TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

** NOTE TO THE READER: The environmental assessment for this study has been integrated into the following feasibility report in accordance with Engineer Regulation 1105-2-100. Sections of the report that are required for compliance with the National Environmental Policy Act (NEPA) are noted by an asterisk (*) in the Table of Contents.*

EXECUTIVE SUMMARY

Kansas City District, Northwestern Division, U.S. Army Corps of Engineers (USACE) conducted this feasibility study under the authority of the Resolution of the Committee on Transportation and Infrastructure, U.S. House of Representatives, Docket 2616, adopted February 16, 2000. The purpose of the study is to determine the federal interest in constructing a flood risk management project in the City of Merriam in Johnson County, Kansas along Turkey Creek. This effort is documented in the feasibility report with an integrated environmental assessment.

The focus of this study is established as the Upper Turkey Creek watershed, located in a heavily urbanized area of approximately 20 square miles where Turkey Creek and tributaries are prone to damaging floods. The primary project sites considered for flood risk management plan formulation were: a) in the City of Merriam, Kansas; b) in the Unified Government of Wyandotte County and Kansas City, Kansas at the Roe Lane Industrial Park, and c) on a flood prone segment of highway, Interstate 35 in Johnson County running between Merriam downstream into the Unified Government area. Only the City of Merriam site has an alternative plan carried forward for recommendation. Alternatives considered include channel widening, levees and floodwalls, and a combination of these. A nonstructural buyout plan was also carried forward in plan formulation in addition to the No Action plan. Nonstructural measures including a flood warning system were reviewed in initial measures evaluation. The local community will continue utilizing the existing warning system with the strong gage network and alert mechanisms under a continued robust flood risk management system. Findings indicate that the most cost effective plan that addresses the flash flood threat and loss of life risk, and maximizes net annual benefits with least environmental effects is a plan for the construction of low height levees and floodwalls.

Under the USACE concept of collaborative planning, after assessing the existing conditions in the watershed, environmental restoration measures were evaluated in a watershed system perspective along with flood risk management. This effort was to consider the possibility of multipurpose formulation including ecosystem restoration. Valuable system baseline information and data were developed, and some preliminary candidate sites for restoration were indentified. Due to there being no cost-sharing sponsor interested in ecosystem restoration measures in this heavily urbanized watershed, those measures were not carried forward into plan formulation.

The Recommended Plan is a levee and floodwall plan along Turkey Creek in the City of Merriam. The features extend from Shawnee Mission Parkway to Merriam Drive, a stretch that includes Merriam's main downtown reach, as well as a commercial and industrial area just south of Johnson Drive. Most of the protected area is on the right bank of Turkey Creek. The features were formulated and evaluated using updated NOAA Atlas 14 rainfall data. The National Economic Development (NED) Plan is Alternative 2d which provides an estimated $1,712,500 in net annual benefits in flood damages reduced, with a benefit-cost ratio of 2.0. The plan includes 6,822 feet of floodwall up to 6.5 feet in height, 3,383 feet of levees up to 6 feet in height, a foundation system with approximately 12,427 auger grout piles, storm sewer modifications, and adjustments to utilities. For interior drainage the plan includes a 2.14 acre-foot detention area. The total estimated first cost is $37,579,000, with a fully funded cost of $43,697,000. The Federal cost is $28,403,000; non-Federal cost of $15,294,000, with the LERRD requirement of $10,934,000 and estimated average annual OMRR&R costs of $40,800.

The Recommended Plan is shown in Figure ES-1. The figure provides an overview of the Recommended Plan in an aerial view of the Turkey Creek in the City of Merriam.

This document is based on the limited information available at this intermediate stage. As the USACE planning process is dynamic and responsive to public and stakeholder input, the content 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 does not necessarily represent the perceptive of higher review levels within the agencies involved or the Executive Branch of the federal government.

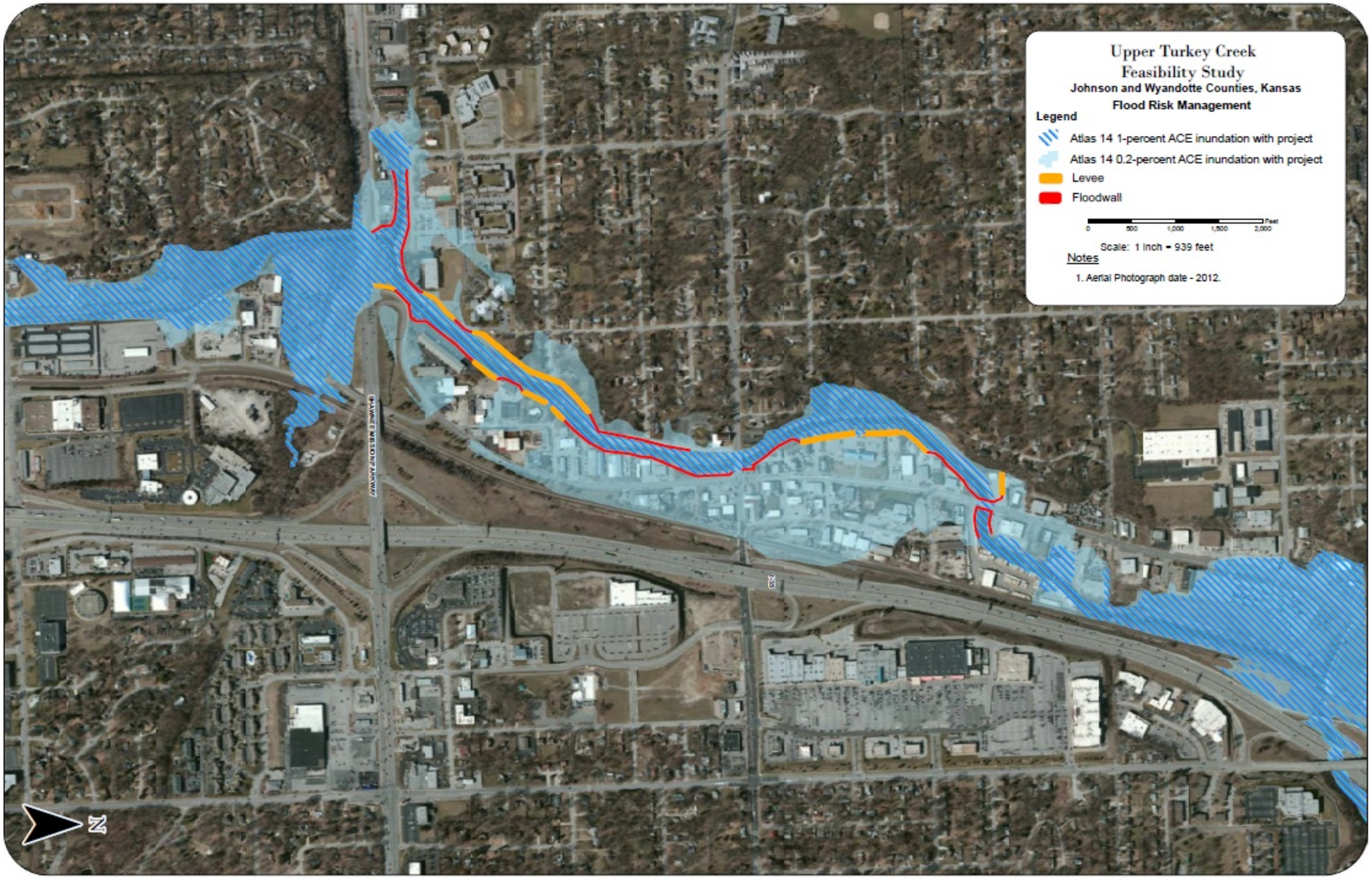


Figure ES-1: Recommended Plan (Alternative 2d)

This document is based on the limited information available at this intermediate stage. As the USACE planning process is dynamic and responsive to public and stakeholder input, the content 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 does not necessarily represent the perceptive of higher review levels within the agencies involved or the Executive Branch of the federal government.

1 CHAPTER 1 – STUDY INFORMATION

1.1 PURPOSE AND NEED FOR THE PROJECT AND REPORT

The purpose of the feasibility study is to identify, evaluate, and recommend to decision makers an appropriate, coordinated, implementable solution to the identified water resources problems and opportunities in the Upper Turkey Creek Basin. Congressional authorization for the Upper Turkey Creek Basin study specifically states this project's primary mission is flood risk management. The feasibility study considers other U.S. Army Corps of Engineers (USACE) mission areas or authorities in accordance with Engineer Regulation (ER) 1105-2-100, *Planning Guidance Notebook*. These mission areas or authorities included the use of a systems approach (specifically a watershed perspective) and collaborative planning, as well as consideration for the ecosystem restoration and recreation mission areas in the plan formulation process. The study product is a decision document in the form of this feasibility report and integrated National Environmental Policy Act (NEPA) environmental assessment (EA) document in accordance with ER 1105-2-100 and the Council on Environmental Quality's (CEQ) Regulations for Implementing NEPA (40 Code of Federal Regulations [CFR] Parts 1500–1508).

The need for the project lies in the potential for flooding that could result in loss of life and/or property damage in the Upper Turkey Creek Basin. Flooding in and around Johnson County, Kansas, led to presidential disaster declarations in 1993 and 1998. The estimated cost of these disasters exceeded $50 million dollars. Heavy rains on October 4, 1998, produced flooding that caused several million dollars in damage to businesses and public property along Turkey Creek in Johnson and Wyandotte Counties, Kansas. Reports indicate that parts of the Kansas City metropolitan area received almost eight inches of rain that day with some locations receiving three to five inches of rain within a three-hour period. More than five inches fell in Lenexa, Kansas, in a little over an hour. Nearly 100 calls for water rescue were received, and numerous roads throughout the area, including individual sections of Interstate 35 (I-35) and Interstate 435 (I-435), were impassible. Two lives were lost, including a death in Lenexa near the intersection of West 93rd Street and Acuff Road, and one in Overland Park, Kansas, on Connell Avenue near 103rd Street. There was also extensive property damage. If the flood peak over I-35 had occurred during rush hour, the loss of life count could have been significant.

The 1998 flood was significant. The 24-hour rainfall amount associated with a 1 percent annual exceedance probability (AEP) (100-year event) for the Johnson County, Kansas, area is 7.8 inches. Also, the 60-minute rainfall amount associated with the 1 percent AEP is 3.75 inches. The storm of October 1998 exceeded the 1 percent AEP for both the 24-hour and 60-minute rainfall amounts.

Following these losses, the U.S. House of Representatives Committee on Transportation and Infrastructure passed the 1999 resolution and adopted the study authority in 2000 (see Section 1.2). The 1999 resolution favored a watershed perspective to future water resource development proposals. A successful plan must fit a broad range of community goals for the whole Turkey Creek watershed to ensure the resulting project would be sustainable in the sense that the community would want to use, maintain, and possibly even enhance the project as a community asset after construction.

The purpose of this report is to present decision makers with the findings of a feasibility phase of this general investigation. This investigation of the Upper Turkey Creek Basin was conducted to determine if it

meets the USACE criteria for Federal involvement in addressing flood hazards, environmental degradation, and related water and land resource needs and opportunities.

This report has detailed analyses of the problems and opportunities and presents the USACE and project sponsor desired outcomes related to planning objectives. Alternatives to address the objectives were developed by the planning team in collaboration with the project sponsor and are presented herein. These alternatives include a range of potential actions including a plan of no action and various combinations of structural and nonstructural measures. The evaluation of economic and environmental impacts is then explained and a feasible plan is selected, where potential Federal cost share is identified. The report also presents details about the USACE and sponsor participation needed to implement the plan. The report concludes with a recommendation for Congressional authorization.

1.2 STUDY AUTHORITY

The Upper Turkey Creek Basin, Kansas, Integrated Feasibility Study and Environmental Assessment is authorized by Resolution of the Committee on Transportation and Infrastructure, U.S. House of Representatives, Docket 2616, adopted February 16, 2000.

> Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That the Secretary of the Army is requested to review the report of the Chief of Engineers on the Turkey Creek Basin, Kansas and Missouri, dated June 21, 1999, and other pertinent reports, to determine whether any modifications of the recommendations contained therein are advisable at the present time in the interest of flood damage reduction for areas of Turkey Creek Basin in Johnson and Wyandotte Counties, Kansas, upstream of the project for flood damage reduction authorized in section 101(a)(24) of Public Law 106-53, the Water Resources Development Act of 1999.

1.3 STUDY LOCATION

The study location includes a portion of the Turkey Creek watershed, which is a right bank tributary of the lower Kansas River (Figure 1-1). The headwaters of the Turkey Creek Basin are in Lenexa, Kansas, just south of 89th Street, and the portion of the watershed upstream of the 4.4 Burlington Northern Santa Fe (BNSF) railroad bridge referred to in this study as Upper Turkey Creek and Lower Turkey Creek is the downstream portion. The entire basin drains 23 square miles before passing through a quarter-mile-long tunnel to the Kansas River. Turkey Creek is approximately 15 miles long and flows parallel to I-35 for almost its entire length. The Turkey Creek drainage basin overlaps the common boundary of Johnson and Wyandotte Counties, Kansas. Countyline Road passes east-west through the basin separating Johnson County to the south from Wyandotte County to the north. For this feasibility report, the Upper Turkey Creek Basin, or sometimes referred to as UTC, is defined as the basin upstream of an authorized flood risk management construction project in the downstream 8,700 feet of the Turkey Creek channel (Figure 1-2), also referred to as Lower Turkey Creek in this report.

1.4 STUDY SPONSOR AND PARTICIPANTS

The City of Merriam, Kansas, is the non-Federal local sponsor for this feasibility study. A Feasibility Cost Sharing Agreement (FCSA) between the City of Merriam, Kansas, and the government was signed in June 2002 and calls for a feasibility study of flood damage reduction and ecosystem restoration in the Turkey Creek Basin at a cost of approximately $2.4 million. Half of the feasibility study cost came from Federal funds. The non-Federal share includes work performed by the non-Federal sponsor as well as cash contributions. The non-Federal sponsor has provided a hydrologic and hydraulic model valued at more than $200,000 in addition to cash payments. The model was obtained through an agreement between Merriam

and Johnson Counties, Kansas. Johnson County and the Unified Government of Wyandotte County and Kansas City, Kansas (UG) both support the study financially through agreements with Merriam County and provided members to the team that monitored the progress of the study.

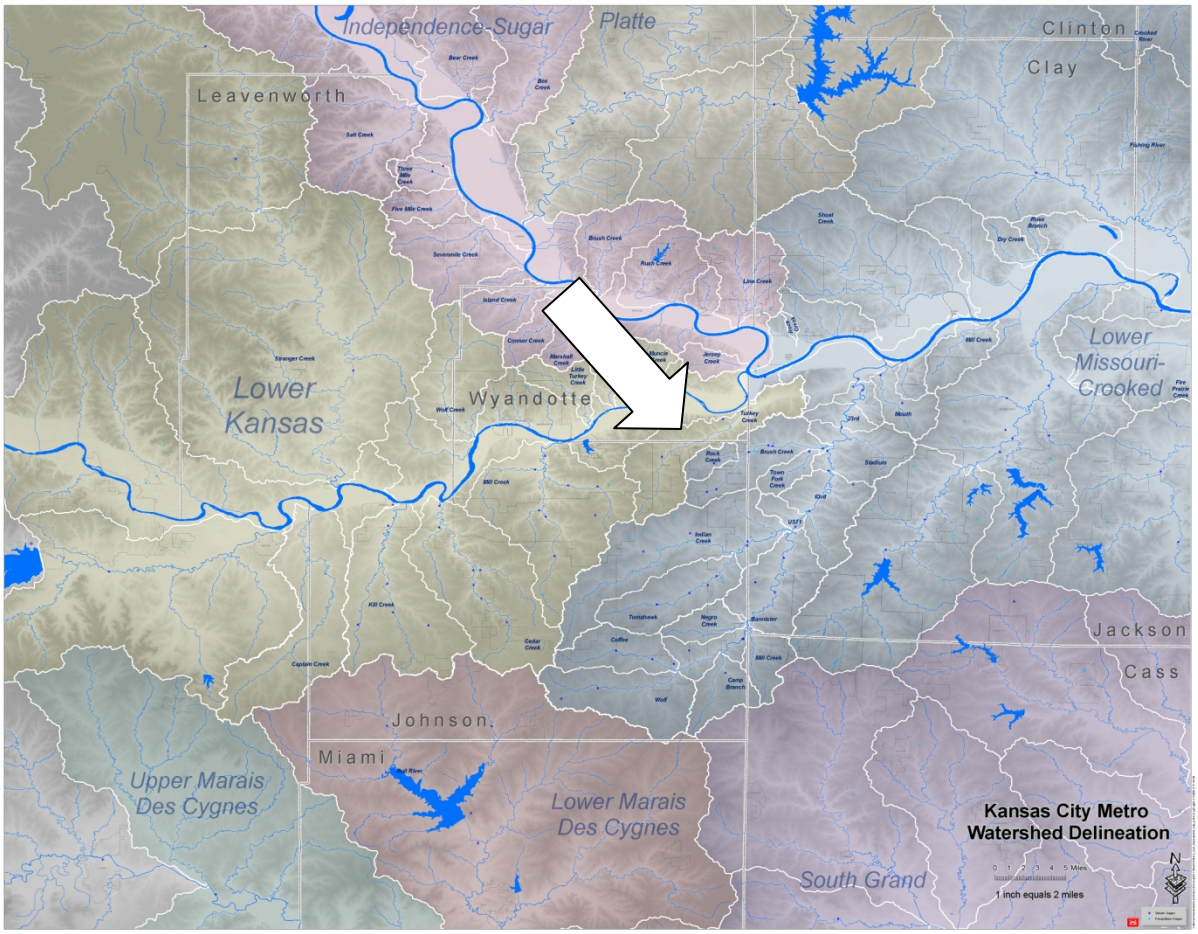


Figure 1-1: Watersheds of Kansas City and Turkey Creek.

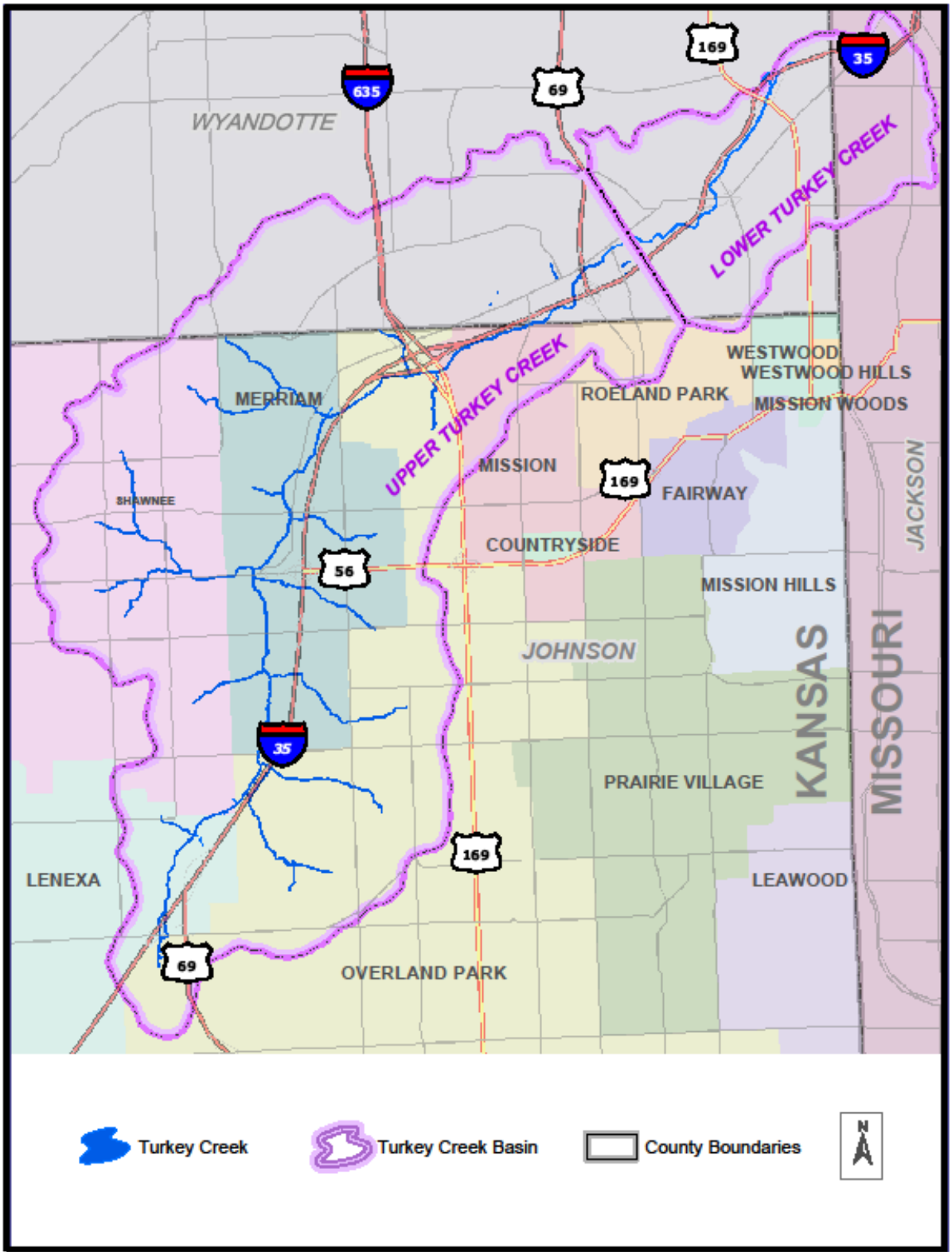


Figure 1-2: Turkey Creek Basin

In addition to the local sponsor, the following agencies and organizations have been major stakeholders and have been active participants in the feasibility study process:

- Johnson County Stormwater Management Program
- Merriam Drainage District
- Mid-America Regional Council and the Turkey Creek Coalition
- Johnson County Public Works and the Stormwater Management Advisory Council
- Kansas Department of Transportation (KDOT)
- U.S. Environmental Protection Agency (EPA)
- Downtown Merriam Partnership

1.5 HISTORY OF TURKEY CREEK INVESTIGATIONS

The Turkey Creek watershed has a history of the USACE involvement. In the past 50 years, major flood events have occurred in 1951, 1958, 1961, 1968, 1977, 1983, 1986, 1993, 1995, 1996, and 1998. Although the floods of 1993 and 1998 were both extreme events, the 1998 flood appears to be the flood of record, based on high water marks, for Turkey Creek.

