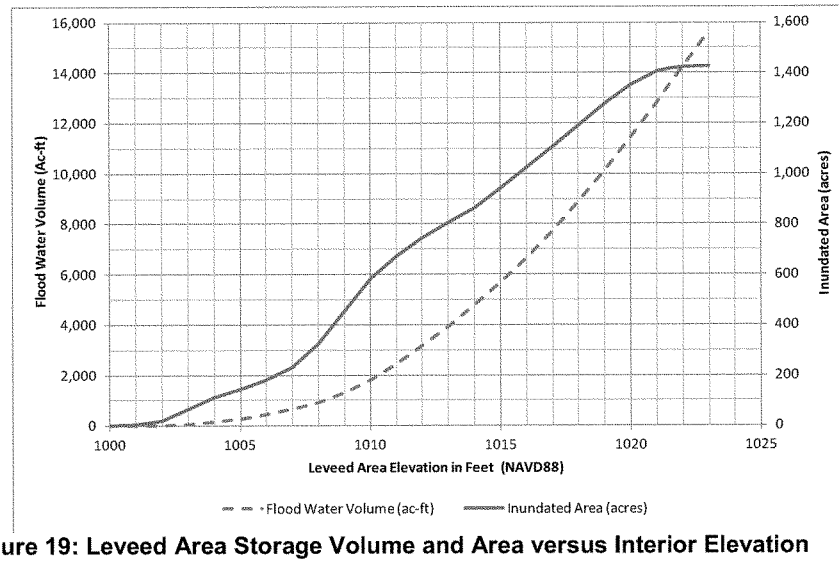


Figure 19: Leveed Area Storage Volume and Area versus Interior Elevation Curves

Hydrologic information from the Manhattan Levee Feasibility Study focused on determining flow frequencies, and accordingly, design hydrographs are not available for each return period flow to route flows from the dam to Manhattan and into the leveed

area. Accordingly, a weir equation was utilized to calculate potential peak flow rates into the leveed area in the event a 0.33% (1/300) ACE flood occurs. Assumptions of the weir equation include a constant flow depth over the levee, no levee erosion or breach, no headloss over the top of levee, an approximate rectangular shape, and a flat overflow section. A weir coefficient of 3.33 was used because it was suggested by Mays (2005). As seen in Figure 18, additional levee overtopping would occur between stations 125+00 and 200+00, however this was assumed to be minor in comparison to stations 200+00 to 275+00, and was not included in the weir calculations to provide a somewhat conservative estimate of peak flow rates into the leveed area. If the 0.33% (1/300) ACE flood occurs, about 95,000 cfs would overtop the levee and the inundated elevation of 1021.5 would be reached in about 2 hours. Approximately 13,500 acre-feet of flood water volume would be expected to fill the leveed area in this event, which would inundate about 1,420 acres.

The time to inundate the leveed area was estimated by dividing the interior volume by the estimated peak overtopping discharge computed with the standard weir equation. This simplified approach assumes a flat hydraulic profile behind the levee. It does not account for the interior drainage pumping plants to return water back to the river and it also does not account for local rainfall that would contribute to interior drainage. Additionally, a levee breach analysis that would likely decrease the time to fill the leveed area was not considered.

2-8.3.3. Egress Readiness

In the event of a surcharge release, when the pool elevation is within about 10 feet of the top of gates (in the 1026-1036 range), it is expected that there would be a heightened level of awareness in the downstream community and the City of Manhattan staff would be readying egress preparedness on the Big Blue floodplain. This would likely contribute to downstream evacuation planning and efficiency but it will not reduce the risk warning time.

2-9. Upstream Reservoir Operation Modification Alternatives

2-9.1. Background

Several upstream flood storage reservoirs exist upstream of the Manhattan Federal Levee that could have been considered for additional flood risk reduction at the Manhattan Levee. However, due to its near proximity to the Manhattan Levee, Tuttle Creek Lake was first considered for analysis. Only a minimal amount of unregulated basin area between the lake and the levee exists on the Big Blue River, and per the existing conditions analysis, the levee height is the most deficient along this segment. Accordingly, it was expected that affecting operations at Tuttle Creek would provide the most benefit for the levee of all the upstream flood control reservoirs. Figure 20 shows the flood control reservoirs that exist upstream of the levee in the Kansas City District.

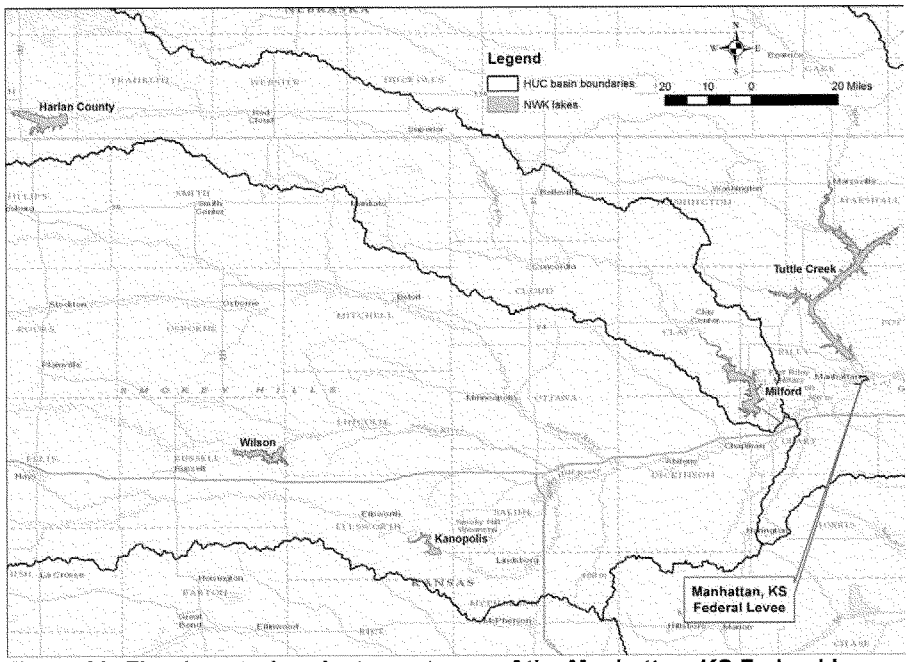
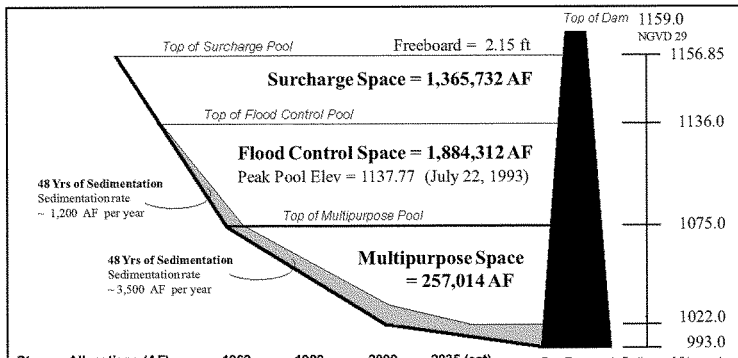


Figure 20: Flood control projects upstream of the Manhattan, KS Federal Levee

Tuttle Creek Lake was originally authorized for flood control and multipurpose pool benefits. The multipurpose pool was designed to meet the authorized and operating purposes of water quality, recreation, fish and wildlife, and navigation flow supplementation. In 1989, the multipurpose pool was reallocated to add an allocation for water supply and to increase the sediment reserve. The increase in the sediment reserve was needed to extend the design life of the pool from 50 years to 100 years. The water quality purpose includes support of minimum releases, normally 100 cfs although the releases can be reduced to 25 cfs during extreme drought conditions (para 8-12, Lake Regulation Manual). When hydrologic conditions permit, the minimum releases are set at 200 cfs, a convenient value for the project personnel operating the gates. Tuttle Creek Lake is also operated as a system with Milford and Perry lakes to support minimum flow criteria on the Kansas River at Topeka and DeSoto. The navigation function consists in providing supplemental releases for support of navigation flow targets on the Missouri River. This is also a system operation in conjunction with Milford and Perry lakes. Figure 21 below shows current storage allocations for Tuttle Creek Lake.



Storage Allocations (AF)	1962	1989	2009	2035 (est)
Total Flood Control Pool	**1,941,705**	**1,922,085**	**1,884,312**	**1,879,000**
Exclusive Flood Control	1,941,705	1,922,085	1,884,312	1,879,000
FC Sediment Reserve	0	0	0	0
Total Multipurpose Pool	**425,312**	**335,100**	**257,014**	**122,000**
Water Supply (in-service)	0	50,000	50,000	50,000
WQ, Nav, Other Purposes	185,000	72,000	72,000	72,000
MP Sediment Reserve	240,312	263,100	135,014	0

The 1989 Reallocation added a water supply allocation and added space to the sediment reserve to extend its design life from 2012 to 2035. The State (KWO) contracted for the water supply, all of which is in service.

Figure 21: Tuttle Creek Lake Storage Allocations

A revised Multipurpose Regulation section in the lake regulation manuals for all three lakes was formally approved in 1995, although elements of the plan were implemented as early as 1990. Downstream targets extend downstream along the Kansas River to the mouth, and then down the Missouri River to Waverly, Missouri. The plan limits the allowable drawdowns for supplemental navigation releases, sets criteria for the Kansas River minimum flow targets, and establishes system operation procedures for the three lakes in support of the downstream flow requirements. The revised multipurpose plan is supplemented with provisions in the Kansas River Master Manual and the Missouri River Master Manual.

Since construction of the dam in 1960, several potentially damaging floods have been prevented by Tuttle Creek Dam. Large inflows since 1960 are shown in Figure 22 and Figure 23 that were largely attenuated by Tuttle Creek Lake. In 1993, when the downstream flood of record occurred, the peak inflow to Tuttle Creek Lake was 95,400 cfs on July 6 and the peak release was 60,000 cfs on July 25.

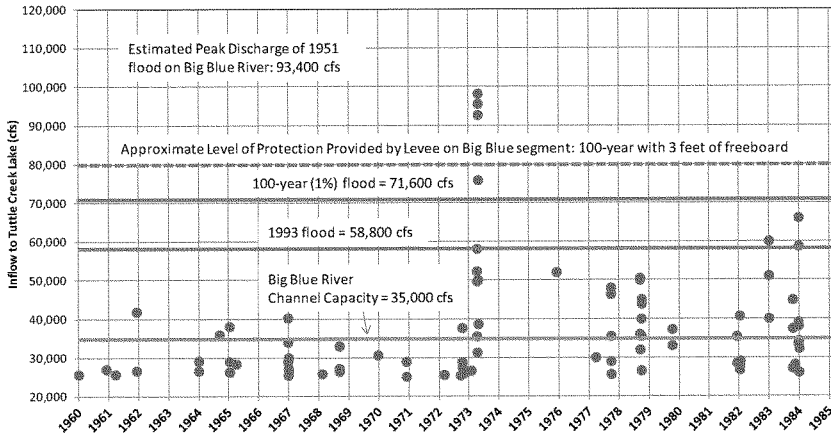


Figure 22: Large Inflows to Tuttle Creek Lake from 1960-1985

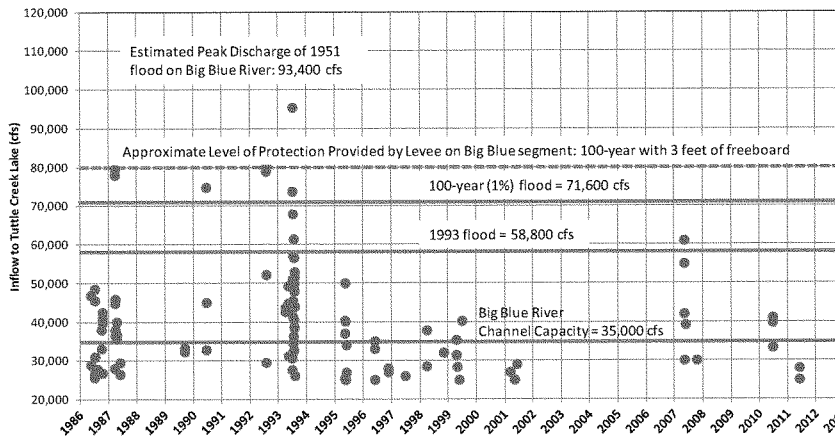


Figure 23: Large Inflows to Tuttle Creek Lake from 1986-2013

2-9.2. Tuttle Creek Lake Alternatives for Consideration

Modifications to the current operating procedures and purposes at Tuttle Creek Lake are technically feasible but are expected to provide marginal improved flood control benefits at high costs. Alternatives to increase downstream flood protection would likely require reducing benefits from other authorized purposes. Two alternatives for consideration involve storage reallocations to increase flood control space and modifying phased release schedules for flood control operations.

2-9.3. Multi-purpose and Flood Control Pool Reallocation Alternative

An analysis was conducted to determine the effects of reallocating all multi - purpose pool storage for the sole purpose of flood control. Tuttle Creek would essentially act as a dry detention facility in normal and drier than normal conditions. After reserving space for sediment through the design life of the reservoir, this would add 0.122 million acre-feet (MAF), to the existing 1.88 MAF of flood control storage allocation and 1.37 MAF of surcharge storage, resulting in an additional 6.5% storage at top of flood control and 3.8% additional storage at the top of surcharge. These small gains in flood control space would not be anticipated to provide any significant flood control benefits. If the 1993 flood reoccurs with all of the multipurpose pool allocation converted to flood control, the additional storage volume represents less than 2 days of releases, compared to 14 days of releases at or above the phase 3 maximum allowable release from flood control pool of 35,000 cfs. During the 1993 event, phase 3 releases were exceeded for 14 days and approximately 500,000 acre-feet of additional storage would have been needed to prevent surcharge releases in excess of 35,000 cfs. This additional storage requirement is about 4 times the available storage in the existing multi-purpose pool allocation. Effects of a single purpose flood control allocation would be at the expense of water supply during drought for urban areas such as Topeka, Lawrence, and Johnson County. This would also be at the expense of water quality on the KS river during drought. Furthermore this would eliminate essentially all water based recreation and fishery benefits on the lake, and eliminate a substantial portion of the supplemental flow source for navigation support on the Missouri River during drought.

Similar gains in flood control space could be realized through other modifications such as a dam raise. If an increase to the flood control pool allocation is considered to prevent surcharge releases during a reoccurance of the 1993 flood, the top of the flood control pool would need to be raised from elevation 1136 to about elevation 1145 to increase the existing storage capacity so it contains an additional 500,000 acre-ft. This would require the spillway gates to be raised about 9 feet above their current elevation to prevent gates from overtopping. The top of dam would also need to be raised in order to maintain both the required surcharge storage for the spillway design flood and existing 2.15 feet of freeboard for wind/wave concerns. Based on extrapolation of the 2009 storage-elevation curves in the Tuttle Creek Lake Regulation Manual, this would require a new top of surcharge at elevation 1163 and a new top of dam about elevation 1165, which is approximately 6 feet above the existing top of dam elevation 1159. Based on extrapolation of the 2009 area-elevation curves in the Tuttle Creek Lake Regulation Manual, approximately 8,000 acres of additional real estate would be effected by inundation around the perimeter of the lake during the spillway design flood and upstream levee systems at Maryville, Blue Rapids, and Frankfort, Kansas would likely require improvements and raises to mitigate a dam of flood control pool raise. Frankfort, Kansas is on the Black Vermillion River and at present does not appear to be significantly affected by backwater from Tuttle Creek. However, the downstream end of the levee at Frankfort, Kansas is at elevation 1146.5. Added pool elevation combined

with some coincident flows would increase the overtopping frequency of this Federal Levee. Additionally, the Blue Rapids Levee was built as part of the Tuttle Creek Dam Project to mitigate impacts of the flood pool. The levee is located in Marshall County, Kansas near the confluence of the Little Blue and Blue Rivers. Top of levee is set at elevation 1147, and a 9-ft raise in top of control would increase frequency of overtopping this levee. Lastly, a non-Federal Levee exists at Marysville, Kansas. This levee likely could also need to be raised to mitigate more frequent high pools. Accordingly, adding flood control space in Tuttle Creek as a measure to avoid raising the Federal Levee at Manhattan, Kansas would induce a need to raise at least two other federally built levees upstream of Tuttle Creek, and potentially a third non-federally built (but in the Corps non-federal PL-84-99 program) levee.

2-9.4. Phased Release Schedule Modification

An alternative was also considered to reduce the frequency at which Tuttle Creek Lake enters surcharge operations. This would require higher releases at lower pool elevations in an effort to lower the pool faster during flood control operations. By doing this, portions of the flood plain at downstream flow targets would be more frequently inundated in an effort to reduce the risk of inundating and damaging larger portions of the flood plain. This alternative would require intentional flooding without full assurance that surcharge operations would be avoided.

In the example of the 1993 flood, releases were held at Tuttle Creek Lake because downstream flooding was occurring at Waverly, Missouri on the Missouri River, not because of phase discharge limits at Tuttle Creek Lake. Figure 24 shows the 1993 flood hydrograph at the Missouri River at Waverly, Missouri and the inflow, outflow, and pool conditions at Tuttle Creek Lake.

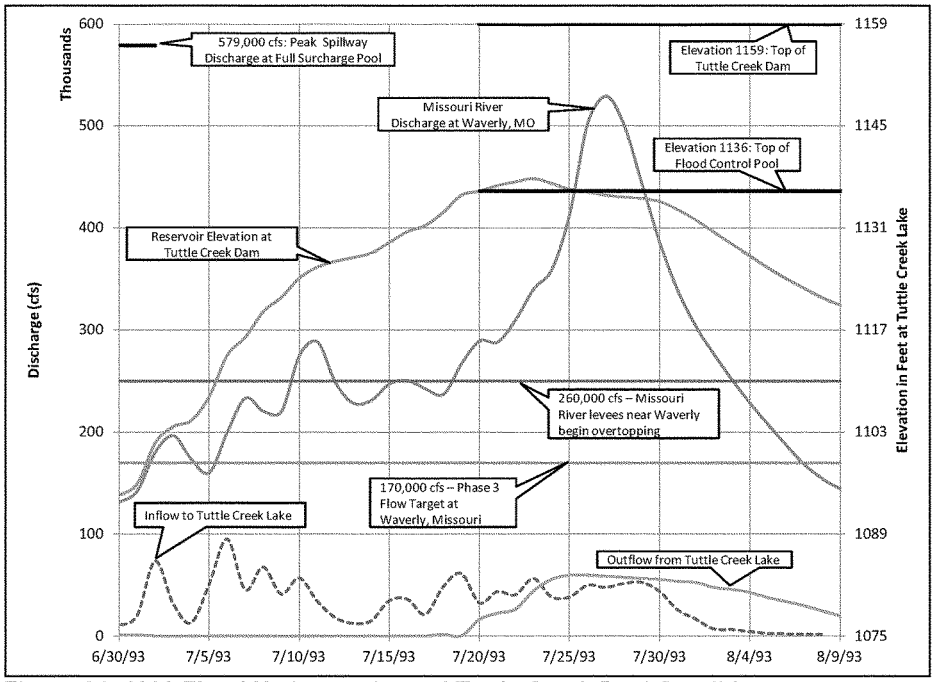


Figure 24: 1993 Flood Hydrographs and Tuttle Creek Pool Conditions

During the flood, Tuttle Creek Lake did not begin evacuating the pool until July 20th, when the pool reached the top of flood control elevation 1136. Before that day, Tuttle Creek Lake was filling its flood control pool to reduce downstream flood damages. Several levee systems were loaded along the Missouri River and additional releases at Tuttle Creek Lake would have likely increased the downstream flood damage risk without the guarantee of preventing surcharge releases from the dam. However, if the maximum phase releases (see Table 4) had been made earlier in the flood event with no consideration to reduce downstream flooding, surcharge conditions may have been prevented.

Currently, the Tuttle Creek Lake Regulation Manual (Aug 1973, pg IX-5) designates three levels of regulated discharges shown in Figure 25 as Phase I, Phase II, and Phase III with flow targets shown in Table 4. The Phase II level corresponds generally to zero damage but an attempt is made to meet flood stage, which is determined by the National Weather Service (NWS). Phase I defines a lower protection level which has been set as 80% of Phase II in the first reach below the dam and 60% of Phase II in all remaining reaches downstream. At the Phase III level, an attempt is made to meet moderate flood stage, which is determined by the NWS. At this point,

damage will be experienced in those areas where banks are below average in height and agricultural encroachment onto adjacent low bottom lands has been effected.

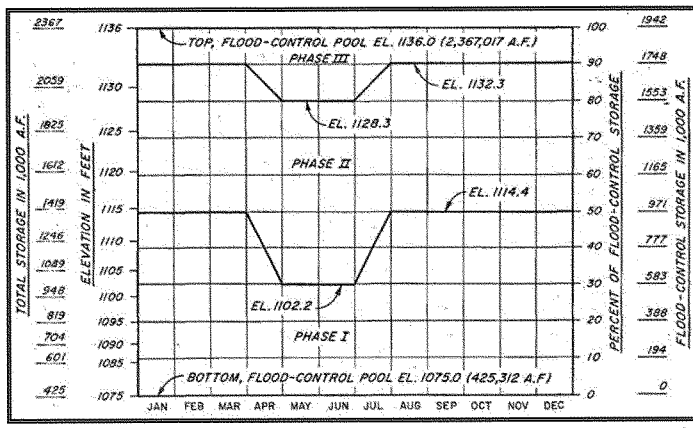
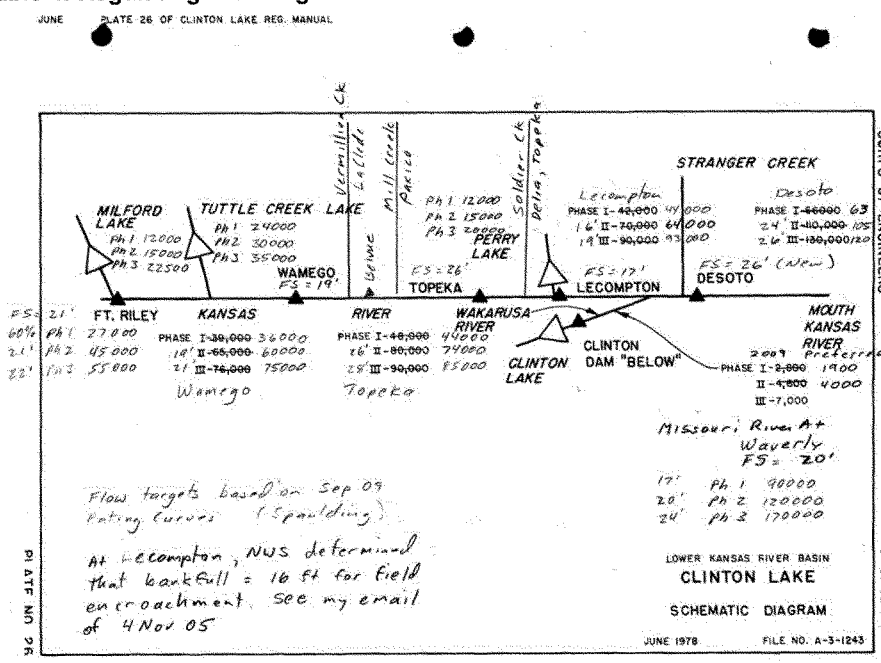


Figure 25: Seasonal Guidelines for Phase Determination (WCM, Plate 37)

Table 4: Regulating Discharges on the Kansas River from Phased Releases



2-9.5. Recommendation

Changes to the allocations and operational phased releases are not recommended to provide flood safety assurance for the City of Manhattan. Changes to storage allocations in Tuttle Creek Lake are not expected to significantly improve downstream flood protection. If phased releases were adjusted for a more aggressive release schedule earlier in a flooding event, it is likely that this would intentionally increase minor and moderate flooding without providing full assurance that surcharge operations would be avoided. In addition, in the example of 1993, this type of earlier evacuation would have increased streamflows by approximately 10% at Waverly, Missouri at a time when Missouri River levees were already substantially loaded and there was not certainty that additional rain would fall at that time. Upstream regulation modifications were analyzed at Tuttle Creek Lake and provided only marginal improvements at the Manhattan Levee. Additional measures at reservoirs located farther upstream are not expected to provide substantial added benefits at Manhattan, KS any more than those evaluated from Tuttle Creek Lake in part because their effects are expected to be attenuated due to their proximity to Manhattan, KS.

2-10. References

1. ESRI ArcMap version 10.0, ArcGIS Desktop 10 Service Pack 3.

2. Hydrologic Engineering Center-River Analysis System Version 4.1 Computer Program. Hydrologic Engineering Center, Davis, CA.

3. International Panel on Climate Change (IPCC), "Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007", M.L. Parry, O.F. Canziani, J.P. Palutikov, P.J. van der Linden, and C.E. Hanson (eds). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 2007.

4. Levee Raising to Meet Freeboard Requirements, Manhattan Levee Project As- As-Built Drawing Set, 2012-12-11. City Project # SM1003.

5. Manhattan Federal Levee Unit Operations and Maintenance Manual Record Drawings, August, 1963. U.S. Army Engineer District, Kansas City, Corps of Engineers, File No. A-13-156.

6. Mays, Larry W., "Water Resources Engineering", 2005 edition. John Wiley and Sons, Inc.

7. National Levee Database Top of Levee Elevations, retrieved September, 2010.

8. NOAA Technical Report NESDIS 142-4, "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment", Department of Commerce, National

Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service, Washington D.C., Jan. 2013.

9. Riley County 2010 LiDAR Dataset, provided by the City of Manhattan Public Works Department.

10. Tuttle Creek Lake Regulation Manual, Volume No. 2, Tuttle Creek Lake, Kansas., Kansas City District, Corps of Engineers, August 1973.

11. U.S. Army Corps fo Engineers Kansas City District "Hydraulics and Hydrology Existing Conditions Engineering Appendix", 2011 April.

12. United States Bureau of Reclamation "Combining and Portraying Risks", March 14, 2011. http://www.usbr.gov/ssle/damsafety/Risk/BestPractices/28-CombiningAndPortrayingRisks20110326.pdf

13. Wetherald, R.T. and Manabe, S. "Simulation of hydrologic changes associated with global warming." Journal of Geophysical Research: Atmospheres (1984-2012), Volume 107 (D19) ACL 7-1 – ACL 7-15, 2002.