Although the 1977 flood is locally known as the Plaza Flood on Brush Creek, significant damage resulted in Rosedale and elsewhere in the Turkey Creek Basin. Flood damage estimates from the September 1977 flood exceeded $8.1 million dollars and prompted the Mid-America Regional Council (MARC), the metropolitan planning organization, to ask the USACE to study the Turkey Creek flood problems as a part of an ongoing Urban Study. The Urban Study determined it was not feasible to develop and implement a program for managing flood risks along Turkey Creek that would contain the 1 percent annual exceedance probability (AEP, or 100-year event) and greater flood events. However, following the 1983 flood, the Cities of Kansas City, Missouri, and Kansas City, Kansas, requested additional studies on Turkey Creek flooding. In 1987, the USACE produced the Reconnaissance Study of Turkey Creek. This commenced a series of studies culminating in an authorized construction project for Lower Turkey Creek in the Water Resources Development Act (WRDA) of 1999. As of 2012, Lower Turkey Creek has an active USACE construction project. One component is the repair of an aging tunnel that diverts all flow from the Turkey Creek watershed through a bluff to the Kansas River. Channel widening has also been done.

Following the 1993 and 1998 flood losses and as Lower Turkey Creek investigations were ongoing, the U.S. House of Representatives Committee on Transportation and Infrastructure passed the 1999 resolution and adopted the Upper Turkey Creek Basin Study authority in 2000. The 1999 resolution favored a watershed perspective to future water resource development proposals. In response to the study authority, the reconnaissance phase of the study was initiated on 16 February 2000 (USACE 2001). This phase of the study resulted in the finding that there was a Federal interest in continuing the study into the feasibility phase. The USACE, Kansas City District, along with the local sponsor, the City of Merriam, Kansas, initiated the feasibility phase of the Upper Turkey Creek watershed in June 2002 to examine measures for flood risk management. This report presents the results of the planning phase.

1.6 EXISTING PROGRAMS, PRIOR STUDIES, AND PROJECTS

This section describes existing programs, prior studies, and projects that are applicable to this feasibility study and were considered in the planning process including identification of problems and opportunities and alternative plan formulation.

1.6.1 PROGRAMS

The following programs are applicable to the Upper Turkey Creek Basin and were considered in the planning process for this feasibility study:

Johnson County Stormwater Management Program

The Johnson County, Kansas Stormwater Management Program (SMP) is a part of the county's public works department. The SMP assists all of the cities in the county in planning, designing, and constructing large stormwater projects. This is an important funding mechanism for smaller cities in the county, such as Merriam. While the annual budget ranges between 10 and 20 million dollars, projects are carefully selected on specific criteria. One merit has to do with projects that involve larger, systems approach. Merriam's position downstream of several major cities has the burden of addressing resulting floodwaters, and this is one reason Merriam has received funding aid. This program is a significant part of the local cost share of this project.

In 1988, the Kansas Legislature authorized counties to adopt a 1/10th-cent sales tax for the purpose of funding stormwater projects. These funds, dedicated to stormwater management, allow Johnson County through its SMP to create a yearly stormwater management plan and provide 75 percent of funding for eligible projects in Johnson County and the cities. The SMP provides financial, technical, and other stormwater assistance services to encourage regional solutions for protecting human lives and property, conserving natural resources, and promoting appropriate public use of Johnson County stream corridors. The Johnson County Stormwater Management Advisory Council (SMAC) operates as an advisory board to the Board of County Commissioners. It is responsible for reviewing recommendations made in the SMP and providing recommendations to the Board of County Commissioners and considering new and innovative ways to properly manage stormwater.

The SMP will recommend that SMP funding be provided to a city's local cost share of the USACE developed construction projects where the project meets the Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP) standards and reduces flood hazards. As a condition the SMP needs levees and or floodwalls to be certifiable in that program per criteria in the NFIP as of 2012.

Clean Water Act Section 319

Section 319 was added to the Clean Water Act (CWA) in 1987 to establish a national program to address nonpoint sources of water pollution. Section 319(h) specifically authorizes the EPA to award grants to states with approved non-point source Assessment Reports and non-point source Management Programs. The funds are to be used to implement programs and projects designed to reduce non-point source pollution. The EPA provides funding for implementation of Kansas' Non-Point Source Management Program through an annual CWA Section 319 grant to the Kansas Department of Health and Environment (KDHE). EPA personnel also provide program guidance and implementation assistance through review of 319 project implementation plans for subgrants to local project sponsors. Other funding is also made available through EPA for water quality related activities, such as the State Wetland Development Grant Program and Targeted Watershed Grant Program, which have been used by local and state partners in Kansas. The annual 319 program grant to Kansas in Federal fiscal year (FFY) 2010 was about $3.5 million. The KDHE provided an EPA 319 grant for funding of the Lower Kansas Watershed Restoration and Protection Strategy (WRAPS) Watershed Plan, which covers the area of the Turkey Creek Basin.

Lower Kansas River Watershed Restoration and Protection Strategy Group

WRAPS is a planning and management framework that engages stakeholders within a particular watershed in a process to:

- Identify watershed restoration and protection needs and opportunities

- Establish management goals for the watershed community
- Create a cost-effective action plan to achieve goals
- Implement the action plan

WRAPS represents a shift from "top-down" government intervention in watershed issues to a more citizen-stakeholder approach, in which funds, guidance, and technical assistance are provided for stakeholders to reach consensus on issues of relevance in their watershed and then design and execute a plan to address those issues.

The Lower Kansas watershed includes parts of six counties including Atchison, Douglas, Jefferson, Johnson, Leavenworth, and Wyandotte Counties. The Lower Kansas WRAPS project area covers the Lower Kansas hydrologic unit code (HUC) level 8, or HUC-8, watershed with the exception of the Wakarusa River drainage, which feeds Clinton Lake. The area has an approved watershed plan completed in 2011. This plan identifies Turkey Creek's ammonia (NH3) total maximum daily load (TMDL) as part of a future priority area and water quality impairment to be addressed.

The WRAPS group could potentially request environmental restoration on Turkey Creek, if so, the planning team has formulated ecosystem restoration sites, which the local communities may choose to implement with just local funds in the future. This work, which the sponsor asked for very early in the feasibility phase, under ecosystem restoration formulation, is primarily discussed in the environmental appendix. This work was considered part of the USACE collaborative planning guidance and was outlined at the project's feasibility scoping meeting.

Federal Emergency Management Agency

The FEMA has many relevant programs. One is the National Flood Insurance Program (NFIP). A second program is Risk Mapping, Assessment, and Planning (MAP), or Risk MAP, which integrates and aligns the individual risk analysis programs of FEMA into a more effective unified strategy. The vision for Risk MAP is to deliver—through collaboration with state, local, and tribal entities—quality data that increase public awareness and lead to mitigation actions that reduce risk to life and property. To achieve this vision, FEMA is transforming its traditional flood identification and mapping efforts into a more integrated process of accurately identifying, assessing, communicating, planning, and mitigating flood-related risks. Risk MAP addresses gaps in flood hazard data to form a solid foundation for risk assessment and floodplain management and to provide state, local, and tribal entities with information needed to mitigate flood-related risks.

For this study, FEMA initiated a Risk MAP discovery phase in 2012 for the Lower Kansas River watershed, which is the name for the HUC-8. The State of Kansas administers all Risk MAP funding through the Kansas Department of Agriculture (KDA), Division of Water Resources.

Kansas Department of Agriculture, Division of Water Resources

The KDA Water Structures Program regulates dams, stream modifications, levees, and floodplain fills for the protection of life, property, and public safety. The program also provides technical assistance and coordination for local communities participating in FEMA's NFIP, Community Rating System (CRS), and Risk MAP, as well as the state levee programs. The State NFIP Coordinator is part of the KDA. Examples of activities regulated by the Water Structures Program include construction, modification, or repair of dams, bridges, culverts, weirs, low-water crossings, low-head dams, intake/outfall structures, boat ramps, pipeline/cable crossings, grassed waterways, other channel modifications, levees along streams, placement of fill within the floodplain, and gravel/sand dredging.

The KDA, specifically the State NFIP Coordinator, has attended this project's team meetings, and KDA is interested in seeing the communities work collaboratively to address system-wide flooding issues. This is a

requirement of participation in FEMA's NFIP. For this reason, KDA will be monitoring the development of the floodplain management plan (see below) for the State of Kansas, and how that plan will improve communities' relationships to neighboring communities that are affected by floodwaters.

Finally, KDA is a co-lead for the Kansas Hazard Mitigation Team (see below), which focuses on the state hazard mitigation plans. Local hazard mitigation plans and floodplain management plans are a part of this effort.

National Flood Risk Management Program

The USACE established the National Flood Risk Management Program (NFRMP) for the purpose of integrating and synchronizing the USACE flood risk management programs and activities, both internally and with counterpart activities of the Department of Homeland Security, FEMA, other Federal agencies, state organizations, and regional and local agencies.

Some of the specific goals of the NFRMP include:

- Providing current and accurate floodplain information to the public and decision makers
- Identifying and assessing flood hazards posed by aging flood damage reduction infrastructure
- Improving public awareness and comprehension of flood hazards and risk
- Integrating flood damage and flood hazard reduction programs across local, state, and Federal agencies
- Improving capabilities to collaboratively deliver and sustain flood damage reduction and flood hazard mitigation services to the nation

As a major Army command, the USACE is assigned mission responsibilities in major construction and other engineering support to the Army and Air Force, in nationwide water resource management, engineering research and development, and real estate services for the Army and the Department of Defense. In addition to these long-standing programs, the USACE has been called upon with increasing frequency to take a leadership role in the nation's flood risk management arena. As a result, the USACE established the NFRMP in May 2006 for the purpose of integrating and synchronizing the USACE flood risk management programs and activities, both internally and externally with counterpart activities of the Department of Homeland Security, FEMA, other Federal agencies, state organizations, regional and local agencies, and non-governmental organizations (NGOs). The official guidance was issued in October 2009, formally establishing the NFRMP in the USACE headquarters, divisions, and districts.

Each district has an appointed flood risk management (FRM) Program Manager, responsible for integrating a district's USACE missions related to flood hazards. These include Emergency Management, the Dam Safety Program, the Levee Safety Program, the Silver Jackets Program, Flood Plain Management Services, Planning Assistance to States Program, and all general investigations that include the USACE FRM mission area. For this project, this program manager is fully in support of the outcome of this report for Turkey Creek.

Silver Jackets Program

The Silver Jackets Program is an innovative USACE program that provides an opportunity to consistently bring together multiple state, Federal, and sometimes tribal and local agencies to learn from one another and apply their knowledge to reduce risk from all natural hazards. State agencies, including those of the State Hazard Mitigation Officer and State NFIP Coordinator, come together with the Federal family of agencies, including the USACE and the FEMA, in a common forum to address the state's flood risk

management priorities. Silver Jacket Programs are developed at the state level, although some states have already established hazard mitigation teams with their own identity and the USACE participates through that existing team. The ultimate goal is to offer an interagency team in every state. As of 2012, 29 active state teams exist.

The program's primary goals are to:

- Create or supplement a mechanism to collaboratively identify, prioritize, and address risk management issues and implement solutions
- Increase and improve risk communication through a unified interagency effort
- Leverage information and resources and provide access to such national programs as the FEMA's Risk MAP program and the USACE's Levee Inventory and Assessment Initiative
- Provide focused, coordinated hazard mitigation assistance in implementing high-priority actions, such as those identified by state mitigation plans
- Identify gaps among agency programs and/or barriers to implementation, such as conflicting agency policies or authorities, and provide recommendations for addressing these issues

Many states have hazard mitigation programs. Some have begun under the Silver Jackets title, while others have already been established in response to the Stafford Act changes in 2000, which required states to have hazard mitigation plans.

Kansas Hazard Mitigation Team

The Kansas Hazard Mitigation Team (KHMT) is a state organized team focused on all hazards mitigation. The team is co-led by the KDA and the Kansas Department of Emergency Management. The stated purpose in establishing this team is to:

- Assess hazard mitigation needs
- Develop and implement statewide hazard mitigation policies
- Promote coordination of mitigation programs at all levels of government
- Pursue alternate mitigation funding strategies

The USACE, Kansas City District, Silver Jackets Coordinator officially conducts the state-level hazard mitigation work with this state led team.

The KHMT focuses on regularly updating the FEMA-required state hazard mitigation plan. For this study, the KHMT is interested in improving floodplain management on Turkey Creek. All local mitigation plans and floodplain management plans are considered part of this initiative. The state remains eligible for FEMA hazard mitigation program and disaster grants as long as the local and state hazard mitigation plans are up-to-date.

Merriam Drainage District

The Merriam Drainage District (MDD) is a state authorized entity per the Kansas Watershed District Act. A three-person board of directors is elected periodically, and their mission is to apply funds collected from a mill levy to maintain a very small portion of Turkey Creek that is located entirely within the City of Merriam, Kansas. The city has no authorized control of this entity, but together MDD and the city’s floodplain manager manage the floodplain. The city is enrolled in the FEMA NFIP and must fulfill the role of floodplain management, including actively reaching out to MDD to satisfy conditions of enrollment in the NFIP. Each of these watershed or drainage districts in Kansas is required to have a General Plan describing its mission.

Upper Turkey Creek Floodplain Management Plan

As a conditional requirement for receiving the USACE construction funds, in accordance with Public Law 104-303 of WRDA of 1996, which amends Section 402 of the WRDA of 1986 (also see 33 U.S.C. 701b-12; 100 Stat. 4133), this floodplain management plan (FMP) is in many regards the beginning of a local program. The FMP will echo findings from this report, establish an inter-local Floodplain Committee, and develop a set of action items for improving flood risk management in Upper Turkey Creek. The bounds of this FMP will be limited to the same watershed area authorized by this feasibility study. The action items will be a local responsibility and will have specific timeframes identified for implementation for years to come. These action items will ensure not only the longevity of the project identified in this report but also will improve public understanding of flood risks and reduce future damages and possibility for loss of life. One of the components of this FMP will tie in the operation of the MDD with all floodplain management activities, specifically the MDD's General Plan, as required by Kansas law.

1.6.2 PROJECTS

The following projects have been implemented or are ongoing in the Turkey Creek Basin:

Green Project, Interstate-35, South of 75th Street, Kansas Department of Transportation Project

The KDOT prepared a planning study that has resulted in active construction during the preparation of this feasibility study. The planning study, the *U.S. 69 and Interstate 435 Major Investment Study*, proposed one location known as the Green Project. Construction upstream of 75th Street, in the extreme southern end of Upper Turkey Creek, has been ongoing in 2011 and 2012. Some of the KDOT construction elements include improvements to storm culverts or bridges at locations identified as overtopping the highway in the 1998 flood (see the map in the Reconnaissance Report [USACE 2001]).

Merriam Drainage District, Channel Project

The MDD has modified the Turkey Creek channel from 63rd Street downstream to 51st Street. Modifications began in stages about 1967, and the work was considered complete in 1972, but the MDD has since accomplished an extensive streambank protection effort relying primarily on large blocks of cut stone placed to armor the channel slope. The last segments of armoring were placed in the early 1980s, but large floods can displace some of the stone blocks, and maintenance of the project continues. The MDD's efforts have produced a channel of nearly uniform width, deepened to bedrock through the identified reach, on which this feasibility study is focused. In addition, the MDD has had difficulty in the past with compliance for CWA 404 permitting because the proposed designs for bank stabilization are not sustainable with the large floods displacing the stone blocks. The City of Merriam, in conforming to NFIP requirements, has worked with the MDD in changing its vision, "the free flow of Turkey Creek," from a vision based entirely on channel widening to one considerate of more comprehensive solutions for adjacent communities and property owners. The MDD is now open to more alternatives, which this study has considered. The MDD will be an important financial partner in supporting future phases of design, construction, and especially the operation and maintenance of a Federal cost-shared project on Upper Turkey Creek.

The USACE Turkey Creek Basin, Construction Project

The authorized USACE Turkey Creek Basin, Kansas City, Kansas and Missouri, flood damage reduction project is a $92 million project, which congress authorized in 2003. The project is sponsored by the USACE, Kansas City, Missouri, District, and the UG. The project, located in Lower Turkey Creek, includes a combination of 1,300 feet of improvements to the 28-foot-diameter horseshoe shaped tunnel (built in 1919), bridge modification, channel widening, and a series of enlargements to the hillside

interceptors. The USACE completed the tunnel and channel construction before 2012. The USACE realized substantial savings by collaborating with the KDOT as construction occurred simultaneously on I-35.

Antioch Bridge Project and the Burlington Northern Santa Fe 7.44 Railroad Bridge

Designed by HNTB Corporation, the Antioch Road Replacement Project over I-35 and the BNSF railroad bridge both span Turkey Creek in Merriam. Construction of the Antioch Bridge was finished in 2000. KDOT completed construction of this bridge, as well as channel improvements, at this Turkey Creek crossing. The new bridge alleviates some of the constriction at this crossing, and the new channel design includes gabion revetment rather than stone riprap. Upstream and immediately adjacent, the railroad bridge work also relieved some of the constriction.

Waterfall Park, City of Merriam

The City of Merriam has made wise use of the floodplain just upstream of the railroad bridge. Many structures have been removed from the floodplain area that is inundated just upstream of the Antioch Bridge and the railroad bridge. The city has dedicated the area as a park, which is a compatible use for this frequently flood area. Periodic maintenance has been needed to address erosive conditions at the upstream face of the railroad bridge, where a significant drop in the channel invert provides park visitors with a waterfall. The proximity of the waterfall, and change in channel flow direction both make maintaining bank erosion a challenge.

Johnson County Hazard Mitigation Projects

Johnson County and cities within the county have actively sought to reduce flood risk by planning, designing, and constructing/implementing structural and nonstructural measures. Structural measures implemented recently include channel improvement projects (including straightening, lining, widening, and removing obstructions) and detention projects on both a regional scale and onsite. Nonstructural activities include:

- Home buyouts to remove/relocate homes to areas of lesser risk. For example, following the floods of 1998, 33 homes in Merriam were purchased for a total cost of 5.3 million and were subsequently demolished
- Adoption of floodplain land use ordinances
- Implementation of components of a flood warning system (StormWatch), including county-wide hydrometeorological observation, some computer-aided threat recognition, road barricading, and limited site-specific forecasting

i-Tree Eco Project, Mid-America Regional Council

i-Tree Eco is state-of-the-art, peer-reviewed software from the U.S. Department of Agriculture (USDA), Forest Service, that provides urban forestry analysis and benefits assessment tools. The program provides affordable, easy-to-use tools communities can use to collect and analyze information on their urban forests. i-Tree Eco helps strengthen management and advocacy efforts by quantifying the structure of community trees and the environmental services that trees provide. While it is understood that trees provide numerous community benefits, quantifying them often proves challenging. The Kansas City regional i-Tree program will help identify these benefits by analyzing data such as:

- Effects of trees on energy usage
- Air quality improvements from trees
- Carbon sequestration

- Rainfall interception
- Potential impact of destructive pests

In fall 2010, a sample inventory was conducted for 340 plot locations across the Kansas City region. The randomly selected plots are 1/10 of an acre in size and consist of private and public-owned trees within the nine-county region. Project staff recorded information on species, condition, tree height, trunk diameter, canopy density, and other criteria. Inventory data were analyzed in 2011. The information collected from the i-Tree Eco study will help guide local forestry planning efforts.

1.6.3 STUDIES

The following previously conducted or ongoing studies are related to the Upper Turkey Creek Basin:

- Design Memorandum No. 2, General Design Memorandum, Turkey Creek Diversion, USACE, Kansas City District, January 1956
- Flood Protection Project, Turkey Creek, Merriam, Kansas, USACE, September 1962
- Letter Report for Proposed Inclusion of Turkey Creek Improvements, Modification of Local Protective Works, Kansas River, Kansas City, Kansas (Flood Control Act of 1962), USACE, Kansas City District, May 1968
- Flood Plain Information Report for Turkey Creek in Metropolitan Kansas City, USACE, January 1974
- Turkey Creek Improvement, 75th Street and I-35 Interchange, January 1983
- Planning Aid Report for the Turkey Creek Basin, Kansas and Missouri Reconnaissance Study, U.S. Fish and Wildlife Service (USFWS), Kansas State Office, Manhattan, September 1987
- Reconnaissance Report: Turkey Creek Basin, Kansas and Missouri, USACE, December 1987
- Flood Insurance Study, City of Kansas City, Kansas, FEMA revision of January 1995
- Design Concept Report Supplement: Burlington Northern Railroad at Turkey Creek, HNTB Corporation, August 1996
- Draft Fish and Wildlife Coordination Act Report for the Turkey Creek, Kansas City, Kansas, and Kansas City, Missouri, Local Flood Protection Project, USFWS, Kansas State Office, Manhattan, April 1997
- Use Attainability Analysis of Turkey Creek, Johnson and Wyandotte Counties, Kansas, Gary E. Welker and Dr. Donald G. Huggins, EPA, Environmental Services Division, Kansas City, Kansas and the Kansas Biological Division, University of Kansas, Lawrence, Kansas, July 1997
- Final Fish and Wildlife Coordination Act Report for the Turkey Creek Flood Damage Reduction Project, Kansas City, Kansas, and Kansas City, Missouri, USFWS, Kansas State Office, Manhattan, October 1998
- Feasibility Report and Environmental Assessment, Turkey Creek Basin, Kansas City, Kansas and Missouri, Kansas City District, USACE, December 1998
- TMDLs for the Kansas - Lower Republican Basin, Kansas Department of Health & Environment, June 30, 1999
- Upper Turkey Creek Basin, Johnson and Wyandotte Counties, Kansas: Section 905(b) Analysis, USACE, July 2001

- Draft Supplemental Final Fish and Wildlife Coordination Act Report for the proposed General Reevaluation Report and revised Environmental Assessment, Lower Turkey Creek flood damage reduction project – Kansas City, Kansas and Missouri, USFWS, March 29, 2002, Kansas State Office, Manhattan
- Final Supplemental Final Fish and Wildlife Coordination Act Report for the proposed General Reevaluation Report and revised Environmental Assessment, Lower Turkey Creek flood damage reduction project – Kansas City, Kansas and Missouri, USFWS, September 9, 2002, Kansas State Office, Manhattan
- Stormwater Management Ordinance, Chapter 7, Article 1 of City code of ordinances, City of Merriam, June 24, 2002
- Johnson County Flood Warning/Flood Forecasting: Feasibility Study, Johnson County SMP, August 2002
- General Reevaluation Report and Environmental Assessment, Turkey Creek Basin, Kansas City, Kansas and Kansas City, Missouri, USACE, January 2003
- Upper Turkey Creek Basin Environmental Restoration Report: Feasibility Phase – Draft, USACE, August 2004
- Northeast Johnson County Watershed Study, Johnson County, Kansas. 2005
- Effects of Contaminant Sources on Streamwater Quality in Johnson County, Northeastern Kansas, October 2002 through June 2004, C.J. Lee, D.P. Mau, and T.J. Rasmussen. U.S. Geological Survey (USGS), Fact Sheet 2005–3080, August 2005
- Effects of Nonpoint and Selected Point Contaminant Sources on Stream-Water Quality and Relation to Land Use in Johnson County, Northeastern Kansas, October 2002 through June 2004, C.J Lee, D.P. Mau, and T.J. Rasmussen, 2005, USGS, Scientific Investigations Report 2005–5144
- Special Area Management Plan (SAMP), Upper Turkey Creek Watershed, Watershed Institute, Inc., 2007
- Rock Creek Watershed Planning Final Feasibility Report, USACE, August 2007. Rock Creek Alternative Futures Study, USACE, August 2009
- Manual of Best Management Practices for Stormwater Quality, Mid-America Regional Council and American Public Works Association (APWA), Second Edition, August 2009

Complete descriptions of these studies and reports are included in Chapter 13.

1.7 PLANNING PROCESS AND REPORT ORGANIZATION

The Upper Turkey Creek Basin feasibility study follows the USACE six-step planning process specified in the U.S. Water Resources Council *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G) and ER 1105-2-100. The process identifies and responds to problems and opportunities associated with the Federal objective and specified state and local concerns. The planning process consists of six major steps:

1. Specification of water and related land resources problems and opportunities
2. Inventory, forecast, and analysis of water and related land resources conditions within the study areas
3. Formulation of alternative plans

4. Evaluation of the effects of the alternative plans
5. Comparison of the alternative plans
6. Selection of the recommended plan based upon the comparison of alternative plans

In accordance with ER 1105-2-100, the *Planning Guidance Notebook*, the planning process also followed a systems approach, in this case a watershed perspective (per the ER), in completing the six-step process. This approach was consistent with the interests of the local sponsor, in particular the desire to consider environmental enhancement through best management practices (BMPs).

The organization of this report reflects the integration of the feasibility report with the environmental assessment. As required by NEPA, all required components are included and identified with an asterisk (*) throughout. Chapters of the report also relate to the six steps of the planning process as follows:

- Chapter 2, *Need for and Objectives of Action*, covers the first step in the planning process.
- Chapter 3, *System Baseline Condition and Inventory*, covers the second step of the planning process.
- Chapter 4, *Plan Formulation*, covers the third step in the planning process and presents the initial plan formulation considerations.
- Chapter 5, *Alternative Evaluation and Comparison*, covers the fifth step in the planning process and includes evaluation and screening of the array of alternatives.
- Chapter 6, *Environmental Effects*, ensures that the effects analysis is part of the evaluation/comparison process and covers the fourth step of the planning process.
- Chapter 7, *The Recommended Plan*, describes the sixth step of the planning process.
- Chapter 8, *Public Involvement, Review, and Coordination*, describes the public outreach efforts conducted as part of the feasibility study process.

2 CHAPTER 2 – NEED FOR AND OBJECTIVES OF ACTION

This chapter presents the results of the first step of the planning process, which is the identification of water and related land resources problems and opportunities in the study area. This chapter concludes with the establishment of planning objectives and planning constraints to serve as the basis for the formulation of alternative plans.

2.1 STUDY AREA DESCRIPTION

The Kansas City metropolitan area (see Figure 1-1) is divided into many basins. Within these basins, dozens of small, fast-rising streams drain urban and rural watersheds. The flooding risk has increased substantially over time, particularly in the northeastern portion of Johnson County as development has progressed to the southwest over the past several decades.

The Turkey Creek watershed, encompassing parts of Johnson and Wyandotte Counties in Kansas, consists almost exclusively of highly developed urban areas. Turkey Creek and its floodplain have been a part of the Kansas City metropolitan infrastructure since the 1800s. The relatively flat topography associated with the creek and its floodplain has been favorable to the location and development of railroads, highways, and utilities. Commercial and residential development associated with the railroad and highways also has paralleled the creek.

Urbanization and ongoing development in the Upper Turkey Creek watershed has resulted in degradation of environmental resources associated with the creek. The creek has been deepening and widening its channel as a result of high runoff volumes and flow rates associated with urbanization in the watershed. In response, much of the creek channel has been enclosed in culverts, lined with concrete, or otherwise hardened to address channel instability. Stream reaches where the channel has been enclosed or hardened with concrete provide little or no habitat value and represent impassable biological dead zones for most of the fish and other aquatic wildlife in Turkey Creek. Failure of Turkey Creek to attain its designated recreational and aquatic life uses is, in part, a result of these channel modifications.

The modification of natural hydrologic characteristics in the stream and surrounding watershed also has contributed to more flooding. The Turkey Creek Basin experienced major floods in 1951, 1958, 1961, 1968, 1977, 1983, 1986, 1993, 1995, 1996, and 1998. The flood events resulted in significant property damage in the downstream reaches of Turkey Creek. There was one fatality in the 1993 flood in Turkey Creek Basin. In the 1998 flood, multiple fatalities occurred in the Brush Creek Basin, and in Turkey Creek, multiple fatalities were narrowly avoided in several instances.

Johnson County is a county government comprising municipal jurisdictions established within its boundaries and minimal unincorporated area. Kansas City, Kansas, is the dominant municipality in Wyandotte County. In 1997, the Wyandotte County and Kansas City, Kansas, electorate approved a measure to combine the city and county governments under a single executive. The resulting municipal body is referred to as the UG.

The boundaries of the City of Merriam lie in the bottom of the Upper Turkey Creek watershed (see Figure 1-2). Headwaters concentrate all runoff to areas largely in the heart of Merriam. The result of development upstream of this small city has brought more frequent flooding overtime.

2.2 FEDERAL AND NON-FEDERAL OBJECTIVES

The criteria for national or Federal objectives are specified in the *Principles and Guidance* and covered by ER 1105-2-100, *The Planning Guidance Notebook*. The objectives must meet goals that derive from four accounts for all Federal agencies. Under these accounts, the Federal objective is to maximize the net

annual benefits. These accounts include National Economic Development (NED), Regional Economic Development (RED), Other Social Effects (OSE), and Environmental Quality (EQ). Project planning should contribute to the NED consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the nation. The NED plan is that alternative that maximizes net benefits over the period of analysis. The RED is similar in most respects, except looks at the more local or regional benefits. The EQ account displays non-monetary effects on significant natural and cultural resources. These objectives (NER, RED, OSE) are compatible with local initiatives for addressing urban streambank erosion, BMPs, and recreational opportunities (biking trails).

Collaborative planning is encouraged for traditional project-scale planning and is essential to the success of watershed-scale planning. In addition, such collaboration can improve the regulatory climate by addressing all the regulatory issues together and reaching agreements for siting various activities in advance of an action. The USACE uses its planning capability to facilitate, convene, and advise, as well as to work collaboratively with other Federal and state programs in developing solutions to integrate programs, policies, and projects across public agencies that reflect the full range of the national Federal interest.

The local, or non-Federal, objectives also address the economic and environment considerations. Local policies have evolved over the past several decades. Many professional organizations and NGOs have shared the concern that standards of design, for example, for stormwater facilities, should be more consistent with neighboring communities. Previously developed areas were subject to much less stringent policies. In addition, green solutions are now considered important for local objectives. The local chapter of the APWA has established one set of design criteria for the Kansas City metropolitan area. The MARC has had several initiatives that shape the local objectives, including the *Manual of Best Management Practices for Stormwater Quality*, MetroGreen®, and *i-Tree*. Also, MARC has developed a natural hazard mitigation plan for the metropolitan area. As for the City of Merriam, the city's goal is to gain as much assistance as possible in managing flood risks, such as within a floodplain management plan (FMP). The objective is to focus first on the downtown area, adjacent commercial and industrial business sites, and residents. A second objective is to seek to protect these land owners where they are by minimizing the number of property buyouts.

2.3 PROBLEMS AND OPPORTUNITIES

The evaluation of public concerns reflects a range of needs perceived by the public. This section describes these needs in the context of problems and opportunities that can be addressed through water and related land resource management. The principal opportunity is the identification of a plan for significant improvement in flood risk management and reduction of economic damages.

2.3.1 PUBLIC CONCERNS

Input was received through coordination with the sponsor, coordination with other agencies, public review of draft and interim products, and workshops and public meetings. A number of public concerns have been identified during the course of the study. A discussion of public involvement is included in Chapter 8, *Public Involvement, Review, and Consultation*.

The most serious water resources problems in the Upper Turkey Creek Basin include the existing flood hazard and the associated flood damages. The increased runoff caused by the rapid development of the area accounts for most of the flooding problems. Local interests have sought measures to reduce flood damages for many years. Initial concerns were expressed in the study authorization. Turkey Creek floods

have caused substantial damage throughout the basin in 1961, 1977, 1993, and 1998. The primary interest in Merriam is to reduce flood damages in the commercial downtown area that experiences recurring flooding from overbank flows on the main stem of Turkey Creek. The flood of July 1993 caused one fatality and resulted in damages estimated at $3.4 million in Merriam, and $20 million in the lower basin areas. The flood of October 1998 caused an estimated $12 million of damages in Merriam, and damages in the lower basin equivalent to those of 1993. The flood peak occurred in the late evening, and if the peak had occurred during rush hour, loss of life would have been very likely for travelers on I-35, which was overtopped by flood waters at multiple locations.

Frequent flooding of Turkey Creek has caused severe damage to structures, inventory, infrastructure, and transportation access, along with the associated loss of business and wages. The flood damage also has caused intangible costs, such as human suffering and inconvenience. The long-term consequences of flooding include threat of life, increased frequency of structure and inventory damage, slowed economic growth, possible escalation of vacancies in the area, higher costs associated with repairing flood damage, and interrupted transportation access. The recurring nature of the flooding problem represents a threat to the health and safety of those who live and work in the flood-prone areas.

The Merriam Farmers' Market is a community event pavilion located in the City of Merriam. It houses many special events and programs and also is an access point for Werner Park and Turkey Creek Streamway Trail. The local sponsor has expressed concerns and a desire to avoid impacts to the Farmers' Market area and the existing walking/biking trail from proposed alternatives. The public also has voiced concerns during public engagements throughout the feasibility study of potential impacts to the Turkey Creek Streamway Trail.

Part of the Turkey Creek channel in the study area is operated and maintained by the MDD under a state charter that provides the MDD authorities independent of the City of Merriam or Johnson County. The MDD is led by three publically elected board members. This board has represented some of the public concerns at planning meetings for this project. The MDD has institutional responsibilities and real estate holdings in and near the Turkey Creek channel, where channel erosion repairs were needed, and, therefore, involvement of the MDD is a key element in assessing of future planning for Turkey Creek.

2.3.2 FLOOD HAZARDS

The Upper Turkey Creek watershed is centrally located in a metropolitan region that is committed to coordination and watershed-based planning. The watershed planning effort provides an opportunity to promote interagency cooperation, multipurpose project planning, and the protection of existing investment in the flood risk management infrastructure.

The existing flood hazard and associated flood damages constitute the most serious water resources problem in the Turkey Creek Basin. Flooding within the basin is caused principally by the rapid development of the area, which has resulted in a large increase of storm water runoff. This increased runoff, coupled with inadequate channel capacities and undersized bridge openings, accounts for most of the flooding problems. Flooding causes physical damage to property and loss of commercial, industrial, and public activity, along with the associated loss of business and wages. Rail and vehicular traffic also are adversely affected and cause losses to those who are dependent upon those modes of transportation. The recurring nature of the flooding problem represents a threat to the health and safety of those who live and work in the flood-prone areas.

As recorded on Johnson County's Stormwatch website (City of Overland Park 2012), a significant part of the flood hazard is flash flooding. Rate of rise, according to a USGS gage at Ward Parkway on the adjacent Brush Creek, documents a rise of seven feet in one hour. The tributary area is similar in size and degree of urbanization as Turkey Creek. Although no USGS gages are on Turkey Creek, the Stormwatch

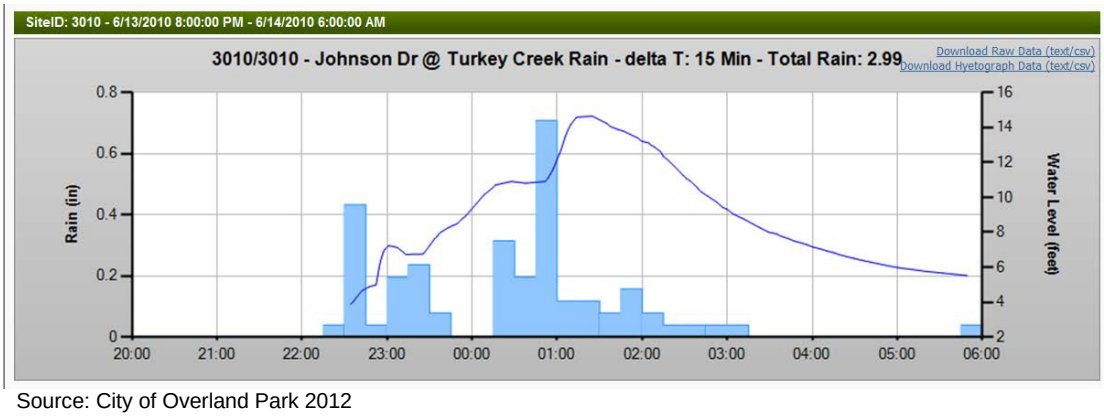
website, which began collecting data following the 1998 flood event, has historical flooding information (Table 2-1).

Table 2-1: Site/Sensor ID 3010/3013 - Johnson Drive at Turkey Creek Water Level
Maximum Water Level Events (on Record)
Sensor was first online on September 14, 1999, at 4:13:48 PM.

Stage (ft)	Date
14.65	6/14/2010
14.6	8/27/2004
14.17	8/9/2007
13.38	8/20/2005
13.18	6/24/2009
12.67	9/13/2008
12.54	6/4/2008
12.3	6/9/2009
12	8/13/2005
11.7	4/5/2010

Source: City of Overland Park 2012

As seen at the Johnson Drive stream gage (Figure 2-1), even a small amount of rain can cause sharp rises in water surface elevations. The Johnson Drive gage is in the heart of the area for which alternatives will be developed as discussed in Chapter 5. Flash flooding, with characteristics shown below, means that little time is available to respond with significant actions. Channel capacity is generally able to convey the 10 percent AEP (10-year event) flow at the top of bank, which means any event added to a 1998 base flood would be hazardous in terms of rate of rise, not to mention extent of inundation. Loss of life is such a high risk, and velocities are high enough for the subject creek, that evacuating and avoiding the area is important.



Source: City of Overland Park 2012

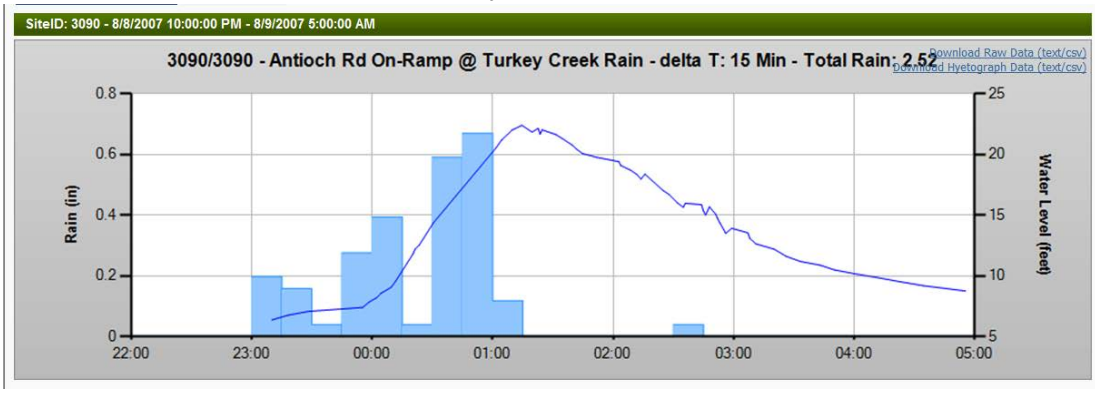
Figure 2-1: Johnson Drive at Turkey Creek Water Surface Elevations

Similar findings are shown just downstream of Johnson Drive at Antioch Road (Table 2-2; Figure 2-2).

Table 2-2: Site/Sensor ID 3090/3093 – Antioch Road On-Ramp at Turkey Creek Water Level
Maximum Water Level Events (on Record)
Sensor was first online on October 6, 2006, at 2:04:31 PM.

Stage (ft)	Date
22.40	08/09/2007
18.13	05/06/2007
18.02	06/04/2008
17.72	06/14/2010
17.67	06/24/2009
17.61	06/03/2008
16.58	06/12/2008
15.66	10/13/2007
15.48	05/06/2012
15.19	07/30/2008

Source: City of Overland Park 2012



Source: City of Overland Park 2012

Figure 2-2: Antioch Road at Turkey Creek Water Surface Elevations

As development occurs in the watershed, the floodwater volumes and flood peaks increase because less water soaks into the ground and more water runoff occurs from the increasing amount of land covered by impervious surfaces, including buildings, roads and parking lots. Increases in impervious land cover have reduced the portion of every rainstorm that historically soaked into the ground and provided recharge water for the shallow groundwater aquifers. Although a majority of the watershed is highly developed, stormwater management ordinances and stormwater management measures implemented in the communities within the Upper Turkey Creek watershed are helping to prevent increases in peak discharges from changes in development that may occur, thereby reducing impacts to flooding on Turkey Creek and its tributaries.

The hydrologic study developed to evaluate flooding on Upper Turkey Creek was analyzed to determine the stage of development in each watershed and to determine whether analysis of future land use was necessary for the hydraulic analysis. This determination was made using Johnson County's Automated Information Mapping System (AIMS) aerial photographs and field observations. Future redevelopment on existing developed areas and in-fill development of small parcels within an otherwise fully developed area was not considered a condition to create a significant change in hydrology.

Figure 2-3: Merriam Existing Inundation

Within the Upper Turkey Creek watershed, communities must work to preserve routing characteristics so that the USACE flow assumption for runoff (not to increase) remains true. Converting streams to concrete and or straightening their alignments can increase flash flooding to areas downstream. Communities need to be aware of and do coordination as part of expectations of the FEMA NFIP coordination requirements. This means that per the FEMA NFIP, communities (and agencies, such as the state DOT), should already be coordinating any drainage system improvements so as not to induce flood damages on downstream stakeholders.

In addition, communities must address how to coordinate drainage changes in the future, and this needs to be a process that is addressed in the FMP. Communities are responsible for preparing the FMP per USACE guidance (Policy Guidance Letter No. 52 and Public Law 104-303 WRDA 1996 amending WRDA 1986).

The majority of the Turkey Creek channel that passes through the City of Merriam can contain a 20 percent AEP (5-year event), although two areas flood at the 50 percent AEP (2-year event). Figure 2-3 shows the existing level of inundation through the City of Merriam. The areas along the main stem of Upper Turkey Creek and its tributaries contain limited open space to provide the potential flood storage required to reduce flooding in Merriam. However, some open spaces in the upper reaches and along the banks of the tributary streams may be available for conversion into detention basins, which could reduce peak discharges.

2.3.3 ECOSYSTEM RESTORATION

Although the Upper Turkey Creek project's authority relates to flood risk management, the environmental degradation due to urbanization can be addressed under a systems approach, using a watershed

perspective to provide cost-effective, multipurpose, and environmental benefits to address environmental degradation within an urban environmental setting.

The Upper Turkey Creek Basin is a historically connected tributary to the Kansas and Missouri Rivers, which are important ecological resources for the region. Development in the watershed has degraded these natural systems. Direct development impacts have included floodplain filling, channel straightening, channel re-alignment, concrete lining of channels, channel enclosures, filling on-stream lakes, streambank armoring and fills, loss of streamside vegetation, and disruptions due to numerous road and utility crossings. Indirect impacts have resulted from development in the watershed, increasing the rate at which water reaches the creek and tributaries.

The Upper Turkey Creek Valley is a degraded environmental resource that is still undergoing development. The combination of the direct and indirect impacts has increased the flood peak flows, flood flow volumes, channel flow velocities, and the rapid rate at which stream flows rise and fall after a storm. The result has been instability in the stream as noted by channel incision and streambank erosion. Preventative measures have included enclosing the channels in culverts or lining the channels with concrete in many places. These concrete and enclosed channel sections become generally impassable biological dead zones for most aquatic species in Turkey Creek.

Because of the urban setting and the extensive amount of highly developed ground in the study area, environmental design opportunities for the flood risk management aspects of the project are somewhat limited. Although limited, a few opportunities do exist. For example, environmental design agreements developed for the Lower Turkey Creek project would also fit nicely into any designs for this project. These design agreements include using bioengineering in lieu of riprap where feasible; minimizing the clearing of riparian timber; replanting trees along the new channel; constructing in-stream habitat, such as riffle/pool complexes and a meandering pilot channel, channel overflow benches, riparian tree planting or wetland creation; and avoiding environmentally sensitive areas to preserve the natural stream channel and riparian area. Additionally, opportunities to coordinate with existing local programs include locally funded flood buy-out areas.