2-11. Enclosures

2-11.1. Enclosure 1: Existing Conditions Inundation Maps

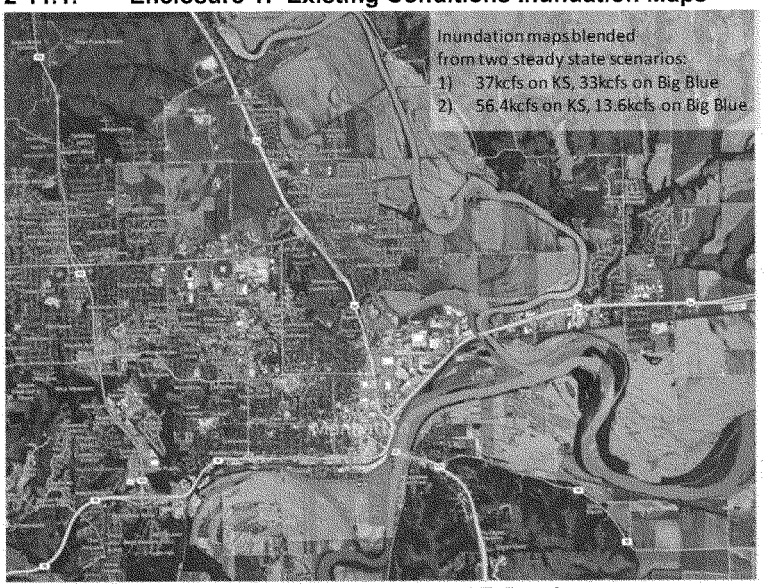


Figure 26: Inundation map of the EC 4% (1/25) ACE flood

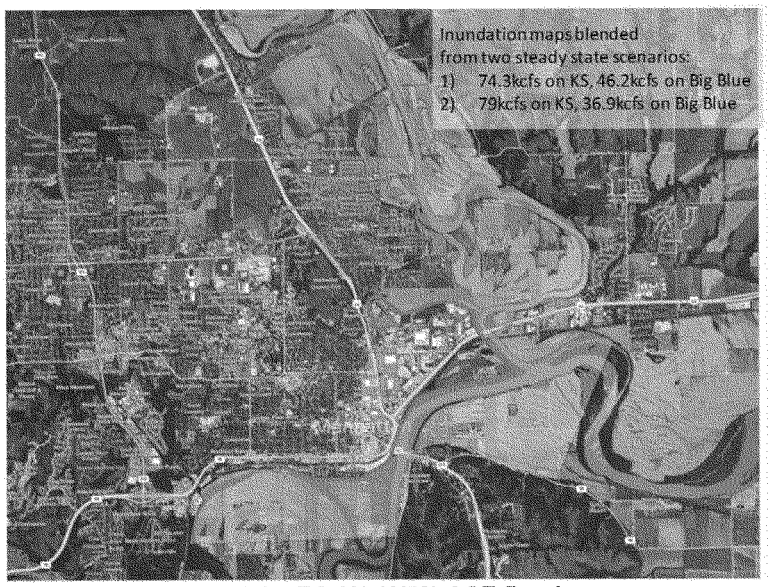


Figure 27: Inundation map of the EC 2% (1/50) ACE flood

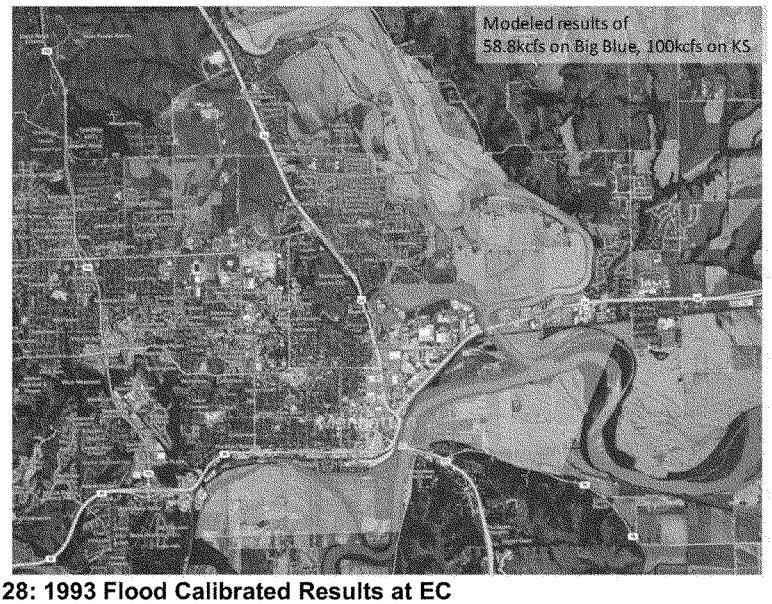


Figure 28: 1993 Flood Calibrated Results at EC

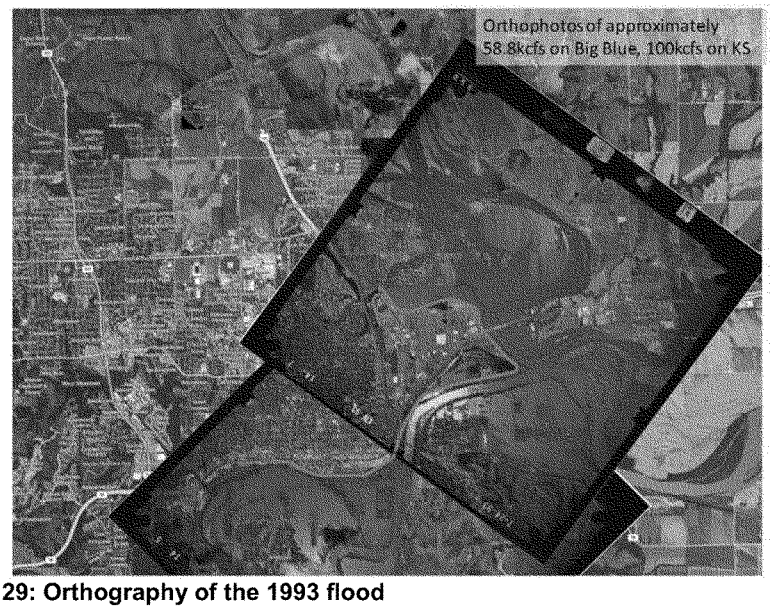


Figure 29: Orthography of the 1993 flood

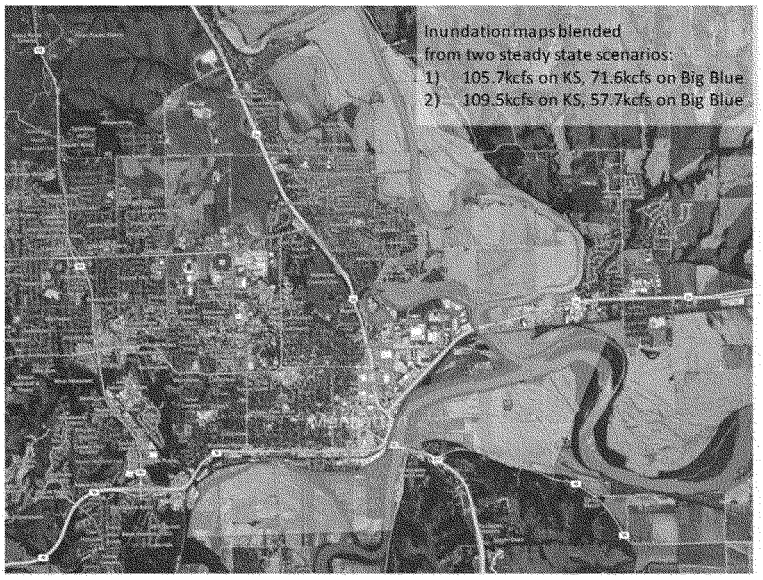


Figure 30: Inundation map of the EC 1% (1/100) ACE flood

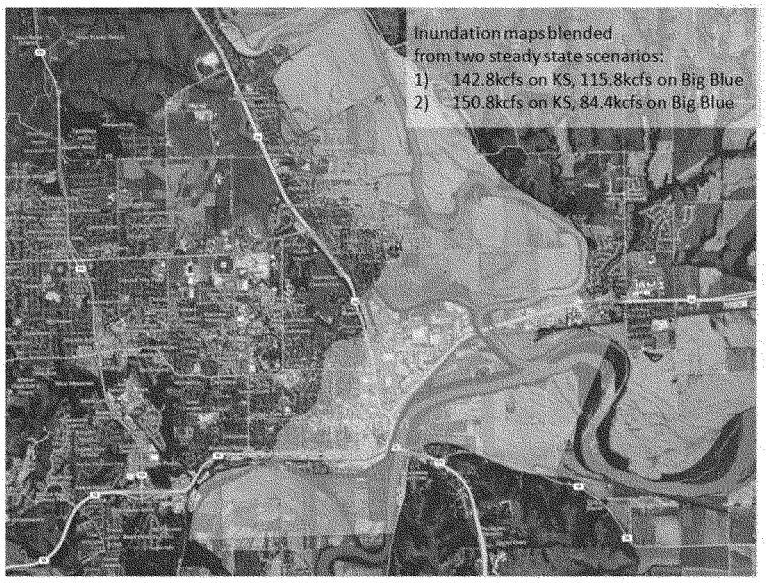


Figure 31: Inundation map of the EC 0.5% (1/200) ACE flood

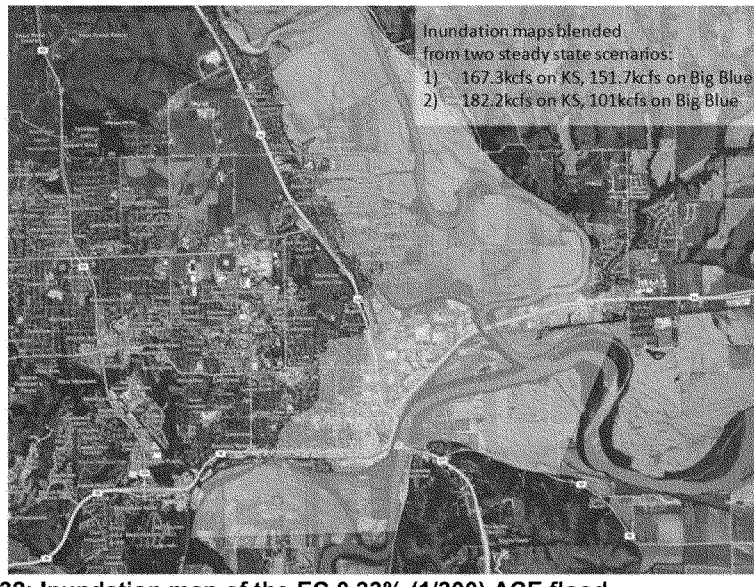


Figure 32: Inundation map of the EC 0.33% (1/300) ACE flood

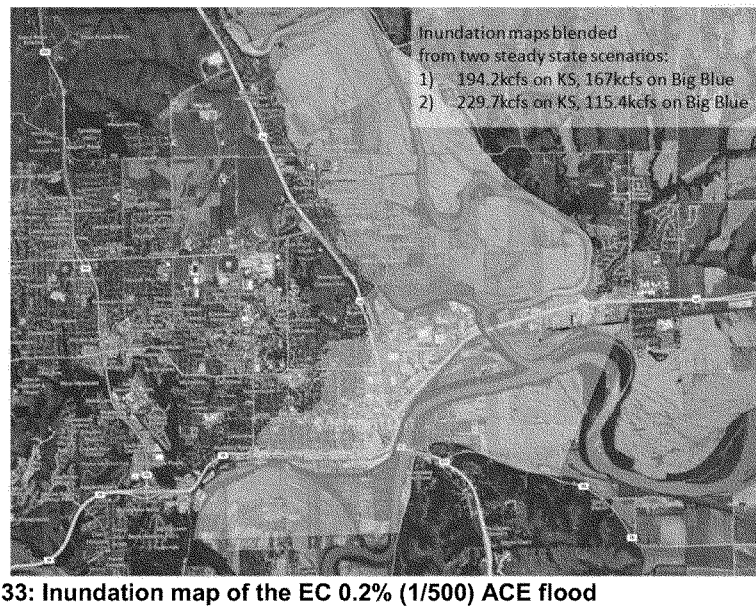


Figure 33: Inundation map of the EC 0.2% (1/500) ACE flood

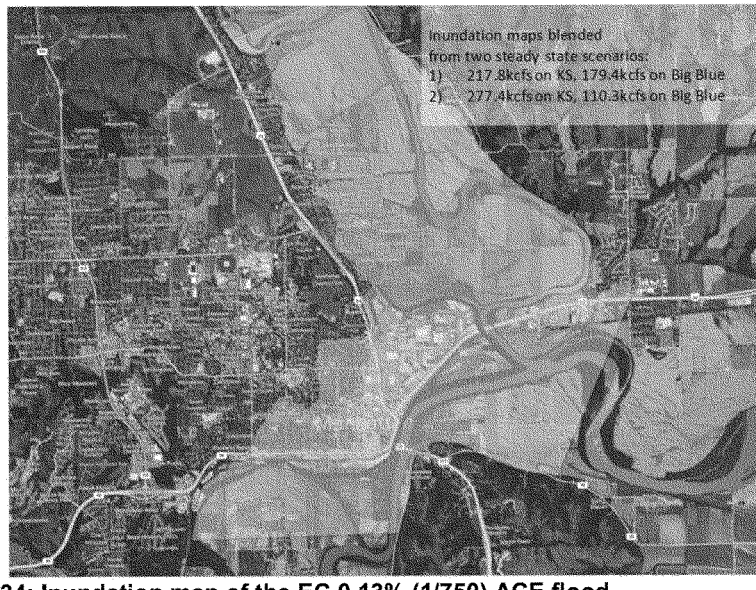


Figure 34: Inundation map of the EC 0.13% (1/750) ACE flood

2-11.2. Enclosure 2: Fragility Curve Combinations

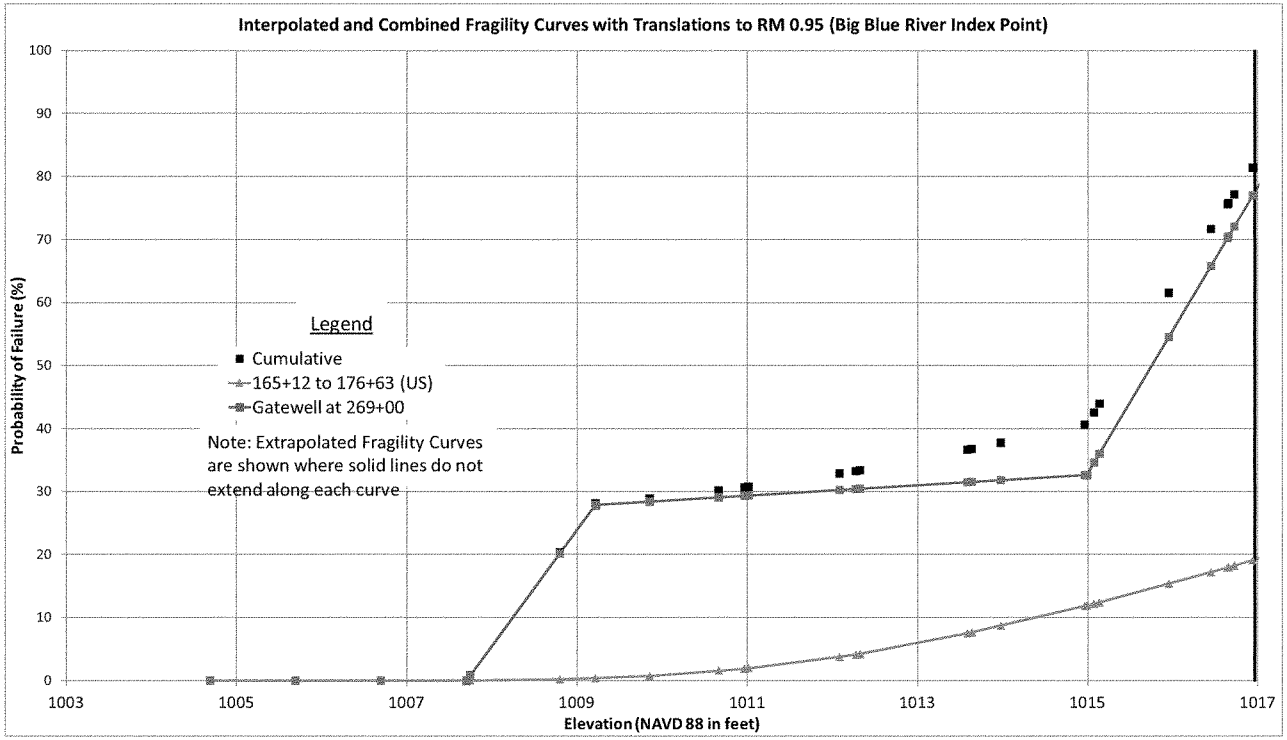


Figure 35: Cumulative Probability Plot at Index Point 0.95 on Big Blue River

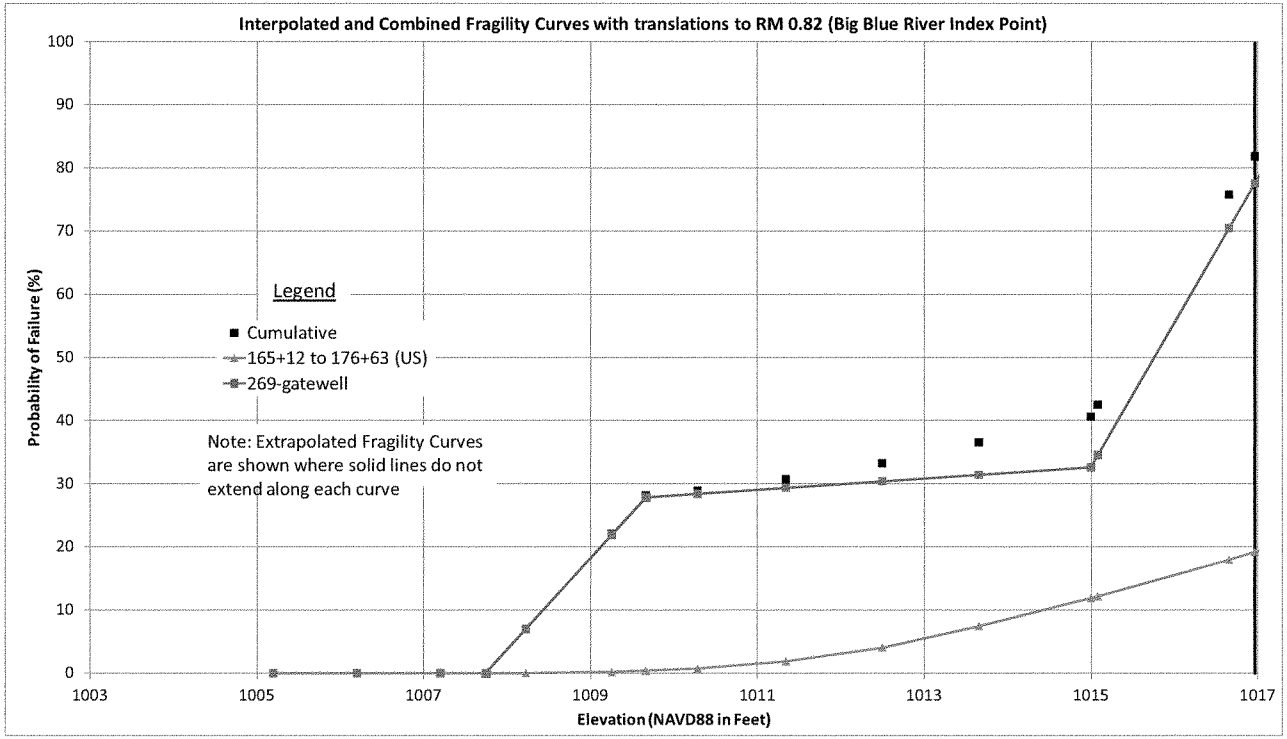


Figure 36: Cumulative Probability Plot at Index Point 0.82 on Big Blue River

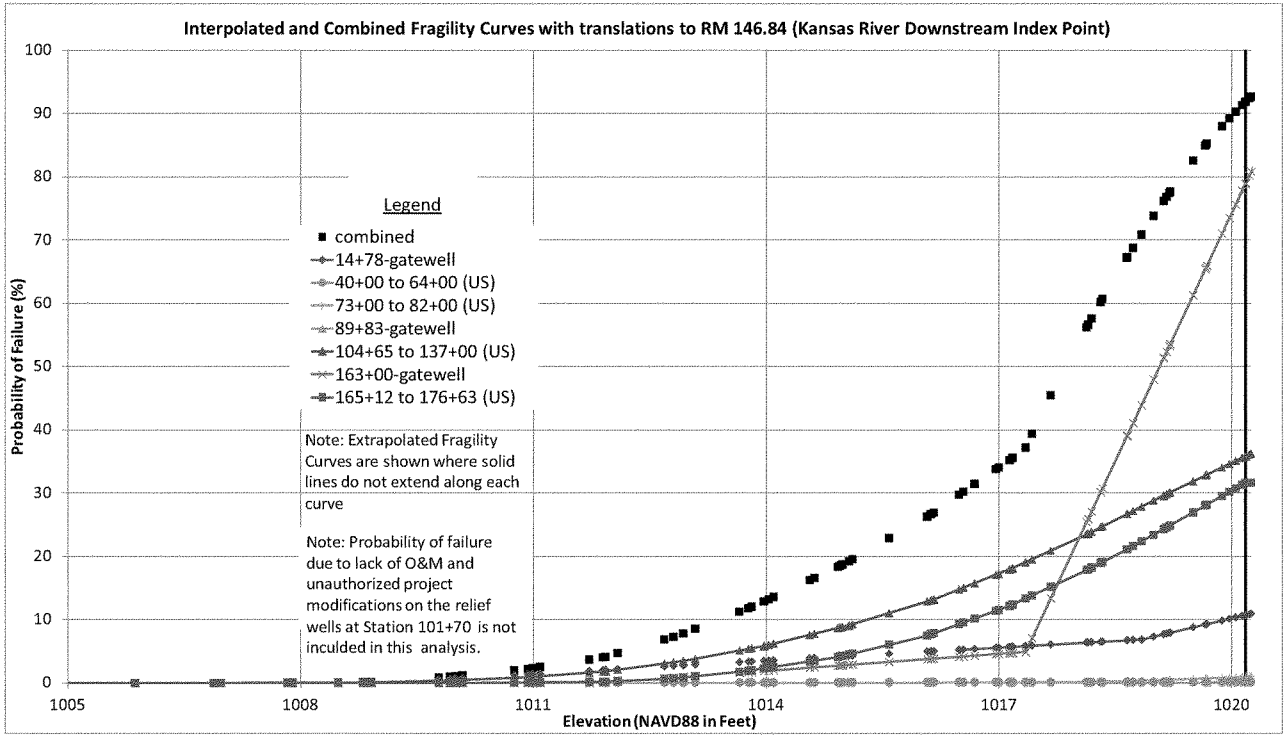


Figure 37: Cumulative Probability Plot at Index Point 146.84 on Kansas River

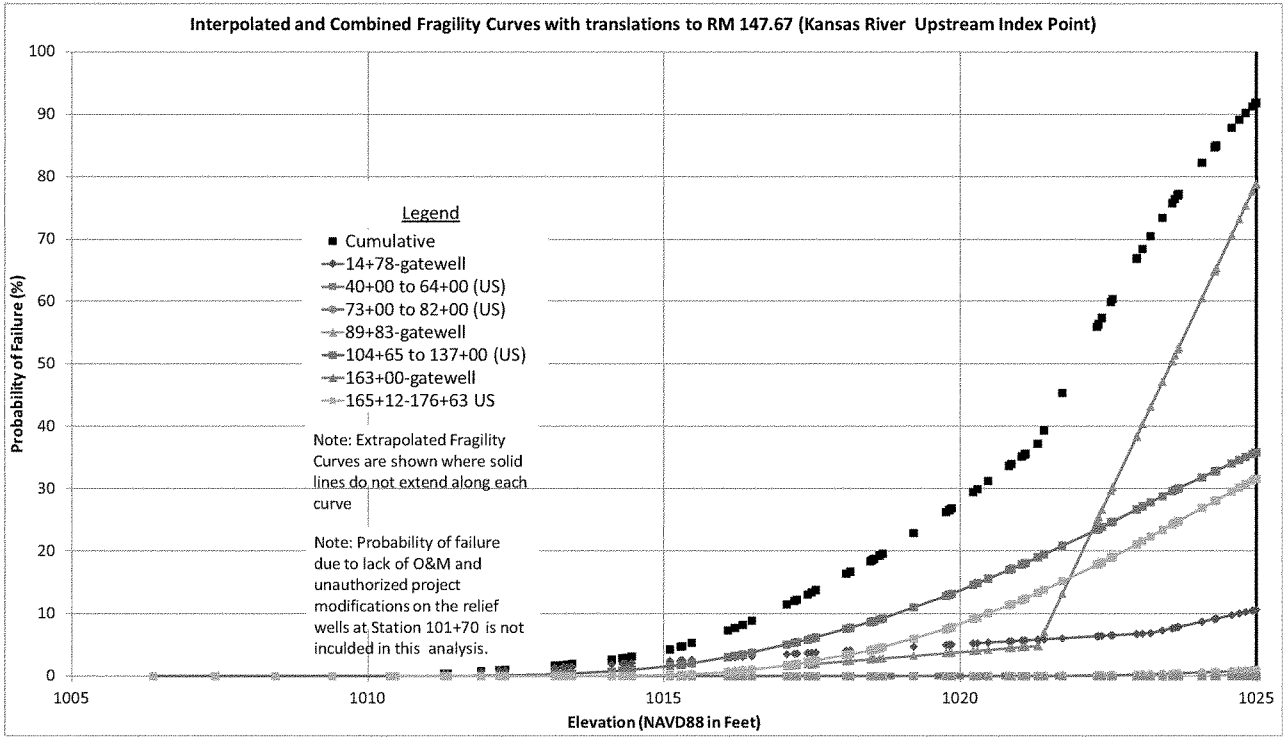


Figure 38: Cumulative Probability Plot at Index Point 147.67 on Kansas River

US Army Corps
of Engineers
Kansas City District

Part 3
Geotechnical
Levee Raise Alternatives and Underseepage and Slope Stability Improvements

Alternatives Engineering
Manhattan, KS

August 2014

Contents

3.1. Introduction 1
3.2. Underseepage Analysis Methodology and Criteria 1
3.3. Slope Stability Analysis Methodology and Criteria 3
3.4. 0.50% and 0.33% Chance of Exceedance of Levee Raise 5
3.5. 0.20% Chance of Exceedance of Levee Raise 5
3.6. Underseepage Control: 0.50%, 0.33%, and 0.20% Chance of Exceedance 6
a. 0.50% and 0.33% Chance of Exceedance of Levee Raise 6
b. 0.20% Chance of Exceedance of Levee Raise 7
3.7. Slope Stability Control 8
3.8. Expected Settlement of Design Features 8
3.9. Recommendations for PED Phase 9

List of Tables

Table 3-1: Permeability Ratios for Blanket Material Based on Material Type Used in Underseepage Analysis 3
Table 3-2: Kansas City District Underseepage Guidelines for Berm Toe 3
Table 3-3: Minimum Factors of Safety 4
Table 3-4: Slope Stability Design Strengths 5

Enclosures

Enclosure A: Preliminary Underseepage Analysis, Underseepage Berm Design, and Relief Well Design
Enclosure B: Schematics of Potential Solutions to Slope Stability and Underseepage Concerns
Enclosure C: Preliminary Slope Stability Analysis with Landside Stability Berm and Filter Drain

3.1. Introduction

A Feasibility study of the Manhattan Levee Unit was initiated after the 1993 flood event to investigate protection adequacy, see Phase I of the Manhattan Feasibility Study. The feasibility identified high risk areas for underseepage and landside slope stability failure modes for the existing levee. Details of the analysis are documented in the Phase I report.

Phase 2 of this study was to evaluate features needed to address identified risk areas with respect to underseepage and landside slope stability for array of alternatives. Three proposed levee raise alternatives were evaluated: 0.50%, 0.33%, and 0.20%. The proposed alternatives were determined based on hydrologic models that account for historical performance of the levee unit during flood events. Details of the hydrology models are in the Hydrology chapter of this study.

During the 1993 flood event, most of the water loading was along the Big Blue River levee reach which had about 4 ft of freeboard. As a result all three levee raise options involve raising the levee unit along the Big Blue River. The 0.50% chance of exceedance improvement alternative is limited along the Big Blue River, the 0.33% chance of exceedance improvement alternative extends to the Kansas River between Station 130+00 and 169+00 (Confluence), and the 0.20% chance of exceedance improvement alternative covers the whole levee unit except between Station 70+00 and 100+00. The proposed alternatives involve levee raises along the Big Blue River. The average levee raise for each of the proposed alternative is 0.75, 1.5, and 2.1 ft, respectively. Due to minimal differences in the levee raise between the 0.50 and 0.33% chance of exceedance alternatives, an analysis was only performed for the 0.33% chance of exceedance and the results used for the 0.50% chance of exceedance.

Details on the levee unit, levee features, foundation conditions, and other pertinent information relevant to this study are found in the Phase I report. The following sections discuss underseepage and stability improvements needed along the levee raises based on current criteria, for the raise alternatives.

3.2. Underseepage Analysis Methodology and Criteria

For each alternative, sections of levee raise were analyzed deterministically to identify all areas not meeting current criteria under existing conditions, see **Enclosure A**. Underseepage performance was assessed in general accordance with Engineering Manual (EM) 1110-2-1913 *Design and Construction of Levees*. The methodology used in the underseepage analyses follows EM 1110-2-1913; however, the Kansas City

District uses the following variations: **1**) permeability ratios are used instead of blanket and aquifer permeabilities (see **Table 3-1**), **2**) an infinite landside blanket is assumed (Case 7 in EM 1110-2-1913), and **3**) no blanket transformations are performed and a representative permeability ratio is used.

The design of future alternatives was based on a minimum Factor of Safety (FS) of 1.6 at the levee toe with water at top of levee. Levee segments with FS equal to or greater than 1.6 are adequate and do not need underseepage control measures. However, levee reaches with FS less than 1.6 require underseepage control measures such as underseepage berms or relief wells. It is recognized the design FS of 1.6 is not consistent with the current EM 1110-2-1913 (2000), which specifies criteria based on gradient. However, the design FS of 1.6 is consistent with ETL 1110-2-569 (expired 2010). A design FS of 1.6 was also recommended for use in NWK in a 2011 Memorandum for Records on seepage criteria for ongoing NWK levee design projects on high consequences levees. The NWK 2011 criterion was established considering ETL 1110-2-569 and Draft EM 1110-2-1913 (2013). While the Manhattan Levee is not called out in the memorandum, it is similar to the levees specifically mentioned. Additionally, coordination has recently taken place with the USACE team working on revisiting EM 1110-2-1913 and a design FS of 1.6 at the levee toe is the likely guidance that will be in the revised document. The design FS of 1.6 selected for Manhattan ensures long term performance and is consistent with current USACE underseepage considerations.

Areas identified in Phase 1 that represent underseepage risk or that do not meet the selected design underseepage criteria outside the proposed raise reaches are recommended for underseepage improvements. This is to ensure high confidence in performance of the entire levee during flood events and to match the high reliability modeled in the economic benefit calculation for the future condition alternatives for water loadings up to overtopping.

Underseepage berm design was performed in accordance with the Kansas City District guidelines for underseepage berm shown in **Table 3-2**. The relief well systems were designed in general accordance with EM 1110-2-1914 *Design, Construction, and Maintenance of Relief Wells* with the following variations:

1) The excess head computed at the landside toe was used as the net head on the system of wells instead of full driving head. This was done because the procedure outlined in Figure 5-3 in EM 1110-2-1914 assumes an impervious blanket. However, a semi-impervious blanket was assumed for the underseepage calculations.
2) An efficiency reduction factor of 0.8 was applied to the expected well flows. This was done to account for the reduction in efficiency with time of the relief wells. An efficiency of 0.8 was chosen as EM 1110-2-1914 requires remedial action once a loss of 20% in specific capacity of a well is observed from pumping test.

Design details are found in **Enclosure A**. Schematics of the underseepage and slope stability solutions are found in **Enclosure B**.

Table 3-1: Permeability Ratios for Blanket Material Based on Material Type Used in Underseepage Analysis

Blanket Material Type (USCS)	Assumed Permeability Ratio
SM	100
ML	200-400
ML-CL	400
CL	400-600
CH	800-1000

Table 3-2: Kansas City District Underseepage Guidelines for Berm Toe

NWK Guidelines (2011)				
Distance From Landside levee toe (ft)				
[1]100	200	300	400	500
$FS_i = 1.5$	$FS_i = 1.4$	$FS_i = 1.3$	$FS_i = 1.2$	$FS_i = 1.1$
[1]100 feet is the proposed minimum berm width from the landside levee toe				

3.3. Slope Stability Analysis Methodology and Criteria

In this study, preliminary steady state slope stability analyses were performed in general accordance with EM 1110-2-1913 *Design and Construction of Levees*. Stability analysis was only performed for the landside slope with water at top of levee. All analysis was performed using the SLOPE/W package in the Geo-Slope software using Spencer's method. The Spencer's method is generally used because it satisfies both force and moment equilibrium. Foundation seepage conditions were modeled in Geostudio SEEP/W for use in SLOPE/W stability analysis. Boundary conditions were changed in the SEEP/W model until the excess foundation pressures at the levee toe matched the results of the deterministic underseepage analysis performed using EM 11102-1913 *Design and Construction of Levees* methodology.

The analyses were conducted to meet the requirements of EM 1110-2-1913 summarized in **Table 3-3**. End-of-Construction and Rapid drawdown performance were not analyzed due to lack of laboratory testing. Detailed analysis of the End-of-Construction and Rapid drawdown conditions in this project needs to be assessed during the Project Engineering Design (PED). Design strengths used for the steady state analysis were based on the Design Memorandum (DM), boring logs drilled by AMEC in 2010 for the levee certification, and engineering assumptions based on

experience with similar projects, see **Table 3-4**. The embankment and blanket friction angles were assumed similar since the boring logs revealed similar strata.

In this analysis, the embankment was assumed to be homogenous and impervious, even though it is comprised of impervious and random zones. This was done to simplify the analysis and because the random material is mostly comprised of impervious material. The steady state piezometric surface through the levee section was assumed approximately linear between the water surface-riverside slope intersection and the landside toe.

Phase 1 indicated that most of the levee does not likely meet required landside steady state seepage stability factors of safety with water at the levee top. The original stability design was for steady state seepage conditions for the "design water surface" (levee top minus 3ft freeboard). As discussed in Phase 1, the likelihood of having steady state seepage through the embankment with water at the levee top is extremely low. As such, areas where there is no levee raise proposed for each alternative will not be recommended for stability improvements such as internal drainage or stability berms. Instead, these areas will be evaluated in detail during the design phase to ensure that there is not considerable risk remaining after the proposed projects are complete. Even though areas where the levee will be raised are at low risk of experiencing steady state seepage with water at the levee top, a raise can easily accommodate internal embankment drainage or stability berms as part of the already planned earthwork, with minor cost impacts. This will ensure that areas being raised will meet criteria and that there are no unacceptable slope stability risks remaining in unraised areas at project completion.

A slope stability analysis was performed on a representative levee segment to determine what stability modifications will be needed for the raised reaches. The representative levee segment was Station 97+00 to 102+30 was analyzed to determine adequate slope stability solutions to address potential future concerns during flood loading. The levee segment between Station 97+00 and 102+30 is of average height (10 ft) and has representative underseepage characteristics.

Table 3-3: Minimum Factors of Safety

Loading Conditions	Recommended Factor of Safety
End-of-Construction	1.3
Steady State	1.4
Rapid Drawdown	1.0 to 1.2[a]
[a]Lower factors of safety may be appropriate when consequences of failure in terms of safety, environmental damage, and economic losses are small.	

Table 3-4: Slope Stability Design Strengths

Material	Friction Angle (ϕ) Degrees	Unit Weight (pcf)[1]
Embankment	26	115
Blanket[2]	26	115
Foundation	32[3]	120
Berm Sand	32[3]	120
Riprap	40[1]	140

[1]Assumed based on experience.

[2]Assummed similar to embankment fill based on 2010 AMEC certification boring logs.

[3]Assummed based on average blow count of 10 reported in 2010 AMEC certification boring logs.

3.4. 0.50% and 0.33% Chance of Exceedance of Levee Raise

This levee raise alternative is between Station 131+00 and 272+00 with an average raise of approximately 1.5 ft. The levee reach between Station 130+00 and 169+00 is along the Kansas River. The levee raise is proposed to be constructed to the landside with exception between Station 149+00 and 163+00 where the levee raise will be on the riverside due to sanitary treatment plant constraint.

3.5. 0.20% Chance of Exceedance of Levee Raise

This levee raise applies between Station 8+00 and 272+00 except between Station 72+00 and 101+00. The levee raise is proposed to be constructed to the landside with an average raise of approximately 2.1 ft. The exception is between Station 40+00 and 64+00 and between Station 149+00 and 163+00 where the levee raise will be on the riverside due to the presence of private properties and a sanitary treatment plant, respectively. Between Station 149+00 and 163+00 the levee raise will require lengthening of the outlet pipe at approximately Station 156+00 and raising of the gatewell at roughly Station 163+00.

3.6. Underseepage Control: 0.50%, 0.33%, and 0.20% Chance of Exceedance

There is not a levee performance report available for the levee from the 1993 flood. However, recollections of field observations by the sponsor indicated that there may have been significant seepage and possible pin boils observed between Station 130+00 and 150+00. While the flood performance documentation is extremely limited, this information does help to lend confidence in the underseepage deficiencies identified in this study between Station 104+95 and 137+00. This study identified poor underseepage performance at Station 101+70 due to poor relief well maintenance and an unauthorized removal of two relief wells along the Poyntz Avenue pump station ditch. The removal is an unauthorized modification to the project, and improving the performance of this area cannot be performed under the authorized study. For the rest of the levee alignment, the following underseepage control features are recommended for each alternative:

a. 0.50% and 0.33% Chance of Exceedance of Levee Raise

Station 40+00 to 64+00: This levee reach has a landside ditch which does not meet criteria when it is empty. Private property lines are adjacent to the ditch and modification will require costly real estate purchases. It is recommended that a minimum ponding elevation of 1015 ft be maintained during flood events to maintain criteria.

Station 64+00 to 97+00: This levee reach is a reach of a generally thin blanket. Private properties are located near the landside toe which excludes underseepage berm as a solution. Installation13 fully penetrating relief wells fully with 12 inch diameters spaced between 200 and 300 ft.

Station 110+00 to 120+00: This levee reach is a reach of a generally thin blanket. Railroad tracks constraint real estate on the landside. Relief well design requires installation of 12 fully penetrating relief wells spaced 100 ft apart.

Station 120+00 to 137+00: This levee reach is a reach of a generally thin blanket. A 100 ft wide underseepage berm with a minimum thickness of 3 ft at the berm toe is recommended to meet criteria.

Station 165+12 to 173+50: This levee reach is a reach of a generally thin blanket. This levee reach is along the Big Blue and Kansas River confluence. A farm is located on the protected side which allows for construction of a 300 ft wide underseepage berm with a minimum thickness of 3 ft at the berm toe is required to meet criteria.

Station 265+70 to 272+00: This levee reach is a reach of a generally thin blanket. The landside contains business buildings adjacent to the levee toe which excludes the construction of underseepage berms. Relief well design requires the installation of 4 fully penetrating relief wells with 12 inch diameters spaced 200 ft apart.

b. <u>0.20% Chance of Exceedance of Levee Raise</u>

Station 18+00 to 23+00: This levee reach has a ponding area located approximately 75 ft from the landside toe. Analysis revealed that it does not meet criteria. Due to the presence of railroad tracks on the landside, relief wells were recommended instead of underseepage berms. The relief well design requires the installation of 6 fully penetrating relief wells with 12 inch diameters spaced 100 ft apart.

Station 40+00 to 64+00: This levee reach has a landside ditch which does not meet criteria when it is empty. Private property lines are adjacent to the ditch and modification will require costly real estate purchases. It is recommended that a minimum ponding elevation of 1015 ft be maintained during flood events to maintain criteria.

Station 64+00 to 97+00: This levee reach is a reach of a generally thin blanket. Private properties are located near the landside toe which excludes underseepage berm as a solution. Installation 13 fully penetrating relief wells fully with 12 inch diameters spaced between 200 and 300 ft. This levee reach will not be raised; as a result, the solution is identical to the 0.33% chance of exceedance.

Station 110+00 to 120+00: This levee reach is a reach of a generally thin blanket. Railroad tracks constraint real estate on the landside. Relief well design requires installation of 12 fully penetrating relief wells spaced 100 ft apart. This solution is identical to the 0.33% chance of exceedance because the levee raise is minimal.

Station 120+00 to 137+00: This levee reach is a reach of a generally thin blanket. A 200 ft wide underseepage berm with a minimum thickness of 3 ft at the berm toe is recommended to meet criteria.

Station 165+12 to 173+50: This levee reach is a reach of a generally thin blanket. This levee reach is along the Big Blue and Kansas River confluence. A farm is located on the protected side which allows for construction of a 300 ft wide underseepage berm with a minimum thickness of 3 ft at the berm toe is required to meet criteria. The berm width is identical to the 0.33% chance of exceedance because the levee raise difference is approximately 1 ft.

Station 190+00 to 210+00: This levee reach is a reach of a generally thin blanket. The landside contains business buildings, water wells, Highway 24, and railroad tracks adjacent to the levee toe which excludes the construction of

underseepage berms. Relief well design requires the installation of 10 fully penetrating relief wells with 12 inch diameters spaced 400 ft apart. The spacing of the relief wells will have to be evaluated in detail due to the heavy presence of infrastructure on the landside.

Station 265+70 to 272+00: This levee reach is a reach of a generally thin blanket. The landside contains business buildings adjacent to the levee toe which excludes the construction of underseepage berms. Relief well design requires the installation of 4 fully penetrating relief wells with 12 inch diameters spaced 200 ft apart. The solution is identical to the 0.33% chance of exceedance because the levee raise difference is about 0.5 ft.

3.7. Slope Stability Control

Evaluation of the representative levee segment indicated a need to construct internal embankment drainage near the landside toe as part of proposed raises. The proposed drain extends from the new landside toe to a point equivalent to the landside crest shoulder projected landward at a 1V:1H slope. The required drain thickness is 3 feet. For a typical section, the drain will be 28 feet wide; the 0.33% chance of exceedance quantities were estimated using 76 ft^3/ft of material, see details in Enclosure C. Potential borrow areas are discussed in the Civil portion of this report.

3.8. Expected Settlement of Design Features

No calculations were performed to determine expected settlement resulting from the 0.33 and 0.20% chance of exceedance levee raises. In this study it is assumed that since the levee raise is minimal it will not lead to significant foundation consolidation since the foundation materials have already consolidated due to the existing levee.

3.9. Recommendations for PED Phase

The following recommendations should be considered in the PED phase of this project:

1) Perform subsurface exploration at locations with sparse boring logs to refine underseepage blanket elevations and facilitate laboratory testing of "undisturbed" samples to determine/refine strength parameters for steady state, end-of-construction, rapid drawdown, and settlement analysis.

Station	Investigation Type	Location	Depth	Proposed Laboratory Testing
95+00	Boring	Centerline	40 ft	[a]R-bar /Index
100+00	Boring	Centerline	40 ft	[a]R-bar /Index
110+00	Boring	Centerline	40 ft	[a]R-bar /Index
113+00	Boring	Centerline	40 ft	[b]Index
116+00	Boring	Centerline	40 ft	[b]Index
119+00	Boring	Centerline	Refusal	[a]R-bar /Index
122+00	Boring	Centerline	40 ft	[b]Index
125+00	Boring	Centerline	Refusal	[a]R-bar /Index
128+00	Boring	Centerline	40 ft	[b]Index
131+30	Boring	Centerline	Refusal	[a]R-bar/Index
134+00	Boring	Centerline	40 ft	[b]Index
137+00	Boring	Centerline	40 ft	[b]Index
140+00	Boring	Centerline	40 ft	[a]R-bar/Index
[d]200+00	Boring	Centerline	40 ft	[c]Consolidation
[d]220+00	Boring	Centerline	40 ft	[c]Consolidation
[d]240+00	Boring	Centerline	40 ft	[c]Consolidation
[d]260+00	Boring	Centerline	40 ft	[c]Consolidation

[a] Used for Underseepage analysis and "undisturbed sampling for steady state, end-of-consolidation, and rapid drawdown slope stability analysis.
[b]Used for Underseepage analysis.
[c]Used for settlement analysis along levee raise.
[d]Borings along Big Blue River Levee Reach.

2) Dig test pits along landside levee toe in locations of proposed sand drains to confirm landside toe material type.

Station	Investigation Type	Location	Depth	Information to be Used For
[a]95+00	Test pit	Landside toe/slope	6 ft or until impervious material is encountered	Determine random material for underseepage analysis
[a]100+00	Test pit	Landside toe/slope	6 ft or until impervious material is encountered	Determine random material for underseepage analysis
[a]130+00	Test pit	Landside toe/slope/Riverside toe	6 ft or until impervious material is encountered	Determine random material for underseepage analysis
[a]140+00	Test pit	Landside toe/slope	6 ft or until impervious material is encountered	Determine random material for underseepage analysis
[a]150+00	Test pit	Landside toe/slope	6 ft or until impervious material is encountered	Determine random material for underseepage analysis
[a]163+00	Test pit	Landside toe/slope	6 ft or until impervious material is encountered	Determine landside random material for stability and underseepage analysis
[a]165+00	Test pit	Landside toe/slope	6 ft or until impervious material is encountered	Determine random material for stability and underseepage analysis
[b]170+00	Test pit	Landside toe/slope/Riverside toe	6 ft or until impervious material is encountered	Determine random material for stability and underseepage analysis
180+00	Test pit	Landside toe/slope	6 ft or until impervious material is encountered	Determine random material for stability analysis
230+00	Test pit	Landside toe/slope	6 ft or until impervious material is encountered	Determine random material for stability analysis
240+00	Test pit	Landside toe/slope/Riverside toe	6 ft or until impervious material is encountered	Determine random material for stability analysis
250+00	Test pit	Landside toe/slope	6 ft or until impervious material is encountered	Determine random material for stability analysis
260+00	Test pit	Landside toe/slope	6 ft or until impervious material is encountered	Determine random material for stability and underseepage analysis
270+00	Test pit	Landside toe/slope/Riverside toe	6 ft or until impervious material is encountered	Determine random material for stability and underseepage analysis

[a]Levee reach along Kansas River.
[b]Levee reach at confluence of Kansas and Big Blue Rivers.

3) Perform settlement analysis to determine levee overbuild requirements in levee raise sections.

4) Detailed analysis of landside slope stability in areas outside proposed levee raises based on anticipated development of embankment through seepage and underseepage for design flood events.

5) Finalize design of relief wells and flow collection systems based on pilot holes boring logs.

US Army Corps
of Engineers
Kansas City District

Part 4
Structural Engineering

Alternatives Engineering
Manhattan, KS

August 2014

Contents

4.1 Background 1
4.2 References 1
4.3 Structural Features for Alternative Plans 1
4.3.1 Plan 2 1
4.3.2 Plan 3 2
4.3.3 Plan 4 2
4.3.4 Plan 5+CW 2
4.4 Structural Feature Overview 4
4.4.1 Drainage Structures 4
4.4.2 Closure Structures 4
4.4.3 Pumping Plant Structures 4
4.5 Enclosures 7
4.5.1 Photos of Structures 7

List of Tables

Table 4-1: Structures and Sandbag Gaps 5

Table of Figures

Figure 1: Riverside face of former stop log gap Sta. 83+24 prior to placement of fill. 7
Figure 2: Sta. 101+26 Poyntz Ave. pump station in foreground adjacent to levee. 8
Figure 3: New Poyntz Ave pump station. Sta. 101+26 8
Figure 4: Sand Bag Gap at Sta. 20+00. Fernandez/Duku standing on right abutment (if viewed from landside). Gap extends across Manhattan Ave. to left abutment across street. Manhattan Ave. pump station in background. 9

4.1 Background

The structural features considered for the Manhattan Levee feasibility study alternative plans (future with project conditions) consist mainly of pump stations and gatewell replacements, additions, or strengthening. The alternative plans examined and documented within Part 4 are listed below:

- Plan 2 raising current level of protection to satisfy passing the .5% flood
- Plan 3 raising current level of protection to satisfy passing the .33% flood
- Plan 4 raising current level of protection to satisfy passing the .2% flood
- Plan 5 +CW raising levee to pass .33% flood and widening of the Big Blue River channel

Structural analysis of the alternatives involved using the previous assessment of structural existing conditions found in the reference below, experience with similar levee improvement projects within the Kansas City District, and engineering judgment. The recommended structural measures for each of the final alternatives are listed below. This analysis was conducted at a level suitable for costing at this stage of the feasibility study. Additional refinements to the structural measures and cost are expected as the plan alternatives are compared and a final alternative selected.