Early in the study process preliminary ecosystem restoration needs were considered as a goal throughout the watershed in anticipation of a potential multipurpose project (see Appendix J). However, the ecosystem restoration concerns were not carried forward as an objective or used to formulate because there was no local sponsor with an interest in cost-sharing ecosystem restoration measures.

2.3.4 WATER QUALITY

Increased urbanization has caused changes in land use, resulting in more residential, commercial, and industrial developments and increased impervious surface area that may have a substantial effect on stream water quality. Contamination may come from point sources and nonpoint sources. These contaminants may remain dissolved in stream water, adsorb to streambed or suspended sediment, or accumulate in aquatic life (USGS 2005).

The EPA and the Kansas Biological Survey (KBS) undertook a Use Attainability Analysis (UAA) of Turkey Creek in Johnson and Wyandotte Counties, Kansas (EPA and KBS 1997). The UAA indicates that Turkey Creek is classified by the State of Kansas water quality standards for “non-contact recreation” or recreation where ingestion of surface water is not probable, and this use includes, but is not limited to, wading, boating, fishing, trapping, mussel harvesting, and hunting. The same report notes that Turkey Creek is classified by the state as “expected aquatic life use waters” or surface waters containing habitat types and indigenous biota commonly found or expected in the state. The study performed biological and water quality sampling on three sites on Turkey Creek and compared those sites to three sites sampled on

Mill Creek and three sites sampled on Cedar Creek—two adjacent Johnson County watersheds of similar size that are tributaries to the Kansas River.

The UAA (EPA and KBS 1997) found that contact recreation was an attainable use for Turkey Creek; however, it was not in attainment for its current designated non-contact recreation use in part to fecal coliforms, hazards, and aesthetics. The report also noted that Turkey Creek is not in attainment for expected aquatic life uses. Although the greatest number of fish in the three watersheds was found at the mid-watershed sampling point on Turkey Creek, phytoplankton concentrations, macro invertebrate and fish richness and diversity were significantly lower in Turkey Creek. The report indicated the lack of attainability appeared due to non-point source pollution associated with urbanization and point source pollution associated with a wastewater treatment plant.

Water quality conditions were evaluated visually in 2005 during the stream health assessment of the Upper Turkey Creek watershed. Water quality factors assessed included sediment deposition, water appearance, nutrient enrichment, and the presence of trash. Approximately 69 percent of the reaches included in the assessment exhibited moderate to slight sediment deposition, 81 percent were considered to have moderate nutrient enrichment, and a majority of the reaches contained trash in their floodplains and riparian areas.

Water quality is an important component of ecosystem structure, and good water quality is generally integral to healthy functioning ecosystems. An important USACE contribution in rehabilitating ecosystems, where water characteristics are a critical structural component of those ecosystems, may involve improvement of water quality characteristics using engineering solutions. USACE restoration and protection projects may involve cost-effective solutions to improve aeration, temperature, turbidity, acidity, sedimentation, and other water quality parameters. Consideration should be given to whether the water quality improvements will accomplish restoration of the system because in many instances, other functional or structural ecosystem components may require attention as well.

For ecosystem restoration and protection opportunities, which include water quality issues clearly defined in the missions of other agencies (e.g., non-point source pollutant regulation or removal), it is appropriate to use existing agreements or create new arrangements for collaborative use of respective agency authorities and resources in order to implement a more complete and sustainable approach to the restoration. There may also be instances in which it is appropriate for the USACE to play a supporting role or provide assistance through reimbursable arrangements, rather than to lead the initiative.

The EPA expressed interest in developing a Special Area Management Plan (SAMP) for the Upper Turkey Creek Basin. The EPA contracted the Watershed Institute, Inc. to conduct the initial background research for phase one of the SAMP process and to prepare a summary report. Implementation for the remaining three phases currently has not taken place for the Upper Turkey Creek watershed.

The goal of the SAMP is to attain a balance between aquatic resource conservation, infrastructure maintenance, and sound economic development to minimize the individual and cumulative impacts of future projects. The most important benefit of a SAMP is the streamlining of the process to permit redevelopment in this already developed watershed, mainly by identifying the critical water resources and where mitigation is needed in advance, prior to the occurrence of redevelopment, thereby improving water quality to support native aquatic communities and enhance and maintain high quality aquatic and terrestrial habitat in the Upper Turkey Creek watershed. Stakeholder participation (i.e., local government, businesses, citizens, state and Federal agencies, nonprofit organizations) is essential to successful development and implementation of a SAMP. At the end of the SAMP process, areas should be identified for protection, preservation, and enhancement, as well as areas where future activities would be allowed to occur, if they meet the criteria developed for protection of the watershed.

The watershed assessments performed were used to describe the existing, and potential future, habitat conditions in select locations of the watershed and to analyze environmental effects. However, the water quality concerns were not carried forward as an objective or used to formulate. A plan which includes a primary objective of flood risk management would also benefit water quality by limiting the amount of trash and debris that enters the stream from surrounding industrial/commercial properties during storm events.

2.4 PLANNING GOALS AND OBJECTIVES

The water and related land resource problems and opportunities identified in this study are stated as specific planning objectives to provide focus for the formulation of alternatives. These planning objectives reflect the problems and opportunities and represent desired positive changes in the process without project conditions.

The principal goal of the feasibility study is to identify a flood risk management alternative that significantly reduces flood risk and flood damages. A systems approach has been used wherein flood risk management and other opportunities for ecosystem restoration consideration and compatible recreation have been considered. Specific ecosystem restoration measures were formulated in the watershed but not carried forward into screening or inclusion in plan formulation because no cost sharing partners were identified. There is the opportunity to accommodate compatible recreation (trail system) in the immediate study area.

2.4.1 REDUCE FLOOD RISKS

The primary goal is to develop alternative plans that will examine the full range of structural and nonstructural measures that address the flood risk management authorization and significantly reduce flood risk. The USACE seeks to identify the plan that provides maximum reduction of net economic flood damages, which is in the national interest, known as the NED plan. The vision consists of the following objectives:

1. Significantly reduce flood risk and damages for events with an AEP in the range of 1 percent in the highly urbanized Upper Turkey Creek watershed caused by recurring and severe flash flooding.
2. In partnership with other floodplain management agencies, provide the sponsor and stakeholders in the study area with a clear understanding of flood and residual flood risk. This will be accomplished through public meetings, inclusion of risk information in the report, public presentation and implementation of the FMP, and ongoing assistance to the sponsor in flood preparedness via the O&M Manual, PL 84-99 Program, and other programs as funding provides. This objective will be accomplished throughout project life including during design, construction and post construction project support.

2.4.2 USE A SYSTEMS APPROACH FOR THE WATERSHED

The use of a systems approach was referenced in both of the previous goals. By using a systems approach, community planners find better solutions that:

- Consider the long-term
- Are more sustainable for the community
- Are the most effective way to spend money

Although three damage reaches, as identified in the USACE reconnaissance report, are separated by some distance, they interact as part of a system, and tracking how various alternatives react to each other is of critical importance to mitigate flood hazards. To address this, the USACE planners have included the

work by Johnson County Public Works regarding FEMA Flood Insurance Rate Map (FIRM) updates, which has included new HEC-RAS models. As the timeline for the project stretched out, their work included more recent updates to the HEC-RAS models. The planners have integrated these updates into analysis tools to aid in the systems approach.

2.5 PLANNING CONSTRAINTS

Unlike planning objectives that represent desired positive changes, planning constraints represent restrictions that should not be violated. Further, plan formulation must provide safe conditions in the interest of public safety and be socially acceptable to the community. The planning constraints identified in this study area are in compliance with local land use plans and the resolution from the Committee on Transportation and Infrastructure, U.S. House of Representatives, Docket 2616, adopted February 16, 2000.

The Upper Turkey Creek Basin of Johnson and Wyandotte Counties, Kansas, is heavily urbanized, comprising residential, commercial, and industrial land uses. The Turkey Creek channel and floodplain have become a common location for public infrastructure including utilities, transportation, drainage diversions, homes, businesses, and public areas. For most of its length in Johnson and Wyandotte Counties, Turkey Creek is constrained between I-35 on one side and naturally high, non-floodplain banks on the opposite side. What may have been a 1,000-foot-wide floodplain a hundred years ago, is from 50 to 400 feet wide today. Further development along the higher bank areas has caused the floodplain, channel banks, and, in some areas, the waterways to be filled in or relocated for development, leaving limited space for conveyance of floodwaters. Therefore, one planning constraint is a lack of space in which to formulate alternatives along the creek.

Another constraint is that deepening a channel is not cost effective due to the geology along the main channel. Geotechnical borings in the area document this constraint (Appendix B). The channel bottom of the creek and tributaries is primarily limestone underlain by black/gray shale. Based on the differences in channel bottom elevations compared to older stormwater and utilities and the development of several waterfalls, it appears the channel bottom in many areas has been lowered or is incising, such as the tributaries. Long stretches of Turkey Creek through the City of Merriam have been lined with limestone blocks to stabilize the stream banks, and many of the tributaries have sections that have been channelized. There have been no natural, undisturbed stretches of Turkey Creek identified to date.

Despite ongoing efforts to reduce flooding the increasing development has resulted in increased flood frequency, peak flood flows, flood flow volumes, and channel velocities. Additionally, these modifications have shortened the lag time from peak precipitation to peak flow.

A systems approach is mindful of potential impacts to the USACE flood risk management project being constructed downstream. Any develop built in Merriam should not adversely affect reaches in Lower Turkey Creek by changes to flow or timing. Already implemented improvements are those to the very large bypass tunnel and the new, widened channel adjacent to the cooperative work with KDOT for I-35. Construction of the levee, railroad bridge improvements, and walled channel is currently happening adjacent to the channel.

In addition to the planning constraints discussed above the following were also considered:

- **Hazardous, Toxic, and Radioactive Waste**—Alternatives cannot cause disturbance of hazardous, toxic, and radioactive waste (HTRW) to minimize and prevent Federal liability under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).
- **Flood Heights**—Alternatives cannot negatively impact the 100-year flood profile (within the floodway, per NFIP).

- **Environmental and Cultural Resources**—Alternatives should be designed to minimize adverse impacts to environmental and cultural resources.
- **FEMA Voluntary Acquisition Program**—Alternatives will not be developed that interfere with restrictive use guidelines established for properties purchased with Hazard Mitigation Grant Program funding.
- **Avoidance of Induced Flooding**—Inducing adverse flood impacts associated with the implementation of any flood risk management project should be avoided.

Part of the Turkey Creek channel in the study area is operated and maintained by the MDD under a state charter that provides the MDD authorities independent of the City of Merriam or Johnson County. The MDD has institutional responsibilities and real estate holdings in and near the Turkey Creek channel; therefore, the future of the MDD is a key element in assessing of any plan for Turkey Creek.

2.6 OTHER PLANNING CONSIDERATIONS

Other purposes will not be the focus of the planning activity, but they may be recognized in the interest of accommodating the flood risk management and ecosystem restoration plan to the plans of others.

2.6.1 RECREATION

The recommended plan may include recreational features directly associated with either flood risk management or ecosystem restoration measures within the cost ceilings established for those purposes. Independent or single-purpose recreational development will not be recommended; however, recreation can be included as part of a multipurpose approach. The total project cost for the recommended alternative attributed to the cost of recreation features, such as trails, is allowed to increase the federal cost up to 10 percent under the USACE policy. In addition, for nonstructural flood risk management (FRM) features, such as buying out a part of the floodplain, the recreation features may cost up to one-half of the total project cost of the nonstructural FRM feature plus recreation.

Recreational opportunities considered in the floodplain of Upper Turkey Creek could include the following:

- **Trail Development**—Multi-use trails (biking, walking, and running) with lanes or other use controls, access to parking and distance information (trails could be interconnected to create a larger system)
- **Access Points for Fishing and Wildlife**—Parking areas and access to pools and other areas where fish may be prevalent, garbage disposal areas, and kiosks of local fish species
- **Nature Viewing Areas**—Viewing platforms and native plantings
- **Park/Greenway Amenities**—Composting restroom facilities, parking areas, lighting, and garbage disposal areas (to reduce trash)
- **Educational Outreach**—Kiosks along trails and at trail heads describing the local biota and the stream processes

2.6.2 GREEN SOLUTIONS

The Kansas City, Missouri, Johnson County, Kansas, the MARC, and the Kansas City Chapter of the APWA have been pushing initiatives forward that are very relevant with this watershed and the project.

Kansas City recently pushed an initiative aimed at treating rain where it falls in the *10,000 Rain Gardens* initiative. The rain gardens are a feature that when aggregated and combined through a large area, can significantly help rain water infiltration into the very clayey soils in this region.

MARC is planning for a greener transit system, and under MetroGreen®, is establishing trails along stream corridors with significant support from local entities, and MARC's work along the Turkey Creek corridor is the TCC. MetroGreen® has been a gradual effort to implement an interconnected system of public and private natural areas, greenways and trails linking together communities throughout the Kansas City metropolitan area. Benefits of MetroGreen® include cost effective improvements of air and water quality; stabilization of streams; reduction of flood risks; protection of wildlife habitat; opportunities for biking, hiking and walking; and ultimately, the formation of a framework around which more sustainable urban development patterns can occur, possibly included as parts of flood risk management project sites. A recent TCC product is a joint resolution, drafted July 21, 2009, that has since been adopted by several cities, including Overland Park, Roeland Park, and the Unified Government of Wyandotte County and Kansas City. The sponsor, Merriam, is also in support. In addition, MARC has expanded from transportation planning into watershed planning. This meaningful work has lead to MARC starting up the TCC, which could be the core of a watershed-level partnership interested in a watershed management plan that includes floodplain management work.

As previously noted, MARC also has an initiative known as i-Tree. Because suburban forests are a significant part of the watershed, the amount of rainfall caught by trees can be another planning consideration. Studies have referenced as much as 50 gallons of water can be held on a mature oak tree. Any policies that continue to support the suburban tree population may be important for the health of the watershed.

Finally, and most relevant, MARC has developed a *Manual of Best Management Practices for Stormwater Quality* (MARC and APWA 2009). Those participating in the manual's development recognize the need to fine tune how BMPs should be standardized in the metropolitan area. The manual has condensed nation-wide BMPs for consideration under local conditions and addresses a variety of features, such as filter strips or native planting. The APWA is also collaborating with the effort.

2.6.3 SPECIAL AREA MANAGEMENT PLAN

The EPA, Region VII, started a process for an SAMP, and the Upper Turkey Creek planning team has considered this information as appropriate in the planning efforts. A SAMP was not implemented at that time. EPA hired a consultant to complete a Phase I of this SAMP from July 31, 2005, through April 30, 2006. With the assistance of the Turkey Creek SAMP Coordinator, The Watershed Institute, Inc. (TWI) and TWI staff:

1. Identified potential stakeholders, including local, state, and Federal government agencies within the Upper Turkey Creek watershed
2. Gathered information and copies of studies, reports, plans, and other available information concerning natural resources, hydrology, water quality monitoring, Geographic Information Systems (GIS) layers, soils, capital improvement and infrastructure programs, economic development programs and projects, parks and trails, and neighborhood plans related to the Upper Turkey Creek watershed.
3. Reviewed all information that has been collected for the watershed
4. Identified data gaps and potential information sources that are needed to complete a SAMP or an Advance Identification (ADID) for the watershed (see http://www.epa.gov/owow/wetlands/facts/fact28.html)
5. Prepared a preliminary summary report for the watershed, identifying the following:
    a. Past and present projects and planning efforts, including who, what, when and where
    b. Existing information sources

c. Relevant studies
d. Current conditions, problems, technical challenges, and restoration opportunities

2.6.4 FLOODPLAIN MANAGEMENT PLAN

With the significant planning work from the feasibility study, the USACE and the sponsor have agreed to prepare an FMP during design phase. Preparation of an FMP is required by Public Law 104-303 of the WRDA of 1996, which amends Section 402 of the WRDA of 1986 (also see 33 U.S.C. 701b-12; 100 Stat. 4133).

The planning team recognizes that few FMPs have been done per Policy Guidance Letter (PGL) 52, in alignment with Public Law 104-303. The planning team has noted that communities frequently do not have the resources to do a comprehensive systems approach to floodplain planning when the subject area crosses multiple urban jurisdictions. Because this effort has been a major focus of this study, the USACE planners have encouraged the sponsor, major stakeholders, and adjacent communities to use relevant portions of the feasibility study as the core of a strong FMP. A significant number of major stakeholders share the flood risks in Upper Turkey Creek: the UG; the MDD; KDOT; the BNSF railroad; and the USACE because of its construction and completed infrastructure downstream.

The development of this plan will help communities in Upper Turkey Creek address several things. First, flood hazards and the beneficial functions of floodplains can be integrated under a living document shared by these communities. Many of the planning considerations in Section 2.6 can be included in the final product. Second, the FMP will establish a communication plan for these communities to work together with a systems approach in the watershed. Finally, and most importantly, the FMP will set up a series of action items for managing flood risks. In addition to implementing features formulated in this report, activities and policies will need to be established, and timeframes for completion of all the action items will also be included. One of the first will be to establish how USACE-constructed features will be maintained in the long term.

3 CHAPTER 3 – SYSTEM BASELINE CONDITION AND INVENTORY

Turkey Creek is a right bank tributary of the lower Kansas River located in Johnson and Wyandotte Counties, Kansas (Figure 3-1). The Turkey Creek watershed is approximately 23 square miles in size. Turkey Creek is approximately 15 miles in long and runs parallel to I-35 nearly its entire length. The watershed contains the some of the most intensely developed urban locations in Johnson and Wyandotte Counties, Kansas. Approximately 75 percent of Turkey Creek consists of residential, commercial, and industrial land use (Lee et al. 2005). Additionally, nearly 30 percent of the watershed consists of constructed impervious surfaces. Construction of the I-35 embankment reduced the width of the Turkey Creek floodplain from approximately 1,000 feet to approximately 50 to 400 feet. Further development has highly altered much of the floodplain and creek channel.

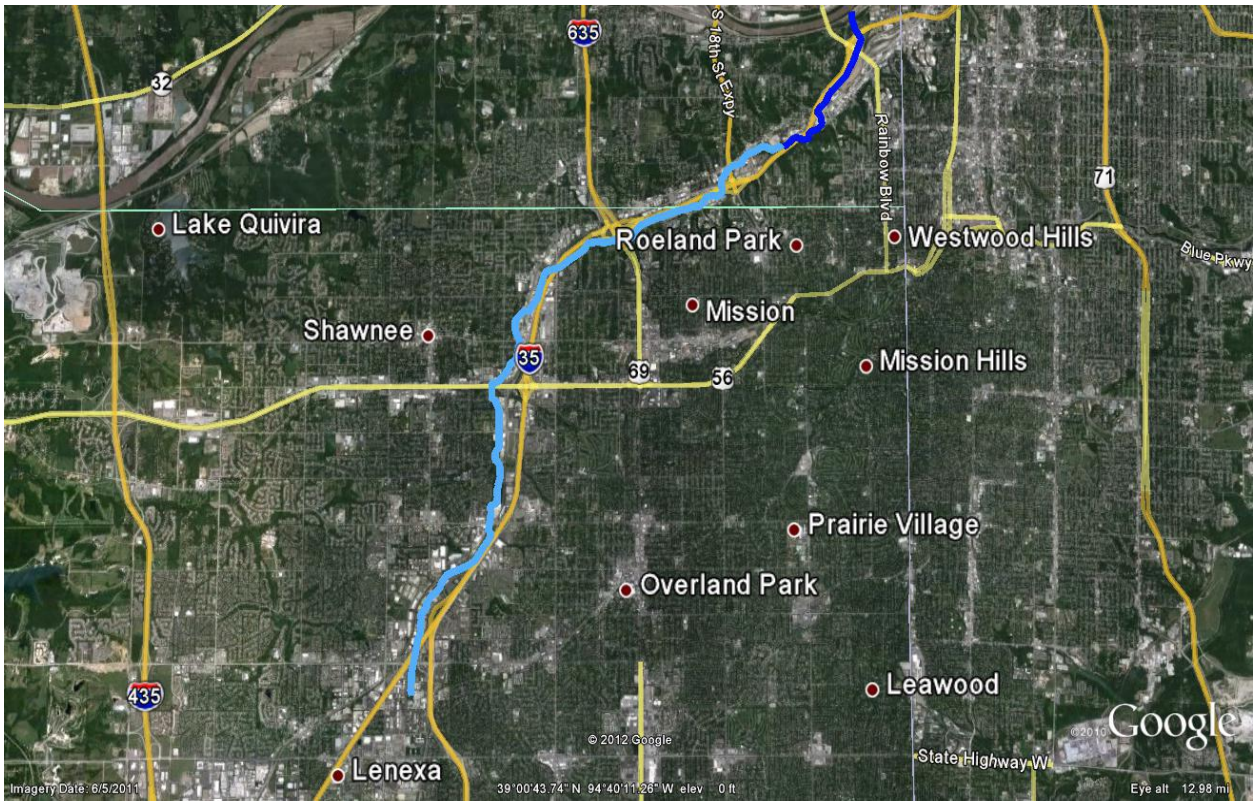


Figure 3-1: Turkey Creek Upper and Lower Reaches
(Source Google ™ Earth ®, © 2012 Google)

Most of Turkey Creek and its tributaries have been channelized, having numerous reaches where the banks have been lined with rock or both the channel and banks have been lined with concrete. At least four lakes exist on the tributaries, and the upper reach of Turkey Creek in Lenexa has several small (one- to two-foot-high) dams. Several waterfalls, approximately five feet or less in height, exist on the creek and tributaries. In at least one of those locations, upstream of 47th Street, the waterfall is at an area where the channel has been relocated. Some of the smaller (three-foot or less) waterfalls found between Lamar and Metcalf Avenues and 63rd and 67th Streets, for example, are due to concrete-covered utility crossings that are exposed. In evaluating the difference in channel bottom elevations of the current creek and tributaries and comparing to that of older adjacent stormwater and utilities, it appears the channel bottom in many areas has been lowered or is incising. In the stretch of stream between Lamar and Metcalf, the limestone along the stream banks appears to be failing, exposing the softer underlying shale material.

Within the City of Merriam in Johnson County, the MDD has modified the Turkey Creek channel from 63rd Street downstream to 51st Street in stages beginning in about 1967. The work was considered complete in 1972, but the MDD has since accomplished an extensive streambank protection effort relying primarily on large cut limestone blocks to armor the channel slope. The last segments of armoring were placed in the early 1980s, but large floods occasionally displace the stone blocks, requiring continual maintenance of the project. The MDD's efforts have produced a channel of nearly uniform width deepened to bedrock through the project area.

3.1 EXISTING CONDITIONS

3.1.1 WATERSHED ASSESSMENT

Physical, habitat, and biological data collection and evaluation was conducted in representative reaches throughout Upper Turkey Creek in May and June 2005 with follow-up in September 2005. Fish surveys and the macroinvertebrate composition of Upper Turkey Creek also were determined through biological surveys conducted along the length of Upper Turkey Creek and its tributaries during the same period. These data were then used to develop an overall stream quality assessment ranking for approximately 100 locations on the Upper Turkey Creek and its tributaries, using a ranking methodology that weights the physical, habitat, and biological assessment scores of a given stream reach and generate a single number to represent the overall conditions at that reach. A report documenting the methods and results of the assessment is provided in Appendix J.

Limited modeling was conducted using HEC-RAS (hydraulic) and HEC-1 (hydrologic) Corps models and using the modeling from the Johnson County watershed study. The Johnson County watershed study included HEC-1 files for that portion of the watershed in Johnson County. The Johnson County HEC-1 model was used as the existing conditions hydrologic model for the Upper Turkey Creek Feasibility Study. Johnson County also provided HEC-RAS files, and after review, they were matched to the USACE-supplied HEC-RAS files. The matched HEC-RAS files were used only to evaluate the two locations along the main stem that appeared most promising for storage to achieve flood reduction, providing results by end of 2005. The HEC-RAS model supplied by the USACE was used for the storage evaluation discussed above and to determine bank shear stress and resultant allowable bio-stabilization techniques at locations where bank stabilization was identified as a problem. The USACE version of the HEC–RAS model contained data for the main stem of the creek and two of the tributaries. The HEC-RAS model from Johnson County, which had most of the other tributaries, was used to calculate shear stress in tributaries not contained in the USACE's HEC-RAS model.

Of the approximately 100 reaches evaluated for stream quality, 33 were located adjacent to locations that were in need of bank stabilization as determined from the HEC-RAS modeling. In 2009, data from the 33 stream quality assessments were later converted into scores that could be input into the Kansas Department of Wildlife and Parks (KDWP) Subjective Evaluation of Aquatic Habitat and Subjective Evaluation of Terrestrial Habitat assessment methods (KDWP 2004). The KDWP's habitat assessment methods are subjective evaluation procedures that can rapidly evaluate aquatic and terrestrial resources through a series of variables designed to provide a holistic evaluation of the physical, chemical, and biological resources. The conversion of data from the initial stream quality assessment to the KDWP subjective assessments was done so that the results could be presented as an output from a single assessment method, rather than a combination of assessment methods. Results from the KDWP subjective evaluations are located in Appendix J, *Stream Assessment*. After further consideration and additional field evaluation, the 33 reaches in need of bank stabilization were reduced to 11 reaches that would be the most feasible locations for ecosystem restoration projects. Results from the KDWP subjective evaluations were used as one method to describe the existing, and potential future, habitat conditions in select locations of the watershed. However, they were not used to formulate alternatives for Federal involvement because there was no local interest in cost sharing.

3.1.2 ENVIRONMENTAL DESCRIPTION

Engineering Circular (EC) No. 1105-2-412 requires that all planning models that the USACE uses must be certified or approved prior to use to ensure that they are technically and theoretically sound and can be used as a functional tool during the planning process. EC 1105-2-412 defines a planning model as "any models and analytical tools that planners use to define water resources management problems and opportunities, to formulate potential alternative to address the problems and take advantage of the opportunities, to evaluate potential effects of alternative and to support decision-making." The use of certified models for all planning activities is mandatory. The USACE National Ecosystem Planning Center of Expertise (ECO-PCX) is responsible for implementation of the certification process for ecological models.

The USFWS Habitat Evaluation Procedure (HEP) was used to evaluate the need for compensatory mitigation for Section 404 authorization and to better compare project alternatives. The HEP method was developed by the USFWS in the 1970s (USFWS 1980). It is a method that can be used to document the quality and quantity of available habitat for selected wildlife species. The HEP provides information for two general types of wildlife habitat comparisons: one, the relative value of different areas at the same point in time, and two, the relative value of the same area at future points in time. By combining these two types of comparisons, the impact of proposed land and water use changes on wildlife habitat can be quantified. The HEP describes habitat for selected wildlife species as a Habitat Suitability Index (HSI) with a value ranging from 0.0 to 1.0. This value is multiplied by the area of available habitat to obtain Habitat Units (HUs). To calculate habitat value over a period of time, such as 50-year period of analysis, HUs are averaged on a yearly basis to provide Average Annual Habitat Units (AAHU). Specific HSI models used for this method were the green sunfish (*Lepomis cyanellus*) and the fox squirrel (*Sciurus niger*). These models were selected because these species are expected to be found in urban environments in the Midwestern United States.[1] The fox squirrel model best represented existing forested habitat that had scattered hard mast canopy trees with little underbrush. Other existing HSI models were not sensitive enough for the existing habitat type to adequately reflect changes in this type habitat, therefore the fox squirrel model was chosen. The HEP method and USFWS HSI models have been approved for use for USACE planning projects in accordance with EC 1105-2-412.

3.2 RESOURCES OF CONCERN

Primary resources of concern identified for evaluation in this study include geology, soils, and geomorphology; climate; hydrology; water quality; aquatic habitat; wetlands and waters of the United States; terrestrial habitat; fish and wildlife; threatened and endangered species; HTRW; floodplain; land use; socioeconomics; environmental justice; transportation; recreation; and cultural resources.

3.2.1 GEOLOGY, SOILS, AND GEOMORPHOLOGY

The study area is part of the Osage Plains physiographic section of western Missouri and eastern Kansas. The topography was developed on Pennsylvanian shale interspersed with beds of limestone and sandstone. The surface geology of the project area consists of Holocene alluvium, and Virgilian Lane Shale and Wyandotte Limestone of the Kansas City Group. Because of human-made features, the floodplain is 50 to 400 feet wide in most locations. Bank heights along Turkey Creek vary from 10 to 20 feet and the stream width averages 25 feet within the project area. The project is located in an area of air quality attainment in accordance with the National Ambient Air Quality Standards (40 CFR part 50).

[1] These models are available online at http://el.erdc.usace.army.mil/emrrp/emris/ EMRIS_PDF/GreenSunfish.pdf and http://el.erdc. usace.army.mil/emrrp/emris/EMRIS_PDF/FoxSquirrel.pdf.

3.2.2 CLIMATE

The climate for the area consists of hot humid summers and cold winters. The mean annual temperature of Kansas City, Missouri, is 53.6 degrees Fahrenheit (°F). July is the warmest month with an average temperature of 78.5°F, and January is the coldest with an average temperature of 25.7°F. Kansas City averages 37.6 inches of precipitation a year, with May through September being the wettest months. Over the past 100 years, precipitation has increased by 10 to 20 percent in the eastern parts of Kansas (EPA 1998). Average temperatures in Manhattan, Kansas, located about 100 miles to the west of the project area, have increased by 1.3°F over the past century (EPA 1998).

3.2.3 HYDRAULICS AND HYDROLOGY

The hydrology of Turkey Creek upstream of the Johnson and Wyandotte County line is dominated by groundwater sources during baseflow conditions and surface water runoff during precipitation events. The amount of impervious cover associated with urban development, approximately 30 percent, has increased the rate of stormwater runoff reaching the creek, thereby causing an increase in the peak discharge volumes of Turkey Creek following storm events. The amount of impervious cover within the Turkey Creek watershed has likely reduced groundwater recharge, thus reducing the baseflow in portions of Turkey Creek. Baseflow conditions of Turkey Creek at 67th Street, just upstream of the downtown Merriam project area, were recorded at approximately 1 cubic foot per second (cfs) as part of a field study conducted by the USGS in November 2000, and July 2003 (Lee et al. 2005). Baseflow conditions downstream of the Johnson and Wyandotte County line are dominated by discharges from the Myron Nelson Wastewater Treatment Plant Complex and typically average around 25 cfs. No USGS gage stations exist on Turkey Creek.

An inventory of the various factors in the existing conditions can be established through a number of ways, including maps, GIS, and using hydrologic and hydraulic modeling software (see Section 4.7 for details).

This study's existing conditions associated with land use, imperviousness, rainfall runoff, and storm drainage systems are captured in a hydrologic model (HEC-1) and a hydraulic model (HEC-RAS). Existing conditions hydrologic modeling began in May 31, 2005, when the Larkin Group Inc. (Larkin) began a study titled *The Northeast Johnson County Watershed Study for Johnson County, Kansas* to assist the county in FEMA FIRM revisions for three or four of the smaller and well-developed watersheds of the county (Larkin 2005).[2] The study was produced by Larkin for the Storm Management Program of Johnson County, Kansas, Public Works. As part of the study, Larkin developed a hydrologic model using the HEC-1 software. Many of the existing enclosed storm drainage systems needed specific assumptions and analytical processes, specifically for setting up an open channel flow tool, to best characterize the watersheds in northeastern Johnson County, which is the portion closest to the center of the Kansas City metropolitan area.

The HEC-1 model produced by Larkin included the complete watershed contributing to Upper Turkey Creek. During the early stage of the feasibility study, planners and hydraulic engineers in the Kansas City District decided to use Larkin's HEC-1 model as the official existing conditions hydrologic model for the Johnson County study.

Statistical rainfall distribution and quantity of precipitation correlates estimated rainfall amounts to statistical rates of return (Table 3-1). Typical return rates are the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2 percent AEP. The following table correlates the statistical rate of return to the 24-hour rainfall amount and the probability of occurrence. The rainfall amounts were acquired from the U.S. Department of Agriculture Technical Release 55 (TR-55, U.S. Department of Agriculture 1986).

[2] Especially relevant portions of Larkin (2005) are Sections 6 and 7.

Table 3-1: Statistical Rate of Return Correlated to a 24-Hour Rainfall

Annual Exceedance Probability (percentage)	24-hour Rainfall Amount (inches)	Statistical Rate of Return
50	3.6	2-year event
20	4.5	5-year event
10	5.4	10-year event
4	6.2	25-year event
2	7.0	50-year event
1	7.9	100-year event
0.5	8.4	200-year event
0.2	9.3	500-year event

Gages help to establish existing conditions by tying possible flows to statistical records. One USGS stream gage lies within the northeastern watershed. However, this gage, identified as Gage 06893557, is on Brush Creek located near Ward Parkway in Kansas City, Missouri. The gage monitors Brush Creek downstream of the northeastern watershed study area. The USGS has reported data for this gage since 1999, and the average annual mean stream flow for this gage is 10.31 cfs. Based on conversations with Don Wilkinson, of the USGS, in 2002, the 100-year flow at this location has been estimated at approximately 16,000 cfs based on variety of source data, but not enough data has been collected from the gage to verify this estimate. Although this gage is not directly related to Turkey Creek, it was an important calibration tool for Larkin during the preparation of the Johnson County HEC-1 model. The Johnson County Public Works maintains a stream gage network, which is part of the StormWatch system (City of Overland Park 2012) and available on the internet, consisting of five gage stations within the area included in the northeast Johnson County watershed study area. Two of these stream gage stations are within the Turkey Creek watershed (Table 3-2). These gage stations are not set up for stream flow measurement; they collect precipitation and water level data.

Table 3-2: Turkey Creek Watershed Gages in the Storm Watch Gage Network

Gage	Location	Oldest Available Record
3010	Johnson Drive	September 14, 1999
3020	65th Street	March 23, 2000

The large majority of the northeast Johnson County watershed study area is fully developed and urbanized, including the Turkey Creek watershed. A quantitative analysis of existing land use was not required for the study because the required hydrologic data were acquired from a detailed study of impervious surfaces. However, the study area can be roughly characterized as follows:

- About 36.0 square miles of the northeast Johnson County study area is urbanized and fully developed. About 0.5 square mile of undeveloped land, planned for future development is present in the Lake Quivira watershed in western Shawnee, Kansas. This undeveloped land is either pasture or woodlands. Open areas also are present in the community of Lake Quivira, but the planned use is for those areas to remain as wooded open space.
- About 60 to 70 percent of the urban area is residential usage (subdivisions of single-family homes, multi-family dwellings, and apartment complexes).

- About 20 to 25 percent of the land is used for commercial, business, or institutional uses, including retail shopping, restaurants, entertainment, offices, hospitals, schools, churches, and synagogues.
- Less than 5percent of the urban land is used for light industries.
- The remainder of the urban land is open space (such as floodplain areas), parks, golf courses, or transportation corridors.
- The average percent imperviousness for the entire study area is approximately 38 percent.

The basin experienced significant development in the 1980s and 1990s, and basically used up any remaining developable land. This contributed to increased Turkey Creek stormwater flows; however, no flows are expected to increase in the future due to additional impermeable surfaces. The existing stream-hydraulic conditions of Turkey Creek were modeled using the HEC-RAS. The base of the Upper Turkey Creek feasibility study existing condition model was the northeast Johnson County watershed study hydraulic HEC-RAS model. This model was modified in 2003 by USACE engineers to incorporate the proposed new BNSF railroad bridge just downstream of Merriam.

As part of this study, USACE monitored progress on Johnson County Public Work's efforts to update FEMA FIRMs and used HEC-RAS models prepared by the Corps and Johnson County. The Johnson County model was originally based on earlier USACE modeling efforts, and the latest, updated model was combined with the USACE Wyandotte County HEC-RAS segments to model the Merriam portion of Turkey Creek because it had recently undergone review by FEMA. Once approved, the model set the limits for 100-year FEMA FIRMs. The model for the northeast Johnson County watershed study was used for flood reduction improvements within the downtown Merriam area. This area sustained the most damage during the 1998 flood and was the focal point of the study. The channel modifications within this area were predominantly bounded by the Shawnee Mission Parkway and Merriam Drive bridges. The USACE model was used to study flood reduction measures within the Roe Lane Industrial Park. The USACE, Kansas City District’s senior hydraulic engineer set up very specific split-flow modeling assumptions and parameters in the Wyandotte County portion of the HEC-RAS model. This segment was not needed to complete the evaluation of the final array of alternatives. This area, which is located at the downstream end of the Upper Turkey Creek reach in Wyandotte County between Route 69 and Roe Lane, not only floods from channel overtopping but also has back flooding problems through a rail opening in the Route 69 bridge. Both models were combined into a single existing conditions model to establish a baseline to evaluate the proposed alternatives during the feasibility phase.

ESTIMATED FLOOD DEPTHS AND VELOCITY: To provide an indication of the nature of the flooding problem, flood depths and velocities for the 1 percent ACE event were estimated for the Merriam Reach of Turkey Creek as follows:

Shawnee Mission Parkway Bridge: 0.22 feet at 6.3 feet/second

Merriam Marketplace: 3.67 feet at 8.1 feet/second

West 61st Street: 3.0 feet at 11.8 feet/second

Merriam Drive Bridge: 1.73 feet at 9.1 feet/second

3.2.4 WATER QUALITY

As with many urban creeks in the Kansas City metropolitan area, water quality within Turkey Creek is impacted by nonpoint sources of pollution. Non-point sources of pollution include urban runoff, such as lawn and garden chemicals, petroleum products, and industrial pollutants. Turkey Creek is listed as an impaired water body under Section 303 (d) of the CWA for total ammonia from unknown sources. Water from a wastewater treatment plant downstream of the project location near the Johnson and Wyandotte County line provides a base flow to the downstream portions of Turkey Creek throughout the year. The wastewater

treatment plant maintains a National Pollutant Discharge Elimination System (NPDES) permit, and currently, there are no violations of this permit.

As noted in Section 1.1.4, the EPA and KBS conducted a UAA of Turkey Creek in Johnson and Wyandotte Counties (Welker and Huggins 1997). EPA and KBS (1997) indicates that Turkey Creek is classified by the State of Kansas water quality standards for "non-contact recreation" or recreation where ingestion of surface water is not probable and this use includes but is not limited to wading, boating, fishing, trapping, mussel harvesting, and hunting. The report notes that Turkey Creek is classified by the state as "expected aquatic life use waters" or surface waters containing habitat types and indigenous biota commonly found or expected in the state. The UAA report also found that Turkey Creek was not in attainment for its current designated non-contact recreation use due in part to fecal coliform, hazards, and aesthetics and that Turkey Creek was not in attainment with regard to expected aquatic life uses. The report indicated the lack of attainability appeared to be due to nonpoint source pollution associated with urbanization and point source pollution associated with wastewater treatment plant discharge. This study also found that concentrations of dieldrin, heptachlor expoxide, diethyl phthalate, Arochlor® (a polychlorinated biphenyl), and mercury exceeded the State of Kansas and/or EPA water quality criteria.

3.2.5 AQUATIC HABITAT

Past channel modifications and urban development have greatly impacted the aquatic habitat within Turkey Creek. In 2005, a stream quality assessment was conducted for the Upper Turkey Creek watershed at approximately 100 reaches of Turkey Creek and its tributaries. The assessment was based on a combination of the Rapid Bioassesment Protocols for Use in Streams and Wadeable Rivers (Barbour et al. 1999), and the USDA, Natural Resources Conservation Service (NRCS), Stream Visual Assessment Protocol (USDA 1998). Seventeen different variables were used to characterize physical stream conditions, habitat characteristics, and the biologic community. Each variable was scored on a scale of 1 to 10. Poor conditions for a given variable would result in a low score, while good conditions would result in a higher score. Those reaches with an overall score of 0 to 6.0 indicated poor conditions, scores of 6.1 to 7.4 indicated fair conditions, scores of 7.5 to 8.9 indicated good conditions, and scores of 9.0 to 10 indicated excellent conditions. As shown in Table 3-3, stream quality conditions were generally evenly distributed between good, fair, and poor categories. Only five assessed stream reaches were characterized as excellent for an urban stream; four of these reaches were located in the northern portions of the Turkey Creek watershed. Reaches with poor conditions were located throughout the watershed, with poor bank stability, riparian impairment, and obstructions to fish passage as variables that often related in low overall scores.

Table 3-3: Overall Stream Health Assessment Scores for Upper Turkey Creek.

Assessment Score	Percent of Reaches
Excellent	5
Good	32
Fair	34
Poor	29
Total	100

Three reaches were evaluated within the project area between Shawnee Mission Parkway and Merriam Drive. These reaches, which were all categorized as poor because of stream assessment scores ranging between 3.91

and 4.75, were among the lowest scores within the entire Upper Turkey Creek watershed. At times, the Turkey Creek channel within the project area becomes dominated with filamentous algae. Emergent aquatic vegetation is virtually non-existent. Additionally, as an indicator of the condition of the aquatic habitat for compliance with Section 404 of the CWA and to better compare alternatives, the HEP method was utilized to calculate a HSI score and determine the existing number of HUs for green sunfish (*Lepomis cyanellus*) within the downtown Merriam reach of the project area. Within this reach, there are approximately 7 acres of aquatic habitat. The HSI for green sunfish was 0.54, resulting in 3.8 HUs for this reach of the river.

3.2.6 WETLANDS AND WATERS OF THE UNITED STATES

The USACE performed a preliminary jurisdictional determination for the project area on March 2, 2012, to determine the presence of wetlands and other classified waters of the United States. No jurisdictional wetlands were identified within the proposed project area. In 2003, the USACE conducted a field inventory of the entire Turkey Creek watershed and identified very few wetlands. At that time, only 5.4 acres were identified as possibly meeting wetland criteria within the entire watershed. Turkey Creek is classified as waters of the United States within the entire project area. To evaluate the existing condition of the riparian corridor for compliance with Section 404 of the CWA and to better compare alternatives, the HEP method was used to calculate an HSI score and determine the existing number of habitat units for the fox squirrel (*Sciurus niger*). Within this reach, the HSI score for the fox squirrel was 0.12, resulting in 3.18 HUs over a 26.5-acre area.

3.2.7 TERRESTRIAL HABITAT

The Turkey Creek drainage basin contains only remnants of the pre-settlement vegetation. The area was initially cleared for farms and homes and later developed for commerce and industry. Currently, tree species typically found within the floodplain and riparian area are dominated by eastern cottonwood, American sycamore, box elder, silver maple, and American elm. Black walnut is also common in some locations, including the project area between Shawnee Mission Parkway and Merriam Drive. The project area is approximately 30 acres in size, and approximately 25 percent of the project area contains tree canopy cover. Most of the locations with tree canopy cover also contain manicured lawns. The remaining areas include buildings, roads, parking lots, and other intensive land use practices.

3.2.8 FISH AND WILDLIFE

Fish species observed in Turkey Creek as part of a UAA study included red shiner, green sunfish, fathead minnow, and creek chub (Welker and Huggins 1997). These same species were identified again in biological samples collected by the EPA at three different locations along Turkey Creek in 2006 to 2009 (www.kcwaters.org). These species of fish are known to be tolerant of polluted waters. The steep angle of the Turkey Creek tunnel as it enters the Kansas River prevents most fish from moving from the Kansas River into Turkey Creek (USFWS 1998). The UAA report (Welker and Huggins 1997) concluded that the fish and macroinvertebrate communities in Turkey Creek are severely degraded by both point and nonpoint sources of pollution. The wastewater treatment plant provides a constant flow of warm water that creates open water in the winter months that is used by waterfowl. However, the warm water may be harmful to aquatic species that depend on cool water for all or part of their life cycle. Wildlife found in the riparian corridor along Turkey Creek includes small mammals, such as eastern cottontail rabbit, gray and fox squirrel, ground hog, opossum, and raccoon. Whitetail deer and a variety of birds such as house sparrow, starling, and American robin, reptiles, and amphibians also use the area.

3.2.9 THREATENED OR ENDANGERED SPECIES

No Federally listed threatened or endangered species are known to occur within or adjacent to the proposed project area. The only Federally listed threatened and endangered species for Wyandotte County, Kansas, is the

pallid sturgeon, and this fish species is restricted to the Kansas and Missouri Rivers. A copy of the letters from USFWS and KDWPT has been placed in the appendix H of this report.