Note that in the existing conditions analysis (Volume 1, Part 4); the components of the existing levee structures were analyzed without factors of safety and with consistent assumptions in order to evaluate the relative risk and consequences for economic and risk-informed decision-making purposes. Risk and Reliability studies do not replace Load and Resistance Factored Design (LRFD) analysis, nor do such studies confirm that the structure and its components satisfy any design criteria, past or present. The existing condition analysis simply provides information about the possible performance of the structure for the loads under consideration.

4.2 References

1. Volume 1 Existing Conditions Engineering Analysis, Part 4

4.3 Structural Features for Alternative Plans

4.3.1 Plan 2

Structural Features - This alternative primarily consists of an average levee raise of .75 feet which will add additional loads to the already non-conforming structures (as detailed in the reference). This would entail replacing of five gatewells and having an Emergency Closure Structure (ECS) of fill and plastic sheathing available if flooding occurs during construction as detailed in the Hydrology and Hydraulics section of the Engineering Appendix Vol. 2.

Costs - Were determined by taking recent information regarding the construction of gatewells for Dodson Flood Protection Project in Kansas City, MO in 2011 with

contingencies added. A potential exists for modifying the existing structures to increase strength verses full replacement that will be investigated during the next phase of work. Structural modifications if proven adequate could lower the overall cost of the project verses full replacement.

4.3.2 Plan 3

Structural Features - This alternative consists of an average levee raise of 1.5 feet which will add additional loads to the already non-conforming structures (as detailed in the reference). This would entail replacing five gatewells and providing the ECS mentioned above.

Costs - Were determined by taking recent information regarding the construction of gatewells in 2011 for Dodson Flood Protection Project in Kansas City, MO with contingencies added.

4.3.3 Plan 4

Structural Features - This alternative consists of an average levee raise of 2.1 feet which will add additional loads to the already non-conforming structures (as detailed in the reference). This would entail replacing thirteen gatewells, raising one gatewell, strengthening the walls and floor slabs of one pump station, and abandonment of the Old By-Pass pump station near Poyntz Ave and adding a Stoplog Gap at Manhattan Avenue and ECS mentioned above.

Costs - Were determined by taking recent information regarding the construction of gatewells in 2011 for Dodson Flood Protection Project in Kansas City, MO. Pump station and stoplog costs were obtained using parametric cost data from cost engineering with contingencies added.

4.3.4 Plan 5+CW

Structural Features - This alternative consists of an average levee raise of 1.5 feet which will add additional loads to the already non-conforming structures (as detailed in the reference). This would entail replacing five gatewells and providing an ECS as mentioned above. This alternative also includes expansions of the Highway 24 and Union Pacific railroad (UPRR) bridges. This expansion would entail extensive rehabilitation of the existing Highway 24 Bridge by extending the eastbound and westbound lanes by approximately 160 feet. The Union Pacific Railroad Bridge, is estimated to be approximately 80+ years-old, and assumed to be a total replacement for cost estimating purposes.

Costs - Were determined by taking recent information regarding the construction of gatewells in 2011 for Dodson Flood Protection Project in Kansas City, MO. with contingencies added. Bridge cost information was taken from the MoDOT preliminary design manual tables. Bridge costs breakdown is as follows:

Highway 24 Bridge Expansion Estimate for Manhattan Feasibility Study								
$ 250.00	Avg. price per SQFT of deck major river crossing per MoDOT reference provided							
	by USACE structural engineering section member with DOT bridge experience.							
160	New total length of bridge (ft) (includes replacement of existing span on left bank)							
32	Width (ft)							
$ 1,280,000								
$ 2,560,000	Two Bridges(East and West), each 2 lanes							
	100% contingency due to unknowns.							
$ 5,120,000	Total Cost							
say								
$5,000,000								

New UP RR Bridge								
$ 405.00	per SQFT	http://on.dot.wi.gov/dtid_bos/e			per SQFT			
$ 9,160.00	per LF	http://www.dot.state.mn.us/pa			per LF			
600	New total length of bridge (ft)							
	(existing is 440 lf plus 160 foot extension from CW)							
20	Width (ft)							
$ -	by SF cost							
$ 5,496,000	by LF cost	Assume higher cost and apply contingency						
	100% contingency due to unknowns:							
$ 10,992,000	Total Cost							
say								
$11,000,000								

Another significant concern with this alternative is on the west side (the City side) of the Highway 24 and UPRR bridges, as there is a highly complex situation involving aesthetic, historic, and recreational aspects. This location is near the main entrance of the Linear Park Trail, a main entrance for hiking and biking. The trail goes under the bridge, and it is fairly evident that it was selected to go through this area in part due to the scenic and historic nature of this particular area. The UPPR Bridge appears to have been constructed during the 1920's or 1930's, and may be eligible for the national registry of historic bridges. Based on these factors, the channel widening alternative could potentially be highly problematic and costly as a result of the many public interests associated with this area.

4.4 Structural Feature Overview

4.4.1 Drainage Structures

Drainage structures associated with the Manhattan Levee include: gated through levee drainage structures and a conduit over the levee. The project has 29 drainage structures with two located in the ponding levee. The project contains 16 gated main embankment structures and two gated ponding levee structures. Table 4-1 below provides details of these structures as well as for other project structures.

4.4.2 Closure Structures

Closure structures associated with the Manhattan Levee originally included one stoplog gap and two sandbag gaps. The stoplog gap at Station 83+24 and the sandbag gap at Station 194+48 were constructed to accommodate railroad lines that intersected the flood protection system. The railroad line that used the stoplog gap has since been abandoned. The stoplog gap has been permanently closed with the construction of a floodwall spanning between the stoplog slots. It is unclear exactly when this wall was constructed. The railroad constructed the original stoplog gap and no plans are available of that construction. In addition, it is unclear who constructed the floodwall to close the structure, and no plans are available for this replacement (see appendix, photo # 1). An analysis was conducted of the in-fill wall for strength during this phase of work and can be found in reference 1. The in-fill wall was found to be unacceptable for strength with water to top-of-wall. Per the recommendations in reference 1, the Sponsor has since added approved fill to the riverside of the structure to equalize loading. The sandbag gap at Station 194+48 has a concrete sill and was constructed with the rest of the levee project in 1963. The third, a sandbag gap at Manhattan Avenue, was constructed to accommodate the main levee flood protection system (see appendix, photo # 4). This sandbag gap simply consists of the roadway and shoulders and was constructed with the rest of the levee project in 1963.

4.4.3 Pumping Plant Structures

There are three structures associated with the Manhattan Levee. The Manhattan Avenue Pumping Plant is located at Station 20+13, Poyntz Avenue Pumping Plant located at Station 101+26 reconstructed in 2002, and the Old-By-Pass pump station located at Station 98+80. In addition to the pump wells and the associated gatewell structures, each of these plants has building structures that protect the pumps and equipment. The Manhattan Avenue and Old-By-Pass plants have a metal panel building enclosing its pumps. The Poyntz Avenue plant has modular block retaining walls surrounding a block wall building enclosing its pumps (see appendix, photos # 2, 3, 4).

Table 4-1: Structures and Sandbag Gaps

TABLE 3.1 Structures and Sandbag Gaps													
Station	Element in which Structure Located	Pipe ф (inch)	Type	Qty	Pipe Invert (ft) (at the Outlet)	Entrance/Exit Structure		Gate Type(s)			Drawing Year	Recorded In	Remarks
						Inlet	Outlet	GW	FG	SG			
14+78	Tieback Levee	84	RCP CMP	1	1000.88	ST	CS	X	X	X	1963	ABD	2 Gatewells Plate Nos.14, 18 & 20
20+00	Tieback Levee	Sandbag Gap at Manhattan Ave.									1963	ABD	Plate No. 3
20+13	Tieback Levee	72	RCP	1		ST	CS	X	X	X	1963/ 2003	ABD	Manhattan Ave Pumping Plant and GW Plate Nos. 23-25, 30-35, 37-38
34+62	Tieback Levee	24	RCP	1	1007.72	ST	CS	X	X	X	1963	ABD	Plate Nos. 15, 19 &21
40+00	Tieback Levee	66	RCP	1	*	*	*	X	*	*	*	2010 AI	Structure construction noted in 2010 AI photos
62+20	Tieback Levee	48	RCP	1	1002.9	CS	CS	X	X	X	1963	ABD	Plate Nos. 15 & 20
69+00	Tieback Levee	60	RCP	1	*	*	*	X	*	*	*	2009 Letter	Structure construction approved in 2009 ED-G Letter
81+25	Tieback Levee	24	RCP	1	1005.5	CS	CS	X	X	X	1963	ABD	Plate Nos. 15, 19 & 21
83+24	Main Levee	Stoplog Gap at UPRR. Gap constructed by RR. Gap later closed with floodwall (After 1977 PI). ED-DS is planning to make a site visit to obtain field measurements of the floodwall prior to PI.									1963	ABD	Plate No.5 and info. from Feasibility Study
89+83	Main Levee	72	RCP	1	995.7	ST	CS	X		X	1963	ABD	Plate Nos. 15 & 19
98+80	Main Levee	14	CIP	1	999.7	*	CS	GV	X		1963	ABD	Pressurized Flow Plate Nos. 16, 19 & 21
99+15	Main Levee	24	RCP	1	991.34	ST	CS	X	X	X	1963	ABD	Plate Nos. 16, 19 & 21
99+29	Main Levee	24	CIP	1	*	*	CS	*		*	*	PI 1	Recorded in 1971 PI 1, Page III-4-8
101+26	Main Levee	10' x10'	RCB	1	989.3	CS	CS	X	X	X	1963	ABD	Poyntz Ave Pumping Plant and GW Plate Nos. 26-38
105+05	Main Levee	24	CIP	1	1000.4	*	CS	X	X	X	1963	ABD	Plate Nos. 16, 19 & 21
155+00	Main Levee	*	*	1	*	*	*	X	*	X	*	PI 2	Recorded in 1977 PI 2, Page III-2-3-2
163+00	Main Levee	84	RCP	1	992.8	CS	CS	X		X	1963	ABD	Plate Nos. 53, 55 & 56
194+48	Main Levee	Sandbag Gap at UPRR.									1963	ABD	Plate No. 54
234+00	Main Levee	24	RCP	1	1000.0	CS	CS	X	X	X	1963	ABD	Plate Nos. 53, 54 & 56
269+50	Main Levee	72	RCP	1	996.9	CS	CS	X	X	X	1963	ABD	Plate Nos. 53, 55 & 56
West Crossing of Fairlane	Man. Ave. Ponding Area	36	CMP	1	1010.0						1963	ABD	Plate No. 3

TABLE 3.1 Structures and Sandbag Gaps

Station	Element in which Structure Located	Pipe ф (inch)	Type	Qty	Pipe Invert (ft) (at the Outlet)	Entrance/Exit Structure		Gate Type(s)			Drawing Year	Recorded In	Remarks
						Inlet	Outlet	GW	FG	SG			
East Crossing of Fairlane	Man. Ave. Ponding Area	36	CMP	1	1010.0						1963	ABD	Plate No. 3
Between Southern Ponding Areas	Man. Ave. Ponding Area	48	CMP	1	1010.0						1963	ABD	Plate No. 3 & 14
14+50	Man. Ave. Ponding Area	12	CMP	1		CS					1963	ABD	Plate Nos. 3 & 10
18+25	Man. Ave. Ponding Area	12	CMP	1		CS					1963	ABD	Plate Nos. 3 & 10
10+00	Poyntz Ponding Levee	18	*	1	*	*	*		X		1963	ABD/ Pl 1	Plate No. 48 in ABD and 1971 Pl 1, Page III-4-11
20+73	Poyntz Ponding Levee	18	*	1	*	*	*		X		1963	ABD/ Pl 1	Plate No. 48 in ABD and 1971 Pl 1, Page III-4-11
22+00	Landside Drainage Ditch	24	CMP	1	1016.2						1963	ABD	Plate No. 3
44+95	Landside Drainage Ditch	24	CMP	1	1009.2						1963	ABD	Plate Nos. 4 & 10
47+75	Landside Drainage Ditch	24	CMP	1	1008.5						1963	ABD	Plate Nos. 4 & 10
56+25	Landside Drainage Ditch	36	CMP	1	1006.4						1963	ABD	Plate Nos. 4 & 10
61+12	Landside Drainage Ditch	42	CMP	1	1005.2						1963	ABD	Plate Nos. 4 & 10

4.5 Enclosures

4.5.1 Photos of Structures

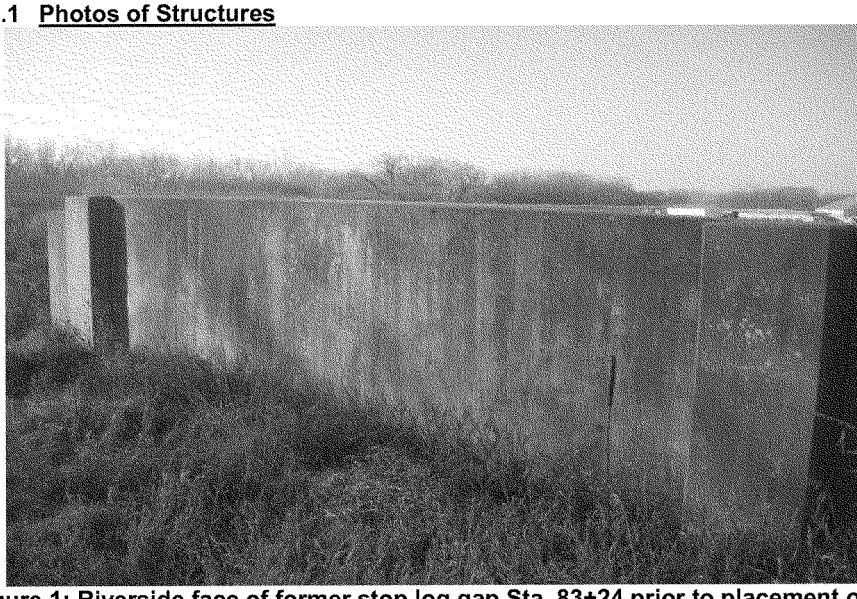


Figure 1: Riverside face of former stop log gap Sta. 83+24 prior to placement of fill.

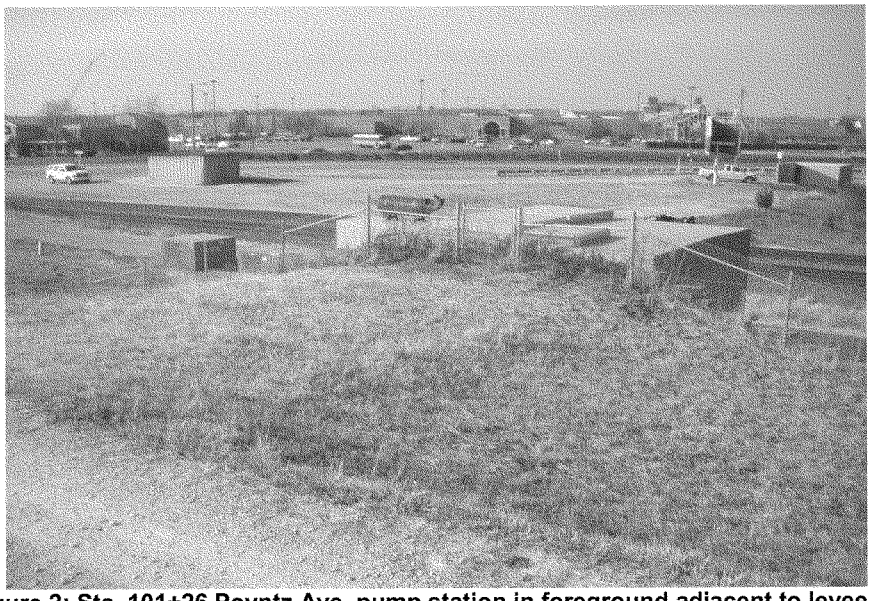


Figure 2: Sta. 101+26 Poyntz Ave. pump station in foreground adjacent to levee. Notice Old By-Pass pump station in the background near white GSA vehicle.

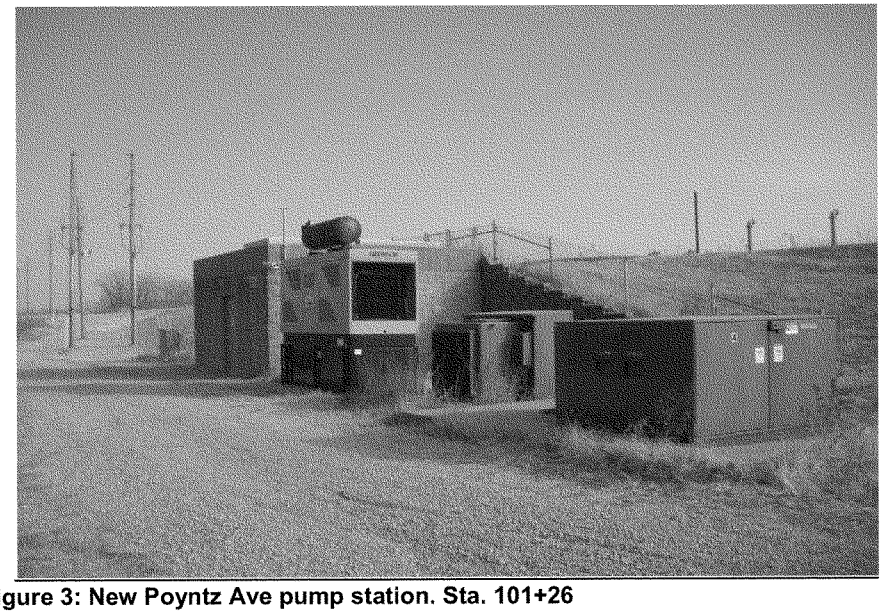


Figure 3: New Poyntz Ave pump station. Sta. 101+26

Figure 4: Sand Bag Gap at Sta. 20+00 Standing on right abutment (if viewed from landside). Gap extends across Manhattan Ave. to left abutment across street. Manhattan Ave. pump station in background.

US Army Corps
of Engineers
Kansas City District

Part 5
Civil

Alternatives Engineering
Manhattan, KS

August 2014

Contents

5-1. Introduction 1
5-2. Utility Uplift Anaylsis 1
5-3. Above Ground Utilities and Features 1
5-4. Pump Station Assessment 1
5-5. Road Raises 2
5-6. Items of Consideration to Improve Reliability of Utilities for Resisting Uplift And Proposed Levee Raises 2
5-7. Alternative Plans 4
5-8. Summary Of Survey Work 4
5-9. References 5

5-1. Introduction

This document presents results of utility uplift and limited hydraulic consideration of pump stations. Plans considered include:

-Plan 1 – No Federal action.

-Plan 2 – 0.5% plan – raising the current levee to pass the nominal 0.5% chance flood event profile with accompanying geotechnical and structural reliability improvements.

-Plan 3 - 0.33% plan – raising the current levee to pass the nominal 0.33% chance flood event profile with accompanying geotechnical and structural reliability improvements.

-Plan 4 – 0.2% plan – raising the current levee to pass the nominal 0.2% chance flood event profile with accompanying geotechnical and structural reliability improvements.

-Plan 5 – 0.33%+CW plan – raising the current levee according to plan 3 with the addition of channel widening (CW) and bridge modifications on the Big Blue River for increased flood conveyance.

Plan 3 is the recommend plan. This alternative entails a levee raise averaging 1.5 feet, with a maximum raise of approximately 3.3 feet. The other plans were considered, but only to sufficient detail to allow comparison and evaluation. Please refer to the existing conditions analysis for full calculations and figures to support the analysis.

5-2. Utility Uplift Anaylsis

Please refer to the existing conditions analysis and the summary section of this document for results of uplift analysis and recommendations for addressing problematic areas.

5-3. Above Ground Utilities and Features

Above ground features such as bridges and overhead utilities were considered with regard to prospective levee raises, and how those levee raises might affect clearance. No bridges were in the range of the plan 3 alternative raise. Levee raises associated with the plan 3 alternative average 1.5 feet, with a maximum raise of 3.3 feet, resulting in a decrease in clearance for overhead electric lines at two locations. Limited field efforts determined that these lines probably would still have sufficient clearance, even with the levee raise, however cost contingencies are included to cover the unlikely possibility that these lines would need to be raised.

5-4. Pump Station Assessment

The plan 3 alternative considers relief wells, all of which would discharge within the drainage area of the Poyntz Avenue pump station. The Manhattan Avenue Pump Plant would be unaffected. The plan 2 alternative would entail somewhat fewer relief wells, but at similar locations.

The original Poyntz Avenue station was demolished and replaced with a new / larger station in 2003 by local interests. While design documentation was unavailable, this larger station was most likely required as a result of extensive development within the drainage area and possibly some filling of the original ponding area. Adding relief well flow would result in this station becoming a "dual purpose" facility, e.g. handling runoff from an intense local storm coincident with river stages just high enough to require pumping (design storm); and handling runoff from a somewhat smaller coincident storm coincident with high river stages, resulting in maximum relief well flow (design river stage). The "design storm" case would be expected to control nearly every time, particularly in this case, where the discharge is up and over the levee and therefore pumping capacity is unaffected by changes in river stage. So while the hydraulic effect of additional relief wells was not calculated, it is assumed to be negligible for the reasons noted above and will be confirmed during the design phase. The possibility for needing to increase pumping capacity at Poyntz, while believed to be very small, was captured as a line item in the cost and schedule risk analysis.

The plan 4 raise would entail extensive numbers of relief wells throughout the system, resulting in the need for at least one new pump station. This was accounted for as a line item in the plan 4 cost estimate.

5-5. Road Raises

The plan 3 levee raise originally considered a 500 foot road raise at the Casement Road tie-in. This road raise would also extend through the intersection at Hayes Drive and terminate near Judson Street. No utility relocations were identified at this location. Cost estimate quantities were considered for pavement removal, fill for the tie in and for transitions, and re-paving. No other road raises were anticipated for plan 3.

The PDT was later asked to consider alternatives to the road raise, and developed preliminary costs for extending the levee southwest along Casement Road, terminating near Judson Street, and leaving a 90 foot long x 2 foot high sandbag gap across Hayes Drive. While this option was found to be feasible, and at less cost than the road raise, it would require the Sponsor to seal off the sandbag gap during times of high flow. This option was cooridinated with the Sponsor, who preferred this type of arrangement to the road raise. As such, the cost estimate was updated to include this levee extension with sandbag gap in lieu of the road raise.

5-6. Items of Consideration to Improve Reliability of Utilities for Resisting Uplift And Proposed Levee Raises

The PDT was asked to consider what improvements would be required to address deficiciencies noted under existing conditions and to provide various magnitudes of levee raises. These improvements include a various levee raises, berms and / or relief wells, improvements to existing structures, and incidental utility relocations and other work.

Vicinity of Station 110+00 to 150+00, ID 17cz, 22cz, 23cz

This area is characterized by an interceptor sewer transitioning from 42-inch to 54-inch as it picks up flow from a 36-inch trunk, in an area where the Kansas River is particularly close to the levee, and excess heads are high under extreme flooding conditions. The manhole with the most uplift force under extreme conditions would require approximately 75,000 pounds of downward force to prevent flotation. This downward force could be provided by anchors, heel extensions, or simply by adding weight. For purposes of estimating potential costs, a 20 foot diameter x 3 foot thick concrete ring is assumed for each of eleven manholes in this area. Any potential alternatives involving berm construction in this area would require top slabs of these manholes to be raised accordingly to match the final ground surface elevation.

Vicinity of Station 255+00 – 272+00, ID 34CZ

This sewer is located in an area where excess heads under conditions of high river stage could cause unacceptable uplift forces on manholes. These manholes will not experience the same level of uplift as those discussed above, however for purposes of estimating potential costs, a 20 foot diameter x 3 foot thick concrete ring is assumed for each of three manholes in this area.

Other Utilities

Thirty power poles within the area of the proposed berm from Station 104+00 to 140+00 would need to be raised an average of 8 feet.

An 8-inch diameter gas line at Station 227+00 currently passes up and over the existing levee. This gas line will need to be raised approximately 3 feet to accommodate the proposed levee raise in this area, and new isolation valves installed.

A 36-inch diameter water line at Station 232+28 currently passes up and over the existing levee. The water line will need to be raised approximately 3 feet to accommodate a proposed levee raise in this area, and new isolation and air release valves installed.

Five gate well structures are proposed for replacement, as described in the structural section of the report. Three of the gate wells are located in areas in which the levee is not being raised. In these cases, the inlet and outlet pipes to be replaced are assumed to be very short; the minimum length so as to allow the existing gate wells to be demolished and new structures built. Two of the gate wells (Sta 163+00 and Sta 269+50) are located in areas in which the levee is being raised. Since these inlet and outlet pipes will experience higher loads as compared to original designs, full pipe replacement is recommended and included in the cost estimate.

Borrow Quantities and Source of Material

The total fill quantity was estimated at 200,000 bank cubic yards (BCY), based on early evaluation of likely levee raise and berm locations. This amounts to an area approximately 13 acres by 10 feet deep. Later refinement resulting in a lesser required borrow amount, however the original 200,000 BCY figure was retained for purposes of identifying prospective borrow areas. There is a large open area approximately one mile north of the Big Blue confluence that was originally considered for purposes of generating estimated costs. "On highway" vehicles (e.g. excavate / load onto trucks, travel on public roads) would be used to transport this material on Knox Lane, west to Casement Road, south to the levee, and then traveling along the levee, for a total one way haul distance of approximately 3 miles. This area was later determined to be unavailable, prompting Corps staff to conduct a limited sensitivity analysis of haul distance effect on estimated construction cost. This effort showed that, even with a doubling of the haul distance (6 miles), cost increases were small (less than 5%) relative to the overall project. Cost increases to the earthwork components of the project (levee raise and berms), however, are more significant. Therefore, the cost estimate includes costs for borrow material purchased as a provision of the construction contract, and also contains contingencies to capture the potential costs associated with a longer haul distance.

5-7. Alternative Plans

The PDT was asked to consider alternate plans to address deficiencies noted under existing conditions and to provide various combinations of features and levels of raise. These alternatives were not developed to the level of the plan 3 preliminary key concept, but contained sufficient detail so as to allow preliminary comparison and evaluation. The alternatives included plan 2, plan 4, and plan 3 with channel widening. Earthwork quantities are included with the cost estimating information, and while they vary between alternatives, tend to be driven largely by fill requirements underseepage berms which are needed for all proposed levee raises. Utility relocations are also provided in the cost estimating information, and are pro-rated based upon results from the plan 3 alternative. Other uplift and utility concerns are the same for all other alternatives as for plan 3, that is, they need to be remedied, as discussed in part 4.6, regardless of the level of levee raise.

5-8. Summary Of Survey Work

Survey information was obtained from a variety of sources, and is discussed in a series of memos in the project file. Most of the recent information is in NAD 83 (H) and NAVD 88 (V) datums. Some of the older information such as Corps of Engineers record drawings is in NAD 27 (H) and NGVD 29 (V) datums. The PDT is aware of the differing survey datums, and adjusts information as required to ensure consistency in the results presented.

The survey information currently available is believed to be adequate for feasibility-level efforts, but not for detailed design. When design efforts commence, a new survey will be conducted.

5-9. References

US Army Corps of Engineers. Operation and Maintenance Manual: Flood Protection Project, Kansas River Basin, Manhattan, Kansas, revised June 1980

Kansas City District Geotechnical Design and Dam Safety Section Guidance for Uplift, January 2003, http://www.nwk.usace.army.mil/geotech/pdf/uplift.pdf

US Army Corps of Engineers, EM 1110-2-2100: Stability Analysis of Concrete Structures

US Army Corps of Engineers. Construction Plans for Levees and Appurtenances: Flood Protection Project, Kansas River, Manhattan, Kansas, February 1961

US Army Corps of Engineers. EM 1110-2-1913: Design and Construction of Levees, 30 April 2000

American Society for Testing and Materials (ASTM). C76: Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe

American Society for Testing and Materials (ASTM). C700: Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated

Flood Protection Project Manhattan, Kansas, Supplemental Design Memorandum No. 1-C (1960) was used in the development of Paragraphs; Design Storm.
Riley County GIS website http://gis.rileycountyks.gov/

REAL ESTATE PLAN (REP)
MANHATTAN LEVEE
FLOOD DAMAGE REDUCTION PROJECT
FEASIBILITY REPORT
RILEY COUNTY AND POTTAWATOMIE COUNTY, KANSAS

1. PURPOSE:

This Real Estate information is developed in support of the Feasibility Report for the subject project under authority of Section 216 of the 1970 Flood Control Act authorizing the review of completed projects. The Reconnaissance Report published in March of 2004 identifies a potential Federal interest in flood damage reduction measures. The non-Federal sponsor (NFS) for the Feasibility Study is the City of Manhattan, Kansas. The purpose of this plan is to include information on any real estate activities that may be involved for the identified project. The levee system is located in and around the City of Manhattan, Kansas, in the counties of Riley and Pottawatomie within the Kansas and Big Blue River basins.

The NFS requested Corps assistance to develop and construct a flood damage reduction project. Potential for overtopping was indicated along the Big Blue River section of the Manhattan levee system during a 1993 flood incident that could result in loss of life and/or property damage in the Big Blue and Kansas River basins created a need for this project.

The City of Manhattan is located in central Kansas, and lies at the confluence of the Big Blue River and the Kansas River. The Big Blue River is on the east side of the downtown area and connects to the Kansas River on the southeast side of the city. Both rivers have a history of repeated and sometimes catastrophic flooding. A number of Corps lake projects have provided some relief for these rivers in the mid-twentieth century, and this has resulted in some reduction of flooding risks in the Manhattan area. The Manhattan levee unit is located generally west and north of the confluence of the Big Blue River and the Kansas Rivers, and is approximately 28,850 feet long. The levee was typically constructed with a 10-foot crown width and three horizontal to one vertical (3H: 1V) embankment slopes. The levee is predominantly an earthen unit - with a limited number of concrete and steel structural components. The land area within the levee unit is almost completely developed and exhibits intense commercial, governmental and light industrial uses accompanied by an extensive residential population generally located near the outer reaches of the current protection.

2. DESCRIPTION OF LANDS, EASEMENTS, RIGHTS OF WAY, RELOCATION AND DISPOSAL (LERRD):

The area consists of a broad range of properties ranging from highly developed urbanized residential, commercial, and industrial areas within the City of Manhattan, to undeveloped areas that are primarily used for agricultural rowcrop production, to the areas riverward of the levee system that consist of remnants of the wooded riparian corridor of the Big Blue and Kansas Rivers.

The recommended plan includes raising approximately 14,100 linear feet of existing levee an average of 1.5 feet and up to 3.3 feet depending on location and existing ground contours. A 500 foot extension and one new sandbag gap is needed for high ground tie-in. The recommended plan will require replacement of five gatewells located between Stations 14+78 and 269+50 , 29 relief wells located between Stations 64+00 to 272+00, one relief well collector system and two underseepage berms located between Stations 120+00 to 173+50.

The plan requires 5.35 acres of permanent easements for flood protection and 6.95 acres of temporary work area easements and is further described in Table 2.1 below. Real Estate interests are not required for the borrow area, which will be purchased from the adjacent landowner on a truckload basis.

Table 2.1 **Manhattan Levee LER Requirements**

Type of Easement/Estate	Owner	Acreage	Number of Tracts	Estimated Value
Permanent Flood Protection Easement	Private Owners	1.85	19	$ 150,482.24
Permanent Flood Protection Easement	City of Manhattan	3.41	18	$ 270,770.79
Permanent Flood Protection Easement	Westar Energy	.02	1	$ 1,587.05
Permanent Flood Protection Easement	Railroad R-O-W	.07	1	$ 5,103.01
Total Permanent Flood Protection Easements		**5.35**	**39**	**$ 427,943.00**
Temporary Work Area Easement (3 yrs)	Private Owners	2.98	41	$ 52,199.61
Temporary Work Area Easement (3 yrs)	City of Manhattan	3.22	22	$ 53,037.92
Temporary Work Area Easement (3 yrs)	Kansas State Military Board	0.14	1	$ 2,152.15
Temporary Work Area Easement (3 yrs)	Westar Energy	0.34	1	$ 5,349.33
Temporary Work Area Easement (3 yrs)	Railroad R-O-W	0.27	3	$ 4,270.90
Total Temporary Work Area Easements		**6.95**	**68**	**$ 117,010.00**
Total LER Requirements		**12.30**	**107**	**$ 544,953.00**

Standard estates to be acquired by the NFS are as follows:

FLOOD PROTECTION LEVEE EASEMENT:
A perpetual and assignable right and easement in (the land to be described) to construct, maintain, repair, operate, patrol and replace a flood protection (levee)(floodwall)(gate closure), including all appurtenances thereto; reserving, however, to the owners, their

heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

TEMPORARY WORK AREA EASEMENT:
A temporary easement and right-of-way in, on, over and across (the land to be described) for a period not to exceed three (3) years, beginning with the date possession of the land is granted to the non-Federal sponsor, for use by the non-Federal sponsor, its representatives, agents, and contractors as a work area, including the right to move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the Flood Protection Project together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3. LERRD OWNED BY NON FEDERAL SPONSOR:

The City of Manhattan owns fee over approximately 264 acres along the project area. These lands are available for the project but not sufficient to cover all improvements, so additional easements will be required as shown in Table 2.1. As per ER 405-1-12, Chapter 12, paragraph 12-38 "The non-Federal sponsor shall not receive credit for the value of any LER, including incidental costs that have been provided previously as an item of cooperation for another Federal project."

4. NON-STANDARD ESTATES:

There will be no non-standard estates proposed for this project area.

5. EXISTING FEDERAL PROJECTS IN THE AREA:

There are no existing Federal Projects within the proposed project area.

6. FEDERALLY OWNED LAND IN PROJECT AREA:

There are no known Federally owned lands within the LER required for the project.

7. NAVIGATIONAL SERVITUDE:

The project does not require any LER below the ordinary high water mark or mean high water mark, therefore Navigational Servitude is not applicable and will not be exercised for this project.

8. REAL ESTATE MAPS:

Project maps are included as EXHIBIT "A" and depict the project boundary, permanent and temporary easements, utilities to be relocated and any known or potential HTRW lands.

9. FLOODING INDUCED BY PROJECT:

Minor induced damages from implementation of the Recommended Plan will occur under certain conditions. Upstream of the project, several residential houses are unprotected by any levee. This area is currently vulnerable to flooding but economic damages did not justify the cost for project inclusion. The hydrologic analysis showed there would be some induced flooding but only once the 190-year event occurred. During these flood events, the Recommended Plan does not significantly increase the area of inundation but can increase the depth of flooding by less than five inches in most cases. Given this, the induced damage impact of the Recommended Plan on each structure is essentially inconsequential compared to the existing damages that would already be occurring from the normal river flooding in these areas. Additional discussion and mapping of the induced damages is provided in the Feasibility Report, Engineering Appendix, Volume 2, Part 2 – Hydrology and Hydraulics, Section 2-3.2.

10. BASELINE COST ESTIMATE ON ACQUISITION OF LERRD:

For a summary of total real estate costs see table 10.1. Temporary work area easements and permanent flood protection levee easements will be required and are included in the cost estimate along with incidental costs for the NFS and in-house Federal administrative costs. When there was an absence of specific information relating to suspect contaminated area, for this cost estimate, it was prudent to value the land as clean. Known areas of contamination will be avoided to the fullest extent possible. The NFS will be responsible for all clean up of environmental contamination and is aware of this fact.

Below is a summary table of the Real Estate Baseline Cost Estimate for LERRD, NFS incidental costs, In-House Labor costs and Contingencies by Sponsor. LERRD values are based upon the Informal Value Estimate completed by the Kansas City District Corps of Engineers Real Estate Appraisal Office.

TABLE 10.1 - Baseline Cost Estimate	
Type of Costs	Total Costs
Land Value Estimate	
Temporary Work Area Easement	$ 117,010.00
Permanent Flood Protection Easement	$ 427,943.00
Total Land Value Estimate	**$ 544,953.00**
25% Contingency	$ 136,238.00
Total Real Estate Acquisition Costs w/ Contingency	$ 681,191.00
Utility/Facility Relocation Costs	
Utility Relocation	$ 685,700.00
26% Contingency (rounded)	$ 180,760.00
Total Utility/Facility Relocation w/ Contingency	$ 866,460.00
LERRD Administrative/Incidental Costs.	
Non-Federal Sponsor Incidental Costs	$698,800.00
Federal Incidental Costs	$ 53,500.00
Total Incidental Costs	**$752,300.00**
20% Contingency	$ 150,460.00
Total Incidental Costs w/ Contingency	$902,760.00
Total LERRDS Costs for Project	$2,450,411.00

For an estimate of the full project, please see the Cost Engineering Appendix located in the Feasibility Report.

11. RELOCATION ASSISTANCE (P.L. 91-646):

The NFS has been provided information on P.L. 91-646 and is aware of the obligation to ensure compliance. There are no persons, farms or businesses being displaced.

12. MINERAL ACTIVITY IMPACTED PRESENT/FUTURE:

A review of the proposed project has been completed to identify any present or anticipated mineral activity. This review included a search for oil, gas or any other subsurface minerals along with any timber harvesting activity. The review indicates that there are no current or anticipated mineral or timber harvesting activity in the vicinity of the proposed project.

13. ASSESSMENT OF NON-FEDERAL SPONSOR LEGAL CAPABILITY:

The Corps has coordinated with the NFS to complete the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capabilities Checklist, See Exhibit "C". The NFS has the legal authority to acquire and hold title to real property and condemnation authority and is fully capable of contracting for all real estate needs for the project. The sponsor will not require

USACE assistance with acquiring real estate. Financial capability is addressed in the main report.

Exhibit "C" indicates that this is the first project working with the NFS. The original Manhattan levee project was 100% Federally funded with the NFS responsible for obtaining LER and providing maintenance, of which they performed these duties with full satisfaction.

14. ZONING ORDINANCES CONSIDERED IN SUPPORT OF LERRD REQUIRMENTS:

There are no zoning ordinances proposed in connection with the project.

15. REAL ESTATE ACQUISITION SCHEDULE:

The project sponsor is responsible for acquiring real estate interests required for the project. A time frame for land acquisition has been outline for the area of interest ranging from six months to one year and can begin when final plans an specs have been completed and the Project Partnership Agreement (PPA) has been executed The Project Manager has coordinated with the Sponsors on the formulation of this schedule and has received their concurrence.

- June 2015 - Execute Design Agreement with Sponsor.
- March 2017 - Execute Project Partnership Agreement with Sponsor and issue notice to proceed with land and easement acquisition to the Sponsor.
- March 2018 - Certification of Real Estate.
- April 2018 - Initiate project construction.
- December 2022 - Complete project construction.

16. FACILITY/UTILITY RELOCATION:

In accordance with Policy Guidance Letter No. 31, a preliminary attorney's opinion of compensability has not been prepared because the relocations do not exceed 30% of the total project costs. The estimated costs for utility relocations are less than 5% of the project costs. A real estate assessment has been prepared and details are discussed after Table 16.1.

"ANY CONCLUSION OR CATEGORIZATION CONTAINED IN THIS REAL ESTATE PLAN, OR ELSEWHERE IN THIS PROJECT REPORT, THAT AN ITEM IS A UTILITY OR FACILITY RELOCATION TO BE PERFORMED BY THE NON-FEDERAL SPONSOR AS PART OF ITS LERRD RESPONSIBILITIES IS PRELIMINARY ONLY. THE GOVERNMENT WILL MAKE A FINAL DETERMINATION OF THE RELOCATIONS NECESSARY FOR THE CONSTRUCTION, OPERATION, OR MAINTENANCE OF THE PROJECT AFTER FURTHER ANALYSIS AND COMPLETION AND APPROVAL OF FINAL ATTORNEY'S OPINIONS OF COMPENSABILITY FOR EACH OF THE IMPACTED UTILITIES AND FACILITIES."

The following utilities are located within the footprint of the project:

Table 16.1: Utilities that Require Relocation

Station (ft.)	Type	Owner	Substitute Facility Required
227+00	8" Gas Line	Kansas Gas Service	No
232+28	36" Raw Water Line	City of Manhattan	Yes
197+85 to 212+70	2 Telephone Cable	SBC & Wamego Telecommunications	No
155+00	Wastewater Treatment Plant Outlet Pipe	City of Manhattan	Yes
120+00 to 137+00	18 Power Poles	Westar Energy, Inc.	No
120+00 to 137+00	11 Manhole Raises	City of Manhattan	Yes

The Real Estate Assessment determined that Westar Energy, Inc., Kansas Gas Service and Wamego Telecommunications were all responsible for the relocation of their own lines in the event that the Sponsor has a public project in progress. In a teleconference with the Sponsor's representative and Attorney, they stated that Southwestern Bell Telephone Company, doing business as AT&T Kansas and Southwestern Bell Telephone L.P., formerly known as SBC Kansas have not agreed to the City's terms of the franchise, therefore they (not the sponsor) are responsible for relocation of their telephone cables. Since all owners of utilities discussed in this paragraph do not have a compensable interest in the property they are responsible for their own utility relocations and the project will not provide substitute facilities for these utilities.

The 36" raw water line, wastewater treatment plant outlet pipe and manhole raises are all owned by the Sponsor, it owns a compensable interest in them, and they are eligible for a substitute facility, therefore the costs of the substitute facilities for these facilities will be included in the relocation costs of the project.

The Sponsor also owns a 14" sanitary sewer line that is located near Station 178+24 within the project footprint, however this sewer line will not need to be relocated or raised.

The Real Estate Assessment discussing all utility relocations is on file in the Real Estate Division.

17. IMPACT OF HTRW:

A phase I Environmental Site Assessment (ESA) was performed for the Manhattan Levee in February 2004 and an updated review was completed in November 2013. In total, six sites were identified as potential areas of concern. The findings are as follows:

a. Manhattan PWS Wells #14 and #15 – Manhattan Industrial Park North of Kretschner:
This is a CERCLIS (Comprehensive Environmental Response, Compensation and Liability Information System) site. Volatile organic compounds (VOCs) have been detected at the wells intermittently since 1986. These two wells are directly adjacent to the riverward toe of the levee at approximately Station 211+00 and Station 213+00. A specific site causing contamination in PWS #14 and #15 wells was identified as the Former Quaker Manufacturing, LLC Facility located at 1111 Kretschmer. Investigations were performed and a groundwater plume contaminated with Trichloroethylene (TCE) was delineated. The plume extends below the levee from station 215+00 to 218+00. This is the only site that overlaps with the required LER. A remedial action has been taken and includes operation of a soil vapor extraction system and injections to enhance anaerobic bioremediation. There is no permanent acquisition or excavation work for the project at the site.

b. Manhattan PWS Wells #12 and #13 – Hayes Drive and North Kretschner Drive:
This site is also a CERCLIS site. VOCs have been detected at the wells intermittently since 1986. These wells are located about 1000 feet landward of the levee, (between Station 249+49 and Station 260+00) but were included due to the nature of contamination. Similar to the PS #14 and #15 site, separate upgradient sites were identified to be the cause of contamination of the PW wells. The plume for the upgradient sites has been delineated and remains well over 1,000 feet from the levee and should have no impact on the proposed modifications. In addition, this site does not overlap with the LER required for the Recommended Plan.

c. Wildcat Creek – 705 South 15th:
This site contains one leaking underground storage tank with a status of Active indicating that levels of contamination exist at the site that are greater than the cleanup levels set by the state. Further remedial work will be required to bring this site into compliance with state and federal laws. It is believed the site is directly adjacent to the start of the levee at Station 8+50 on the creek side and should have no impact on the Recommended Plan. This site does not overlap with the LER required for the Recommended Plan.

d. Private Disposal Site:
A privately owned disposal site was identified at approximate levee Station 63+00. It is located at the intersection of Temple Lane and the levee, on the southeast corner. A drainage ditch exists between the levee and the site. The site is wooded and approximately 3 acres in size. Contents of the site include large and small vehicles, trailers, loaded dumpsters, tires, and appliances. Potential soil and groundwater contamination from numerous sources is possible at this site however no updated information was found for this site and it has not been identified by Kansas Department of Health and Environment (KDHE) as a contaminated site. The site is on the creek side of the levee and the Recommended Plan is confined to the land side of the levee. This site should have no impact on the modifications and there is no overlap with the LER required for the Recommended Plan.

e. Railroad Tracks:
Railroad tracks exist adjacent to the toe of the landward side of the levee from

approximate Station 89+00 to Station 120+00. Potential contamination in the immediate vicinity of the railroad tracks includes creosote from the railroad ties and petroleum products leaking from cars, including greases, hydraulic fluids, brake fluids, and fuel among other things. Since the 2004 ESA, no additional information has been found to indicate contamination of soil or groundwater along the railroad tracks or spills from rail cars. Although no groundwater contamination has been identified in this area, the potential exists. It is recommended that groundwater data be collected in this area to ensure installation of relief wells will not result in the discharge of contaminants to the surface. If contamination does occur, it is the NFS's responsibility to clean up the site. Additional investigations of contamination in the railroad right-of-way will take place prior to construction and any required clean up or response will be performed by the non-Federal sponsor prior to construction.

f. Manhattan Avenue Battery Site:
This Site is located west of 15th Street, immediately adjacent to the Wildcat Creek side of the levee. The site is a former dumpsite for battery casings discarded during lead reclamation processes. In 2005, lead contaminated soil at the site was excavated and disposed of off-site. The contaminated soil was on the creek site of the levee and the proposed modifications are on the land side of the levee. This site should have no impact on the Recommended Plan as there is no overlap with LER required for the project.

18. OPPOSITION/SUPPORT OF PROJECT BY LOCAL LANDOWNERS:

A Public Workshop/Meeting was held in April 2013 and the local landowners were provided an overview of the proposed project and given a chance to ask question and communicate any opposition to the project. No issues or comments were mentioned by the attendees following the meeting. Communication with the public will continue throughout the Feasibility Phase of the project.

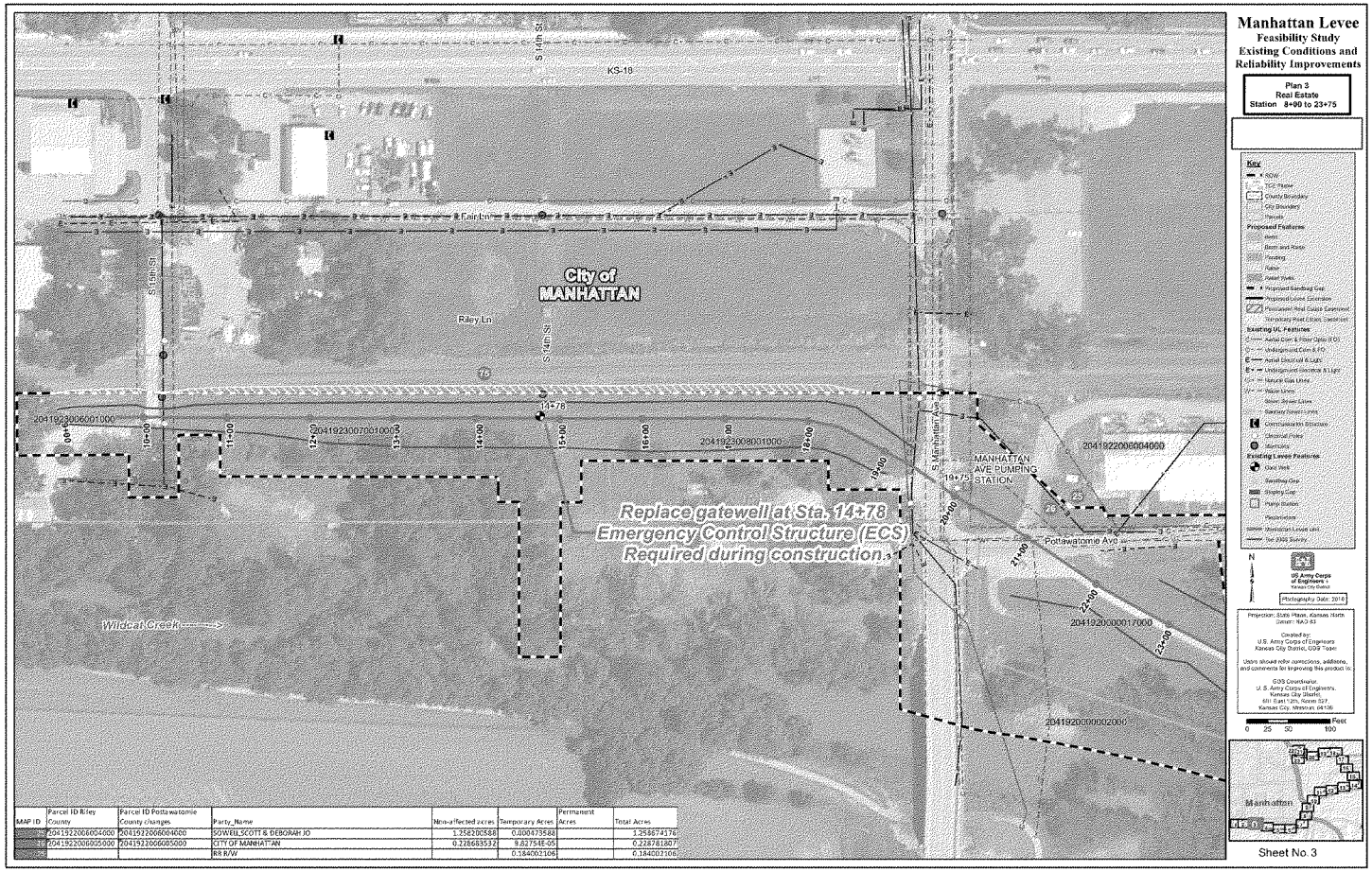
19. NOTIFICATION TO NON-FEDRAL SPONSOR OF EARLY ACQUISITION OF LERRD:

The NFS was issued a risk letter on 25 September 2013 outlining the risk of acquiring lands prior to the issuance of a Notice to Proceed.

20. ALL OTHER REAL ESTATE ISSUES:

District Cultural Resources and Archeologists have researched and performed field surveys of the project area. Coordination with the Kansas State Historic Preservation Office (SHPO) is ongoing. It has been determined that the project will result in no known adverse effects on historic properties, but appropriate measures will be taken to avoid, minimize or mitigate any effects.

Unidentified public utilities could be an issue as most of the areas of interest are heavily developed and have been for close to one hundred years. PDT members are working closely with sponsors to identify possible problem areas and avoid or address any utilities in question.



MAP ID	Parcel ID Riley County	Parcel ID Pottawatomie County changes	Party_Name	Non-affected acres	Temporary Acres	Permanent Acres	Total Acres
25	20419220006004000	20419220006004000	SOWELL,SCOTT & DEBORAH JO	1.258200588	0.000479584		1.258674176
26	20419220006005000	20419220006005000	CITY OF MANHATTAN	0.226683532	9.82754E-05		0.226781607
28			RR R/W		0.184002106		0.184002106

Manhattan Levee

Feasibility Study
Existing Conditions and Reliability Improvements

Plan 3
Real Estate
Station 23+50 to 39+25

Key

Proposed Features

Existing UL Features

Existing Levee Features

US Army Corps of Engineers
Kansas City District

Photography Date: 2016

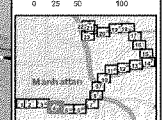
Projection: State Plane, Kansas North
Datum: NAD 83

Created by:
U.S. Army Corps of Engineers
Kansas City District, GDS Team

Users should refer corrections, additions, and comments for improving this product to:

GDS Coordinator
U. S. Army Corps of Engineers
Kansas City District
Suite 1200, Room 527
Kansas City, Missouri 64106

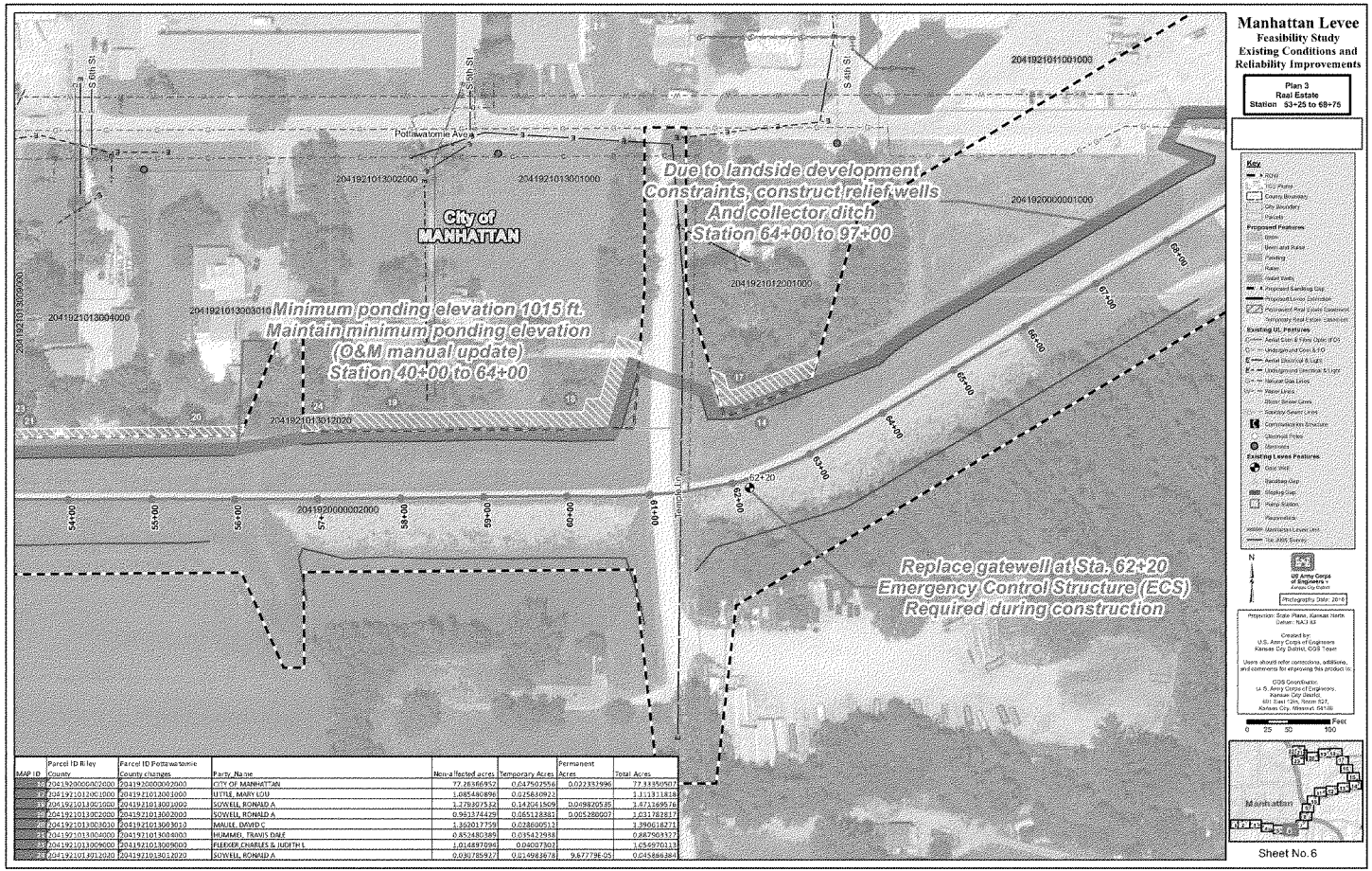
Feet
0 25 50 100



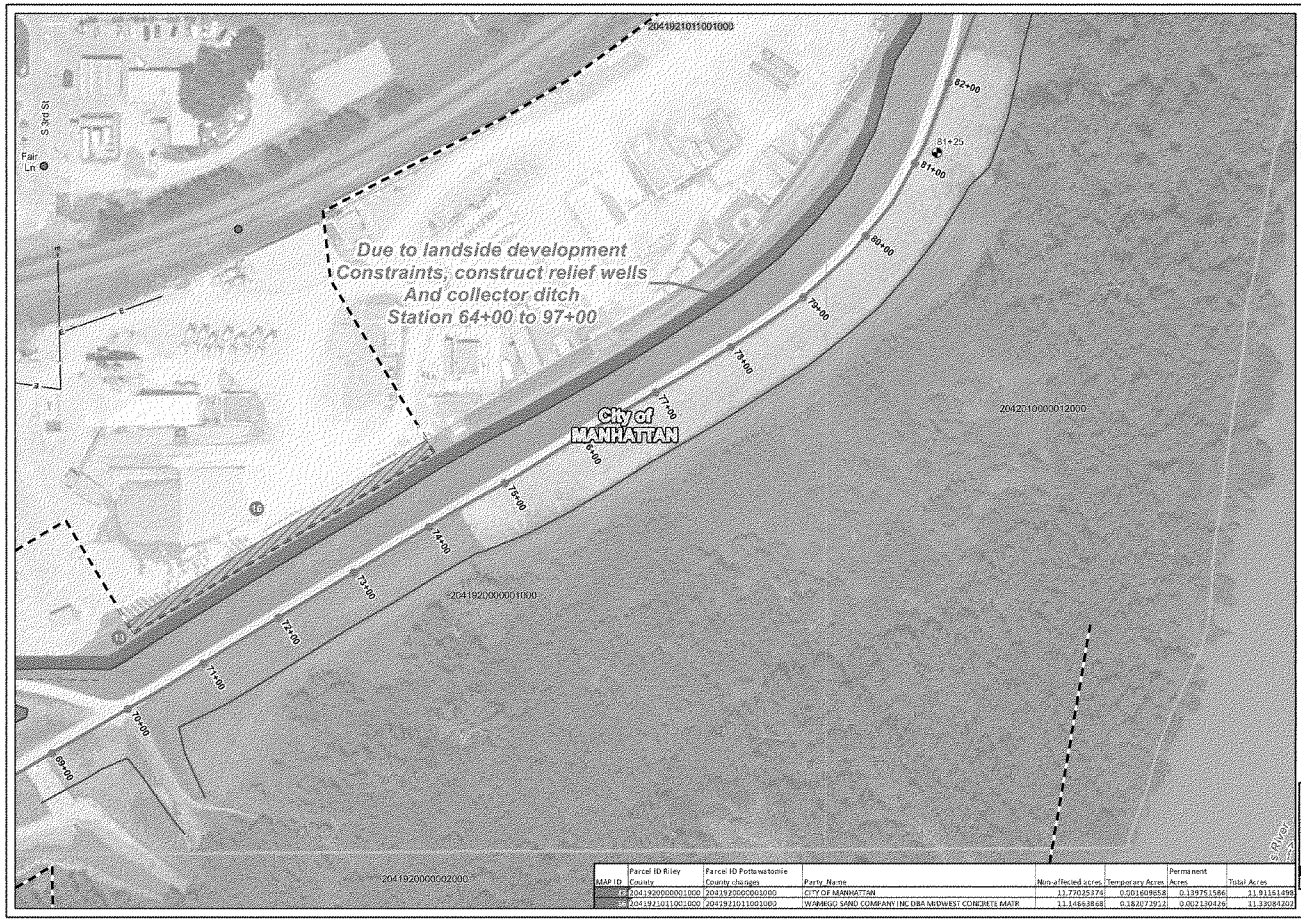
Sheet No. 4

MAP ID	Parcel ID Riley County	Parcel ID Pottawatomie County changes	Party_Name	Non-affected acres	Temporary Acres	Permanent Acres	Total Acres
14	2041920000002000	2041920000002000	CITY OF MANHATTAN	77.26366952	0.047502556	0.022332996	77.33350507
15	2041920000017000	2041920000017000	CITY OF MANHATTAN	3.306905882	0.042778276		3.349724158
16	2041922013005000	2041922013005000	COLEMAN, MAUREEN S	0.203406522	0.003388177		0.206794699
17	2041922013006000	2041922013006000	ZOELLER, AMBER	0.174266878	0.005899741		0.180166618
18	2041922013007000	2041922013007000	HALL RON L & SHEILA L	0.136887338	0.009041059		0.145928397
19	2041922013008000	2041922013008000	WASHINGTON, CLEOPHUS	0.206769605	0.006425178		0.213194781
20	2041922013009000	2041922013009000	SCROGGIN, COLLEEN I	0.248973588	0.001923631		0.250897219

MAP ID	Parcel ID Riley County	Parcel ID Pottawatomie County changes	Party_Name	Non-affected acres	Temporary Acres	Permanent Acres	Total Acres
31	2041920000002000	2041920000002000	CITY OF MANHATTAN	77.26366952	0.047502556	0.022332996	77.33350507
32	2041921013004000	2041921013004000	HUMMEL, TRAVIS DALE	0.852980389	0.035422938		0.887903327
33	2041921013007010	2041921013007010	GIBSON, ROGER E	0.644437351	0.068785117	0.000109456	0.713331924
34	2041921013009000	2041921013009000	FLEEKER,CHARLES & JUDITH L	1.014897094	0.04097302		1.054970113
35	2041922011001000	2041922011001000	MOHR FAMILY TRUST MOHR,R L & D E TRUSTEES	0.976878266	0.079111867		1.055990134
36	2041922011002000	2041922011002000	Cashman,Kathleen A. & Steinmetz,Nikki B. & Sutherland,Sammy G	1.593664299	0.08375981	0.013849915	1.690274024
37	2041922012014000	2041922012014000	MEYER, RODNEY D	0.245449715	0.022120758		0.267570472
38	2041922012015000	2041922012015000	FLEEKER,CHARLES & JUDITH L	0.323789609	0.019874599		0.343664208
39	2041922012028000	2041922012028000	ERDMAN, ASHLEY A	0.240959601	0.051654397	0.001479136	0.294093134
40	2041922012030000	2041922012030000	Melardye, Vakhtang	0.132677246	0.038895335	0.008444457	0.180017038
41	2041922012032000	2041922012032000	JONES,EDGAR A III KISSICK,STACY D	0.126171457	0.038871051	0.013419982	0.178462489
42	2041922012034000	2041922012034000	AMBROSE, JASON W	0.239217573	0.03299225	0.008341588	0.280551411



MAP ID	Parcel ID Riley County	Parcel ID Pottawatomie County changes	Party Name	Non-affected acres	Temporary Acres	Permanent Acres	Total Acres
16	20419200000020000	20419200000020000	CITY OF MANHATTAN	72.16366952	0.647507556	0.022337996	77.33350507
17	20419210120010000	20419210120010000	LITTLE, MARY LOU	1.085490896	0.025830922		1.111321818
18	20419210130010000	20419210130010000	SOWELL, RONALD A	1.278207532	0.142061509	0.009820535	1.427169576
19	20419210130020000	20419210130020000	SOWELL, RONALD A	0.963174429	0.065128882	0.005280007	1.033582817
20	20419210130030010	20419210130030010	MAULE, DAVID C	1.362017759	0.028600513		1.390618271
21	20419210130040000	20419210130040000	HUMMEL, TRAVIS DALE	0.852480389	0.035421998		0.887902387
22	20419210130090000	20419210130090000	FLEEKER, CHARLES & JUDITH L	1.014897096	0.04007302		1.054970113
23	20419210130120020	20419210130120020	SOWELL, RONALD A	0.030785927	0.014983678	9.677778-05	0.045868384



MAP ID	Parcel ID Riley County	Parcel ID Pottawatomie County changes	Party Name	Non-affected acres	Temporary Acres	Permanent Acres	Total Acres
	2041920000001000	2041920000001000	CITY OF MANHATTAN	11.77025374	0.001609858	0.139751586	11.91161498
	2041921011001000	2041921011001000	WAMEGO SAND COMPANY INC DBA MIDWEST CONCRETE MATR	11.14663868	0.182072912	0.002130426	11.33084202

Manhattan Levee

Feasibility Study
Existing Conditions and Reliability Improvements

Plan 3
Real Estate
Station 66+50 to 82+80

Key

- ROW
- TCC Plates
- County Boundary
- City Boundary
- Parcels

Proposed Features

- Berm
- Berm and Raise
- Flooding
- Raise
- Raised Stone
- Proposed Sandbag Gap
- Proposed Levee Extension
- Permanent Real Estate Easement
- Temporary Real Estate Easement

Existing UL Features

- Aerial Gas & Fiber Optic (FO)
- Underground Gas & FO
- Aerial Stack Unit & Light
- Underground Electrical & Light
- Natural Gas Lines
- Water Lines
- Storm Sewer Lines
- Sanitary Sewer Lines
- Communication Structure
- Electrical Poles
- Manholes

Existing Levee Features

- Gate Well
- Sandbag Gap
- Stopping Gap
- Pump Station
- Piezometers
- Manhattan Levee Unit
- Toe 2006 Survey

N

US Army Corps of Engineers
Kansas City District

Photography Date: 2016

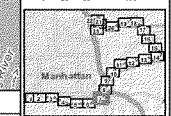
Projection: State Plane, Kansas North
Datum: NAD 83

Created by:
U.S. Army Corps of Engineers
Kansas City District, DOS Topo

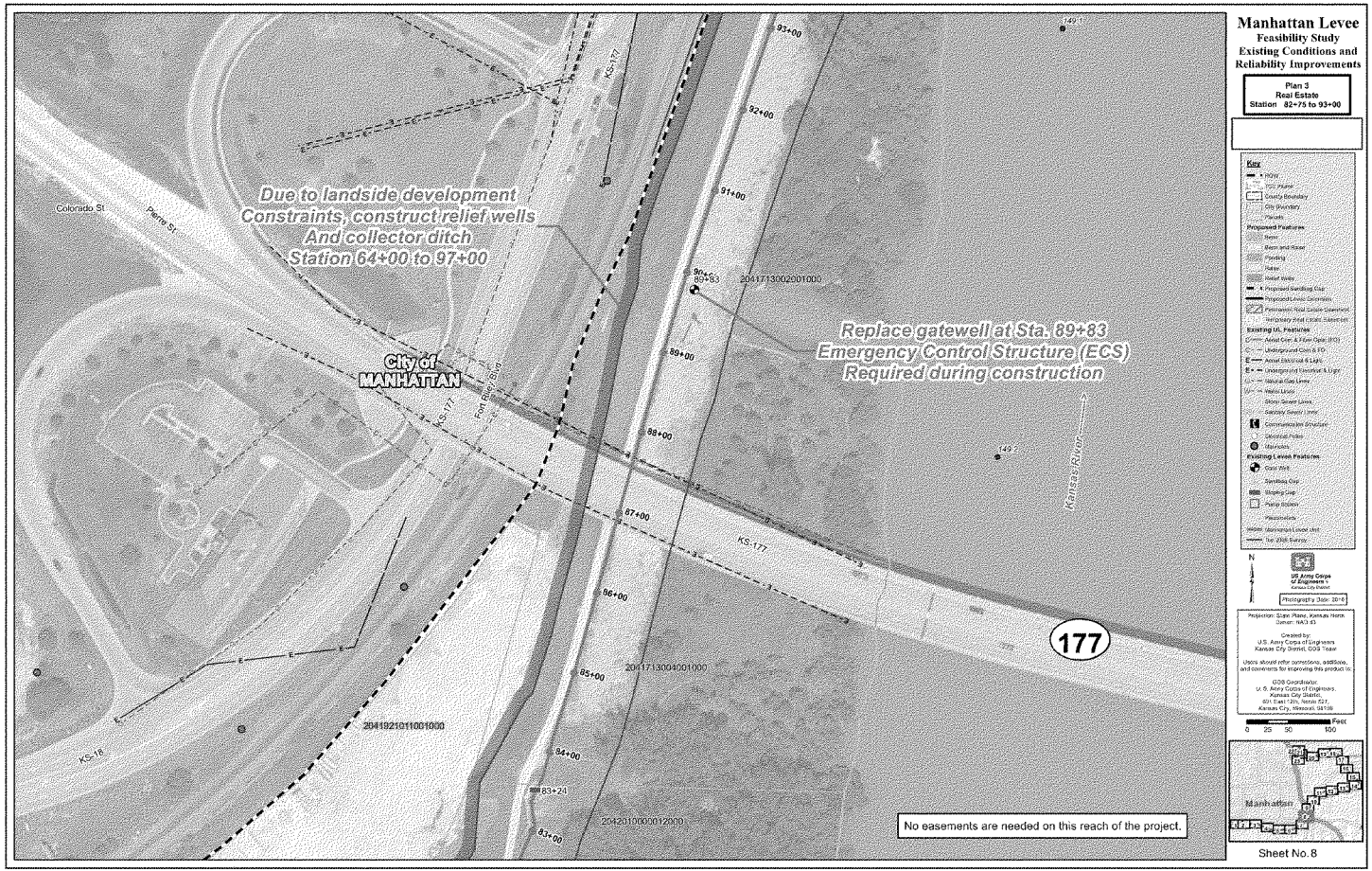
Users should refer corrections, additions, and comments for improving this product to:

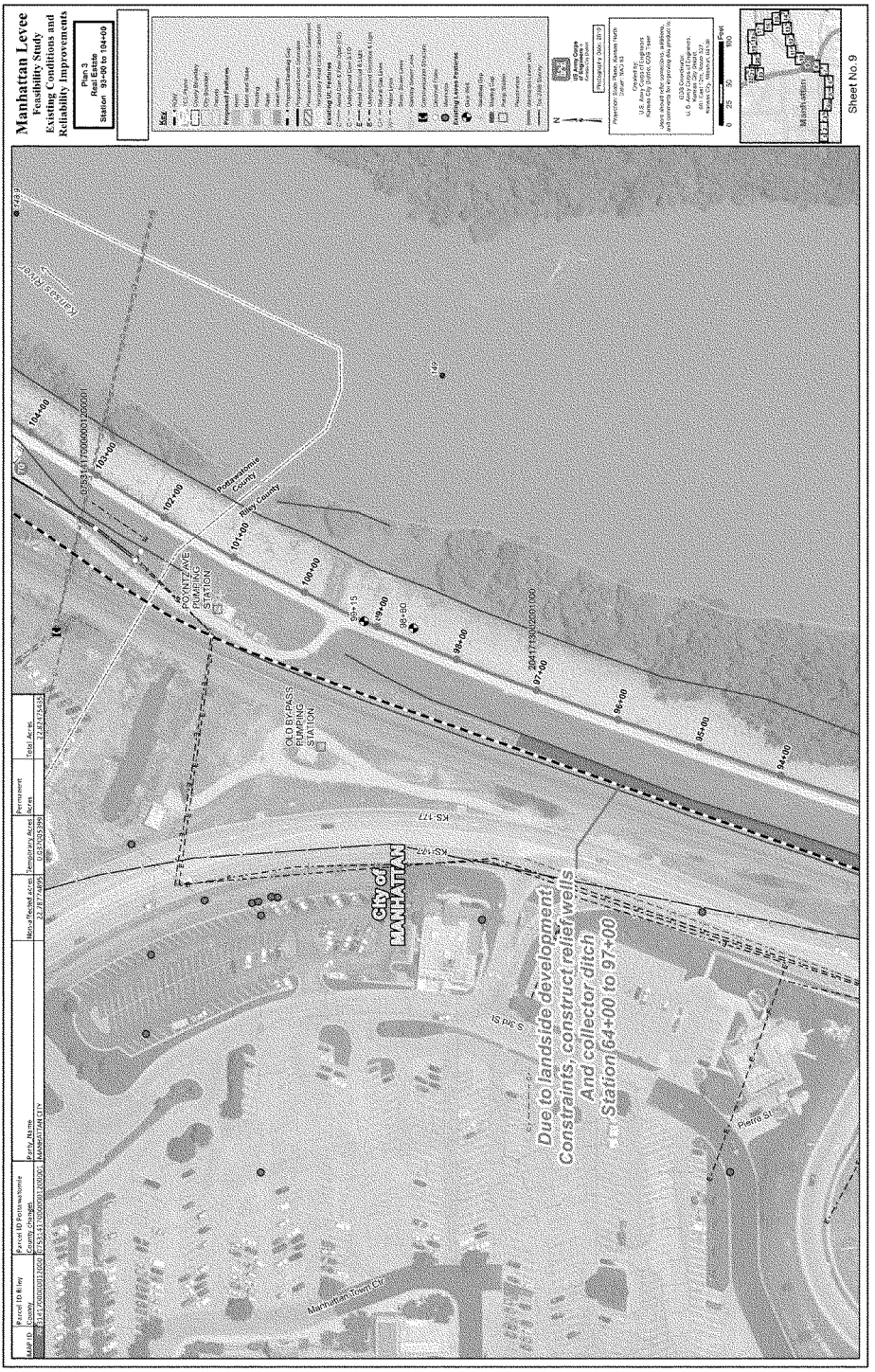
GDS Coordinator,
U.S. Army Corps of Engineers,
Kansas City District
601 East 12th, Room 527
Kansas City, Missouri 64106