3.2.10 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE (HTRW)

In 2011, the USACE conducted a general records search of HTRW sites located along the Upper Turkey Creek corridor. This search included the EPA Enviromapper; EPA Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) database; KDHE Identified Sites list; KDHE aboveground storage tanks and underground storage tanks assessment database; and KDHE database of registered underground storage tanks.

Findings from the records search indicate that no known hazardous waste sites are located within or adjacent to the project area. In addition, no solid waste facilities, such as former landfills, were identified. There are many records of leaking underground storage tanks throughout the Upper Turkey Creek watershed. Some of these tanks were located near the downstream portion of the proposed project area at 5639 Merriam Drive, Merriam, Kansas. This facility is used as a school bus station. The leaking tanks were used to store waste oil and diesel fuel. The storage tanks were removed and approximately 170 cubic yards of contaminated soil was removed. Additional underground storage tanks are currently registered at this location, although they are not known to be leaking. A complete description of the HTRW records search, including maps, is found in Appendix J, *Existing Conditions*.

3.2.11 FLOODPLAIN

Urban development has greatly impacted the Turkey Creek floodplain over the years. The lower reach of Turkey creek was originally channelized before 1920 during the construction of the tunnel bypass. In addition, the construction of I-35 adjacent to Turkey Creek also has impacted the creek channel and floodplain. Urban development of the floodplain has included fill activity; channelization of drainages, including concrete lining and enclosures; and development of numerous buildings, parking lots, roads, and utilities. Indirect impacts have resulted from development in the watershed and have increased the rate at which water reaches the creek and tributaries. The combination of the direct and indirect impacts has increased the flood peak flows, flood flow volumes, channel flow velocities and the rapid rate at which stream flows rise and fall after a storm (flashiness). The stream system has responded to these hydrologic modifications / alterations within the watershed by attempting to deepen and widen the channel, causing additional stream bank erosion and channel instability.

Frequent flooding in the Turkey Creek basin has been an ongoing issue for decades, causing substantial physical damages to property, significant risk to human life, lost revenues during business operational shutdowns, transportation network impacts, and threats to the viability of downtown Merriam. Records assessing these floods, especially before the 1960s, are limited, and none of the available economic damage estimates for any of the historical events are comprehensive, but Turkey Creek floods are known to have resulted in substantial damage in the upper basin in 1961, 1977, 1993 and 1998 among other years. The flood of July 1993 caused one fatality and resulted in estimated damages of $3.4 million in Merriam (equivalent to approximately $6.5 million in FY 2015 dollars) and $20 million in the lower basin. The flood of October 1998 caused an estimated $12 million in damages in Merriam (nearly $20 million in FY 2015 dollars) as well as damages in the lower basin equivalent to those of 1993. I-35 was overtopped at five different locations during the 1998 event. The flood peak occurred in the late evening, but had the peak occurred during rush hour, the risk of loss of life would have been high for drivers on I-35. Table 3-4 summarizes the existing information available concerning the occurrence of historical floods and estimated economic damages. None of the damage totals shown should be regarded as comprehensive accountings.

Table 3-4: Turkey Creek Flood History

Event	Description of Flooding	Estimated Damages (price level based on year of occurrence)
May 5–6, 1904	Not available.	Unknown
October 21–22, 1908	Not available.	Unknown
September 6–7, 1914	Not available.	Unknown
June 1, 1935	Flood depths up to 7 feet occurred with estimated discharge of 13,650 cfs. Commercial, industrial, and railroad damages were experienced in Merriam, Rosedale, and along Southwest Boulevard.	Unknown
April 21–22, 1944	Not available.	
July 30–31, 1958	Flood damage at Merriam and along Southwest Boulevard, at least 69 buildings damaged. Railroad tracks washed out west of Roe. Estimated discharge of 4,400 cfs at Merriam.	$155,000
September 12–13, 1961	Flooding damaged at least 82 buildings; No. 10 Fire Station was flooded to 1 foot depth, and I-35 was under water.	$240,000
July 21, 1968	Not available.	Unknown
September 12–13, 1977	Significant damage occurred along Southwest Blvd in the Rosedale District (estimated discharge of 11,700 cfs) and in Merriam; numerous buildings were damaged.	$8,100,000
April 1, 1983	Rosedale District and the state line area experienced severe flooding. Flood depths reached an estimated 4–6 feet in the state line area (estimated 12,500 cfs discharge).	Unknown
September 17, 1986	Rosedale District experienced severe damage with many buildings flooded. I-35 northbound lanes under water and other transportation damages occurred. Damages to city infrastructure (e.g., bridges, sewers, and streets).	Unknown
July 10, 1993	Largest flood on record. Damages in Rosedale, state line, and the Kansas City Central Industrial District. One fatality, but loss of life could have been greater had flood occurred during business hours rather than in the early morning hours.	$23,000,000 (partial estimate)
October 4–5, 1998	Severe flash flooding in Merriam and along Southwest Boulevard, numerous flooded buildings, mud and debris deposits. Flood depths and extents of flooding were very similar to the 1993 event. I-35 was closed for a few hours.	$25,000,000 (rough partial estimate)
June 27–28, 1999	Some businesses along Southwest Boulevard flooded (approximately 1-foot depth); people rescued from cars stalled in high water; street intersections closed; I-35 closed at 18th Street, and at Lamar, for a couple of hours.	Unknown
August 28, 2004	Limited flooding; buildings downstream along Southwest Boulevard were evacuated.	Unknown

3.2.12 LAND USE

Land use within the Turkey Creek Basin is primarily urban (Figure 3-2). I-35 and the railroad line both run parallel to Turkey Creek and are the major human-made features in the project area that influence land development patterns. These features have resulted in the area becoming an industrial and commercial corridor with some limited residential development. The project area in downtown Merriam is dominated by industrial and commercial development and several city parks.

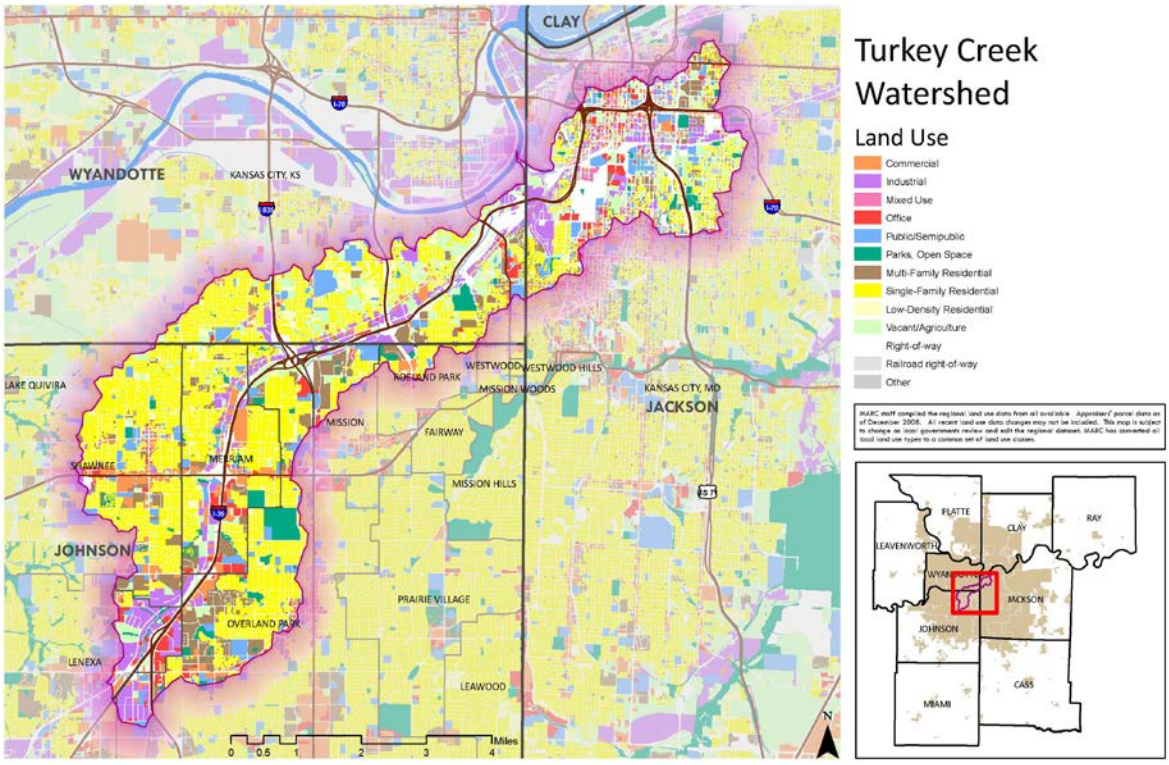


Figure 3-2: Land Use Within the Turkey Creek Watershed
(Source: Mid-America Regional Council [www.marc.org])

3.2.13 CRITICAL FACILITIES

The study area contains only one critical facility: Trinity Nursing and Rehabilitation Center (9700 W. 62nd Street), a Seventh-Day Adventist non-profit facility offering a large range of physical rehabilitation services for long-term care. Trinity has 120 beds, making it one of the largest such facilities in Kansas. Also noteworthy is Interstate Highway 35, a major highway running parallel to Upper Turkey Creek just outside the study area. I-35, which is a vital transportation link for both Merriam and the entire Kansas City metro area, has been inundated by Turkey Creek at several locations near the study area in previous floods.

3.2.14 SOCIOECONOMICS

The Upper Turkey Creek Basin can be described by the study area's demographics, economic indicators, housing conditions, and generalized land use patterns. The study area comprises all, or portions of, various U.S. Bureau of the Census sub-areas designated as census tracts. The study area includes parts of 14 census tracts, Kansas census tracts (KCT) numbers 434, 450, 502, 503.01, 504, 511, 519.03, 519.06, 519.07, 520.01, 520.04, 521.01, 522.01, and 9800.02. The available 2010 Census numbers/estimates were used for this section.

The Merriam project area includes parts of 5 census tracts, all located within Johnson County. These include KCT numbers 519.06, 520.01, 520.04, 521.01, and 522.01.

For comparison purposes, the demographics categories of the study area and its census tracts are also shown for the United States as a whole; the State of Kansas; the Kansas City metropolitan statistical area (MSA); Johnson County, Kansas; Wyandotte County, Kansas; and Merriam, Kansas (see Table 3-5).

Table 3-5: Population, Employment and Housing Characteristics, 2010

	Overall Study Area Census Tracts (RM -1.119 to 7.508)	Merriam Project Area Census Tracts (RM 2.035 to 5.394)	Merriam, Kansas	Johnson County, Kansas	Wyandotte County, Kansas	Kansas City MSA	Kansas	United States
Population 2010	42,503	14,857	11,107	531,228	155,462	1,999,718	2,809,329	303,965,272
Households 2010	19,801	6,804	5,125	210,278	57,207	789,432	1,101,672	114,235,996
Average number of persons per household	2.1	2.1	2.2	2.5	2.7	2.5	2.5	2.6
% Under age 18	20.5%	19.0%	18.6%	26.7%	28.2%	25.8%	25.5%	24.4%
% Over age 65	12.1%	12.6%	13.4%	10.6%	10.7%	11.7%	13.1%	12.7%
Unemployment	6.1%	3.9%	5.2%	4.6%	12.2%	6.8%	6.0%	7.9%
Median household income	$37,744 to $59,486	$41,910 to $59,486	$49,957	$73,733	$38,503	$55,749	$49,424	$51,914
Housing vacancy rate	8.6%	7.5%	6.2%	6.0%	12.5%	9.5%	9.8%	11.4%
Median [a] house value	$73,600 to $159,000	$148,300 to $158,000	$155,000	$209,900	$97,600	$158,000	$122,600	$188,400

Source: U.S. Bureau of Census 2010

Note: MSA – metropolitan statistical area, RM – river mile

[a] Median values given as the range of median values among the census tracts, excluding Census Tract 9800.02, which did not have enough houses or households to provide a meaningful median.

The 2010 population of the overall study area's 14 census tracts was 42,503, and the population of the Merriam reaches was 14,857, which equates to about 2.1 percent and 0.7 percent of population of the Kansas City MSA, respectively. Only nine residential structures are located within the Upper Turkey Creek floodplain in the Merriam reaches. Given that average number of persons per household for the area is 2.1, an estimated 19 persons reside within the floodplain, all in Reach 3b. Approximately 20.5 percent of the overall study area population and 19.0 percent of the Merriam reaches was 17 years of age or younger. About 12.1 percent of the overall study area's population, and 12.6 percent of the population of the Merriam reaches was age 65 or older. There were 19,801 households in the census tracts in the overall study area with an average household size of 2.1. The 6,804 households in the Merriam reaches have an average household size of 2.1, compared with an average household size of 2.2 for Merriam. There were 21,907 housing units in the overall study area, 46.7 percent of which were owner occupied, 43.6 percent were renter occupied, and the remaining 9.6 percent were vacant. In the Merriam reaches, there were 7,440 housing units, 42.9 percent of which were owner occupied, 48.6 percent were renter occupied, and 8.5 percent were vacant.

The two primary economic indicators in the study area are employment and income. The indicators show the number and the quality of the jobs available to the study area population. At the time the data were collected for the 2010 Census, the census tracts in the overall study area experienced unemployment of 6.1 percent. This was significantly below the national average of 7.9 percent. The 3.9 percent unemployment rate for the census tracts

in the Merriam project area was even lower. The range of median household income is $37,744 to $59,486 for the census tracts in the overall study area and $41,910 to $59,486 for the census tracts in the Merriam project area. For comparison, the median population for the United States is in the middle of these ranges at $51,914. The initial Upper Turkey Creek study area (river mile [RM] -1.119 to 7.508) contains approximately 105 commercial and industrial structures, including about 90 commercial and industrial buildings in the Merriam reaches that are the focus of the analysis (RM 2.035 to 5.394). Most of the structures are in zip code 66203, which in the most recent (2007) economic census had an average of 19.4 employees per establishment. Given that some businesses have more than one building in the Merriam reaches, those businesses would employ somewhat less than 1,746 people (the result of multiplying the average number of employees times the number of commercial and industrial structures). Types of businesses cover a wide range including light manufacturing, construction and earthwork, auto repair, automobile sales, tool and die manufacturing, retail, and service businesses.

INVESTMENT

Initially the entire study area was divided into nine reaches for assessment, and more detailed investment and damage information for the future without project condition was developed in the City of Merriam, Kansas as the study progressed. Comprehensive, structure-by-structure field surveys of the 0.2 percent floodplain from mile -1.199 to mile 7.5087 were carried out by Corps economics staff, and field survey updates were completed periodically throughout the study, most recently in 2014. The field surveys identified a total of 105 commercial structures and 10 residential structures. Of these, 91 commercial structures and 9 residential structures are in the Merriam reaches. Merriam was divided into three reaches along the Turkey Creek main stem for the economic analysis:

- Reach 3A – from river mile 2.035 near Antioch Road to river mile 2.593 near 55th Street
- Reach 3B – from river mile 2.593 near 55th Street to river mile 3.855 near Shawnee Mission Parkway
- Reach 3C – from river mile 3.855 near Shawnee Mission Parkway to river mile 5.394 at 75th Street

Table 3-6 below provides a summary of study area investment subject to flooding. Total investment in the study area was estimated in FY 2012 prices for the screening process. This total has been updated to FY 2015 prices. However, the screening was done at the FY 2012 price level and the discussion of the future without-project condition and the alternatives screening in this report is referenced to the FY 2012 price level. Total investment was estimated at $113.7 million in 2012 and is updated to $120.6 million in 2015. (The increase is based purely on price level adjustment and does not otherwise involve revised structure inventory data.) Investment in the three study area reaches is estimated at $24.9 million (FY 2015 dollars) for Reach 3a (20 structures), $75 million for Reach 3b (78 structures), and $20.7 million for Reach 3c (2 structures).

Table 3-6: Study Area Investment

Reach	# Structures/ groups of structures	1 Oct 11 prices ($1,000s)			1 Oct 14 prices ($1,000s)		
		Structure / infrastructure investment	Contents Investment*	Reach Totals	Structure / infrastructure investment	Contents Investment*	Reach Totals
Reach 3a	20	$8,500.0	$14,800.0	$23,300.0	$9,300.0	$15,600.0	$24,900.0
Reach 3b	78	$28,600.0	$42,600.0	$71,200.0	$29,500.0	$45,500.0	$75,000.0
Reach 3c	2	$11,400.0	$7,800.0	$19,200.0	$12,400.0	$8,300.0	$20,700.0

Study Area Totals	**100**	**$48,400.0**	**$65,200.0**	**$113,700.0**	**$51,200.0**	**$69,400.0**	**$120,600.0**

ECONOMIC DAMAGES

Single-event economic damages, as computed in HEC-FDA, are summarized here for three events:

0.10 ACE Event—A flood event of this magnitude and frequency could impact approximately 58 structures. Reach 3a would incur an estimated $211,000 in damages with a maximum depth of 1.4 feet to structures, approximately $2,000 in damages to roads, and approximately $10,000 in clean-up costs. Reach 3b would incur approximately $8.2 million in damages with a maximum depth of 5.1 feet to structures, approximately $53,000 in damages to roads, and $456,000 in clean-up costs. Reach 3c would incur approximately $2,000 in road damages. (These damage totals are in FY 2012 dollars.)

0.01 ACE Event—A flood event of this magnitude and frequency could impact an estimated 86 structures. Reach 3a would incur approximately $6.1 million in damages with a maximum depth of 5.3 feet to structures, approximately $57,000 in damages to roads, and approximately $234,000 in clean-up costs. Reach 3b would incur approximately $17.6 million in damages with a maximum depth of 6.3 feet to structures, approximately $109,000 in damages to roads, and nearly $1 million in clean-up costs. Reach 3c would incur approximately $2.6 million in damages with a maximum depth of 1.8 feet to structures, approximately $22,000 in road damages, and approximately $258,000 in clean-up costs.

0.002 ACE Event—A flood event of this frequency and magnitude could impact an estimated 98 structures. Reach 3a would incur approximately $13.1 million in damages with a maximum depth of 8.9 feet to structures, approximately $70,000 in damages to roads, and approximately $509,000 in clean-up costs. Reach 3b would incur approximately $27.2 million in damages with a maximum depth of 7.5 feet to structures, approximately $183,000 in damages to roads, and approximately $1.5 million in clean-up costs. Reach 3c would incur approximately $4.1 million in damages with a maximum depth of 2.3 feet to structures, approximately $28,000 in road damages, and approximately $416,000 in clean-up costs.

Table 3-7 shows the existing condition primary damages by flood frequency event and reach for the structural, contents, and other categories. The table is in 2012 price levels, consistent with the phase and timeframe for screening of plans

Table 3-7: Existing Condition Primary Damages (with Risk and Uncertainty) for Structures, Contents, and Other for Selected Events

Damage Category	Existing Condition (2012) Primary Damages (October 2011 prices, $1,000s)		
	0.1 exceedance probability	0.01 exceedance probability	0.002 exceedance probability
Reach 3a			
Structural	$31.3	$1,819.0	$3,605.6
Contents	$176.0	$4,139.0	$9,243.0
Other	$15.9	$410.3	$876.2
Total	$223.2	$6,368.3	$13,724.8
Reach 3b			
Structural	$1,930.4	$4,474.6	$7,144.8
Contents	$4,583.3	$10,744.3	$17,704.6
Other	$2,207.6	$3,451.2	$4,053.2

Damage Category	Existing Condition (2012) Primary Damages (October 2011 prices, $1,000s)		
	0.1 exceedance probability	0.01 exceedance probability	0.002 exceedance probability
Total	$8,721.3	$18,670.1	$28,902.7
Reach 3c			
Structural	$2.1	$1,646.4	$2,394.7
Contents	$0.0	$1,199.9	$2,162.0
Other	$0.0	$0.0	$0.0
Total	$2.1	$2,846.3	$4,556.7
Study Area Total			
Structural	$1,963.8	$7,940.0	$13,145.1
Contents	$4,759.3	$16,083.2	$29,109.6
Other	$2,223.5	$3,861.5	$4,929.4
Total	$8,946.6	$27,884.7	$47,184.2

3.2.15 ENVIRONMENTAL JUSTICE

Executive Order 12898 on environmental justice requires consideration of social equity issues, particularly any potential disproportionate impacts to minority or low-income groups. The study evaluated demographic and census data for the project area and analyzed the potential effects of the proposed project on minority and low-income groups. As can be seen in Table 3-5, the minority populations for the overall study area and the Merriam project area are lower than the national averages. This is also the case for under-18 and over-65 populations relative to the national average. The percentage of the population below poverty level, on the other hand, is somewhat higher for both the overall study area (14.9 percent) and the Merriam project area (17.5 percent) than the national average of 13.8 percent. Only nine residential structures are located and approximately 19 people reside in the floodplain of the Merriam reaches (RM 2.035 to 5.394). Block-level census data for these structures are distorted by the presence of a nursing home just outside the floodplain, so the data for the Merriam project area census tracts, as shown in Table 3-5, are likely to provide a better estimate (in terms of percentages) for the demographics within the floodplain.

Table 3-8: Minority, Low Income, and Vulnerable Populations, 2010

	Overall Study Area Census Tracts	Merriam Project Area Census Tracts	Merriam, Kansas	Johnson County, Kansas	Wyandotte County, Kansas	Kansas City MSA	Kansas	United States
Population 2010	42,503	14,857	11,107	531,228	155,462	1,999,718	2,809,329	303,965,272
% Black or African American	7.4%	10.1%	8.7%	4.0%	26.2%	12.3%	5.8%	12.5%
% Hispanic	14.0%	14.7%	16.1%	6.6%	24.8%	7.7%	9.8%	15.7%
% Asian	2.8%	2.7%	2.9%	4.1%	2.5%	2.2%	2.4%	4.7%
% Below	14.9%	17.5%	14.8%	5.5%	21.3%	11.1%	12.4%	13.8%

	Overall Study Area Census Tracts	Merriam Project Area Census Tracts	Merriam, Kansas	Johnson County, Kansas	Wyandotte County, Kansas	Kansas City MSA	Kansas	United States
poverty level								
Unemployment	6.1%	3.9%	5.2%	4.6%	12.2%	6.8%	6.0%	7.9%
% Under age 18	20.5%	19.0%	18.6%	26.7%	28.2%	25.8%	25.5%	24.4%
% Over age 65	12.1%	12.6%	13.4%	10.6%	10.7%	11.7%	13.1%	12.7%
% Foreign born	9.4%	9.5%	11.4%	7.9%	14.2%	6.0%	6.3%	12.7%
% Foreign born and entered US 2000 or later	3.3%	3.8%	3.6%	3.2%	5.9%	2.4%	2.4%	3.8%

Source: U.S. Bureau of Census 2010

Note: MSA – metropolitan statistical area

3.2.16 TRANSPORTATION

One of the most used roads in the Kansas City metropolitan area and the state of Kansas is the stretch of I-35 that runs through Johnson County, more-or-less parallel to Upper Turkey Creek throughout most of the study area (Figure 3-3). According to the KDOT, the daily traffic counts for this stretch of I-35 range from 108,000 just east of Roe Lane to 155,000 just south of 67th Street. In Reach 1b, where I-35 runs through the Upper Turkey Creek floodplain, the daily traffic count is 117,000. At the point nearest the Merriam Project area (although out of the floodplain), the traffic count for I-35 is 125,000. The road that runs most prominently through the floodplain of the Merriam project area is Merriam Drive, which has an average daily traffic count of 4,610. Shawnee Mission Parkway at the south end of the Merriam Project area has an average daily traffic count of 43,440.

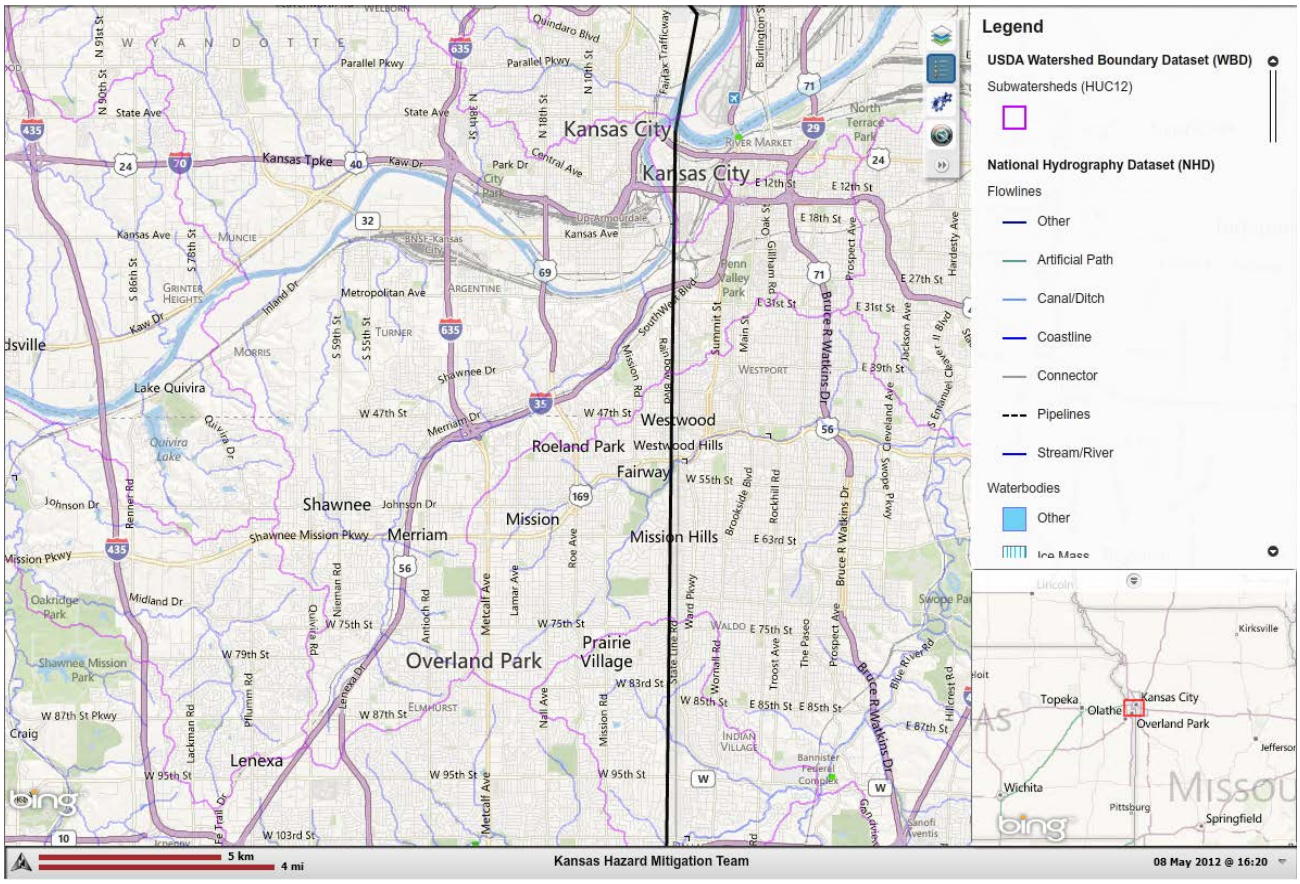


Figure 3-3: Transportation Infrastructure around Turkey Creek

In comparison to the national average, more residents of the study area drive to work alone (85.3 percent to 76 percent), and fewer residents use public transportation (0.4 percent to 4.9 percent). The residents of the study area also have average commute times (18.4 minutes) that are significantly less than the national average (25.2 minutes).

Table 3-9: Residents Commuting to Work, 2010

	Overall Study Area Census Tracts	Merriam Project Area Census Tracts	Merriam, Kansas	Johnson County, Kansas	Wyandotte County, Kansas	Kansas City MSA	Kansas	United States
Drove alone	85.3%	86.1%	85.3%	85.1%	80.5%	83.0%	81.4%	76.0%
Carpooled	8.4%	8.3%	9.2%	7.0%	11.4%	9.1%	9.7%	10.4%
Public transit	0.4%	0.4%	0.4%	0.4%	1.4%	1.3%	0.5%	4.9%
Walked	1.5%	1.2%	1.3%	1.0%	1.8%	1.4%	2.6%	2.8%
Other means	1.4%	0.9%	0.8%	1.1%	3.3%	1.3%	1.4%	1.7%
Worked at home	3.1%	3.1%	3.1%	5.4%	1.6%	3.9%	4.3%	4.1%
Mean travel time to work (minutes)	18.4	18.6	18.4	20.2	21.1	22.6	18.8	25.2

Source: U.S. Bureau of Census 2010
Note: MSA – metropolitan statistical area

3.2.17 RECREATION

Several city parks are located adjacent to Turkey Creek within the project area, including the Merriam Marketplace in downtown Merriam, which includes facility used for the Farmers' Market; Campbell Park located at 61st and Knox Streets; and Werner Park located near 57th and Knox Streets. Another park within the project area is the Turkey Creek Streamway Park. This park has a paved walking trail that follows the west bank of Turkey Creek from 75th Street to Werner Park. None of these parks have received funding through the Land and Water Conservation Fund; therefore, requirements of Section 6(f), of the Land and Water Conservation Act, governing the conversion of these lands to other uses is not applicable. Since 2007, a group known as the Turkey Creek Coalition has worked to develop a plan that would extend the Turkey Creek Streamway Trail from the suburbs of Johnson County to downtown Kansas City. The Turkey Creek Coalition is an informal association comprising public and private participants dedicated to developing this trail. It is supported by representatives from various city, state, and Federal government entities; local, state and Federal elected officials; local businesses and organizations; and private citizens. Detailed information about this initiative can be found at http://www.marc.org/metrogreen/Current_Projects/turkeycreek.aspx.

3.2.18 CULTURAL RESOURCES

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.

No sites listed on or eligible for listing on the NRHP are recorded within the Upper Turkey Creek APE. However, one historic military trail, the Fort Leavenworth-to-Fort Scott Road, is mapped as bisecting the project area. A historical marker is present at the location of the crossing. No trace of the old road remains in the area, primarily the result of the surrounding urban development. An archeological survey of the project area identified no archeological sites. The results of the archeological survey were documented in a report and coordinated with the Kansas State Historic Preservation Officer (SHPO) in a letter dated May 9, 2012. Because no cultural resource sites were identified during the survey and no trace remains of the former military road, the USACE determined the project would have "no effect" on historic properties. The SHPO concurred with this determination in a letter dated May 15, 2012. The survey report and SHPO coordination letters are included in Appendix K.

3.3 FUTURE WITHOUT PROJECT CONDITIONS

Primary resources of concern identified for evaluation include geology, soils, and geomorphology; climate; hydrology; water quality; aquatic habitat; wetlands; terrestrial habitat; fish and wildlife; threatened and endangered species; HTRW; floodplain; land use; socioeconomics; environmental justice; transportation; recreation; and cultural resources.

3.3.1 GEOLOGY, SOILS, AND GEOMORPHOLOGY

The existing conditions for geology, soils, and geomorphology within the Turkey Creek study area would not be expected to change under the future without project condition.

3.3.2 CLIMATE

If the climate trend over the past 100 years continues, eastern Kansas would continue to see increases in precipitation and temperature (USEPA 1998). More intense rainfall events would likely lead to an increase

flooding (USEPA 1998). Any increase in flooding would be particularly detrimental in urban areas, such as the Turkey Creek watershed.

3.3.3 HYDRAULICS AND HYDROLOGY

Without a flood risk management project along Turkey Creek, there would not be any expected major changes from existing conditions in the hydraulics of Turkey Creek within the project area. Flood risk would be sustained at levels that currently exist. However, if higher and more intense rainfall occurs due to changes in climate, there would be an increase in flooding along Turkey Creek, resulting in an increase risk to human health and safety, as well as an increase in property damage.

3.3.4 WATER QUALITY

As more stringent water quality standards are developed, the water quality of Turkey Creek is expected to continue to improve compared to existing conditions. It is believed that out-of-bank flooding along Turkey Creek flushes pollutants, which occur on adjacent lands as a result of the industrial, commercial, and residential development, into the creek. Any structural flood risk management alternative that would help contain floodwaters in the Turkey Creek channel would likely result in minor improvements to the water quality of Turkey Creek. Any non-structural alternatives for flood risk management may or may not result in minor improvements to the water quality, depending on whether any land use changes would occur as a result a particular alternative.

3.3.5 AQUATIC HABITAT

Currently, the aquatic habitat in Turkey Creek is in a degraded condition. No major improvements to the aquatic habitat along Turkey Creek are expected in the future with or without a flood risk management project. Any major improvements to aquatic habitat along Turkey Creek within the project area would require changes to the creek hydraulics.

3.3.6 WETLANDS AND WATERS OF THE UNITED STATES

The future without a flood risk management project would not result in any change in the number of wetlands within the project area. Most wetlands that may have historically existed along Turkey Creek have been filled. Depending on the design of a flood risk management project, new stormwater detention basins could be developed to provide some wetland functions.

3.3.7 TERRESTRIAL HABITAT

No change is expected in the terrestrial habitat of the project area in the future. The area would continue to consist predominately of manicured lawns, buildings, roads, parking lots, and other intensive land use practices. If a watershed-wide ecosystem restoration project were implemented to retain stormwater and reduce the rate at which runoff enters Turkey Creek, there would likely be improvements to the terrestrial habitat if these projects incorporated terrestrial vegetation. The extent of these improvements would be related to the extent of any ecosystem restoration projects.

3.3.8 FISH AND WILDLIFE

In the future, fish and wildlife would continue to consist of species that are tolerant of urban conditions with or without a flood risk management project. These species would likely consist of small animals, such as eastern cottontail rabbit, gray and fox squirrel, opossum, raccoon, groundhogs, and a variety of birds. Whitetail deer would also likely be abundant. Any ecosystem restoration efforts may increase the number of individuals of certain species, but because of the degree of urbanization in the watershed, an ecosystem restoration project would unlikely result in any additional species becoming present within the watershed.

3.3.9 THREATENED AND ENDANGERED SPECIES

Currently, no federally listed species, candidate species, or designated critical habitat occur within the Turkey Creek watershed. It is not expected that this condition will change in the future with or without a flood risk reduction project.

3.3.10 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTES

It is not expected that there will be any changes in the future concerning HTRW with or without a flood risk management project when compared to existing condition. It is unlikely that any hazardous waste sites would develop within the project area unless a major spill or leakage occurred. A flood risk management project would not change the likelihood of this occurring. One possible exception to the above, any underground storage tanks may be a problem in the watershed, and cleanup activities might occur in future. A flood risk management project would not have any effect on leaking storage tanks.

3.3.11 FLOODPLAIN

The future without a flood risk management project would not be significantly different than that described under existing conditions. However, some business and industry may make the decision to move to other locations if flooding problems become too burdensome. Additionally, there may be a greater risk to human health and safety and flood damage if climate conditions result in an increase in the intensity of storm events.

3.3.12 LAND USE

Without a flood risk management project, land use along Turkey Creek is not expected to change much. It is expected that the Turkey Creek watershed would continue to be used for industrial, commercial, and residential purposes. For the most part, the watershed has been completely developed. Several city parks within the project area would be expected to continue providing recreational opportunities for people who live and work in the area.

3.3.13 SOCIOECONOMICS

The future without a flood risk management project would be characterized by continuation of the current flood risk in the Upper Turkey Creek floodplain. Commercial and residential structures would be subject to physical damages from flood events, and the area also would experience a decrease in business income and tax revenue due to business closures during these events. After flood events occur, some businesses and residents may be forced to relocate outside the floodplain.

3.3.14 ENVIRONMENTAL JUSTICE

The future without a flood risk management project would not be expected to have any disproportionate impacts on minority or low-income groups in the Turkey Creek project area or surrounding areas. Only nine residential structures are located in the floodplain, and the census data do not show an exceptionally high presence of minority or low-income families in the area.

3.3.15 TRANSPORTATION

The future without a flood risk management project would not be expected to have any foreseeable permanent impacts on transportation activity or infrastructure in the Turkey Creek project area or surrounding areas. A future with a flood risk management project would reduce expected damage to roads in the floodplain.

3.3.16 RECREATION

In the future, the outdoor recreational opportunities along Turkey Creek would increase if the Turkey Creek Coalition's plan to extend the Turkey Creek Streamway Trail from the suburbs of Johnson County to downtown Kansas City is constructed.

3.3.17 CULTURAL RESOURCES

Because no NRHP-listed or eligible sites are present in the project area and unrecorded sites are unlikely because of urban development, there would be no impacts to cultural resources in the future with or without a flood risk management project.

4 CHAPTER 4 –PLAN FORMULATION

This chapter presents the results of the third step of the planning process, which is the formulation of alternative plans, and describes the development of alternative plans that address the planning objectives. An array of flood risk management measures and alternatives were developed to address one or more of the planning objectives. Watershed-based considerations have been included to the extent practicable. The alternatives described in this section are the basis for determining the costs and duration for elements of this feasibility study and, ultimately, the overall project schedule and cost.

In formulating, comparing, evaluating, and selecting alternatives for the Upper Turkey Creek project, the purpose, or performance goal, that we have pursued has simply been to maximize flood risk reduction (or minimize residual risk) within the broader goals and constraints of economic efficiency, environmental considerations, and sponsor finances.

4.1 PLAN FORMULATION METHODOLOGY

The results of the existing conditions analysis, observations and effects from historic and recent flood events were used to formulate potential solutions targeted at lowering the risk of flooding using a watershed perspective. Three primary sites of flood vulnerability were identified during the reconnaissance phase of the study: City of Merriam, Johnson County, Kansas; Roe Lane Industrial Area in Wyandotte County, Kansas; and the low-lying areas of I-35 in Johnson and Wyandotte Counties. These areas were the subject of subsequent flood risk management plan formulation and screening.

An initial set of alternative measures were developed that would address one or more of the planning objectives using experience garnered from other flood risk management studies and investigation of current engineering practices. These alternative measures were screened and refined for their application at each of the three project sites. As the process continued, alternatives were identified and examined. Alternatives were examined and compared considering the Federal criteria of completeness, efficiency, effectiveness, and acceptability. Alternatives were closely examined for their potential to impact the environment. As the alternatives passed through this evaluation and screening process, the economic analysis of each alternative's incremental cost was used as a ranking factor in the final selection. Having passed review for engineering adequacy, environmental and public acceptability, and other evaluation criteria as described below, the remaining alternative with the highest net benefits to the national economy was identified as a component of the overall recommended NED plan.

The following sections describe the specific measures considered and the results of the screening and evaluation process.

4.1.1 SYSTEMS APPROACH

One key challenge is to ensure that as the public and government leaders make flood risk management decisions, they integrate environmental, social, and economic factors and consider all available tools to improve public safety. This challenge is especially difficult when evaluating how the various systems in the environment and supporting our economy are closely interwoven. In the case of an urbanized watershed, many tradeoffs occur between areas upstream and downstream of the various stakeholders. Few understand the tradeoffs that previous decision makers have made that brought the communities to the situation they are in today. Therefore, one plan formulation methodology is to use a systems approach when formulating alternatives and evaluating those measurable outputs.

Because time and money also are important factors that limit the extent to which a systems approach can be applied, the planning team has taken advantage of as many existing tools as possible. One primary tool available from interagency efforts for this study is the watershed hydrologic and hydraulic models from Johnson County's update to the FEMA FIRMs (August 2009). These tools, developed by the local communities, enable a system approach. They consider the complex, enclosed urban storm drainage systems and the contributing drainage areas. A second system approach is to evaluate the state of the ecosystems in the study area with environmental field assessments using a watershed perspective.

4.1.2 LOCAL PERSPECTIVE

The local study sponsor, the City of Merriam, Kansas, recognizes the significant flooding threat from Turkey Creek. The MDD maintains the existing local channel project constructed in Merriam. The MDD has stable financing to maintain the channel, but it recognizes that the flood threat exceeds its technical and financial resources. Johnson County's SMP provides for local cost-shared assistance in addressing flooding problems. However, the cost of more comprehensive flood protection would place serious imposition on that program.

In 1988, the Kansas Legislature authorized counties to adopt a 1/10th-cent sales tax for the purpose of funding stormwater projects. These funds, dedicated to stormwater management, allow Johnson County through its SMP to create a yearly stormwater management plan and provide 75 percent of funding for eligible projects in Johnson County and the cities. The SMP provides financial, technical, and other stormwater assistance services to encourage regional solutions for protecting human lives and property, conserving natural resources, and promoting appropriate public use of Johnson County stream corridors. The Johnson County SMAC operates as an advisory board to the Board of County Commissioners. It is responsible for reviewing recommendations made in the SMP and providing recommendations to the Board of County Commissioners and considering new and innovative ways to properly manage stormwater.

The information in this report has been presented to the community through the use of clear and strategic communications with an emphasis on transparency. Direct input provided during the reconnaissance and feasibility phases from sponsors and stakeholders, at public meetings, and through written public comments provided a wide array of potential measures. The various alternatives were compared for their ability to meet the goals of the both the City of Merriam and the UG. Subsequent discussions with the non-federal sponsor were considered throughout the screening process.

Johnson County has continually expressed an interest in working with the City of Merriam and MDD in collaboration with the USACE for a flood risk management project. Initially in the study, the UG expressed interest in flood protection measures at the Roe Lane Industrial Park area (downstream from Merriam) but later on declined participation in a future cost shared project.

4.2 PLANNING CRITERIA

The USACE planning criteria requires that plans be evaluated against four criteria listed in the United States Water Resources Council's P&G: completeness, effectiveness, efficiency, and acceptability.

The following criteria were used to assess the overall characteristics of each alternative measure to identify those most likely to meet the project purpose and objectives.

- Engineering adequacy of the proposed solutions (effectiveness)
- Contribution to planning objectives (related to completeness of solution)
- Consistency with planning constraints and authorities

- Environmental, cultural, and public acceptability
- Early cost indicators (early efficiency indicators for screening purposes)
- Floodway conveyance considerations
- Hazardous and regulated waste site constraints (where applicable)
- Constructability (are construction techniques and quality difficult to attain at reasonable price)
- Construction site constraints (given existing features and development)

Effectiveness—Whether the measure or alternative would be effective in maintaining an acceptable level of flood risk management. The engineering adequacy of alternatives was analyzed and reviewed during the initial screening process. Conceptual measures were assessed for their potential to contribute substantially to the overall effectiveness of any alternative.

Environmental Effects—Direct and indirect effects of natural resources and cultural resources. Direct effects are those effects associated with the construction. Indirect effects are those effects that would occur as a result of a change in environmental conditions resulting from the construction or operation of the project. This criterion is related to the desire to minimize environmental effects and produce an environmentally sustainable project. It is also a component of overall effectiveness. Environmental effects of alternatives were reviewed in concert with appropriate resource agency guidance. Any alternative that had major disruptive effects on the environment was normally eliminated during the screening process. A typical formulation exercise would involve adjusting some of the alternative measures so as to minimize any environmental effects when such impacts could not reasonably be avoided.

Social Effects—Direct and indirect effects on socioeconomic resources, such as transportation, regional growth, public safety, employment, recreation, public facilities, and public services. This criterion is a component of overall effectiveness.

Acceptability—The environmental, cultural, and public acceptability of alternatives. Acceptability was analyzed and reviewed during the screening process. Controversy and potential effects on community cohesion and compliance with policy are indicators of acceptability.

Implementability—The existence of significant outstanding technical, social, legal or institutional issues that could affect the ability to implement the alternative. Implementability is related to the P&G criterion for acceptability.

Cost—The first cost of the project, costs of local operations and maintenance and long-term residual costs. These costs were used to determine if an alternative was prudent for further examination. As the evaluation process continued, cost estimates and economics were refined. Cost is related to two P&G criteria: efficiency and acceptability. Cost alone is not used to eliminate any alternatives, but cost is considered in relationship to the other criteria and for cost affordability considerations.

Risk—The uncertainties, vulnerabilities and potential consequences of the alternative. Risk is related to the P&G criteria of effectiveness and acceptability.

Separable Mitigation—The potential need for mitigation resulting from the project's implementation to address environmental, hydraulic, or other impacts. This criterion is related to all four of the P&G criteria.