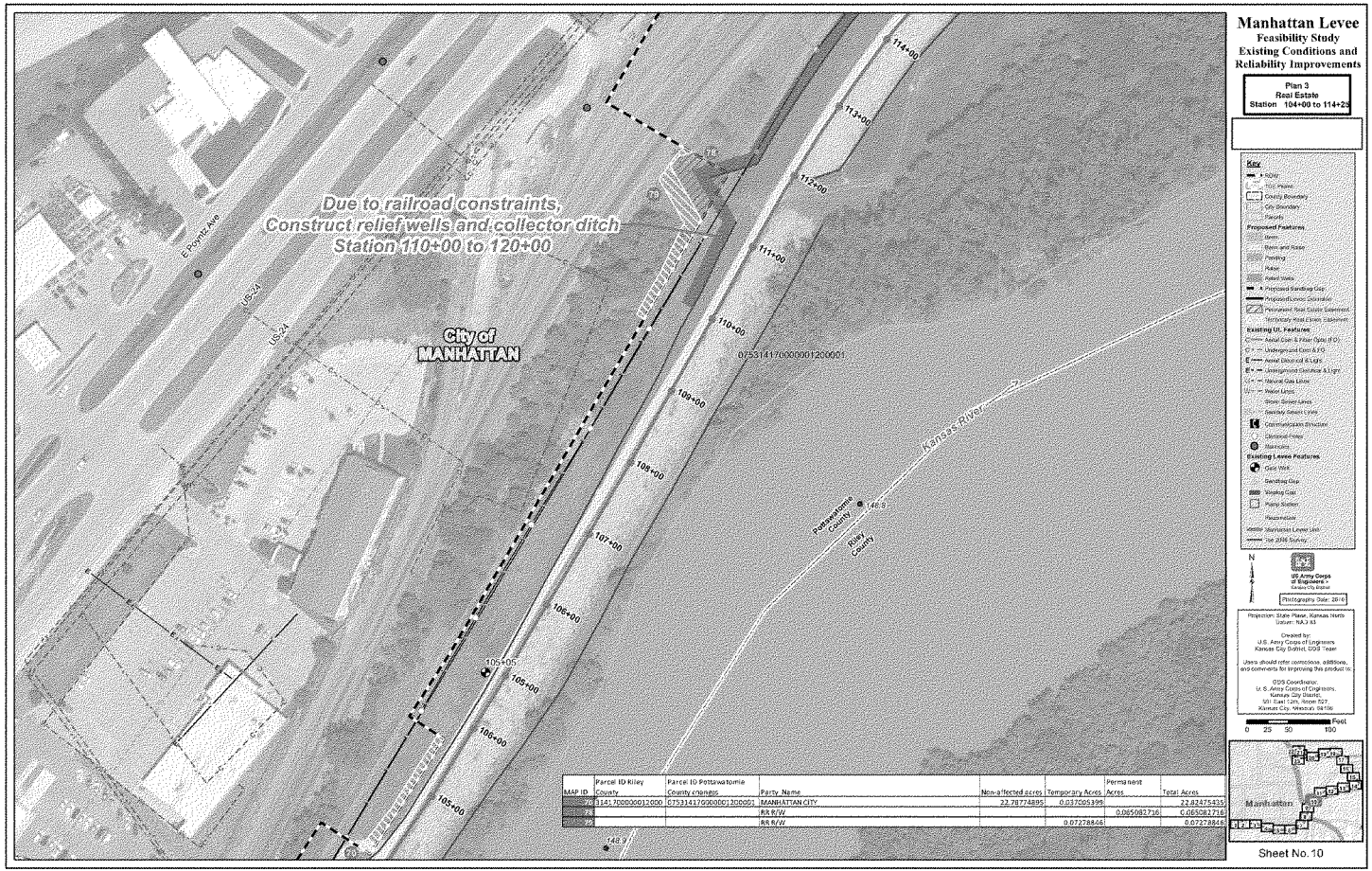
Feet
0 25 50 100



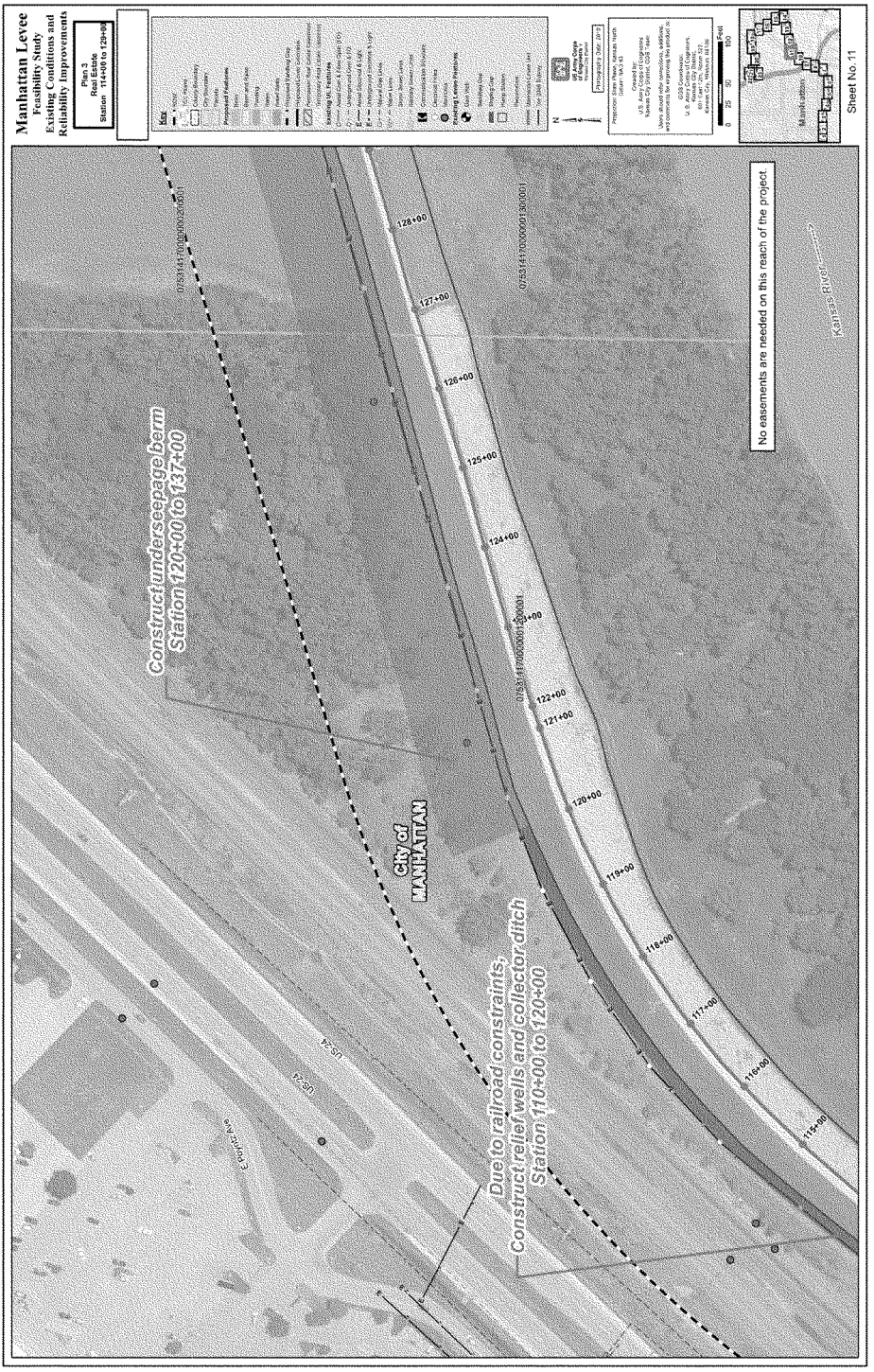
Sheet No. 7

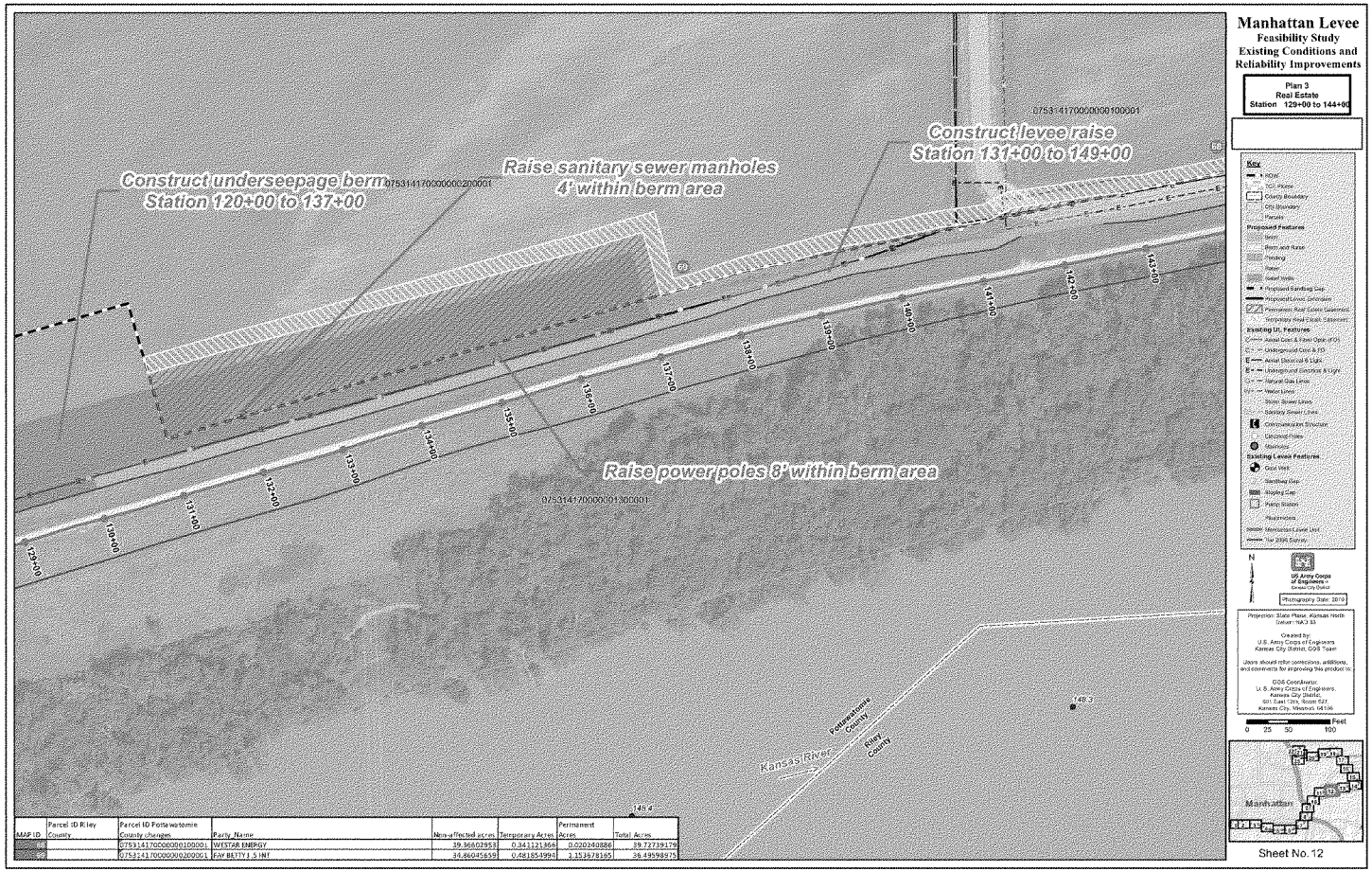

Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Plan 3
Real Estate
Station 82+75 to 93+00
Key
Due to landside development
Constraints, construct relief wells
And collector ditch
Station 64+00 to 97+00
Replace gatewell at Sta. 89+83
Emergency Control Structure (ECS)
Required during construction
City of
MANHATTAN
Colorado St
Pierre St
Fort Riley Blvd
KS-177
KS-18
Kansas River
177
93+00
92+00
91+00
90+00
89+83
89+00
88+00
87+00
86+00
85+00
84+00
83+24
83+00
2041713002001000
2041713004001000
2041921011001000
2042010000012000
149.1
149.2
No easements are needed on this reach of the project.
Manhattan
Sheet No. 8


Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Plan 3
Real Estate
Station 93+00 to 104+00
Key
Sheet No. 9
Kansas River
Pottawatomie County
Riley County
POYNTZ AVE PUMPING STATION
OLD BY-PASS PUMPING STATION
KS-177
City of MANHATTAN
S 3rd St
Pierre St
Manhattan Town Ctr
Due to landside development
Constraints, construct relief wells
And collector ditch
Station 64+00 to 97+00
104+00
103+00
102+00
101+00
100+00
99+15
99+00
98+80
98+00
97+00
96+00
95+00
94+00
Parcel ID Riley County
Parcel ID Pottawatomie County changes
Party Name
Non-affected acres
Temporary Acres
Permanent Acres
Total Acres
MANHATTAN CITY
22.78774895
0.037005399
22.82475435

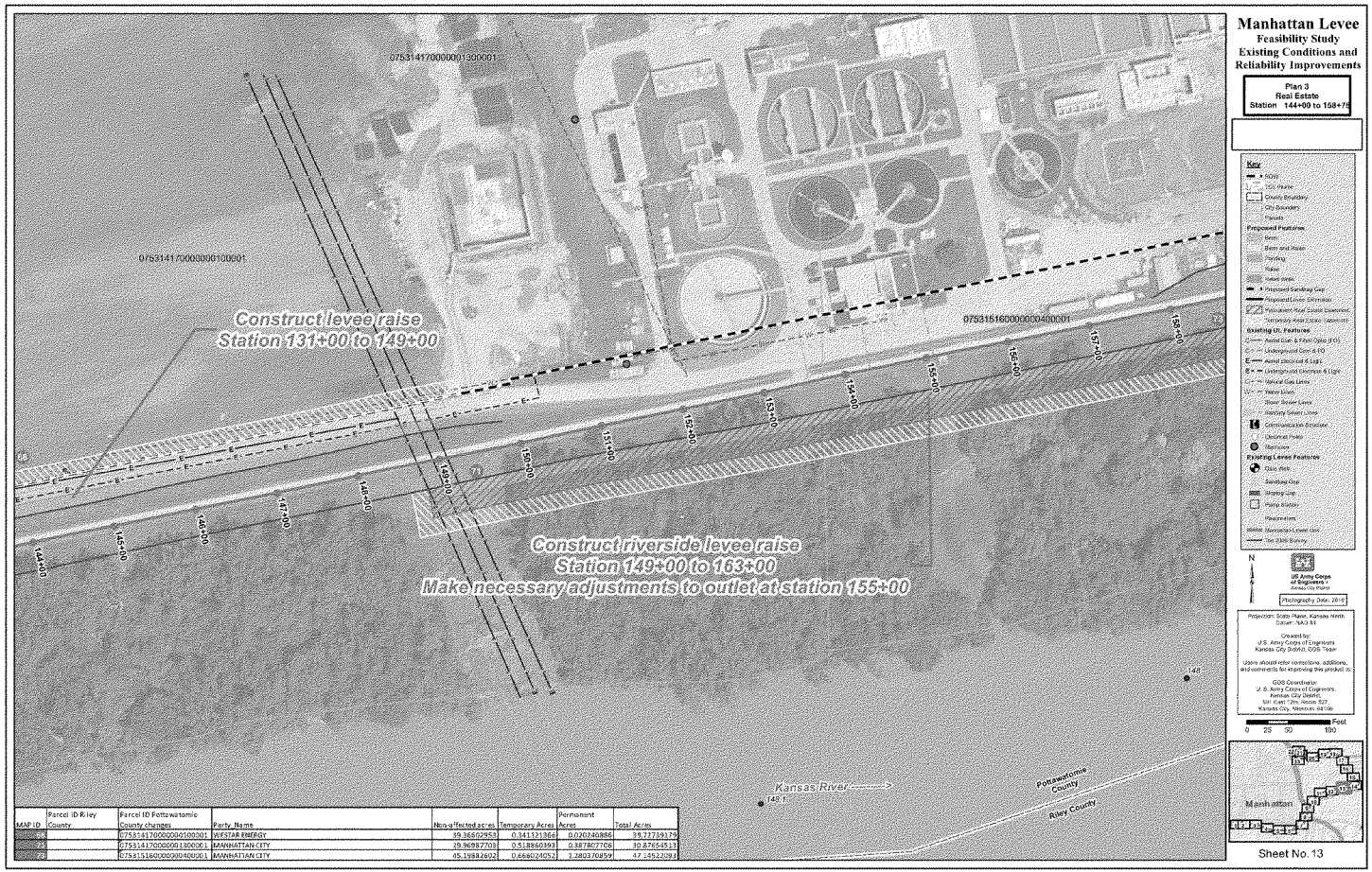


MAP ID	Parcel ID Riley County	Parcel ID Pottawatomie County crosses	Party Name	Non-affected acres	Temporary Acres	Permanent Acres	Total Acres
76	07531417000000120000	07531417000000120000	MANHATTAN CITY	22.78774895	0.037005398		22.82475435
74			RR R/W			0.065082716	0.065082716
75			RR R/W		0.07278846		0.07278846

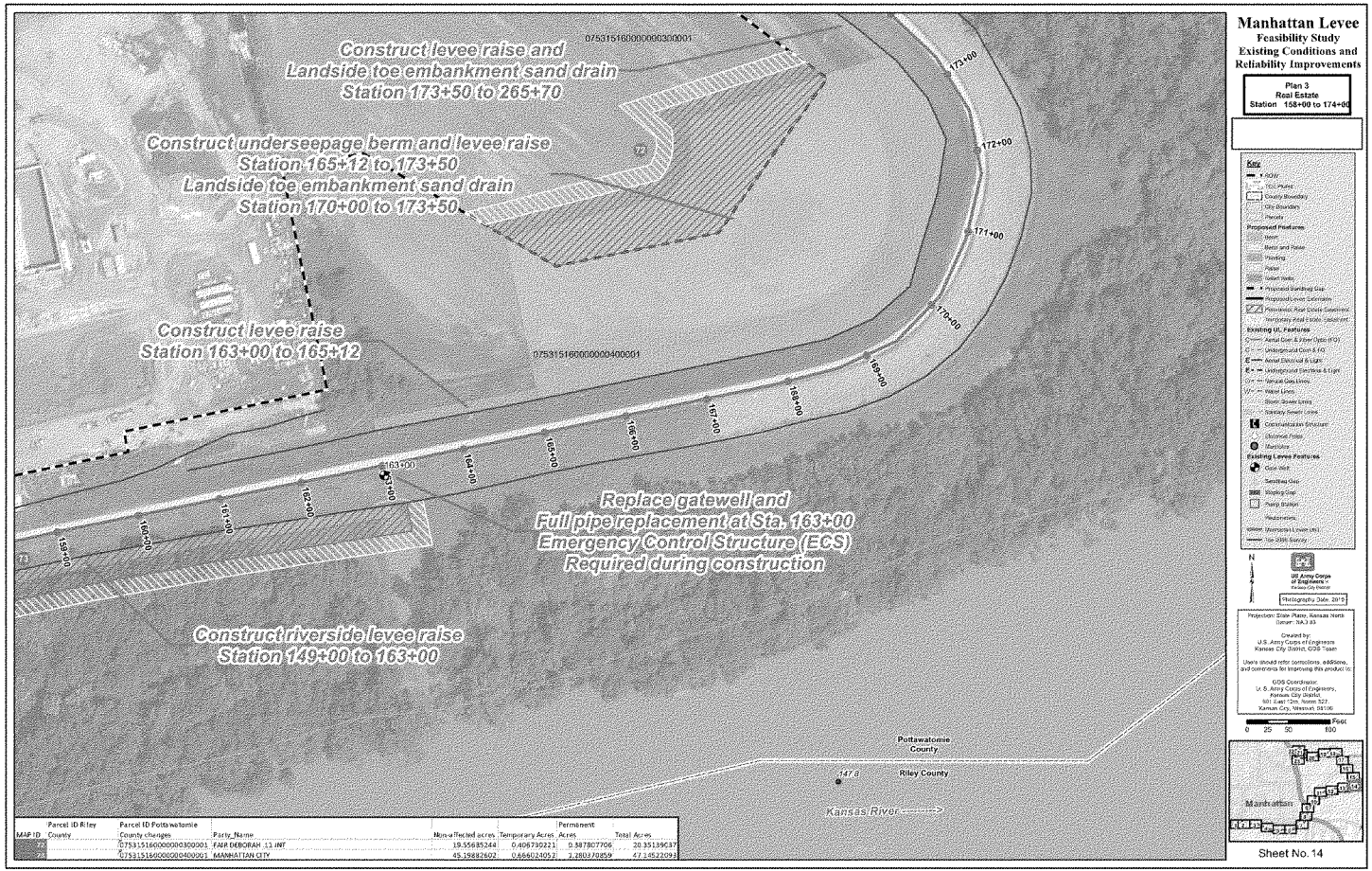

Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Plan 3
Real Estate
Station 114+00 to 129+00
Key
Existing UL Features
Existing Levee Features
Feet
0 25 50 100
Manhattan
Sheet No. 11
No easements are needed on this reach of the project.
Kansas River
Construct underseepage berm
Station 120+00 to 137+00
Due to railroad constraints,
Construct relief wells and collector ditch
Station 110+00 to 120+00
City of
MANHATTAN
US-24
US-24
E Poyntz Ave
128+00
127+00
126+00
125+00
124+00
123+00
122+00
121+00
120+00
119+00
118+00
117+00
116+00
115+00



MAP ID	Parcel ID Riley County	Parcel ID Pottawatomie County changes	Party_Name	Non-affected acres	Temporary Acres	Permanent Acres	Total Acres
11		07531417000000100001	WESTAR ENERGY	39.36602953	0.341121366	0.020240886	39.72739179
12		07531417000000200001	FAY BETTY J. 5 INT	34.86045659	0.481854994	2.153678165	36.49598875



MAP ID	Parcel ID Riley County	Parcel ID Pottawatomie County changes	Party Name	Non-affected acres	Temporary Acres	Permanent Acres	Total Acres
70		075314170000001000001	WESTAR ENERGY	39.36602953	0.341121366	0.020240886	39.72739179
71		075314170000001300001	MANHATTAN CITY	29.96927703	0.518860393	0.887807706	30.87654513
72		075315160000000400001	MANHATTAN CITY	45.19882602	0.646024052	1.280370859	47.14522091



MAP ID	Parcel ID Riley County	Parcel ID Pottawatomie County changes	Party_Name	Non-affected acres	Temporary Acres	Permanent Acres	Total Acres
72		07531516000000300001	FAIR DEBORAH L L INT	19.55685244	0.406730221	0.387807706	20.35139637
73		07531516000000400001	MANHATTAN CITY	45.19882602	0.666024052	1.280370859	47.14522098

MAP ID	Parcel ID Riley County	Parcel ID Pottawatomie County changes	Party_Name	Non-affected acres	Temporary Acres	Permanent Acres	Total Acres
[illegible]		0753120900000000500001	MANHATTAN CITY	1.612351036	0.000906561		1.613257597
[illegible]		0753120900000000500001	MANHATTAN CITY	6.263345981	0.217205259	0.032695142	6.515236382
[illegible]		0753151600000000300001	FAIR DEBORAH 11 IRT	19.55685244	0.400730221	0.387827706	20.35139037
[illegible]		0753151600000000400001	MANHATTAN CITY	45.19882602	0.666024052	1.280370859	47.14512093

Manhattan Levee

Feasibility Study
Existing Conditions and Reliability Improvements

Plan 3
Real Estate
Station 173+75 to 188+25

Key

- ROW
- TCE Parcels
- County Boundary
- City Boundary
- Parcels

Proposed Features

- Berm
- Berm and Raise
- Ponding
- Raise
- Relief Wells
- Proposed Sandbag Gap
- Proposed Levee Centerline
- Permanent Real Estate Easement
- Temporary Real Estate Easement

Existing UL Features

- Aerial Com & Fiber Optic (FO)
- Underground Com & FO
- Aerial Electrical & Light
- Underground Electrical & Light
- Natural Gas Lines
- Water Lines
- Storm Sewer Lines
- Sanitary Sewer Lines
- Communication Structure
- Electrical Pedes
- Manholes

Existing Levee Features

- Open Pipe
- Sandbag Gap
- Sloping Gap
- Flood Gates
- Pedestrian
- Maintained Levee Line
- Top Dike Survey

N

US Army Corps of Engineers – Kansas City District

Photography Date: 2016

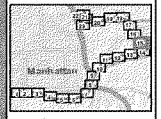
Projection: State Plane, Kansas North
Datum: NAD 83

Created by:
U.S. Army Corps of Engineers
Kansas City District, GIS Team

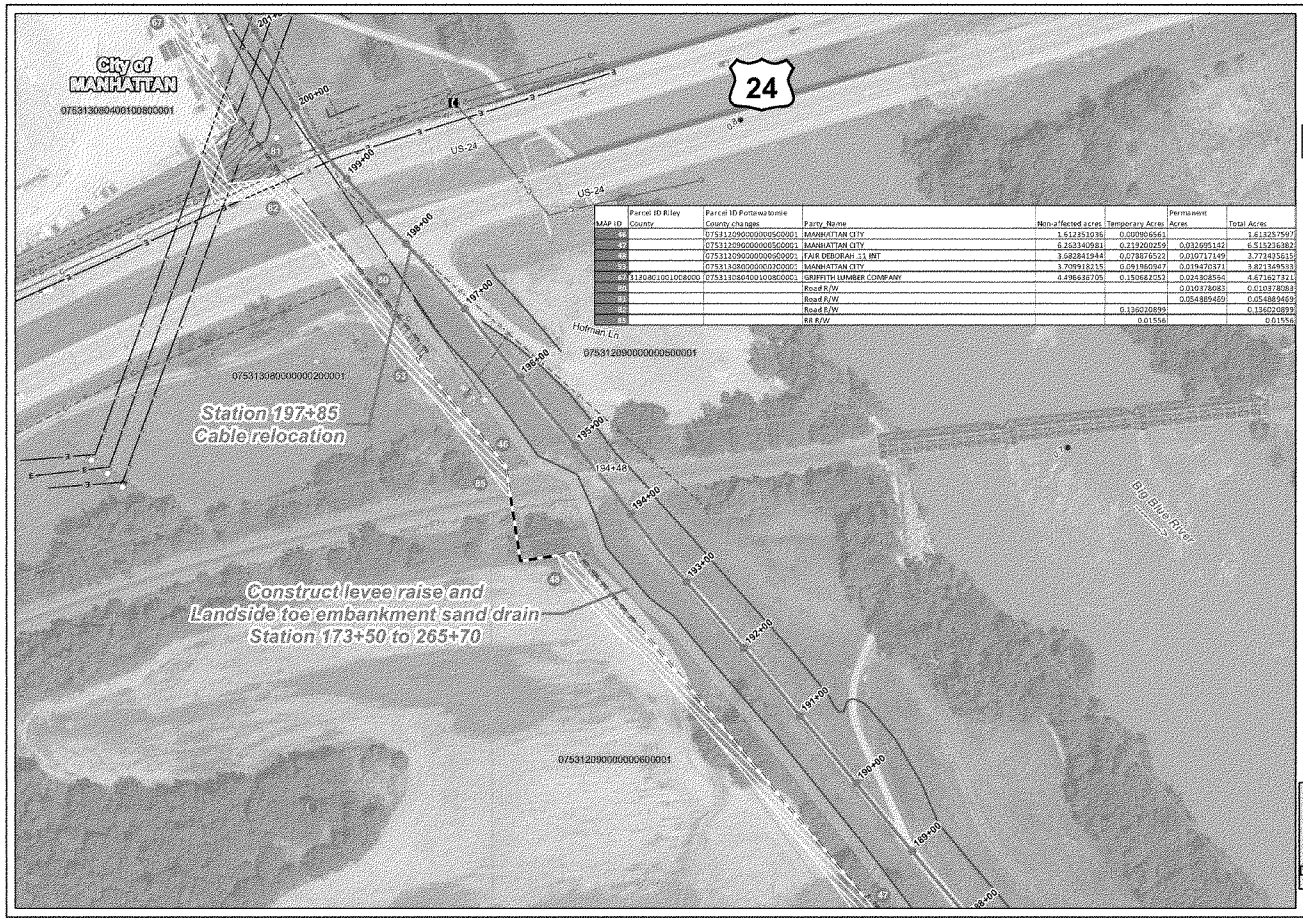
Users should note corrections, additions, and comments for improving this product to:

GIS Coordinator
U. S. Army Corps of Engineers,
Kansas City District
601 East 12th, room 827,
Kansas City, Missouri, 64106

0 25 50 100 Feet



Sheet No. 15



MAP ID	Parcel ID Riley County	Parcel ID Pottawatomie County changes	Party_Name	Non-affected acres	Temporary Acres	Permanent Acres	Total Acres
46		07531209000000005000 1	MANHATTAN CITY	1.612351035	0.000806561		1.613257597
47		07531209000000005000 1	MANHATTAN CITY	6.263340981	0.219200259	0.032695142	6.515236382
48		07531209000000005000 1	FAIR DEBORAH J1 INT	3.682841944	0.078876522	0.010717149	3.771435615
53		07531308000000020000 1	MANHATTAN CITY	3.709918215	0.091860947	0.019476371	3.821305533
67	1160801001008000	07531308400010080000 1	GRIFFITH LUMBER COMPANY	4.496638705	0.150682052	0.024808594	4.671627371
80			Road R/W			0.010378083	0.010378083
81			Road R/W			0.054889469	0.054889469
82			Road R/W		0.136020899		0.136020899
85			RR R/W		0.01556		0.01556

Manhattan Levee
Feasibility Study
Existing Conditions and Reliability Improvements

Plan 3
Real Estate
Station 188+00 to 201+00

Key

- ROW
- HCD Parcel
- County Boundary
- City Boundary
- Parcels

Proposed Features

- Levee
- Berm and Berge
- Footing
- Raise
- Relief Wells
- Proposed Sandbag Gap
- Proposed Levee Orientation
- Permanent Real Estate Easement
- Temporary Real Estate Easement

Existing UL Features

- Aerial Elec & Fiber Optic (F/O)
- Underground Elec & F/O
- Aerial Electrical & Light
- Underground Electrical & Light
- Natural Gas Lines
- Water Lines
- Storm Sewer Lines
- Sanitary Sewer Lines
- Communication Structure
- Electrical Poles
- Manholes

Existing Levee Features

- Relief Well
- Sandbag Gap
- Flapping Gap
- Pump Station
- Pavement
- Alluvium Levee (ft)
- Top (ft) Sidewalk

N

US Army Corps of Engineers
Kansas City District

Photography Date: 2010

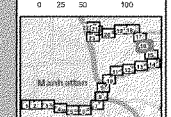
Projection: State Plane, Kansas North
Datum: NAD 83

Created by:
U.S. Army Corps of Engineers
Kansas City District, CO3 Team

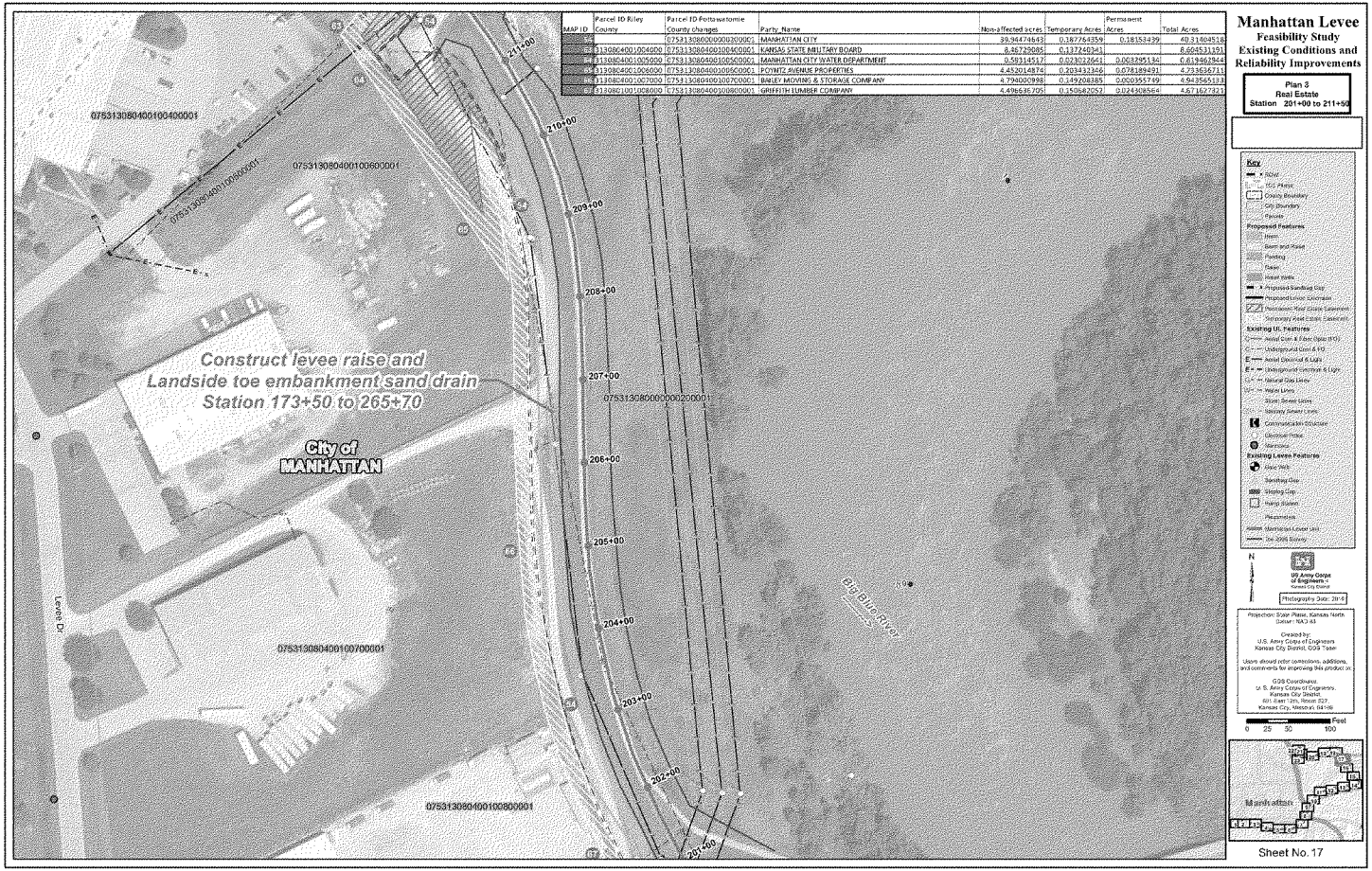
Users should refer corrections, additions, and comments for improving this product to:

CO3 Coordinator
U. S. Army Corps of Engineers,
Kansas City District,
601 East 12th, Room 527,
Kansas City, Missouri, 64106

0 25 50 100 Feet



Sheet No. 16



MAP ID	Parcel ID Riley County	Parcel ID Pottawatomie County changes	Party_Name	Non-affected acres	Temporary Acres	Permanent Acres	Total Acres
[illegible]		0753130800000000200001	MANHATTAN CITY	39.94474643	0.187764359	0.18153439	40.31404518
[illegible]	3130804001004000	0753130804001004000001	KANSAS STATE MILITARY BOARD	8.46729085	0.137240341		8.604531191
[illegible]	3130804001005000	0753130804001005000001	MANHATTAN CITY WATER DEPARTMENT	0.59314517	0.023022641	0.003295134	0.619462944
[illegible]	3130804001006000	0753130804001006000001	POYNTZ AVENUE PROPERTIES	4.452014874	0.203432346	0.078189491	4.733636711
[illegible]	3130804001007000	0753130804001007000001	BAILEY MOVING & STORAGE COMPANY	4.794000998	0.149208385	0.000355749	4.943565133
[illegible]	3130801001008000	0753130804001008000001	GRIFFITH LUMBER COMPANY	4.496636705	0.150682052	0.024308564	4.671627321

MAP ID	Parcel ID Riley County	Parcel ID Pottawatomie County changes	Party_Name	Non-affected acres	Temporary Acres	Permanent Acres	Total Acres
		07531308000000200001	MANHATTAN CITY	39.94474643	0.187764359	0.18153439	40.31404518
	31308040010030000	07531308040010030000	GLOBE PARTNERS	7.464926851	0.00785088		7.472777731
	31308040010040000	07531308040010040000	KANSAS STATE MILITARY BOARD	8.46729085	0.137240341		8.604531191

Manhattan Levee

Feasibility Study
Existing Conditions and Reliability Improvements

Plan 3
Real Estate
Station 211+50 to 226+25

Key

Proposed Features

Existing UL Features

Existing Levee Features

US Army Corps of Engineers

Photography Date: 2016

Projection: State Plane, Kansas North
Datum: NAD 83

Created by:
U.S. Army Corps of Engineers
Kansas City District, GDS Team

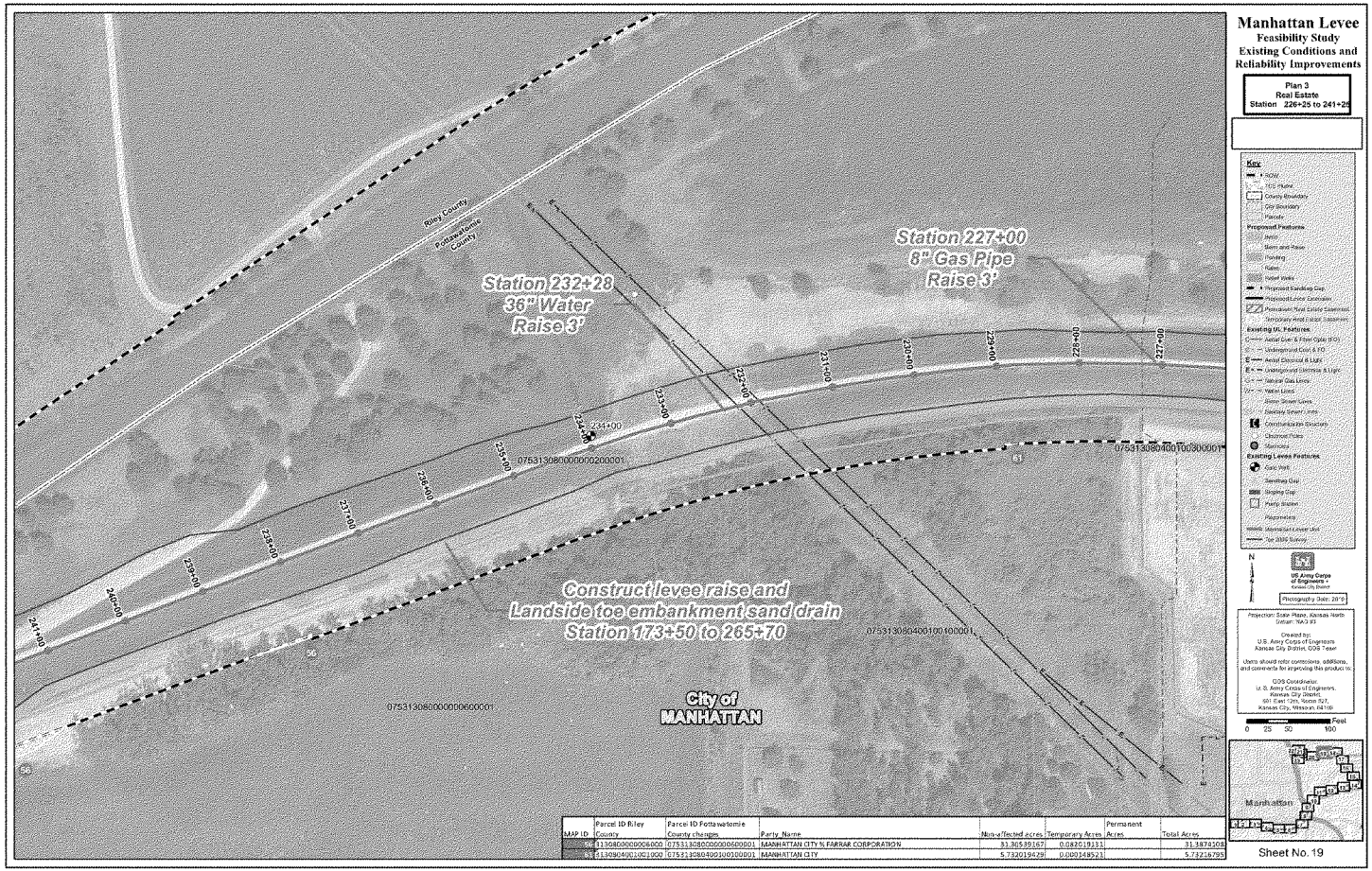
Users should refer corrections, additions, and comments for improving this product to:

GDS Coordinator:
U. S. Army Corps of Engineers,
Kansas City District,
601 East 12th, Room 527,
Kansas City, Missouri 64106

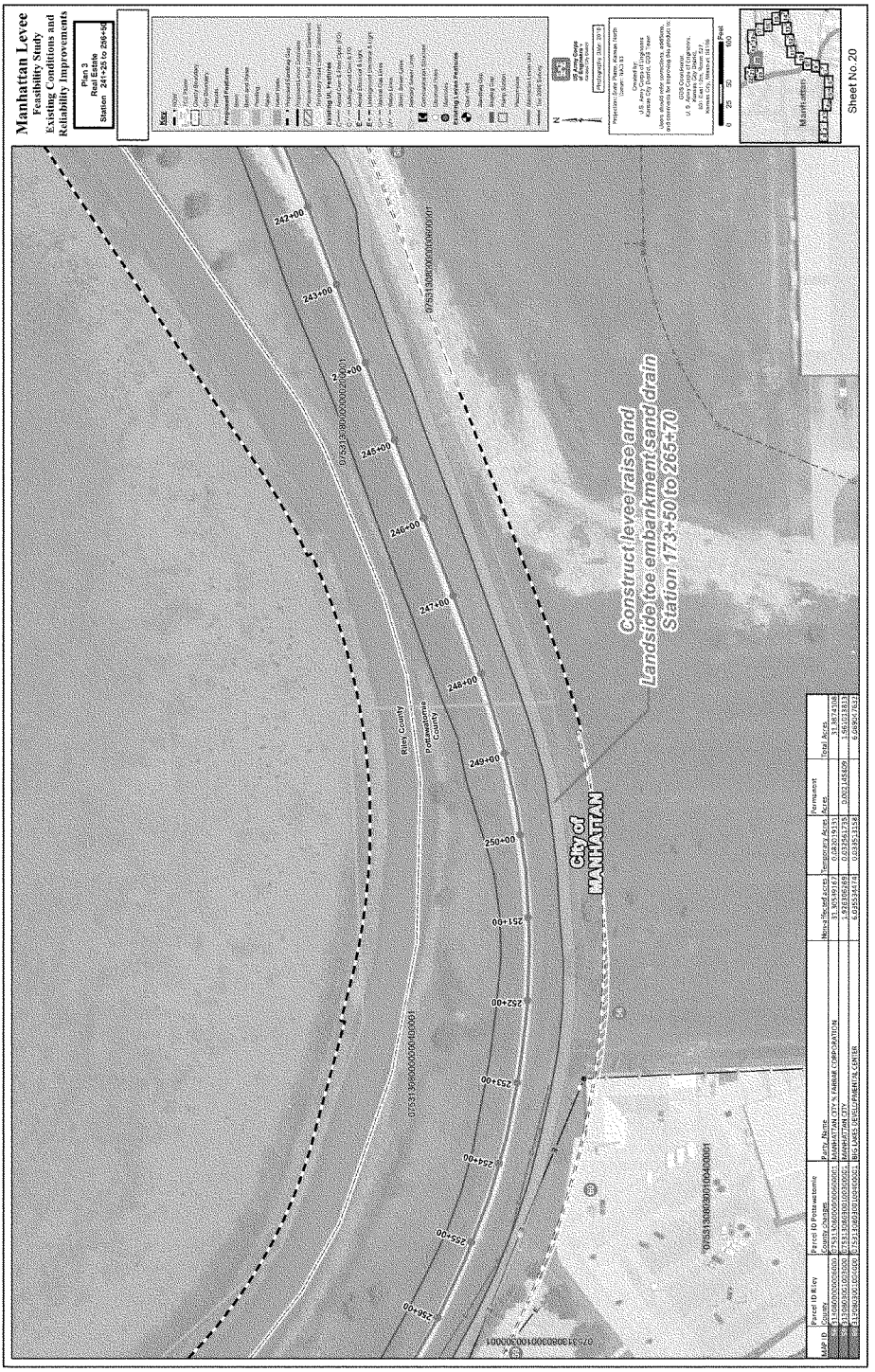
Feet
0 25 50 100

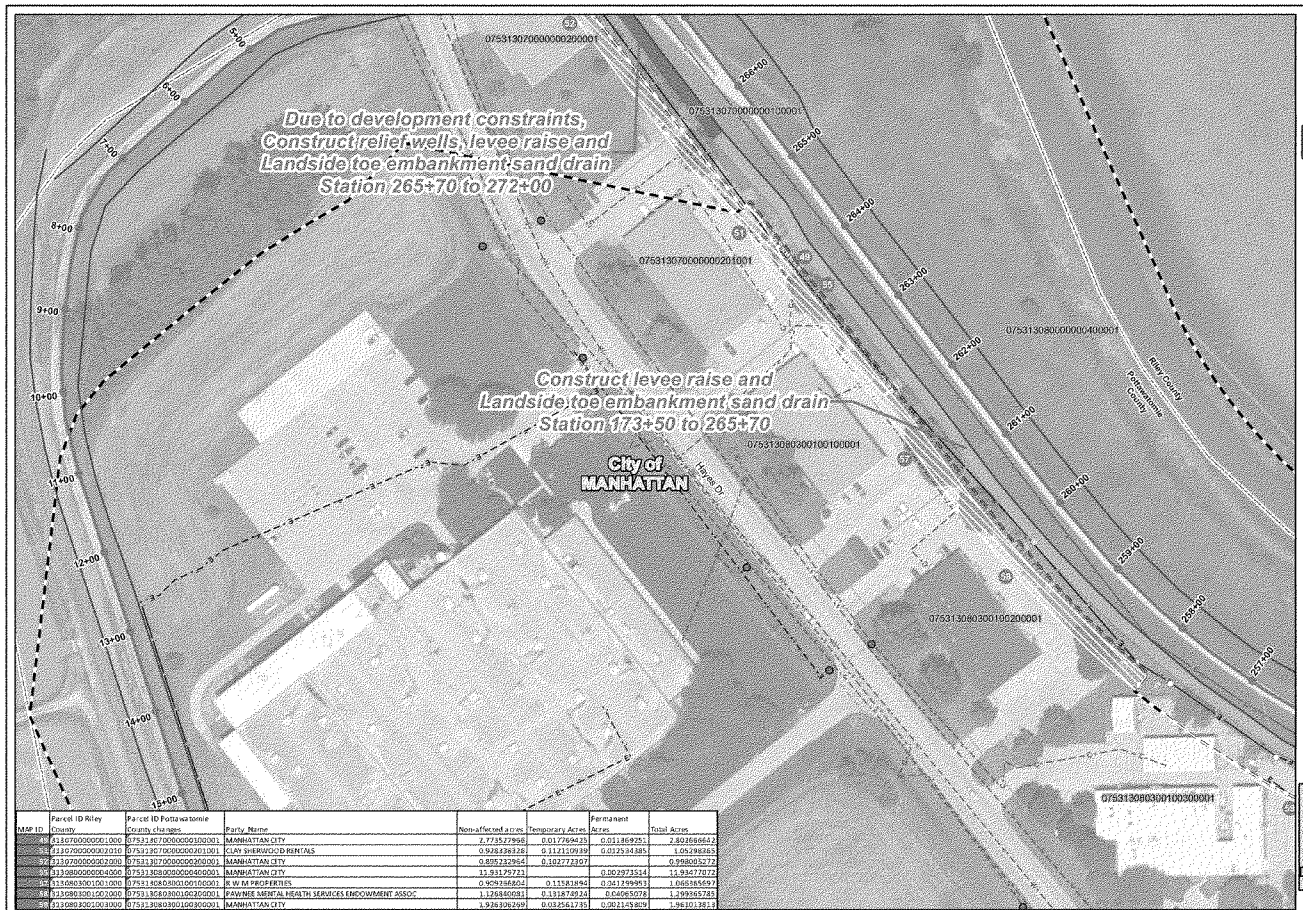
Manhattan

Sheet No. 18



MAP ID	Parcel ID Riley County	Parcel ID Pottawatomie County changes	Party Name	Non-affected acres	Temporary Acres	Permanent Acres	Total Acres
06	0130800000006000	0753130800000000600001	MANHATTAN CITY % FARRAR CORPORATION	31.30539167	0.082019131		31.3874108
07	0130804001001000	0753130804001001000001	MANHATTAN CITY	5.732019429	0.000148521		5.73216795


Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Plan 3
Real Estate
Station 241+25 to 256+50
Key
Proposed Features
Existing UL Features
Existing Levee Features
Construct levee raise and
Landside toe embankment sand drain
Station 173+50 to 265+70
City of
MANHATTAN
Riley County
Pottawatomie
County
242+00
243+00
245+00
246+00
247+00
248+00
249+00
250+00
251+00
252+00
253+00
254+00
255+00
256+00
Feet
0
25
50
100
Sheet No. 20
MAP ID
Parcel ID Riley County
Parcel ID Pottawatomie County changes
Party Name
Non-affected acres
Temporary Acres
Permanent Acres
Total Acres
MANHATTAN CITY % FARRAR CORPORATION
MANHATTAN CITY
BIG LAKES DEVELOPMENTAL CENTER
31.30539167
0.082019131
31.3874108
1.926306269
0.032561735
0.002145809
1.961033813
6.035534474
0.033513158
6.069047632



MAP ID	Parcel ID Riley County	Parcel ID Pottawatomie County changes	Party Name	Non-affected acres	Temporary Acres	Permanent Acres	Total Acres
49	0131070000001000	0753130700000000100001	MANHATTAN CITY	2.773527996	0.017769425	0.011869251	2.802566642
55	0131070000002010	0753130700000000201001	CLAY SHERWOOD RENTALS	0.928328128	0.112119939	0.012534385	1.052982453
57	0131070000002000	0753130700000000200001	MANHATTAN CITY	0.895232964	0.102772397		0.998005272
93	0130800000004000	0753130800000000400001	MANHATTAN CITY	15.93179723		0.022973514	15.94477072
92	0130800300100100	0753130800300100100001	R W M PROPERTIES	0.909268604	0.11583894	0.041299863	1.066853457
94	0130800300100200	0753130800300100200001	FAWNEE MENTAL HEALTH SERVICES ENDOWMENT ASSOC	1.126840081	0.131878924	0.040965078	1.299684083
98	0130800300100300	0753130800300100300001	MANHATTAN CITY	1.926306299	0.032561735	0.002145809	1.961013843

Manhattan Levee

Feasibility Study
Existing Conditions and Reliability Improvements

Plan 3
Real Estate
Station 256+50 to 267+00

Key
- ROW
- TCE Plans
- County Boundary
- City Boundary
- Parcels

Proposed Features
- Berm
- Berm and Relief
- Footing
- Relief
- Relief Wells
- Proposed Sandbag Gap
- Proposed Levee Extension
- Permanent Real Estate Easement
- Temporary Real Estate Easement

Existing Utl. Features
- Aerial Gas & Fiber Optic (UG)
- Underground Gas & FO
- Aerial Electrical & Light
- Underground Electrical & Light
- Natural Gas Lines
- Water Lines
- Storm Sewer Lines
- Sanitary Sewer Lines
- Communication Structure
- Electrical Poles
- Hydrants

Existing Levee Features
- Gate Well
- Sandbag Gap
- Floodgap Gap
- Pump Station
- Piezometers
- Stabilization Levee Line
- Toe Drain Survey

N

US Army Corps of Engineers - Kansas City District

Photography Date: 2018

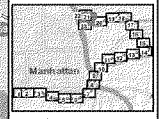
Projection: State Plane, Kansas North Zone; NAD 83

Created by:
U.S. Army Corps of Engineers
Kansas City District, GIS Team

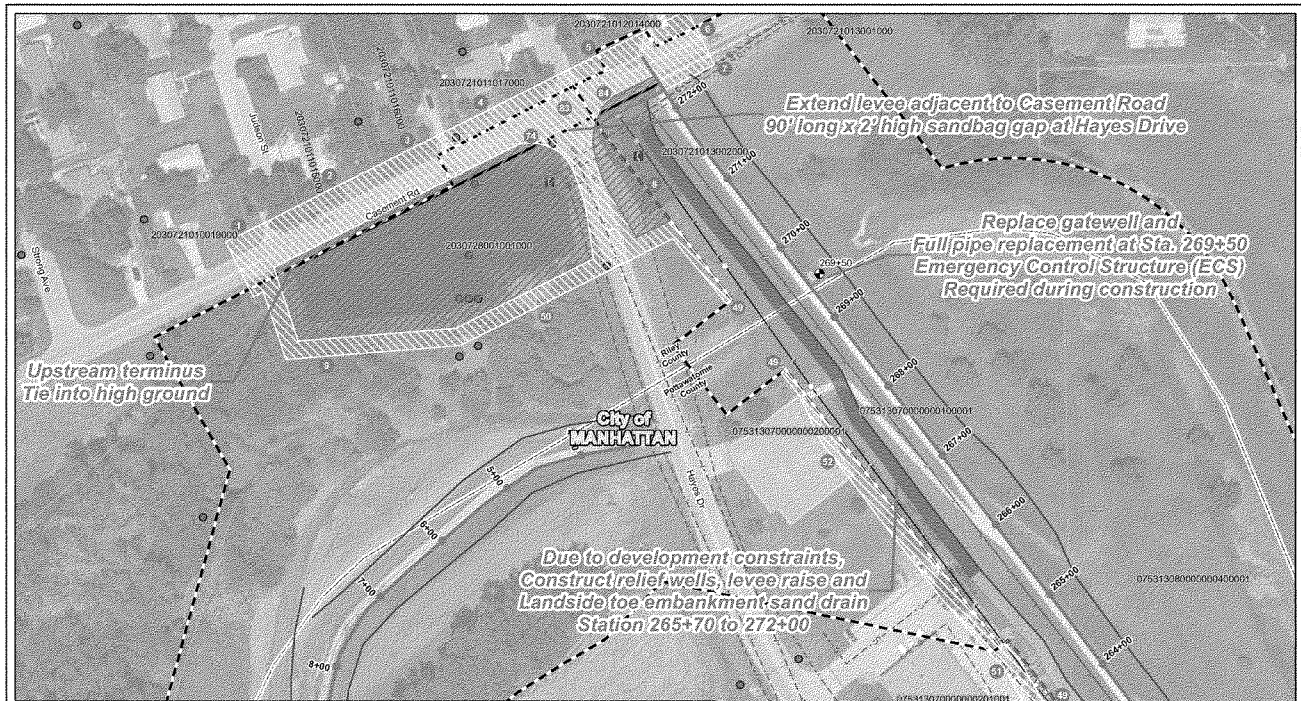
Users should refer corrections, additions, and comments for improving this product to:

GIS Coordinator
U. S. Army Corps of Engineers,
Kansas City District
601 East 12th, Room 527
Kansas City, Missouri 64106

0 25 50 100 Feet



Sheet No.21



MAP ID	Parcel ID Riley County	Parcel ID Pottawatomie County changes	Party Name	Non-affected acres	Temporary Acres	Permanent Acres	Total Acres
1	20307210100190000	20307210101019000	Cimelberry, E.B. Norma K,Trust	0.184214459	0.006909178		0.191124637
2	20307210101015000	20307210101015000	FEBNER,DOUGLAS R & LINDA I	0.224307747	0.011109502		0.245217349
3	20307210101016000	20307210101016000	MCLAIN, JOHN G.	0.432863274	0.011582286		0.444445561
4	20307210101017000	20307210101017000	SANDOVAL, IAN E	0.181074026	0.026843494		0.21991752
5	20307210101014000	20307210101014000	MOOR, MARVIN L	0.17671136	0.023552112		0.200726718
6	20307210101015000	20307210101015000	DEFNER,RONALD D & KIMBERLY	0.186097511	0.005251132		0.191348643
7	20307210101001000	20307210101001000	REITZ,RUSSELL L MD,TRUST REITZ,RUSSELL L MD,TRUSTEE	1.820456222	7.36051E-05		1.820456277
8	20307210101002000	20307210101002000	CITY OF MANHATTAN	1.323009668	0.020882895	0.028573538	1.372466101
9	20307280010001000	20307280010001000	CITY OF MANHATTAN	15.84562761	0.132438031	0.533580843	16.71164639
10	0753070000001000	0753130700000001000	MANHATTAN CITY	2.773527966	0.017769425	0.011363251	2.802656642
11	0753070000001000	0753130700000001000	MANHATTAN CITY	14.43861788	0.059566773	0.001153301	14.49915796
12	0753070000002010	0753130700000002010	DAY SHERWOOD RENTALS	0.978338326	0.013110936	0.012554185	1.004198447
13	0753070000002000	0753130700000002000	MANHATTAN CITY	0.893232964	0.102772507		0.996005472
14	0753080000004000	0753130800000004000	MANHATTAN CITY	11.93173721		0.002973514	11.93473072
15	0753080001001000	0753130800001001000	B.W.M PROPERTIES	0.909246804	0.131581898	0.041289955	1.096135657
16			Road R/W			0.394324136	0.394324136
17			Road R/W		0.818369347		0.818369347
18			Road R/W			0.101503608	0.101503608

Manhattan Levee

Feasibility Study
Existing Conditions and Reliability Improvements

Plan 3
Real Estate
Station 260+50 to 272+50

Key

- Roads
- FEMA Floodplain
- County Boundary
- City Boundary
- Parcels

Proposed Features
- Berm
- Berm and Raise
- Flooding
- Adder
- Relief Wells
- Proposed Sandbag Gap
- Proposed Levee Centerline
- Permanent Real Estate Easement
- Temporary Real Estate Easement

Existing UL Features
- Aerial Cable & Fiber Optic (FO)
- Underground Cable & FO
- Aerial Electrical & Light
- Underground Electrical & Light
- Natural Gas Lines
- Water Lines
- Storm Sewer Lines
- Sanitary Sewer Lines
- Communication Structure
- Electrical Poles
- Manholes

Existing Levee Features
- Relief Well
- Sandbag Gap
- Sandbag Gap
- Pump Station
- Piezometers
- Manhattan Levee Unit
- Top (2010 Survey)

N

US Army Corps of Engineers
Kansas City District

Photography Date: 2010

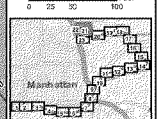
Projection: State Plane, Kansas North
Datum: NAD 83

Created by:
U.S. Army Corps of Engineers
Kansas City District, GDS Team

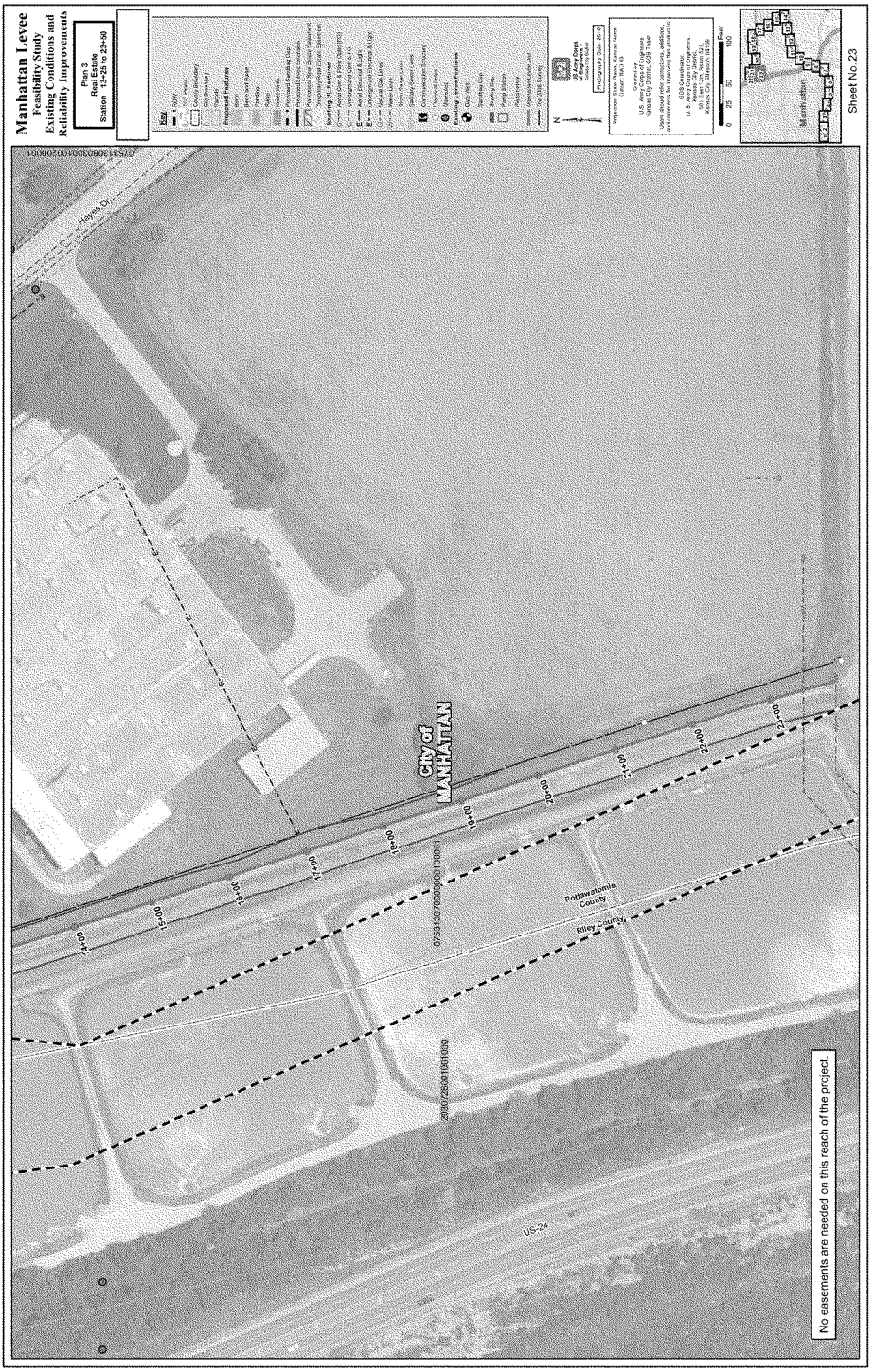
Users should refer corrections, additions, and comments for improving this product to:

GDS Coordinator
U. S. Army Corps of Engineers
Kansas City District
601 East 12th, Room 527
Kansas City, Missouri 64106

0 25 50 100 Feet



Sheet No. 22


Manhattan Levee
Feasibility Study
Existing Conditions and
Reliability Improvements
Plan 3
Real Estate
Station 13+25 to 23+50
Key
Existing Levee Features
Hayes Dr.
City of
MANHATTAN
14+00
15+00
16+00
17+00
18+00
19+00
20+00
21+00
22+00
23+00
Pottawatomie
County
Riley County
US-24
Sheet No. 23
No easements are needed on this reach of the project.

MAP ID	Parcel ID Riley County	Party_Name	Non-affected acres	Temporary Acres	Permanent Acres	Total Acres
1	2030721010019000	Cline,Larry E & Norma K;Trust	0.18423145913	0.00690917792		0.19114063705
2	2030721011015000	TEENER,DOUGLAS R & LINDA I	0.22410774697	0.02110960219		0.24521734916
3	2030721011016000	MCLAIN, JON G	0.39286327432	0.02168228940		0.41454556371
4	2030721011017000	SANDOVAL, IAN E	0.18337402569	0.02664349406		0.21001751975
5	2030721012014000	HOOK, MARVIN L	0.17872136027	0.02335521221		0.20207657249
6	2030721012015000	DREHER,RONALD D & KIMBERLY	0.18600752065	0.00525313253		0.19126065318
7	2030721013001000	REITZ,RUSSELL L MD;TRUST REITZ,RUSSELL L MD;TRUSTEE	1.82086822178	0.00007260514		1.82094082692
8	2030721013002000	CITY OF MANHATTAN	1.32300966830	0.02038296910	0.02857353824	1.37196617564
9	2030728001001000	CITY OF MANHATTAN	15.64562761350	0.13243805135	0.93358084124	16.71164650609
13	2041920000001000	CITY OF MANHATTAN	11.77025373780	0.00160965803	0.13975158579	11.91161498162
14	2041920000002000	CITY OF MANHATTAN	77.26366952150	0.047502556	0.022332996	77.33350507396
15	2041920000017000	CITY OF MANHATTAN	3.30694588217	0.04277827572		3.34972415789
16	2041921011001000	WAMEGO SAND COMPANY INC DBA MIDWEST CONCRETE MATR	11.14663868030	0.18207291243	0.00213042611	11.33084201884
17	2041921012001000	LITTLE, MARY LOU	1.08548089575	0.02583092210		1.11131181785
18	2041921013001000	SOWELL, RONALD A	1.27930753177	0.14204150864	0.04982053543	1.47116957585
19	2041921013002000	SOWELL, RONALD A	0.96137442933	0.06512838055	0.00528000669	1.03178281657
20	2041921013003010	MAULE, DAVID C	1.36201775882	0.02860051250		1.39061827132
21	2041921013004000	HUMMEL, TRAVIS DALE	0.85248038879	0.03542293813		0.88790332692
22	2041921013007010	GIBSON, ROGER E	0.64443735125	0.06878511708	0.00010945552	0.71333192384
23	2041921013009000	FLEEKER,CHARLES & JUDITH L	1.01489709351	0.04007301978		1.05497011329
24	2041921013012020	SOWELL, RONALD A	0.03078592730	0.01498367848	0.00009677786	0.04586638364
25	2041922006004000	SOWELL,SCOTT & DEBORAH JO	1.25820058810	0.00047358768		1.25867417578
26	2041922006005000	CITY OF MANHATTAN	0.22868353181	0.00009827537		0.22878180718
27	2041922011001000	MOHR FAMILY TRUST MOHR,R L & D E;TRUSTEES	0.97687826646	0.07911186722		1.05599013369
28	2041922011002000	Cashman,Kathleen A, & Steinmetz,Nikki R, & Sutherland,Sammy G	1.59366429860	0.08375981	0.01334991545	1.69077402371
31	2041922012014000	MEYER, RODNEY D	0.24544971457	0.02212075793		0.26757047249
32	2041922012015000	FLEEKER,CHARLES & JUDITH L	0.32378960926	0.01987459921		0.34366420847
33	2041922012028000	ERDMAN, ASHLEY A	0.24095960104	0.05165439678	0.00147913581	0.29409313363
34	2041922012030000	Meladze, Vakhtang	0.13267724618	0.03889533490	0.00844445706	0.18001703814
35	2041922012032000	JONES,EDGAR A III KISSICK,STACY D	0.12617145652	0.03887105095	0.01341998182	0.17846248930
36	2041922012034000	AMBROSE, JASON W	0.23921757256	0.03299225	0.008341588	0.28055141095
37	2041922013005000	COLEMAN, MAUREEN S	0.20340652161	0.00338817737		0.20679469898
38	2041922013006000	ZOELLER, AMBER	0.17426687767	0.00589974054		0.18016661821
39	2041922013007000	HALL,RON L & SHEILA L	0.13688733779	0.00904105936		0.14592839715
40	2041922013008000	WASHINGTON, CLEOPHUS	0.20676960519	0.00642517577		0.21319478095
41	2041922013009000	SCROGGIN, COLLEEN J	0.24897358814	0.00192363069		0.25089721883
46		MANHATTAN CITY	1.61235103559	0.00090656106		1.61325759665
47		MANHATTAN CITY	6.26334098103	0.21920025875	0.032695142	6.51523638160
48		FAIR DEBORAH .11 INT	3.68284194369	0.07887652182	0.01071714922	3.77243561473
49	3130700000001000	MANHATTAN CITY	2.77352796632	0.017769425	0.01136925060	2.80266664189
50	3130700000001000	MANHATTAN CITY	14.43863788300	0.05956677076	0.00115330138	14.49935795514
51	3130700000002010	CLAY SHERWOOD RENTALS	0.92833832602	0.11211093926	0.01253438456	1.05298364983
52	3130700000002000	MANHATTAN CITY	0.89523296438	0.10277230750		0.99800527188
53		MANHATTAN CITY	3.70991821485	0.09196094717	0.01947037115	3.82134953316

54		MANHATTAN CITY	39.94474643	0.18776435854	0.18153439	40.31404517557
55	3130800000004000	MANHATTAN CITY	11.93179721110		0.00297351370	11.93477072480
56	3130800000006000	MANHATTAN CITY % FARRAR CORPORATION	31.30539167	0.082019131		31.38741079570
57	3130803001001000	R W M PROPERTIES	0.90926680422	0.11581893960	0.04129995323	1.06638569705
58	3130803001002000	PAWNEE MENTAL HEALTH SERVICES ENDOWMENT ASSOC	1.12684008091	0.13187492378	0.04065078034	1.29936578503
59	3130803001003000	MANHATTAN CITY	1.92630626917	0.032561735	0.00214580902	1.96101381307
60	3130803001004000	BIG LAKES DEVELOPMENTAL CENTER	6.03553447392	0.03351315759		6.06904763151
61	3130804001001000	MANHATTAN CITY	5.73201942881	0.00014852088		5.73216794969
62	3130804001003000	GLOBE PARTNERS	7.46492685095	0.00785088		7.47277773079
63	3130804001004000	KANSAS STATE MILITARY BOARD	8.46729084963	0.13724034119		8.60453119082
64	3130804001005000	MANHATTAN CITY WATER DEPARTMENT	0.59314517008	0.02302264050	0.00329513354	0.61946294412
65	3130804001006000	POYNTZ AVENUE PROPERTIES	4.45201487437	0.20343234557	0.07818949091	4.73363671085
66	3130804001007000	BAILEY MOVING & STORAGE COMPANY	4.79400099842	0.14920838483	0.00035574945	4.94356513269
67	3130801001008000	GRIFFITH LUMBER COMPANY	4.49663670535	0.15068205170	0.024308564	4.67162732096
68		WESTAR ENERGY	39.36602953340	0.34112136648	0.02024088569	39.72739178557
69		FAY BETTY J .5 INT	34.86045658770	0.48185499403	1.153678165	36.49598974628
70	3141700000012000	MANHATTAN CITY	22.78774895	0.03700539925		22.82475434605
71		MANHATTAN CITY	29.96987703	0.51886039329	0.38780770614	30.87654513236
72		FAIR DEBORAH .11 INT	19.55685244150	0.406730221	0.38780770614	20.35139036823
73		MANHATTAN CITY	45.19882602200	0.666024052	1.280370859	47.14522093366
74		Road R/W			0.19432341618	0.19432341618
75		RR R/W		0.18400210561		0.18400210561
78		RR R/W			0.06508271593	0.06508271593
79		RR R/W		0.07278845965		0.07278845965
80		Road R/W			0.01037808287	0.01037808287
81		Road R/W			0.05488946878	0.05488946878
82		Road R/W		0.12046100000		0.12046100000
83		Road R/W		0.81806934714		0.81806934714
84		Road R/W			0.10150360591	0.10150360591
85		RR R/W		0.01556		0.01556000000
TOTAL			**492.41699359297**	**6.94798420668**	**5.34548683511**	**504.71046463476**

ASSESSMENT OF NON-FEDERAL SPONSOR'S REAL ESTATE ACQUISITION CAPABILITY

MANHATTAN LEVEE
FLOOD DAMAGE REDUCTION PROJECT
RILEY COUNTY AND POTTAWATOMIE COUNTY, KANSAS

I. Legal Authority:

a. Does the sponsor have the legal authority to acquire and hold title to real property for project purposes? YES

b. Does the sponsor have the power of eminent domain for this project? YES

c. Does the sponsor have "quick take" authority for this project? YES

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary? NO

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? NO

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirement of Federal projects including P.L. 91-646, as amended? NO

b. If the answer to II.a. is "yes", has a reasonable plan been developed to provide such training? N/A

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? YES

d. Is the sponsor's projected in-house staffing level sufficient considering its other work load, if any, and the project schedule? YES (at this time)

e. Can the sponsor obtain contractor support, if required, in a timely fashion? YES

f. Will the sponsor likely request USACE assistance in acquiring real estate? NO

Exhibit C

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? YES

b. Has the sponsor approved the project/real estate schedule/milestones? YES

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects? Yes. The original Manhattan Levee Project was 100% Federally funded and the sponsor was responsible for obtaining LER and providing maintenance, all of which were performed with full satisfaction.

b. With regard to this project, the sponsor is anticipated to be: (Highly, Fully, Moderate, Marginally capable) Fully Capable.

V. Coordination:

a. Has this assessment been coordinated with the sponsor? YES

b. Does the sponsor concur with this assessment? YES

Prepared by: Patty Richardson — 8/4/14
Patty Richardson, Team Leader — Date

Reviewed by: Kevin L. Bishop — 8/4/14
Kevin Bishop, Chief, Civil Branch & Military - Installation Support Real Estate Division — Date

Approved by: G G Wilson — 8/4/14
Gregory G. Wilson, Chief, Real Estate Division — Date

Exhibit C

US Army Corps
of Engineers®

MANHATTAN LOCAL PROTECTION PROJECT
FEASIBILITY STUDY
MANHATTAN, KANSAS
(Manhattan Levee)

(Section 216 Review of Completed Civil Works)

Cost Estimating Appendix

August 2014 Final Feasibility Report

Cost Engineering Appendix
Table of Contents

1. Overview of Cost Engineering Efforts for the Final Feasibility Report.....1
2. Project Narrative and Cost Estimate Development & Assumptions.....1
3. Abbreviated Cost Risk Analysis and Resulting Contingency Development ...3
4. Total Project Cost Development 5

Attachments
Cost Certification
Total Project Cost Summary
Abbreviated Risk Analysis
Risk Register

Manhattan Local Protection Project
Final Feasibility Report
Cost Engineering Appendix

1. Overview of Cost Engineering Efforts for the Final Feasibility Report

The Cost Engineering contribution to the Final Feasibility Report consisted of the creation of a Total Project Cost Summary (TPCS), an abbreviated cost risk analysis, and coordination of review and certification of these products by the USACE Cost Engineering Mandatory Center of Expertise (MCX).

The estimate of the Recommended Plan was developed and reviewed by the Kansas City District Cost Engineering Section. In addition to the estimate, backup support was created for the excavation/haul production rates, detailed quantity take-offs were performed, and a construction schedule was created.

The abbreviated cost risk analysis consisted of developing the risk register to assist in creating a contingency amount to add to the cost estimate. The Project Delivery Team (PDT) assists in the creation of the risk register. Risks to the major project components were identified and a likelihood of occurrence and magnitude of impact assigned to each risk. Once a contingency amount is developed from the completion of the abbreviated cost risk analysis, the Total Project Cost Summary is created. It documents the project costs by each work breakdown structure account and escalates costs accordingly to the mid-point of each activity.

2. Project Narrative and Cost Estimate Development & Assumptions

The project site is the existing levee at Manhattan, KS. The levee consists of two segments. One is for the Big Blue River segment to the east of the city. The other is the Kansas River segment to the south of the city. The NED (National Economic Development) Plan is Plan 3, a levee raise with accompanying geotechnical and structural reliability improvements. The construction work is assumed to be split out into 3 contracts as shown below:

- Contract #1: Demolition and replacement of two gatewells where levee raise will occur. Gatewells are to be demolished and constructed to match the newly raised levee height. Full replacement of inlet & outlet pipes as well as associated inlet & outlet structures will also be replaced. An emergency closure system is to be used during demolition/construction of the gatewells in lieu of creating/removing ring levees as a cost savings measure. The emergency closure system consists of stockpiling adequate fill material on-site next to the gatewell to be able to use as backfill to plug the hole in the levee should a flood be anticipated. The Kansas City District Hydrology Section stated that the controlled releases from Tuttle Creek Dam on Big Blue River would give the

contractor sufficient time to close the holes in the levee in time before the river reached flood stage. The two gatewells to be replaced are at Sta. 163+00 and 269+50.

- Contract #2: Consists of utility relocations, levee raise, sand drain installation, underseepage berm installation, and relief well installation as described below:
    - Utility Relocations:
        - Raising 11 manhole structures that are located in areas where underseepage berms will be constructed.
        - Re-running 36" water line up and over new levee raise.
        - Minor modifications to outlet of Wastewater Treatment Plant
    - Levee Raise: 14,100 lf of 1.5 ft. average raise
    - Sand Drain Installation: 10,200 lf
    - Underseepage Berm Installation: 2,538 lf (Includes raising 11 manholes where underseepage berm will be placed)
    - Relief Well Installation: 29 (13 at 50' depth and 16 at 60' depth) plus installation of collector system
- Contract #3: Demolition and replacement of three gatewells where levee raise will not occur. These gatewells fail strength criteria under new criteria and will need to be replaced to bring whole levee system up to criteria. Once the levee is touched for any reason, the whole system needs to be updated to the new criteria. Gatewells are to be demolished and constructed to match the existing levee height. One section of 8 lf pipe on the inlet and the outlet sides of the gatewells will also be replaced. The three gatewells to be replaced are at Sta. 14+78, 62+20, and 89+83.

It is assumed that the acquisition strategy will be Invitation for Bid (either Small Business or Full and Open). This is reflected in the contractor markup structure. The prime contractor is assumed to perform the majority of the earthwork. Separate subcontractors are assumed for the Asphalt Paving, Concrete Work, Utility Relocation, Relief Well, and Seeding activities.

A construction schedule for each contract was developed using Microsoft Project. The schedules were developed assuming an 8 hour/day, 5 days/week work week. Two earthwork crews were assumed for the earthwork portions. The rest of the activities were assumed to be performed by one crew. Construction of Contract #1 is assumed to start during FY 18 and last 5 calendar months. Construction of Contract #2 is assumed to start during FY 19 and last 21 calendar months. Construction of Contract #3 is assumed to start during FY 22 and last 6 calendar months.

3. Abbreviated Cost Risk Analysis and Resulting Contingency Development

The major line items analyzed for the abbreviated cost risk analysis were as follows: Mobilization/Demobilization, Borrow Site, Levee Raise & Sand Drains, Underseepage Berms & Manhole Raises, Utility Relocations, Gatewell Replacements, Relief Wells, Planning, Engineering, & Design, and Construction Management.

These line items were analyzed for the following risk elements: Project Scope Growth, Acquisition Strategy, Construction Elements, Quantities for Current Scope, Specialty Fabrication or Equipment, Cost Estimate Assumptions, and External Project Risks.

The PDT met four times to develop the risk register. The first three times involved examining the array of four alternatives, of which the recommended plan (Plan 3) was one such alternative. The fourth meeting was to revisit the abbreviated cost risk analysis for the recommended plan in light of the revisions to the estimate from the original unit cost estimate to the detailed cost estimate. The four meetings and their dates and disciplines represented are listed below:

Meeting #1: July 29, 2013
- Geotechnical
- Structural
- Civil Design
- Cost Engineering
- Cost Engineering
- Real Estate
- Project Manager

Meeting #2: July 30, 2013
- Geotechnical
- Structural
- Cost Engineering
- Hydrology
- Project Manager

Meeting #3: August 7, 2013
- HTRW
- Construction
- Environmental Resources
- Structural
- Cost Engineering
- Project Manager

Meeting #4: October 2, 2013

- Geotechnical
- Structural
- Civil Design
- Economics
- Cost Engineering
- Hydrology
- Project Manager
- Construction

During the fourth meeting, the team identified several items like a relief well collector system that is now included in the refined Plan 3 estimate and could be removed as a risk item. The original risk item discussed the possibility of the header system being added to the project and is no longer applicable as that item is now a project feature. The changes lowered the resulting contingency percentage for the applicable line items in the abbreviated cost risk analysis.

The line items with the largest associated contingency percentages were the Levee Raise & Sand Drains, the Utility Relocations, and the Underseepage Berms & Manhole Raises.

The "Levee Raise & Sand Drains" and "Underseepage Berms & Manhole Raises" portions of the project were identified as having some of the largest risks associated to them. A large risk driver to each of these line items is the possibility of a flood event that could shut down the job and put the contractor on stand-by. This risk was modeled as possible with having a critical impact if it did occur. The cumulative contingency percentages for the "Levee Raise & Sand Drains" and "Underseepage Berms & Manhole Raises" line items are 31.99% and 26.36% respectively.

The "Utility Relocations" line item also was also identified as having some of the largest risks associated to it. One of the largest risks is that not all of the utility relocations necessary for completion of the project work have been identified to date. A thorough search was made of all county and city utilities but there may be more private utilities affecting project work that have yet to be identified. This risk of having to relocate more utilities was identified as a possible occurrence with a critical impact. The cumulative contingency percentage for "Utility Relocations" is 30.27%.

The Real Estate contingency percentage of 25% was provided by the Kansas City District's Real Estate Division. However, the contingency percentage is added before administrative/incidental costs are applied to the total Real Estate costs for the project. Factoring in these costs as "before contingency costs" leads to a 22.10% contingency percentage in order to ensure the correct Real Estate total cost is incorporated in the Total Project Cost.

4. Total Project Cost Development

The Total Project Cost was developed and is presented in the Total Project Cost Summary (TPCS). The current fully funded Total Project Cost is $26,934,000.00. The Total Project Cost is comprised of the totals for the individual account totals for Lands & Damages (01), Relocations (02), Levees & Floodwalls (11), Planning, Engineering, & Design (30), and Construction Management (31). The Effective Price Level of the current account values is July 14, 2014. The Fully Funded Project Costs for each account are calculated by escalating from the Program Year to the mid-point of that account/activity.

The Planning, Engineering, & Design (PED) and Construction Management costs and associated contingency percentages were discussed and determined by the PDT. The engineering team members provided estimated labor budgets for each of the three projects. The remaining PED and S&A costs were based upon a percentage of construction costs. A contingency percentage of 15.62% was used for the PED (30) account and 22.43% was used for the Construction Management (31) account.

The PED cost breakdown includes the following individual costs: Project Management, Planning & Environmental Compliance, Engineering & Design, Engineering Tech Review ITR & VE, Contracting & Reprographics, Engineering During Construction, Planning During Construction, and Project Operations.

The Construction Management costs are composed of the following individual costs: Construction Management, Project Operation, and Project Management.

The cumulative contingency percentage of 26.36% was applied for the two construction accounts. These accounts were Relocations (02) and Levees & Floodwalls (11).

When all the applicable accounts (01, 02, 11, 30, & 31) are factored in, the total project contingency percentage is 24.14%.

WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

For Project No. 106928

NWK – Manhattan, Kansas
Local Protection Project Section 216

The Manhattan, KS Local Protection Project Section 216, as presented by Kansas City District, has undergone a successful Cost Agency Technical Review (Cost ATR), performed by the Walla Walla District Cost Engineering Mandatory Center of Expertise (Cost MCX) team. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies. This certification signifies the products meet the quality standards as prescribed in ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of July 16, 2014, the Cost MCX certifies the estimated total project cost of:

FY 2015 Price Level: $23,754,000
Fully Funded Amount: $26,934,000

It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project management controls and implementation procedures including risk management throughout the life of the project.

NEUBAUER.JAMES.GERARD.1153289898

Digitally signed by NEUBAUER.JAMES.GERARD.1153289898
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=NEUBAUER.JAMES.GERARD.1153289898
Date: 2014.07.16 12:57:53 -07'00'

For Kim C. Callan, PE, CCE, PM
Chief, Cost Engineering MCX
Walla Walla District

****** TOTAL PROJECT COST SUMMARY ******

PROJECT: **Manhattan Local Protection - Plan 3**
PROJECT NO: 106928
LOCATION: Manhattan, KS

DISTRICT: NWK Kansas City PREPARED: 7/14/2014
POC: CHIEF, COST ENGINEERING

This Estimate reflects the scope and schedule in report; Manhattan Local Protection Report August 2013

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC): 2015 Effective Price Level Date: 1 OCT 14									
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2013 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J				M	N	O
02	RELOCATIONS	$686	$181	26%	$866	1.6%	$696	$184	$880	$0	$880	12.4%	$783	$206	$989
11	LEVEES & FLOODWALLS	$12,770	$3,366	26%	$16,136	1.6%	$12,968	$3,418	$16,387	$0	$16,387	12.3%	$14,566	$3,840	$18,406
	CONSTRUCTION ESTIMATE TOTALS:	$13,455	$3,547		$17,002	1.6%	$13,665	$3,602	$17,267	$0	$17,267	12.3%	$15,349	$4,046	$19,395
01	LANDS AND DAMAGES	$1,297	$287	22%	$1,584	1.6%	$1,317	$291	$1,609	$0	$1,609	4.9%	$1,382	$305	$1,688
30	PLANNING, ENGINEERING & DESIGN	$2,990	$467	16%	$3,457	2.2%	$3,054	$477	$3,531	$0	$3,531	17.9%	$3,601	$563	$4,164
31	CONSTRUCTION MANAGEMENT	$1,077	$242	22%	$1,319	2.2%	$1,100	$247	$1,347	$0	$1,347	25.2%	$1,378	$309	$1,687
	PROJECT COST TOTALS:	$18,819	$4,542	24%	$23,361		$19,137	$4,617	**$23,754**	$0	**$23,754**	13.4%	$21,711	$5,223	$26,934

Mandatory by Regulation	CHIEF, COST ENGINEERING	ESTIMATED FEDERAL COST:	**65%** **$17,507**
Mandatory by Regulation	PROJECT MANAGER	ESTIMATED NON-FEDERAL COST:	**35%** **$9,427**
Mandatory by Regulation	CHIEF, REAL ESTATE	**ESTIMATED TOTAL PROJECT COST:**	**$26,934**
	CHIEF, PLANNING		
	CHIEF, ENGINEERING		
	CHIEF, OPERATIONS		
	CHIEF, CONSTRUCTION		
	CHIEF, CONTRACTING		
	CHIEF, PM-PF		
	CHIEF, DPM		

TPCS

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: Manhattan Local Protection - Plan 3
LOCATION: Manhattan, KS
This Estimate reflects the scope and schedule in report; Manhattan Local Protection Report August 2013

DISTRICT: NWK Kansas City
POC: CHIEF, COST ENGINEERING

PREPARED: 7/14/2014

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 7/11/2014 Effective Price Level: 10/1/2013				Program Year (Budget EC): 2015 Effective Price Level Date: 1 OCT 14								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1 or CONTRACT 1													
11	LEVEES & FLOODWALLS	$1,395	$368	26%	$1,762	1.6%	$1,416	$373	$1,790	2018Q4	7.5%	$1,523	$402	$1,925
							$0							
	CONSTRUCTION ESTIMATE TOTALS:	$1,395	$368	26%	**$1,762**		$1,416	$373	$1,790			$1,523	$402	$1,925
01	LANDS AND DAMAGES	$1,297	$287	22%	$1,584	1.6%	$1,317	$291	$1,609	2017Q3	4.9%	$1,382	$305	$1,688
30	PLANNING, ENGINEERING & DESIGN													
1.5%	Project Management	$21	$3	16%	$24	2.2%	$21	$3	$25	2016Q4	6.4%	$23	$4	$26
1.0%	Planning & Environmental Compliance	$14	$2	16%	$16	2.2%	$14	$2	$17	2016Q4	6.4%	$15	$2	$18
30.4%	Engineering & Design	$407	$63	16%	$470	2.2%	$415	$65	$480	2016Q4	6.4%	$442	$69	$511
1.0%	Reviews, ATRs, IEPRs, VE	$14	$2	16%	$16	2.2%	$14	$2	$17	2016Q4	6.4%	$15	$2	$18
20.2%	Life Cycle Updates (cost, schedule, risks)	$270	$42	16%	$312	2.2%	$276	$43	$319	2016Q4	6.4%	$294	$46	$339
1.0%	Contracting & Reprographics	$14	$2	16%	$16	2.2%	$14	$2	$17	2016Q4	6.4%	$15	$2	$18
42.6%	Engineering During Construction	$569	$89	16%	$658	2.2%	$582	$91	$672	2018Q4	14.9%	$668	$104	$773
0.0%	Planning During Construction	$0	$0	16%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	16%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
7.0%	Construction Management	$98	$22	22%	$120	2.2%	$100	$22	$123	2018Q4	14.9%	$115	$26	$141
0.0%	Project Operation:	$0	$0	22%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
1.0%	Project Management	$14	$3	22%	$17	2.2%	$14	$3	$18	2018Q4	14.9%	$16	$4	$20
	CONTRACT COST TOTALS:	$4,113	$884		**$4,997**		$4,185	$899	$5,084			$4,509	$966	**$5,476**

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: Manhattan Local Protection - Plan 3
LOCATION: Manhattan, KS
This Estimate reflects the scope and schedule in report; Manhattan Local Protection Report August 2013

DISTRICT: NWK Kansas City
POC: CHIEF, COST ENGINEERING

PREPARED: 7/14/2014

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 3/15/2014 Effective Price Level: 10/1/2013				Program Year (Budget EC): 2015 Effective Price Level Date: 1 OCT 14								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 2 or CONTRACT 2													
02	RELOCATIONS	$686	$181	26%	$866	1.6%	$696	$184	$880	2021Q1	12.4%	$783	$206	$989
11	LEVEES & FLOODWALLS	$10,017	$2,640	26%	$12,658	1.6%	$10,173	$2,682	$12,854	2021Q1	12.4%	$11,438	$3,015	$14,452
							$0							
	CONSTRUCTION ESTIMATE TOTALS:	$10,703	$2,821	26%	**$13,524**		$10,869	$2,865	$13,734			$12,220	$3,221	$15,442
01	LANDS AND DAMAGES	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
1.5%	Project Management	$161	$25	16%	$186	2.2%	$164	$26	$190	2020Q1	20.6%	$198	$31	$229
1.0%	Planning & Environmental Compliance	$107	$17	16%	$124	2.2%	$109	$17	$126	2020Q1	20.6%	$132	$21	$152
0.0%	Engineering & Design	$0	$0	16%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.3%	Reviews, ATRs, IEPRs, VE	$30	$5	16%	$35	2.2%	$31	$5	$35	2020Q1	20.6%	$37	$6	$43
1.0%	Life Cycle Updates (cost, schedule, risks)	$107	$17	16%	$124	2.2%	$109	$17	$126	2020Q1	20.6%	$132	$21	$152
1.0%	Contracting & Reprographics	$107	$17	16%	$124	2.2%	$109	$17	$126	2020Q1	20.6%	$132	$21	$152
10.7%	Engineering During Construction	$1,077	$168	16%	$1,245	2.2%	$1,100	$172	$1,272	2021Q1	25.4%	$1,380	$216	$1,596
0.0%	Planning During Construction	$0	$0	16%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	16%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
7.0%	Construction Management	$749	$168	22%	$917	2.2%	$765	$172	$937	2021Q1	25.4%	$960	$215	$1,175
0.0%	Project Operation:	$0	$0	22%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
1.0%	Project Management	$107	$24	22%	$131	2.2%	$109	$25	$134	2021Q1	25.4%	$137	$31	$168
	CONTRACT COST TOTALS:	$13,148	$3,261		**$16,409**		$13,367	$3,315	$16,682			$15,328	$3,781	**$19,110**

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: Manhattan Local Protection - Plan 3
LOCATION: Manhattan, KS
This Estimate reflects the scope and schedule in report; Manhattan Local Protection Report August 2013

DISTRICT: NWK Kansas City
POC: CHIEF, COST ENGINEERING

PREPARED: 7/14/2014

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 3/15/2014 Effective Price Level: 10/1/2013				Program Year (Budget EC): 2015 Effective Price Level Date: 1 OCT 14								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J	P	L	M	N	O
	PHASE 3 or CONTRACT 3													
11	LEVEES & FLOODWALLS	$1,358	$358	26%	$1,716	1.6%	$1,379	$364	$1,743	2022Q4	16.4%	$1,605	$423	$2,029
							$0							
	CONSTRUCTION ESTIMATE TOTALS:	$1,358	$358	26%	**$1,716**		$1,379	$364	$1,743			$1,605	$423	$2,029
01	LANDS AND DAMAGES	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
1.5%	Project Management	$20	$3	16%	$23	2.2%	$20	$3	$24	2021Q1	25.4%	$26	$4	$30
1.0%	Planning & Environmental Compliance	$14	$2	16%	$16	2.2%	$14	$2	$17	2021Q1	25.4%	$18	$3	$21
0.0%	Engineering & Design	$0	$0	16%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
2.3%	Reviews, ATRs, IEPRs, VE	$30	$5	16%	$35	2.2%	$31	$5	$35	2021Q1	25.4%	$38	$6	$44
1.0%	Life Cycle Updates (cost, schedule, risks)	$14	$2	16%	$16	2.2%	$14	$2	$17	2021Q1	25.4%	$18	$3	$21
1.0%	Contracting & Reprographics	$14	$2	16%	$16	2.2%	$14	$2	$17	2021Q1	25.4%	$18	$3	$21
0.0%	Engineering During Construction	$0	$0	16%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Planning During Construction	$0	$0	16%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	16%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
7.0%	Construction Management	$95	$21	22%	$116	2.2%	$97	$22	$119	2022Q4	34.4%	$130	$29	$160
0.0%	Project Operation:	$0	$0	22%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
1.0%	Project Management	$14	$3	22%	$17	2.2%	$14	$3	$18	2022Q4	34.4%	$19	$4	$24
	CONTRACT COST TOTALS:	$1,559	$397		**$1,956**		$1,584	$403	$1,988			$1,873	$475	**$2,348**

Manhattan Local Protection: Plan 3
Feasibility (Recommended Plan)
Abbreviated Risk Analysis

Typical Risk Elements	Potential Risk Areas													
	Mobilization - Demobilization	Borrow Site	Levee Raise & Sand Drains	Underseepage Berms	Utility Relocations	Gatewell Replacements	Relief Wells	0	0	0	0	Remaining Construction Ite	Planning, Engineering, & Design	Construction Management
Project Scope Growth	-	-	2	1	3	1	2	-	-	-	-	-	1	1
Acquisition Strategy	1	1	1	1	1	1	1	-	-	-	-	1	1	1
Construction Elements	-	1	1	1	1	1	-	-	-	-	-	-	1	1
Quantities for Current Scope	-	-	1	1	1	2	2	-	-	-	-	-	-	-
Specialty Fabrication or Equipment	-	-	1	-	-	1	-	-	-	-	-	-	-	-
Cost Estimate Assumptions	-	2	2	2	2	2	1	-	-	-	-	-	-	1
External Project Risks	3	1	3	3	1	2	2	-	-	-	-	-	2	3

Risk Register

Project Scope Growth

Mob/Demob:
-Concerns: No concerns
-PDT Discussions/Conclusions: None
-Likelihood: Unlikely
-Impact: Negligible
-Risk Level: 0

Borrow Site:
-Concerns: Need larger borrow site for add'l fill if scope grows.
-PDT Discussions/Conclusions: Borrow requirements decreased as design progressed so unlikely.
-Likelihood: Unlikely
-Impact: Marginal
-Risk Level: 0

Levee Raise & Sand Drain:
-Concerns: Diversionary levee trail assumed to keep trail open during construction. Specifics of where temporary trail is located and for what length are not yet determined. Also, may need to add a minimal amount of rock on the riverside of the levee at the confluence.
-PDT Discussions/Conclusions: Fish & Wildlife will help determine exact details during design to keep trail open. Likely that current plan will change and could have an increase in costs. Also, analysis for adding rock at confluence has not been done but would be minimal if it occurs.
-Likelihood: Likely
-Impact: Marginal
-Risk Level: 2

Underseepage Berms:
-Concerns: If footprint goes up then RE costs will increase as well
-PDT Discussions/Conclusions: Lots of bldgs/businesses restrict to RW's so likely not expanding footprint any further but if had to, then it would be very expensive since businesses occur that land.
-Likelihood: Unlikely
-Impact: Significant
-Risk Level: 1

Utility Relocations:
-Concerns: Possibility for growth in number of relocations as well if scope were increased to impact more area.
-PDT Discussions/Conclusions: Definitely possible for encountering more utilities if project area grows.
-Likelihood: Possible
-Impact: Critical
-Risk Level: 3

Gatewell Replacements:
-Concerns: Possibility for growth in number of gatewell replacements as well if scope were increased to impact more area.
-PDT Discussions/Conclusions: Definitely could impact more gatewells if project area increases. Would need to add in full replacement of pipe for more gatewells if levee raise area increases as well.
-Likelihood: Unlikely
-Impact: Significant
-Risk Level: 1

Relief Wells:
-Concerns: Qty may go up upon detailed design.
-PDT Discussions/Conclusions: Possible and could add significant costs to the RW costs.
-Likelihood: Possible
-Impact: Significant
-Risk Level: 2

Remaining Construction Items:
-Concerns: None
-PDT Discussions/Conclusions: None
-Likelihood: Unlikely
-Impact: Marginal
-Risk Level: 0

Planning, Engineering, & Design:
-Concerns: Long design duration
-PDT Discussions/Conclusions: Would increase costs
-Likelihood: Possible
-Impact: Marginal
-Risk Level: 1

Construction Management:
-Concerns: Longer construction duration.
-PDT Discussions/Conclusions: Would increase S&A costs.
-Likelihood: Possible

-Impact: Marginal
-Risk Level: 1

Acquisition Strategy

Mob/Demob:
-Concerns: Unknown contracting vehicle at this time.
-PDT Discussions/Conclusions: MATOC, Sole-Source, or SB acquisition methods could increase projects costs significantly as estimate assumes IFB with prime contractor performing all the earthwork.
-Likelihood: Unlikely
-Impact: Significant
-Risk Level: 1

Borrow Site:
-Concerns: Same as Mob/Dembob
-PDT Discussions/Conclusions: Same as Mob/Dembob
-Likelihood: Unlikely
-Impact: Significant
-Risk Level: 1

Levee Raise & Sand Drain:
-Concerns: Same as Mob/Dembob
-PDT Discussions/Conclusions: Same as Mob/Dembob
-Likelihood: Unlikely
-Impact: Significant
-Risk Level: 1

Underseepage Berms:
-Concerns: Same as Mob/Dembob
-PDT Discussions/Conclusions: Same as Mob/Dembob
-Likelihood: Unlikely
-Impact: Significant
-Risk Level: 1

Utility Relocations:
-Concerns: Same as Mob/Dembob
-PDT Discussions/Conclusions: Same as Mob/Dembob
-Likelihood: Unlikely
-Impact: Significant
-Risk Level: 1

Gatewell Replacements:
-Concerns: Same as Mob/Dembob
-PDT Discussions/Conclusions: Same as Mob/Dembob
-Likelihood: Unlikely
-Impact: Significant
-Risk Level: 1

Relief Wells:
-Concerns: Same as Mob/Dembob
-PDT Discussions/Conclusions: Same as Mob/Dembob
-Likelihood: Unlikely
-Impact: Significant
-Risk Level: 1

Remaining Construction Items:
-Concerns: No Remaining Construction Items. All are covered under other line items.
-PDT Discussions/Conclusions: None
-Likelihood: Unlikely
-Impact: Significant
-Risk Level: 1

Planning, Engineering, & Design:
-Concerns: Same as Mob/Dembob
-PDT Discussions/Conclusions: Same as Mob/Dembob
-Likelihood: Unlikely
-Impact: Significant
-Risk Level: 1

Construction Management:
-Concerns: Same as Mob/Dembob
-PDT Discussions/Conclusions: Same as Mob/Dembob
-Likelihood: Unlikely
-Impact: Significant
-Risk Level: 1

Construction Elements

Mob/Demob:
-Concerns: No Concerns
-PDT Discussions/Conclusions: None
-Likelihood: Unlikely
-Impact: Negligible
-Risk Level: 0

Borrow Site:
-Concerns: Colder weather could make compaction difficult and cause fill to be difficult to work with.
-PDT Discussions/Conclusions: Contractor may need to disk material or add admixtures if schedule requires him to work during the winter and he experiences cold weather/snow.
-Likelihood: Possible
-Impact: Marginal
-Risk Level: 1

Levee Raise & Sand Drain:
-Concerns: Colder weather could make compaction difficult and cause fill to be difficult to work with.
-PDT Discussions/Conclusions: Contractor may need to disk material or add admixtures if schedule requires him to work during the winter and he experiences cold weather/snow.
-Likelihood: Possible
-Impact: Marginal
-Risk Level: 1

Underseepage Berms:
-Concerns: Colder weather could make compaction difficult and cause fill to be difficult to work with.
-PDT Discussions/Conclusions: Contractor may need to disk material or add admixtures if schedule requires him to work during the winter and he experiences cold weather/snow.
-Likelihood: Possible
-Impact: Marginal
-Risk Level: 1

Utility Relocations:
-Concerns: Contractor may have to rush to complete relocations depending on window that utility provides for doing the relocations.
-PDT Discussions/Conclusions: Coordination for relocations with utility companies should be done well in advance or construction activities occurring.
-Likelihood: Unlikely
-Impact: Significant
-Risk Level: 1

Gatewell Replacements:
-Concerns: May have to accelerate repairs if it looks like river stages are coming up.
-PDT Discussions/Conclusions: Possible and would cause some overtime to occur.
-Likelihood: Possible
-Impact: Marginal
-Risk Level: 1

Relief Wells:
-Concerns: Relief Wells would likely be restricted to being installed and tested during fairer weather. This could delay the schedule.
-PDT Discussions/Conclusions: Contractor should be able to schedule relief well work around other activities.
-Likelihood: Unlikely
-Impact: Marginal
-Risk Level: 0

Remaining Construction Items:
-Concerns: No Remaining Construction Items. All are covered under other line items.
-PDT Discussions/Conclusions: None
-Likelihood: Unlikely
-Impact: Negligible
-Risk Level: 0

Planning, Engineering, & Design:
-Concerns: Accelerated schedule may require timely responses on RFI's and cause engineering personnel to be pulled away from other projects or use overtime to accomplish RFI's in a timely manner.
-PDT Discussions/Conclusions: None
-Likelihood: Possible
-Impact: Marginal
-Risk Level: 1

Construction Management:
-Concerns: Accelerated schedule may require add'l oversight during overtime hours.
-PDT Discussions/Conclusions: None
-Likelihood: Possible
-Impact: Marginal
-Risk Level: 1

Quantities for Current Scope

Mob/Demob:
-Concerns: No Concerns
-PDT Discussions/Conclusions: None
-Likelihood: Unlikely
-Impact: Negligible
-Risk Level: 0

Borrow Site:
-Concerns: Compaction factor could change. Could hit water as dig deeper if qtys increase.
-PDT Discussions/Conclusions: Exact material qualities are unknown as no testing of borrow material has been done but this same site was used for original levee construction. Also, borrowing activities are assumed to not be performed if river stage is up.
-Likelihood: Unlikely
-Impact: Marginal
-Risk Level: 0

Levee Raise & Sand Drain:
-Concerns: Fairly accurate and recent Lidar survey. However, hydraulic profile could increase due to a change in the model.
-PDT Discussions/Conclusions: During design, H&H would like to have an actual survey performed and estimates that qtys could vary up to 10-15% from Lidar survey so there's a prossible need for qty change. Also, hydraulic profile change would only marginally increase scope.
-Likelihood: Possible
-Impact: Marginal
-Risk Level: 1

Underseepage Berms:
-Concerns: Qtys could change as design is refined.
-PDT Discussions/Conclusions: Berms are fairly constricted in size so it's possible that their dimensions could change but not by much.
-Likelihood: Possible
-Impact: Marginal
-Risk Level: 1

Utility Relocations:
-Concerns: Overhead electric at approx. Sta. 205+00 may need to be raised to accommodate the levee raise at that location. Also, could find currently unknown private utilities even though lots of research has already been done.

-PDT Discussions/Conclusions: Based on recent site visit and discussions with Electrical Engineers, it is not thought that a small decrease in clearance height will be a problem. Unlikely to find more utilities but would have significant impact if they were found.
-Likelihood: Unlikely
-Impact: Significant
-Risk Level: 1

Gatewell Replacements:
-Concerns: No ring levees needed in current scope. Also, qty of gatewell replacements could grow if criteria for replacement change.
-PDT Discussions/Conclusions: Stockpiled material on-site is normally sufficient. Critical increase in costs if had to create 100 year level of protection ring levees though. For number of gatewells, confident in criteria and qty that needs replacement
-Likelihood: Unlikely
-Impact: Critical
-Risk Level: 2

Relief Wells:
-Concerns: See "Project Scope Growth". Could need to build ponds for collecting & controlling drainage
-PDT Discussions/Conclusions: Large effort in cost and design.
-Likelihood: Unlikely
-Impact: Critical
-Risk Level: 2

Remaining Construction Items:
-Concerns: No Remaining Construction Items. All are covered under other line items.
-PDT Discussions/Conclusions: None
-Likelihood: Unlikely
-Impact: Negligible
-Risk Level: 0

Planning, Engineering, & Design:
-Concerns: No Concerns
-PDT Discussions/Conclusions: None
-Likelihood: Unlikely
-Impact: Negligible
-Risk Level: 0

Construction Management:
-Concerns: No Concerns
-PDT Discussions/Conclusions: None
-Likelihood: Unlikely

-Impact: Negligible
-Risk Level: 0

Specialty Fabrication or Equipment

Mob/Demob:
-Concerns: No Concerns
-PDT Discussions/Conclusions: None
-Likelihood: Unlikely
-Impact: Negligible
-Risk Level: 0

Borrow Site:
-Concerns: No Concerns
-PDT Discussions/Conclusions: None
-Likelihood: Unlikely
-Impact: Negligible
-Risk Level: 0

Levee Raise & Sand Drain:
-Concerns: Large qty of sand needed (~150k tons) and this could be difficult to come by for the gradiations needed. May need to haul sand in from long distances.
-PDT Discussions/Conclusions: Sand supplier said they could meet those qtys over the span of a few construction seasons, which is what this project would take.
-Likelihood: Unlikely
-Impact: Significant
-Risk Level: 1

Underseepage Berms:
-Concerns: No Concerns
-PDT Discussions/Conclusions: None
-Likelihood: Unlikely
-Impact: Negligible
-Risk Level: 0

Utility Relocations:
-Concerns: No Concerns
-PDT Discussions/Conclusions: None
-Likelihood: Unlikely
-Impact: Negligible
-Risk Level: 0

Gatewell Replacements:
-Concerns: Large qty of concrete will be ordered so this will require coordination with the concrete supplier to ensure timely deliveries and preparation for large qtys.
-PDT Discussions/Conclusions: Schedule could be delayed if contractor is waiting on concrete trucks for deliveries
-Likelihood: Possible
-Impact: Marginal
-Risk Level: 1

Relief Wells:
-Concerns: Screens for RW's could be delayed if manufacturer has a backlog
-PDT Discussions/Conclusions: Unlikely to affect project schedule as there should be float within the schedule to accomplish RW work.
-Likelihood: Unlikely
-Impact: Marginal
-Risk Level: 0

Remaining Construction Items:
-Concerns: No Remaining Construction Items. All are covered under other line items.
-PDT Discussions/Conclusions: None
-Likelihood: Unlikely
-Impact: Negligible
-Risk Level: 0

Planning, Engineering, & Design:
-Concerns: No Concerns
-PDT Discussions/Conclusions: None
-Likelihood: Unlikely
-Impact: Negligible
-Risk Level: 0

Construction Management:
-Concerns: No Concerns
-PDT Discussions/Conclusions: None
-Likelihood: Unlikely
-Impact: Negligible
-Risk Level: 0

Cost Estimate Assumptions

Mob/Demob:

-Concerns: Assuming multiple contracts so multiple mob/demobs should already be covered.
-PDT Discussions/Conclusions: No concerns.
-Likelihood: Unlikely
-Impact: Negligible
-Risk Level: 0

Borrow Site:

-Concerns: Borrow site assumed at farm fields adjacent to borrow site that was used in construction of original levee. Borrow will be purchased through a per cubic yard royalty fee. Also, could hit water table as need to excavate down to 5'.
-PDT Discussions/Conclusions: Water table could be near these depths unless high flows are occuring and probably would not be working during high flows.
-Likelihood: Possible
-Impact: Significant
-Risk Level: 2

Levee Raise & Sand Drain:

-Concerns: Estimate assumes enough easement room for 1-way haul routes at levee toe along length of levee raise. Haul routes would be in a circuitous route to get back to borrow site since routes would be 1-way. May be tight to fit haul routes in some locations where levee backs up to businesses.
-PDT Discussions/Conclusions: Could need to re-route haul routes which would increase length and costs. Could have to haul atop levee which would require time for rutting repairs. Re-routing could take place on city streets, which would require restoration of roads.
- Likelihood: Possible
-Impact: Significant
-Risk Level: 2

Underseepage Berms:

-Concerns: Increase in fuel prices could have impact on costs of berms. Topsoil assumed to be able to be re-used but could have to haul in topsoil.
-PDT Discussions/Conclusions: Both concerns could significantly increase costs.
- Likelihood: Possible
-Impact: Significant
-Risk Level: 2

Utility Relocations:

-Concerns: Casement Road Raise will change existing drainage at that location. No analysis has been done to see if that change will require additional modifications to handle the drainage pattern changes. Also, privately-owned utilities are not well mapped out at this location at this time. Also, unsure at this time how traffic control at this intersection will be need to be altered.
-PDT Discussions/Conclusions: Biggest concerns are unknown utilities and traffic control.
- Likelihood: Possible
-Impact: Significant
-Risk Level: 2

Gatewell Replacements:

-Concerns: Increase in steel prices could impact new gatewells as they would require lots of steel. Also, the assumed methodology and production rates may be lacking depending on the actual constuction conditions.
-PDT Discussions/Conclusions: Definitely possible and could have marginal increase in costs for steel prices. Larger and more significant impact on costs is risk of being low in assumptions for methodology and production rates.
- Likelihood: Possible
-Impact: Significant
-Risk Level: 2

Relief Wells:

-Concerns: Increased flow from RW's may require upgrades to pumping capacity, specifically at Poyntz Pump Station at Sta. 100+00. May need to add an additional pump to meet need. Increase in stainless steel prices could impact relief well costs.
-PDT Discussions/Conclusions: Recent quote for installed pump of size needed is around $50k. Civil Design section believes need for upgrade is unlikely. Also, stainless steel price increases are definitely possible and would have marginal increase in costs.
- Likelihood: Possible
-Impact: Significant
-Risk Level: 2

Remaining Construction Items:

-Concerns: No Remaining Construction Items. All are covered under other line items.
-PDT Discussions/Conclusions: None
-Likelihood: Unlikely
-Impact: Negligible
-Risk Level: 0

Planning, Engineering, & Design:

-Concerns: No concerns.
-PDT Discussions/Conclusions: None
-Likelihood: Unlikely

-Impact: Negligible
-Risk Level: 0

Construction Management:

-Concerns: Assuming multiple contracts so project should be easier to manage this way.
-PDT Discussions/Conclusions: Easier to manage multiple smaller contracts. Possible risk of coordination issues with lots of construction occurring at once.
-Likelihood: Possible
-Impact: Marginal
-Risk Level: 1

External Project Risks

Mob/Demob:

-Concerns: Multiple mob/demobs per contract could be needed due to funding stream limitations
-PDT Discussions/Conclusions: Adding additional mob/demobs would add significant cost increase to this line item
-Likelihood: Likely
-Impact: Significant
-Risk Level: 3

Borrow Site:

-Concerns: Some areas nearby were used as emergency landfills in the past and could cause HTRW concerns.
-PDT Discussions/Conclusions: Current borrow site does not show up in records as having been used as an emergency landfill so this is unlikely but could have a significant HTRW impact.
-Likelihood: Unlikely
-Impact: Significant
-Risk Level: 1

Levee Raise & Sand Drain:

-Concerns: Flood event would likely shut down job site and put contractor on stand-by.
-PDT Discussions/Conclusions: Definitely possible as big releases could come from Tuttle Creek in the event of flood and could have critical impact to cost & schedule.
-Likelihood: Possible
-Impact: Critical
-Risk Level: 3

Underseepage Berms:

-Concerns: Flood event would likely shut down job site and put contractor on stand-by.

-PDT Discussions/Conclusions: Definitely possible as big releases could come from Tuttle Creek in the event of flood and could have critical impact to cost & schedule.
-Likelihood: Possible
-Impact: Critical
-Risk Level: 3

Utility Relocations:

-Concerns: Flood event would likely shut down job site and put contractor on stand-by.
-PDT Discussions/Conclusions: Shorter duration activity than levee raise or berm construction
-Likelihood: Unlikely
-Impact: Significant
-Risk Level: 1

Gatewell Replacements:

-Concerns: Flood event would test the Emergency Closure System as it would be the weakest point of the levee. Floods out of Tuttle Creek will likely be large and long durations.
-PDT Discussions/Conclusions: Might have to armor for long duration or continuously add more fill.
-Likelihood: Unlikely
-Impact: Critical
-Risk Level: 2

Relief Wells:

-Concerns: Contaminated plumes could cause relief wells to not be a viable option within certain reaches.
-PDT Discussions/Conclusions: According to HTRW section: Knowledge of contaminated areas are at Levee Sta. 63+00 and Sta. 211+00 to 213+00. Sta. 63+00 was a privately-owned landfill and not within our study area. Sta. 211+00 to 213+00 is a CIRCLA site that contains VOC's. Water flowing during high water scenarios would be from the river and not the plumes.
-Likelihood: Possible
-Impact: Significant
-Risk Level: 2

Remaining Construction Items:

-Concerns: No Remaining Construction Items. All are covered under other line items.
-PDT Discussions/Conclusions: None
-Likelihood: Unlikely
-Impact: Negligible
-Risk Level: 0

Planning, Engineering, & Design:

-Concerns: Interruption in funding stream could be devastating if project is spanned over multiple contracts as levee would be raised in some areas but not others. Therefore, it could potentially induce flooding in certain areas since whole system is not in place.
-PDT Discussions/Conclusions: Unlikely that funding would be interrupted once committed to on a project of this manner/life safety.
-Likelihood: Unlikely
-Impact: Critical
-Risk Level: 2

Construction Management:

-Concerns: Incremental funding stream could spread project out over many smaller contracts and increase costs due to inflation. Could cause funding delays as well.
-PDT Discussions/Conclusions: Likely under current funding climate for incremental funding and possible for funding delays. Would have critical impact on costs.
-Likelihood: Possible
-Impact: Critical
-Risk Level: 3

US Army Corps
of Engineers
Kansas City District

MANHATTAN LOCAL PROTECTION PROJECT
FEASIBILITY STUDY

MANHATTAN, KANSAS
(Manhattan Levee)

(Section 216 Review of Completed Civil Works)

Public Involvement Appendix

August 2014 Final Feasibility Report

Manhattan, Kansas
Local Protection Project
Final Feasibility Report

PUBLIC INVOLVEMENT APPENDIX

Public meetings were held in the Manhattan area during the Feasibility Study as described in Section VI.J of the Feasibility Report. The purpose of this report appendix is to document the public review process conducted for the Draft Feasibility Report and to provide responses to the comments received.

The Draft Feasibility Report was released on June 13, 2014, for a thirty (30) day public review and comment period via the Kansas City District website. Copies of the Draft Report were made available to the public at the Manhattan City Hall and the local public library.

Notice of the report availability and public comment period was posted on the Kansas City District website and provided to local Manhattan area media outlets. Additionally, notice was mailed to Kansas congressional offices; state and local elected officials; Federal, State, County, and City agencies; community and environmental interest groups; Indian tribes; and businesses and property owners within the project area.

Written comments were requested to be submitted by mail or through the project website. The mailing list, public notice, and press release are included in this appendix as Exhibits 1, 2, and 3 respectively.

In response to the Public Notice and public comment period, comments were received from the following entities:

Choctaw Nation of Oklahoma
Mr. Mel G. Borst of Manhattan, KS
Federal Aviation Administration
U.S. Environmental Protection Agency
U.S. Department of the Interior, Fish and Wildlife Service

The comment letters received are included in this appendix as Exhibit 4. Responses to written comments received are included in Exhibit 5. In addition to these comments there were two telephone inquiries to the Kansas City District Public Affairs Office from local media.

Regular contact and coordination has been maintained throughout the Feasibility Study with the local sponsor to provide updates on the status and findings of the study. With the sponsor's assistance, project status information has been shared with multiple stakeholder groups representing businesses and industries in the project area. Continually throughout this process, the local sponsors have expressed their desire to see their levee system improved to acceptable reliability. The local sponsor has initiated and maintained

contact with local agencies and their Congressional representatives to share project status information and urge continued support for the project.

Exhibit 1 – Public Notice Mailing List

Congressional Offices
Senator Pat Roberts
Senator Jerry Moran
Representative Tim Huelskamp

Local Elected Officials
Governor Sam Brownback
County Executive – Riley County
Mayor – City of Manhattan

Federal Agencies
Environmental Protection Agency, Region 7
Federal Aviation Administration
Federal Highway Administration
Federal Railroad Administration
Federal Transit Authority
FEMA, Region 7
National Park Service
Natural Resources Conservation Service
U.S. Coast Guard
U.S. Fish and Wildlife Service
U.S. Geological Survey
U.S. Department of the Interior

State Agencies
KS Biological Survey
KS Department of Agriculture
KS Department of Health and Environment
KS Department of Transportation
KS Department of Wildlife, Parks & Tourism
KS Division of Emergency Management
KS Geological Survey
KS State Conservation Commission
KS State Historical Society
KS Water Office
MO Dept of Natural Resources
MO Dept. of Transportation
MO Dept. of Conservation
MO Dept. of Public Safety

Local Government Agencies
City of Manhattan City Manager
City of Manhattan Public Works Department

Business and Community Organizations
Kansas Corporation Commission
Kansas Chamber of Commerce

Environmental and Recreation Interest Groups
Audubon of Kansas
Sierra Club – Kansas Chapter
Friends of the Kaw
Kansas Canoe & Kayak Association

Project Area Property Owners
See property owner listing in Real Estate Appendix

Indian Tribes
Absentee-Shawnee Tribe
Apache Tribe of Oklahoma
Cherokee Nation
Cheyenne River Sioux Tribe of South Dakota
Cheyenne-Arapaho Tribes
Choctaw Nation of Oklahoma
Citizen Band Potawatomi Indian Tribe of Oklahoma
Crow Creek Sioux Tribe of South Dakota
Delaware Nation
Delaware Tribe
Eastern Shawnee Tribe
Forest County Potawatomi Community
Fort Sill Apache Tribe of Oklahoma
Hannahville Indian Community
Ho-Chunk Nation of Wisconsin
Iowa Tribe of Kansas and Nebraska
Iowa Tribe of Oklahoma
Kaw Nation
Kickapoo Traditional Tribe of Texas
Kickapoo Tribe of Kansas
Kickapoo Tribe of Oklahoma
Jicarilla Apache Nation
Kiowa Tribe of Oklahoma
Match-e-be-nash-she-wish Patawatomi
Mescalero Apache Tribe
Miami Tribe

Exhibit 1 – Public Notice Mailing List

Northern Cheyenne Tribe of Montana
Nottawaseppi Huron Potawatomi Nation
Oglala Sioux Tribe of South Dakota
Omaha Tribe of Nebraska
Osage Nation
Otoe-Missouria Tribe of Oklahoma
Ottawa Tribe
Pawnee Nation of Oklahoma
Pokagon Band Potawatomi
Ponca Tribe of Nebraska
Ponca Tribe of Oklahoma
Prairie Band Potawatomi Nation
Rosebud Sioux Tribe of South Dakota
Sac and Fox Nation of Missouri in Kansas
and Nebraska
Sac and Fox Nation of Oklahoma
Sac and Fox Tribe of the Mississippi in Iowa
Santee Sioux Nation of Nebraska
Seneca-Cayuga Tribe
Shawnee Tribe
Spirit Lake Tribe of North Dakota
Three Affiliated Tribes of North Dakota
United Keetoowah Band of Cherokee
Wichita and Affiliated Tribes
Winnebago Tribe of Nebraska
Wyandotte Nation
Yankton Sioux Tribe of South Dakota

Media Outlets receiving Press Release

Exhibit 2 – Public Notice

PUBLIC NOTICE

US Army Corps of Engineers Kansas City District

Issue Date: 13 Jun 2014
Expiration Date: 13 July 2014

30-Day Notice

Request for Comments
Manhattan, Kansas
Local Protection Project Feasibility Study
Draft Feasibility Report

PROPONENT: Kansas City District, Corps of Engineers
Room 529, PM-PF
601 E. 12th Street
Kansas City, Missouri 64106-2896

PROJECT LOCATION (As shown in the enclosed media)**:** The existing Manhattan, Kansas, Local Protection Project includes a single earthen levee unit on the Kansas River, Big Blue River, and Wildcat Creek providing flood risk management to the City of Manhattan, Kansas.

AUTHORITY: The U.S. Army Corps of Engineers, Kansas City District, at the request and with the cooperation of the non-Federal sponsor, the City of Manhattan, has studied flood risk management and reliability improvements of the existing unit under the authority of Section 216 of the 1970 Flood Control Act.

ACTIVITY: The purpose of the overall study of the existing levee was to determine whether one or more plans for improvements to reduce flood risk and improve levee reliability is technically viable, economically feasible, and environmentally acceptable, or if no action is warranted. Failure of any part of the existing flood risk management system during a major flood would have significant adverse impacts on the human environment including property damage and potential loss of human life.

The recommendations for the reliability and performance improvements are addressed and available for review in the Draft Feasibility Report (DFR). The DFR presents the completed feasibility analysis of alternatives. Proposed alternatives considered to improve flood risk management and reliability include, but are not limited to, earthen levee raises, pump station modifications, floodplain management, property relocations and flood-proofing, and the no action alternative. DFR analysis concluded that a levee raise based on the projected water surface profile

of the nominal 0.33% annual chance (300-yr) flood event and associated structural and geotechnical improvements is the preferred alternative. The DFR identifies a combination of measures as the Corps' overall Recommended Plan and presents an analysis of the costs and impacts associated with the alternatives.

The purpose of this public notice is to provide the public; Federal, state and local agencies and officials; Indian Tribes; and other interested parties the opportunity to review and provide comment on the information presented within the DFR.

NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) OF 1969, as amended: Considering potential significant impacts on the human environment, and in accordance with the National Environmental Policy Act, the Corps has prepared as Environmental Assessment (EA) to accompany the DFR. The EA presents the feasibility analysis, no action, action alternatives, preferred alternatives and associated environmental impacts for the Manhattan levee unit.

PUBLIC INTEREST REVIEW: The Corps of Engineers is soliciting comments on the DFR and EA from the public; Federal, state, and local agencies and officials; Indian Tribes; and other interested parties in order to consider and evaluate the impacts of this proposed activity. Any comments received will be considered by the Corps of Engineers to determine whether to modify the recommendations within the report.

COMMENTS: Any interested party is invited to submit to this office written comments relative to the DFR and EA on or before the public notice expiration date. Comments both favorable and unfavorable will be accepted, included within the project record and will receive full consideration in determining whether to modify report recommendations. Comments should be mailed to the address shown on page 1 of this public notice or submitted by electronic mail through the project website noted below.

ADDITIONAL INFORMATION: The DFR and EA may be viewed at the following website: http://www.nwk.usace.army.mil/Missions/CivilWorks/CivilWorksProgramsandProjects/ManhattanKansas.aspx or may be obtained by writing to the address shown on page 1 of this public notice or by sending an electronic mail through this website.

A copy of this public notice may also be viewed at the following website: http://www.nwk.usace.army.mil/Media/PublicNotices.aspx

Exhibit 3 – Press Release

NEWS RELEASE

U.S. ARMY CORPS OF ENGINEERS **BUILDING STRONG ®**

For Immediate Release:
Release #PA-2014-27
DATE 6/13/2014

Contact:
U.S. Army Corps of Engineers
Public Affairs Office
Kansas City, Mo. 64106-2896
Phone: (816) 389-3486
Fax: (816) 389-3434

Corps seeks public comments for Manhattan, KS, levee report

KANSAS CITY, Mo.— The U.S. Army Corps of Engineers Kansas City District has studied flood risk management and reliability improvements for the existing levee unit at Manhattan, Kansas, and is seeking review and public comment on the information presented within the Draft Feasibility Report (DFR).

The study was conducted at the request and with cooperation of the sponsor of the levee unit under the authority of Section 216 of the 1970 Flood Control Act. Any comments received will be considered by the Corps of Engineers to determine whether to modify the recommendations within the report.

The purpose of the overall study of the existing levee unit was to determine whether one or more plans for improvements to the existing levee unit to reduce flood risk and improve levee reliability is technically viable, economically feasible, and environmentally acceptable, or if no action is warranted. Failure of any part of the existing flood risk management unit during a major flood would have significant adverse impacts on the human environment including property damage and potential loss of human life.

The recommendations for the reliability and performance improvements are addressed and available for review in the DFR.

Proposed alternatives considered to improve flood risk management and reliability include, but are not limited to, earthen levee raises, pump station modifications, floodplain management, property relocations and flood-proofing, and the no action alternative. DFR analysis concluded that a levee raise based on the projected water surface profile of the nominal 0.33% annual chance (300-yr) flood event and associated structural and geotechnical improvements is the preferred alternative. The DFR identifies a combination of measures as the Corps' overall Recommended Plan and presents an analysis of the costs and impacts associated with the alternatives.

NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) OF 1969, as amended: Considering potential significant impacts on the human environment, and in accordance with the National Environmental Policy Act, the Corps has prepared as Environmental Assessment (EA) to accompany the DFR. The EA presents the

feasibility analysis, no action, action alternatives, preferred alternatives and associated environmental impacts for the Manhattan levee unit.

PUBLIC INTEREST REVIEW: The Corps of Engineers is soliciting comments on the DFR and EA from the public, federal, state, and local agencies and officials, Indian Tribes and other interested parties in order to consider and evaluate the impacts of this proposed activity. Any comments received will be considered by the Corps of Engineers to determine whether to modify the recommendations within the report.

COMMENTS: Any interested party is invited to submit written comments relative to the DFR and EA on or before the public notice expiration date. Comments both favorable and unfavorable will be accepted, included within the project record and will receive full consideration in determining whether to modify report recommendations. Comments should be mailed to:

Kansas City District, Corps of Engineers
Manhattan Levee Project Manager
Room 529, PM-PF
601 E. 12th Street
Kansas City, MO 64106-2896

ADDITIONAL INFORMATION: The DFR and EA may be viewed at the following website: http://www.nwk.usace.army.mil/Missions/CivilWorks/CivilWorksProgramsandProjects/ManhattanKansas.aspx or may be obtained by writing to the address shown on page 1 of this public notice or by sending an electronic mail through this website.

A copy of this public notice may also be viewed at the following website: www.nwk.usace.army.mil/Media/PublicNotices.aspx . For more information, please contact the Public Affairs Office at (816) 389-3486.

-30-

Exhibit 4 – Comments Received

Written Comments Received In Response to Public Notice

Written comments were received from the following individuals and organizations:

Choctaw Nation of Oklahoma, letter dated June 19, 2014.
Mr. Mel Borst of Manhattan, KS, letter dated June 22, 2014
Federal Aviation Administration, letter dated July 3, 2014
U.S. Environmental Protection Agency, letter dated July 9, 2014
U.S. Fish and Wildlife Service, letter dated July 11, 2014

Choctaw Nation of Oklahoma

P.O. Box 1210 • Durant, OK 74702-1210 • (580) 924-8280

Gregory E. Pyle
Chief

Gary Batton
Assistant Chief

June 19, 2014

US Army Corps of Engineers
Kansas City District
Room 529, PM-PF
601 E. 12th Street
Kansas City, MO 64106

RE: Local Protection Project Feasibility Study, Draft Feasibility Report, Manhattan, KS

To Whom It May Concern,

The Choctaw Nation of Oklahoma thanks the U.S. Army Corps of Engineers, Kansas City District, for the correspondence regarding the above referenced project. The state of Kansas lies outside of the Choctaw Nation of Oklahoma's area of historic interest. The Choctaw Nation of Oklahoma respectfully defers to the other Tribes that have been contacted. If you have any questions, please contact our office at 580-924-8280 ext. 2631.

Sincerely,

Dr. Ian Thompson, Ph.D., RPA
Tribal Historic Preservation Officer
Tribal Archaeologist, NAGPRA Specialist

By: Lindsey Bilyeu

Lindsey Bilyeu
NHPA Senior Section 106 Reviewer
lbilyeu@choctawnation.com
Choctaw Nation of Oklahoma
P.O. Drawer 1210
Durant, OK 74701

Choctaws...growing with pride, hope and success!

MEL G. BORST

June 22, 2014

Kansas City District, Corps of Engineers
Manhattan Levee Project Manager
Room 529,PM-PF
601 E. 12th Street
Kansas City, MO 64106-2896

Dear Manhattan Levee Project Manager,

Thank you for this opportunity to comment on potential changes to our levee system.
As a frequent bicycle user of the Liner Trail on the levee, I suggest considering design changes that would include a wider and paved trail surface. This improvement would allow for year round use of the trail that is limited with the limestone screenings. This current surface is getting increasing traffic that gets soft and hard to use in wet spells and during the long winter months.

I visited earlier with (then) city engineer Rob Ott and parks dept. head Eddie Estes and they may have also asked you about this possibility. Perhaps some kind of partnership could be worked out on planning and expenses.

Sincerely,

Mel G. Borst

U.S. Department
of Transportation

**Federal Aviation
Administration**

Central Region
Iowa, Kansas,
Missouri, Nebraska

901 Locust
Kansas City, Missouri 64106

JUL 0 3 2014

Kansas City District, Corps of Engineers
Room 529, PM-PF
601 E. 12th Street
Kansas City, Missouri 64114

To Whom It May Concern:

We have received your letter dated June 13, 2014. We generally do not provide comments from an environmental standpoint.

The project may require formal notice and review for airspace review under Federal Aviation Regulation (FAR) Part 77, Objects Affecting Navigable Airspace. To determine if you need to file with FAA, go to http://oeaaa.faa.gov and click on the "Notice Criteria Tool" found at the left-hand side of the page.

If after using the tool you determine that filing with FAA is required, I recommend a 120-day notification to accommodate the review process and issue our determination letter. Proposals may be filed at http://oeaaa.faa.gov.

We hope this adequately addresses your concerns.

for Joseph N. Miniace
Regional Administrator

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 7
11201 Renner Boulevard
Lenexa, Kansas 66219

JUL 9 2014

U.S. Army Corps of Engineers
Kansas City District
601 E. 12th Street
Room 529, PM-PF
Kansas City, Missouri 64106-2896

Dear Sir or Madam:

In response to the public notice of June 13, 2013, requesting comments on the draft Environmental Assessment and Finding of No Significant Impact for the Local Protection Project, Section 216 Feasibility Study, Manhattan, Kansas, the U.S. Environmental Protection Agency, Region 7, offers the following comments. These comments are based primarily on an evaluation of the identified 'preferred alternative.' Should that alternative be modified or should another alternative be selected, we request that you re-notice that new alternative and a revised draft EA.

The existing Flood Protection Project in Manhattan, Kansas, is comprised of one 5.4 mile levee unit and associated appurtenances. As a result of its performance during the high water event in 1993, local concern was expressed about the ability of the existing flood risk reduction system to respond to future similar events as originally designed. The Manhattan Levee is located west and north of the confluence of the Big Blue River and Kansas River bracketing the City of Manhattan roughly following Wildcat Creek along the City's southern edge, the Kansas River to its confluence with the Big Blue River, north along the Big Blue River and extending northwest. The Corps has identified four action alternatives along with the 'no action' alternative. The Corps' identified 'preferred alternative' calls for increasing the height of the levee to provide protection for the 0.33% high water event, including a 500-foot extension of the levee, under-seepage berms, relief wells and sand drains.

Range of Alternatives

The draft EA included no analysis of the potential for implementing non-structural alternatives to achieve needed reductions in flood risk for the project area. Although the public notice references non-structural approaches to reducing flood risk among the alternatives considered, the draft EA contains no evidence that any approaches other than raising the levee and widening a river cross-section were considered and evaluated. As mentioned below, the document lacks any assessment of possible alternatives to levee raising or any evaluation of watershed-scale management modifications which could provide the desired flood risk reduction without raising or extending the existing levee. Potential future changes in the hydrograph and the location of City infrastructure within the floodplains of three

Printed on Recycled Paper

rivers will likely lead to the evaluation of flood risk reduction farther upstream into each watershed and/or the removal of public assets from the floodplain. The currently proposed alternatives appear short-sited and could lead to a continual and repeated raising and lengthening of the levee over time.

Affected Environment

Maps included within the draft EA are too small to be useful. At least in the printed version, the legends for several of the maps are unreadable. In addition, it would be useful to include a detailed map showing the extent of the levee 'improvements' under each alternative, including any lateral extensions of the levee footprint.

Section 3.3 describes existing groundwater contamination within the site and, specifically, a plume of trichloroethylene in groundwater extending below the levee from station 215+00 to 218+0. The document notes that this contamination is currently being remediated under the national Superfund program. The final EA should identify how planned construction activities in this area have been coordinated with the Kansas Department of Health and Environment, which is the lead agency for this remedial action. In addition, the final EA should describe in detail how the water produced from sand drains and relief wells in this area will be monitored for contaminants and how any contaminated water will be treated and disposed. A plan for construction of wells and drains in this vicinity as well as management of any groundwater withdrawals should be coordinated with KDHE in advance of any construction. Any possible future action or modification to the existing levee which could affect other contamination sites (e.g., USTs, battery site, private disposal site) in the area should be closely coordinated with KDHE as well.

The draft EA contradicts itself within sections discussing the status and presence of Interior Least Terns and Piping Plovers. The document states that no historic records of nesting on the Kansas River exist for nesting by both species and then immediately notes recent nesting observations for both species.

The draft EA should more thoroughly describe actions and land management throughout Wildcat Creek and the Kansas River watersheds upstream of the project area. Contemporary land management decisions affecting land surface, drainage and floodplain access also affect the hydrograph and resulting flood risk. Agency correspondence contained in Appendix II recognizes changes in the watershed negatively affecting flood management performance by this project and yet very little is described within this draft EA. This omission weakens the rationale for augmenting existing flood risk reduction design and suggests that continuing mismanagement of the floodplain above the project site could eventually limit the effectiveness of the proposal.

Environmental Consequences

Although Section 2.2 states that all four action alternatives would include an extension of the levee footprint, nowhere within Section 4.0 does the document mention an extension of the levee length nor does the document clearly identify any impacts from extending the levee beyond its existing footprint. Any increase in levee length and, therefore, an increase in the area protected by the levee should be thoroughly characterized and any impacts on further restricting creek or river access to its floodplain

assessed. As mentioned previously, the document should include diagrams clearly depicting which sections of existing levee will be raised and, most importantly, where the levee will be extended.

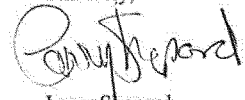
Although not selected as the 'preferred alternative', statements made regarding the "long term increase in aquatic habitat" resulting from channel widening within the Big Blue River under Plan 5 are speculative and without basis and should not be retained in the final EA without further analysis. Such statements appear to be based completely upon the increase in surface area within the river channel and not based on the suitability, quality or stability of this "increased habitat."

Cumulative Impacts

This section should include an assessment of land use and planning decisions made by local, regional or state government in the past which might have compromised floodplain integrity upstream of the project area. Development within the floodplain and actions to further isolate the floodplain contribute to increased flood risk to the project area possibly contributing to the need to raise levee elevation and/or extend its length. The draft EA provides no information or characterization of this important component of cumulative impact analysis.

I appreciate the opportunity to provide comments on the draft EA. If you have any questions regarding these comments, please contact me at 913-551-7441 or shepard.larry@epa.gov.

Sincerely,



Larry Shepard
NEPA Review

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Kansas Ecological Services Field Office
2609 Anderson Avenue
Manhattan, Kansas 66502

July 11, 2014

Kansas City District, Corps of Engineers
Room 529, PM-PF
601 East 12th Street
Kansas City, MO 64106-2896

RE: Manhattan, Kansas Local Protection Project Feasibility Study, Draft Feasibility Report

FWS Tracking # 2014-CPA-0474

Dear Sir or Madam:

This letter is in response to your request for comments on the Draft Feasibility Report for the Manhattan, Kansas Local Protection Project. We appreciate the opportunity to work with the Kansas City District, Corps of Engineers on this project and the cooperation between our agencies.

We have no objection to the selection of Alternative Plan 3 as the Recommended Plan and National Economic Development (NED) plan. Plan 3 would raise the current levee to pass the nominal 0.33% chance flood event profile with accompanying geotechnical and structural reliability improvements. We believe that this plan will meet the Corp's objectives while having minimal environmental impacts in the project area.

We have one recommendation in relation to the statement made in Section J3.0 - Mitigation on page 68 which stated that "If it is not possible to avoid select, individual, mature trees during construction, replacement trees of the same species would be planted in the project area." If a tree to be removed is not native to the local area, the replacement tree should be a native species. We advocate protecting local genotypes by using plant sources that are within 100 miles in latitude and 200 miles in longitude of the planting site. Plants evolve to local conditions (climate, soil, moisture conditions, etc.) and can develop different genetic structure (genotypes) within the same species. Gene pools of remnant plant communities can be altered genetically by the invasion of non-native genotype plant species. In addition, we recommend planting 3 trees for every tree removed as many of the planted trees will not survive to maturity.

Information concerning Federal threatened and endangered species and Federal Trust Resources has been discussed in our Fish and Wildlife Coordination Act reports.

Thank you for the opportunity to comment on this project. If you have any questions, please

contact me or Susan Blackford of my staff at (785) 539-3474.

Sincerely,

Heather Whitlaw
Field Supervisor

cc: EPA, Kansas City, KS (Wetland Protection Section)
KDWPT, Pratt, KS (Ecological Services)
FWS, Robert Stewart, Denver, CO

HW/shb

Exhibit 5
Draft Feasibility Report Public Review
Comment/Response Summary

Commenter	Nature of Contact/Date	Comment Summary
Choctaw Nation of Oklahoma	Letter dated 6/19/2014	"The Choctaw Nation of Oklahoma respectfully defers to the other Tribes that have been contacted."
Response Summary		
Comment noted.		

Commenter	Nature of Contact/Date	Comment Summary
Mr. Mel G. Borst	Letter dated 6/22/2014	Consider design changes that would include a wider and paved trail surface to allow year round use of the trail.
Response Summary		
The Corps of Engineers is neither a proponent of, nor an opponent to, the incorporation or expansion of recreational trail systems in a levee unit. The Corps has sought to ensure that, as practical, the Recommended Plan of this flood risk management study does not adversely impact existing recreational features or preclude future development of recreational opportunities. Wider paved trails have been incorporated into other levee units in the Kansas City District at the request of local levee sponsors. However, the design and implementation costs of recreational components are the responsibility of that local levee sponsor. The Corps monitors and inspects local sponsor operation and maintenance of the unit for compliance with Federal criteria to ensure the existing unit will perform as intended during a flood event. If local recreation proponents desire expanded or additional recreational features they should continue to meet with the local levee sponsor to determine the constraints and opportunities applicable to recreational activity. If agreement on a potential local plan is reached by all parties, the levee sponsor must formally submit to the Corps a request for technical review of the locally-developed plan. The Corps technical oversight review would identify any components of the proposed plan that might compromise operation, maintenance, or performance of the levee system in accordance with its primary function to provide flood risk management. Upon resolution of any technical concerns the recreation plan could be implemented at local expense. If such a recreation plan were developed, reviewed, and approved prior to the construction of the Recommended Plan, the design could be modified accordingly.		

Commenter	Nature of Contact/Date	Comment Summary
Federal Aviation Administration	Letter dated 7/3/2014	"The project may require formal notice and review for airspace review under Federal Aviation Regulation (FAR) Part 77, Objects Affecting Navigable Airspace."
Response Summary		
Use of the online "Notice Criteria Tool" as described in the received letter indicated that the proposed project does not exceed notice criteria.		

Commenter	**Nature of Contact/Date**
United States Environmental Protection Agency	Letter dated 7/9/2014

Comment Summary

1. The draft EA included no analysis of the potential for implementing non-structural alternatives to achieve needed reductions in flood risk for the project area. Although the public notice references nonstructural approaches to reducing flood risk among the alternatives considered, the draft EA contains no evidence that any approaches other than raising the levee and widening a river cross-section were considered and evaluated. As mentioned below, the document lacks any assessment of possible alternatives to levee raising or any evaluation of watershed-scale management modifications which could provide the desired flood risk reduction without raising or extending the existing levee. Potential future changes in the hydro graph and the location of City infrastructure within the floodplains of three rivers will likely lead to the evaluation of flood risk reduction farther upstream into each watershed and/or the removal of public assets from the floodplain. The currently proposed alternatives appear short-sighted and could lead to a continual and repeated raising and lengthening of the levee over time.

Response Summary

Potential non-structural measures are discussed in Section IV of the Feasibility Report accompanying the Environmental Assessment. The evaluation of non-structural measures concluded that the expected depths of inundation resulting from failure of the levee would overwhelm the capabilities of typical flood-proofing methods and that the dense urban development in the study area precluded cost-effective relocation or elevation of structures. Non-structural measures were screened out of the array of viable alternatives for restoring authorized performance of the existing levee. Only those alternatives carried forward from the initial screening were evaluated in the EA for their potential environmental impact.

Evaluation is continuing of non-structural methods and other means of floodplain management within the watersheds of the Big Blue River, Wildcat Creek, and the Kansas River beyond the study area of this proposed levee modification. An interagency Silver Jackets program is actively working with the City of Manhattan, local County governments, and public interests, to identify and implement measures that, while not directly related to the existing levee, may serve to reduce flood risks and address possible future hydrograph changes.

Comment Summary

2. Maps included within the draft EA are too small to be useful. At least in the printed version, the legends for several of the maps are unreadable. In addition, it would be useful to include a detailed map showing the extent of the levee 'improvements' under each alternative, including any lateral extensions of the levee footprint.

Response Summary

Maps included in the EA will be reviewed and revised for readability. The maps in the EA were originally created at the 11 x 17 size but reduced for ease of internet downloading and printing by those who may not have access to larger format printers. Additional maps of the proposed project features are included in the maps section of the Feasibility Report.

Comment Summary
3. Section 3.3 describes existing groundwater contamination within the site and, specifically, a plume of trichloroethylene in groundwater extending below the levee from station 215+00 to 218+0. The document notes that this contamination is currently being remediated under the national Superfund program. The final EA should identify how planned construction activities in this area have been coordinated with the Kansas Department of Health and Environment, which is the lead agency for this remedial action. In addition, the final EA should describe in detail how the water produced from sand drains and relief wells in this area will be monitored for contaminants and how any contaminated water will be treated and disposed. A plan for construction of wells and drains in this vicinity as well as management of any groundwater withdrawals should be coordinated with KDHE in advance of any construction. Any possible future action or modification to the existing levee which could affect other contamination sites (e.g., USTs, battery site, private disposal site) in the area should be closely coordinated with KDHE as well.
Response Summary
Review of available site information published by KDHE has been used to identify the location and status of the contamination plume and remediation activities undertaken by the property owner. This available information indicates that the site is in the process of being reclassified from Active to Resolved. No relief wells are proposed in the known area of the TCE plume. The sand drains will be constructed in the new levee toe, at or above the existing ground surface. They purpose of the sand drains is to lower the water pressure gradient in the embankment during flood events that load the levee long enough to saturate the embankment. This study has not estimated any flow rates through the sand drain material. Any seepage flow from the sand drains will be drive by floodwaters and not groundwater. There are currently no proposed future Federal actions that would affect the other identified HTRW sites.

Comment Summary
4. The draft EA contradicts itself within sections discussing the status and presence of Interior Least Terns and Piping Plovers. The document states that no historic records of nesting on the Kansas River exist for nesting by both species and then immediately notes recent nesting observations for both species.
Response Summary
The reference to historic was referring to the period prior to the 1993 flood. Discussion in the EA of Tern and Plover nesting has been edited for clarity. There has not been any known nesting since 2009. A previous study of the conditions in the Kansas River concluded that the habitat for Terns and Plovers was unsustainable and unlikely to support future populations.

Comment Summary
5. The draft EA should more thoroughly describe actions and land management throughout Wildcat Creek and the Kansas River watersheds upstream of the project area. Contemporary land management decisions affecting land surface, drainage and floodplain access also affect the hydrograph and resulting flood risk. Agency correspondence contained in Appendix II recognizes changes in the watershed negatively affecting flood management performance by this project and yet very little is described within this draft EA. This omission weakens the rationale for augmenting existing flood risk reduction design and suggests that continuing mismanagement of the floodplain above the project site could eventually limit the effectiveness of the proposal.
Response Summary
Federal and local interagency Silver Jackets Program initiatives to address floodplain management in the Big Blue River and Wildcat Creek watersheds and adjacent areas of the Kansas River are currently underway and are summarized in the Feasibility Report. The current Silver Jackets effort is scheduled for conclusion in 2015. It is expected that these efforts will produce effective floodplain management and land use planning that will prevent or minimize future activities that would impact the modified levee.

Comment Summary
6. Although Section 2.2 states that all four action alternatives would include an extension of the levee footprint, nowhere within Section 4.0 does the document mention an extension of the levee length nor does the document clearly identify any impacts from extending the levee beyond its existing footprint. Any increase in levee length and, therefore, an increase in the area protected by the levee should be thoroughly characterized and any impacts on further restricting creek or river access to its floodplain assessed. As mentioned previously, the document should include diagrams clearly depicting which sections of existing levee will be raised and, most importantly, where the levee will be extended.
Response Summary
With the exception of Plan 4, the only extensions of the levee length are along the edge of Casement Road to tie the northern end of the existing levee into high ground. As shown in the Map Section of the Feasibility Report, Sheet No. 10, the length of this extension is 200 feet for Plan 2 and 500 feet for Plans 3 and 4. Map sheets 22 and 23 show the location of this extension for the Recommended Plan. A description of the potential terrestrial habitat impacts of levee footprint expansion is included in Chapter 4 of the Environmental Assessment. The impacts are described as a whole for each alternative and are not separated between impacts attributable to these short length extensions and those attributable to the rest of alternative, i.e. widening of the levee footprint to accommodate the raise along its existing length. The levee width will increase approximately three feet horizontally for each foot of vertical raise. The footprint expansions and minor length increases are integral to the levee raise itself and cannot be separated for determining impacts. The Plan 4 expansion that parallels Wildcat Creek is much larger and longer, approximately 1700 feet, and these potential impacts are included within the description of Plan 4 impacts.

Comment Summary
7. Although not selected as the 'preferred alternative', statements made regarding the "long term increase in aquatic habitat" resulting from channel widening within the Big Blue River under Plan 5 are speculative and without basis and should not be retained in the final EA without further analysis. Such statements appear to be based completely upon the increase in surface area within the river channel and not based on the suitability, quality or stability of this "increased habitat."
Response Summary
The EA, Section 4.2.1 Aquatic Habitat (including Fisheries and Wetlands) – the description of impact for Plan 5 includes the following statement: "An additional 19.7 acres of aquatic habitat would be added to the Big Blue River as a direct result of widening the channel. The quality of that habitat could vary depending on the final design of that portion of the stream. It is anticipated that habitat features would be designed in and constructed should this alternative be selected." As this alternative was not selected, no other assessments of the quality or suitability of this habitat, or specific designs of habitat features, were conducted.

Comment Summary
8. This section should include an assessment of land use and planning decisions made by local, regional or state government in the past which might have compromised floodplain integrity upstream of the project area. Development within the floodplain and actions to further isolate the floodplain contribute to increased flood risk to the project area possibly contributing to the need to raise levee elevation and/or extend its length. The draft EA provides no information or characterization of this important component of cumulative impact analysis.
Response Summary
Past upstream impacts to the floodplain integrity are dominated by the Federal levees and reservoirs constructed in the Kansas and Big Blue River basins. The City of Manhattan was already established at the time of the existing levee construction. The area within the existing project is currently fully developed and the proposed modification project does not increase the protected area or induce additional local floodplain development. The City of Manhattan has continued to grow in areas outside the existing Federal levee, including residential neighborhoods in the Big Blue River floodplain immediately upstream of the existing levee. The proposed project improves the performance of the existing levee consistent with the original authorization and design

intent. It is not expected to add to the cumulative floodplain impacts above the impacts that have already occurred.

Commenter	Nature of Contact/Date	Comment Summary
United States Fish and Wildlife Service	Letter dated July 11, 2014	No objection to the selection of the Alternative Plan 3 as the Recommended Plan. If a tree removed is not native to the local area, the replacement tree should be a native species. Recommend planting 3 trees for every tree removed as many of the planted trees will not survive to maturity.
Response Summary		
The EA currently states: "Temporary construction easements as well as the permanent easements that are cleared during construction will be planted with native vegetation where possible following construction." This will apply to any trees that cannot be avoided. Mitigation for tree removal is not currently anticipated as mature tree avoidance will be stressed during the project design. If tree avoidance is not possible in the final design, impacts will be assessed and suitable replacement plantings will be implemented.		