Cost Effectiveness—Detailed cost estimating and economic analysis. The detailed cost estimate and economic analysis normally focused only on those alternatives that remained viable solutions after early screening criteria were passed. This criterion is a comparison of expected economic benefits and estimated costs for each alternative and between alternatives. Cost effectiveness is a primary

consideration in determining whether there is a federal interest in the project and to what extent federal participation can be justified. This is a component of the P&G criteria of efficiency.

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

Sustainability Considerations—The consideration of sustainable measures and activities important for the long-term viability of the community. The development and screening of alternatives also involved the consideration of a number of criteria suggested during the reconnaissance phase.

- The expected benefits will extend over long periods, i.e., 50 years or more.
- The proposed work will be compatible with applicable Federal, state, and local laws and ordinances, as well as ongoing efforts.
- Public health, safety, and well-being will be protected.
- The proposed work to be implemented will be compatible with local sponsor priorities.
- The most practical property interest/estates will be used and will vary between project features.
- The non-Federal sponsor is willing to cost share the planning, design, and construction of features and is willing to operate and maintain projects.

4.3 PROJECT SITING

The reconnaissance phase found two distinct and independent project sites that merited additional evaluation and development of flood risk management measures for the Upper Turkey Creek watershed. They are reaches of Turkey Creek associated with the downtown area in the City of Merriam, Kansas, and the Roe Lane Industrial Park in Wyandotte County. Flood risk management measures were considered for both the downtown Merriam area and Roe Lane Industrial Park. The I-35 corridor areas most prone to flooding were evaluated and dismissed from further consideration due to lack of a cost-sharing partner in that reach and low likelihood of measures that would significantly reduce flood damages. Ongoing coordination with KDOT revealed that it will continue to work with local jurisdictions to improve flood response in that corridor and the planning team will continue to highlight the flood risk there and cooperate with these activities to the maximum extent possible. Figure 4-1 shows the three flood risk management projects sites that were evaluated during

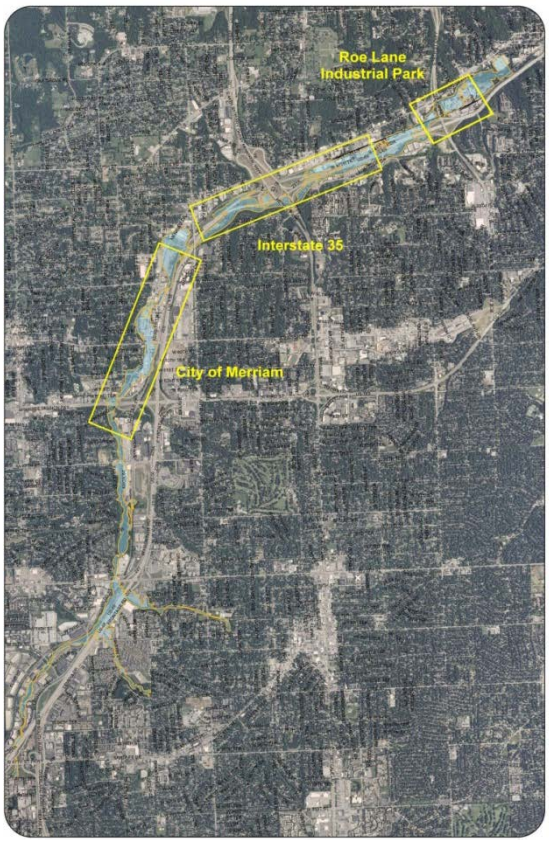


Figure 4-1: Project Sites

the initial plan formulation.

4.3.1 FLOOD RISK MANAGEMENT PROJECT SITES

The Merriam Reach project site is an area extending from Shawnee Mission Parkway downstream to Merriam Drive. This is river station (RS) 3.7260 to RS 2.6230. The channel was evaluated with respect to current and anticipated future hydrology, hydraulics, and watershed urbanization. Flood risk management features evaluated for this area involved replacement of bridges, retrofit of one bridge, channel modification, levees and floodwalls, and potential evacuation (removal) of structures. The planning goal is to contain flooding within the channel or modify the conveyance to the extent that flood damage to structures would be significantly reduced.

The Roe Lane Industrial Park in Wyandotte County is farther downstream; it begins just upstream of the Congressional project limit extending upstream to the railroad crossing of Turkey Creek just north of I-35 (RS 1.2720 to RS -0.5410). The Turkey Creek channel was evaluated for adequacy with respect to the anticipated future urbanization of the watershed. Flood risk management alternatives for this area involved replacing existing bridge structures with longer structures and reshaping the channel. The planning goal was to contain the flooding in the channel or modify conveyance to the extent that flood damage to structures would be significantly reduced.

4.4 MEASURES

A measure is a feature or activity at a site that addresses one or more of the planning objectives. Throughout the watershed, specific management measures, either a feature or an activity, can be implemented at specific geographic sites or across broad areas of the watershed to achieve desired effects. A feature is a physical element that generally requires site construction. An activity is an institutional (drainage district, city, or county) action that causes a change without immediate physical change, which may be a one-time occurrence or ongoing. Several alternative measures were identified for consideration in evaluating future possible actions in the Upper Turkey Creek watershed. Each measure was assessed using screening criteria and a determination was made regarding whether it should be retained in the formulation of alternative plans. Analyses for identification of the NED plan involved identifying an array of measures to achieve the stated objectives and then determining the most cost-effective combination of those measures that fully address the identified problems. Measures become part of alternatives, making each alternative unique in how measures are formulated together.

4.4.1 FLOOD RISK MANAGEMENT MEASURES

Flood risk management measures are either structural or nonstructural. Structural alternatives modify the flood and “take floods away from people” by features such as channels, levees, and dams. Nonstructural alternatives basically “take people away from floods,” leaving the flood to pass unmodified. Nonstructural measures include both features and activities. Example nonstructural activities include land use regulations, redevelopment and relocation policies, disaster preparedness, flood warning and forecasting systems, flood plain information, flood plain acquisition and easements. Nonstructural measures also include features such as flood proofing, and onsite detention of flood waters by protection of natural storage areas or in human-made areas. Documenting the full menu of measures will contribute to better flood risk management in the watershed, and this information will be carried forward in the FMP.

Importantly, the public must be educated about flood risk management risks and actions that can be taken to reduce these risks. Because of this complex arrangement of responsibilities, only a life-cycle, comprehensive, and collaborative watershed perspective enables communities to sustain an effective

reduction of risks from flooding.

The methods used to evaluate the formulated alternatives include those for the primary authorized mission, flood risk management. The methods used for characterizing water surface elevations included standard hydraulic modeling program, HEC-RAS, and the standard hydrologic program, HEC-1. The HEC-Hydrologic Modeling System (HMS) was required for portions of the work. Because of the high degree of urbanization and the number of enclosed conveyance systems, standard practices (i.e., formulae for time of concentration adjustments) were used in the modeling and the characterization of hydrology patterns. The hydraulic and hydrologic modeling also used the hydrologic and hydraulic analysis prepared by Johnson County to develop the revised Flood Insurance Study.

STRUCTURAL FLOOD RISK MANAGEMENT MEASURES

The following structural measures were considered for flood risk management during plan formulation.

- **Off-line Impoundment Detention**—Floodwaters can be managed by providing off-line or channel storage, which is designed to contain only the peak of the flood hydrograph. The excess flow is diverted out of the stream over a long weir on the side of the channel into a separate storage facility.
- **In-line Impoundment/Detention**—Impoundment and managed release of floodwaters by a dam, reservoir, and detention basin can be an effective flood management measure. The dam site should be upstream but fairly close to the area to be protected and should be capable of storing sufficient amounts of water.
- **Levees**—A levee is defined as an earthen embankment whose primary purpose is to furnish flood protection from seasonal high water and that is therefore subject to water loading for periods of only a few days or weeks a year. Traditionally, in areas of high property values, high land use, and good foundation conditions, levees are built of compacted earth with relatively steep slopes and the levee alignment is dictated primarily by flood protection requirements. Levees built with smaller sections and steeper slopes generally require more comprehensive investigation and analysis during design than do levees with broad sections and flatter slopes whose design is more empirical.
- **Floodwalls**—The application of floodwalls was considered where space limitations made levees infeasible. A floodwall is defined as any wall having as its principal function the prevention of flooding of adjacent land. They are frequently built at the edge of the water to withstand periods of high water. Most floodwalls are of the inverted T type. The cross bar of the T serves as a base and the stem serves as the water barrier. When founded on earth, a vertical base key is sometimes used to increase resistance to horizontal movement. If the wall is founded on rock, a key is usually not provided. Where required, the wall can be supported on piles.
- **Bridge Retrofit or Replacement**—Flooding is increased where an existing bridge causes a substantial constriction in the channel flow area. It is sometimes necessary to replace the bridge with a wider or higher structure, thus modifying a bridge to increase the amount of flow area under the bridge. Although this can be costly, if the bridge is the managing factor in the flooding, the modifications are necessary to realize substantial benefits from other flood reduction measures, such as channel modifications.
- **Channel Modifications**—Reduced flood stages can be achieved by the widening, deepening, clearing, and straightening of the stream channel. Channelization results in a uniform channel cross section that improves hydraulic efficiency and thus allows the channel to contain larger storm events. The advantage of channel modifications is that they afford flood reduction/protection without advance actions prior to a flood event and do not fail when flows

exceed the design capacity.

- **Flow Diversion**—Diverting water during high flows rather than replacing the bridge or culvert is sometimes more cost effective at locations where flooding is caused by an inadequate structure. This option is only feasible in very specific circumstances.

NONSTRUCTURAL FLOOD RISK MANAGEMENT MEASURES

The following nonstructural measures were considered for flood risk management during plan formulation.

- **Flood Proofing**—Flood proofing is a combination of structural 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 water entry, thus, reducing flood damages. Nonstructural alternatives include a plan for flood proofing existing development in the protected areas comparable to the protection that would be provided by structural alternatives. Flood proofing measures could include the following:
  - **Dry Flood Proofing**—Features applied to a structure, or adjacent to a structure, to prevent entrance of flood waters
  - **Wet Flood Proofing**—Features applied to a structure and/or its contents that prevent flooding, or damage from flooding, by allowing flood water to enter the structure
- **Elevation**—Lifting of existing structures to an elevation greater than flood elevations using fill material, extended foundation walls, piers, posts or piles.
- **Relocation**—Physical movement of at-risk structures out of the flooding area and buying land upon which the structure is located.
- **Floodplain Evacuation**—The permanent relocation or evacuation of existing developments subject to flood damages involves the acquisition of land and structures in the floodplain either by purchase or through the exercise of powers of eminent domain, if necessary. Following this action, commercial and industrial developments and residential property on the floodplain are either dismantled or moved to a site away from the flood-prone area. Roads, railroads, telephone, and sewerage utilities also would have to be removed from the floodplain. Floodplain acquisition can be used to retire land that frequently floods to preclude Federal disaster payments, allow levee setbacks, or limit use of the land. However, all measures must be economically, environmentally, and socially defensible and technically sound. All long-term benefits must be weighed against the cost of continued damage on an average annual basis.
- **Flood Warning Systems**—A flood emergency preparedness system consists of a warning mechanism and a response plan. The implementation of flood warning systems is a long-term goal for many of the governmental agencies within the Upper Turkey Creek Basin.
- **Floodplain Ordinance**—The City of Merriam has a floodplain ordinance to ensure compliance with the FEMA NFIP. The City of Merriam must modify the existing ordinance or otherwise adopt a resolution that establishes the FMP, which will be drafted in conjunction with this study, as a formal planning document for managing floodwaters and the floodplains in the city.
- **Stream Setback or Buffer Ordinance**—Offsetting streams for the dedicated use by floodwater conveyance and environmental enhancement is a wise activity to consider and can be combined with structural measures. Within these areas or zones, the use of environmental features, including native plants and bioengineered stabilized stream banks, allow natural water quality improvement processes. These techniques also encourage infiltration of water to the groundwater table. Compatible uses, including parks and sports fields, are part of this type of policy. The policy can be reinforced with a stream setback/buffer, designated through an established offset

distance from the stream bank. This type of activity supports the beneficial use of floodplains and is considered wise use of the floodplain.

- **Freeboard Ordinance**—New development of finish floor elevations, by Kansas State law, must be a minimum of one foot above the base flood water surface, as defined by the NFIP. However, in some locations, communities adopt higher distances, which results in wider floodplains. These areas can then be left to support beneficial functions of floodplains.
- **Floodplain Management Plan**—An FMP is a living document (updated regularly) that explains flood risks, historical decisions about managing the flood risks, and, most importantly, a list of action items with specific details about what, who, and when the actions items will be conducted. The FMP will provide the public with better understanding of the residual risks of the alternative that is selected for any USACE construction cost sharing. The FMPs are policies used by FEMA and USACE. The USACE requires sponsors to have one as a condition for receiving construction funding. FEMA hazard mitigation grant programs and the NFIP Community Rating System (CRS) also require them. Besides the USACE criteria, the CRS criteria will be satisfied, and if the City engages in more eligible CRS activities, then not only will flood insurance premiums be reduced but also the public will better understand flood risks. The sponsor will prepare the Floodplain Management Plan coincident with design phase.
- **Emergency Action Plan**—The response to a flood event can be planned in advance within an Emergency Action Plan (EAP). Considerations such as evacuation routes, rally points for flood fight personnel, and other details can be established in an EAP. Plans such as this should be referenced in FMPs, and usually each should be a stand-alone document.
- **Local Hazard Mitigation Plan**—This type of plan may address all natural hazards, not just flooding. The preparation of such a plan allows a community to target repetitive loss properties, possibly for engaging FEMA hazard mitigation grants and for buyouts when a window of opportunity opens after a flood event. These plans must be completed in advance of events to be eligible for hazard mitigation grants. An FMP could be a sub-chapter or large section of such a plan. Note that county-wide plans are typically too broad to capture all the actionable items within an FMP, and a county-level mitigation plan may make a community less safe and unable to score higher points in the FEMA CRS.

4.4.2 ECOSYSTEM RESTORATION AND RECREATION MEASURES

Early in the study, ecosystem restoration measures were considered for potential multipurpose plan formulation throughout the watershed, but no cost-sharing sponsors were identified as willing to participate. However the data gathered in this early phase are very useful in facilitating a thorough understanding of the environmental conditions in the watershed. Recreation measures were not formulated, but consideration was given for accommodation of sponsor recreation features that will not impact project purposes. This primarily applies to accommodation of sponsor desires to maintain or, in some locations, expand a trail along Turkey Creek.

4.5 EVALUATION OF PROJECT SITES AND MEASURES

The initial plan formulation concepts that guided early portions of the feasibility study were based on producing a plan and report that addressed all areas within the study area. This approach began in the abbreviated studies conducted during the reconnaissance phase, which indicated the possibility of system-wide alternatives.

The initial broad feasibility evaluations of existing conditions undertaken during the first several years of this study allowed subsequent formulation efforts more focus. The development of measures was

narrowed to alternatives that indicated significant risk, offered the best opportunity for significant flood risk management improvements, and had the greatest potential for economic return on investment. These alternatives also were reviewed for compatibility with the basic planning objectives and constraints that emphasized the desirability of a relatively uniform level of flood risk management across the system.

The results of the preliminary evaluation of the project sites and measures considered and discussed in Section 4.3 and Section 4.4 include:

4.5.1 PROJECT SITES

Interstate 35 Project Site—Preliminary flood risk management measures were developed along the portion of I-35 most prone to flooding but were eliminated from further consideration because there was no likelihood of significant damage reduction. A state and locally managed flood response plan currently in place appears to be the most feasible alternative for the I-35 site. As a result, the I-35 project site was not carried forward in the development of flood risk management alternatives.

Roe Land Industrial Park Project Site—The Roe Lane Industrial Park project site flood risk management measures were developed but the UG found resources to be too strained to pursue a flood risk management project. As a result, the Roe Lane Industrial Park project site was not carried forward in the development of flood risk management alternatives.

Merriam Reach Project Site—The Merriam Reach project site was carried forward in the development of Alternative 1, Channel Widening; Alternative 2, Levees/Floodwalls; and Alternative 3, Combination. The City of Merriam is an active partner with a strong interest in flood risk management.

4.5.2 STRUCTURAL FLOOD RISK MANAGEMENT MEASURES

Off-Line Impoundment Detention—A preliminary investigation was performed of several tributaries to Upper Turkey Creek by review of aerial photography and selected site visits to locate potential areas for off-line impoundment/detention.

To achieve a reduction in discharge on the order of 45 to 50 percent of the 1 percent AEP flow, it is estimated that flood storage in excess of 1,000 acre-feet would be required. The areas along the tributaries in this watershed contain no significant open space to provide the potential flood storage required to reduce flooding in Merriam or downstream.

Significant property acquisition would be necessary to create the required volume of flow storage of approximately 1,000 acre-feet. Depending upon depth, this would require an area of at least 100 acres in zones that could affect the hydrograph, and realistically more than that. The Upper Turkey Creek watershed is highly developed and the volume of open space required to achieve a significant reduction in peak discharges to reduce flood elevations would require the acquisition of developed real estate. The cost of land acquisition, relocations, construction, and application of USACE Dam Safety criteria would make any such measures cost prohibitive in this watershed. This acquisition would likely exceed the cost of the Buy-Out non-structural plan. As a result, this measure was eliminated from further consideration in the development of alternatives. A similar evaluation was performed during the initial planning phases for the Lower Turkey Creek Basin project (currently under construction) with the same result.

In-line Impoundment/Detention—It was initially attempted to store potential flood flows within upstream watershed areas of Turkey Creek by creating flood storage within existing or proposed over bank areas of Upper Turkey. Analysis was conducted using HEC-1 on two potential in-line storage areas, identified as Area 1 and Area 2. Area 1 was from approximately 70th Street to 75th Street and Area 2 was from approximately 76th Street to 80th Street. It is estimated that the 1 percent AEP discharges would have to be reduced as much as 45 to 50 percent in order to remain within the channel. In order to achieve

a reduction in discharge on the order of 45 to 50 percent of the 1 percent AEP event, it is estimated that flood storage in access of 1,000 acre-feet would be required. Several alternatives were analyzed using different volumes and depths for Area 1 and Area 2.

After extensive work with both the HEC-1 and HEC-RAS models, it was determined that the available volume of flood storage in these two proposed storage areas are not sufficient to significantly reduce peak flood flows in the flood damage areas. The ability to significantly increase the volume of storage necessary to effectively reduce the peak discharges and reduce water surface elevations was not feasible. The areas along the main stem of Upper Turkey Creek and its tributaries contain limited open space to provide the potential flood storage required to reduce flooding in Merriam. Because of the high urbanization of the Upper Turkey Creek Basin and its narrow and steep nature, the availability of useful detention basin sites is limited. The area of open space, from review of aerial photography, does not appear adequate for the total estimated volume required. Therefore, land acquisition would be necessary to create the required volume of flow storage of approximately 1,000 acre-feet. The Upper Turkey Creek watershed is highly developed and the volume of open space required to achieve a significant reduction in reducing peak discharges to reduce flood elevations would require the acquisition of developed real estate. This acquisition would likely exceed the cost of the Buy-Out plan and was therefore eliminated from further consideration. As a result, this measure was eliminated from consideration in the development of alternatives. A similar evaluation was performed during the initial planning phases for the Lower Turkey Creek Basin project (currently under construction) with the same result.

Levees—Based on the review of the channel cross sections and hydraulic analyses, it was determined that levees between two and six feet in height could provide protection for up to a 1 percent chance of discharge with the possibility of larger levees for greater discharges. As a result, this measure was retained in the development of Alternative 2, Levees/Floodwalls; and Alternative 3, Combination. Levees by themselves require a wider footprint than floodwalls and real estate and existing buildings are a constraint. Therefore, levees and floodwalls were only considered in combination in the development of Alternative 2, Levees/Floodwalls; and Alternative 3, Combination.

Flood Walls—The preliminary review of channel cross sections and hydraulic analyses indicated that flood walls would be a viable measure for flood risk management in areas where there was insufficient space for construction of levees. As a result, this measure was retained in the development of Alternative 2, Levees/Floodwalls; and Alternative 3, Combination. However, an alternative utilizing floodwalls only was not considered due to a higher overall cost to construct floodwalls in comparison to the cost to construct levees. Therefore, floodwalls and levees were only considered in combination in the development of Alternative 2, Levees/Floodwalls; and Alternative 3, Combination.

Bridge Retrofit or Replacement—The preliminary evaluation indicated that the Merriam Drive and Shawnee Mission Parkway crossings would require modifications since both the 10 and 1 percent AEP events overtop the bridge, and the constriction causes a two-foot rise in water surface elevation in the upstream storm profile. As a result, the modification of these crossings was retained in the development of Alternative 1, Channel Widening; and Alternative 3, Combination.

Channel Modifications—Hydraulic analyses indicated that channel modifications, either alone or in conjunction with levees and floodwalls, would have potential for significant flood risk reduction. As a result, this measure was retained in the development of Alternative 1, Channel Widening; and Alternative 3, Combination.

Flood Diversion Around Structure—A flood diversion tunnel was considered and evaluated in the development of alternatives, but was eliminated from further consideration in the development of alternatives. The cost for a diversion tunnel was estimated at approximately $200 million and a drop shaft and detention facilities would also be required at additional costs. The diversion would need to operate by

gravity flow while only removing 40 percent of the peak flows in downtown Merriam. The intensive investment, topography and geology in the study area precluded this from being a practical measure. As a result, this measure was eliminated from consideration in the development of alternatives. A similar evaluation was performed during the initial planning phases for the Lower Turkey Creek Basin project (currently under construction) with the same result.

4.5.3 NONSTRUCTURAL FLOOD RISK MANAGEMENT MEASURES

Flood Warning Systems—Integration of a flood warning system across jurisdictional boundaries was investigated because the effectiveness or acceptability of some of the nonstructural flood risk management solutions may be affected by the accuracy and reliability of flood warning. A flood warning system is an integrated package of equipment, plans, procedures, and human resources that permits its users to:

- Detect and recognize a flood hazard early in its existence, prior to the point at which lives and property are at imminent risk
- Notify those whose lives and/or property are at risk
- Make wise decisions and respond in a timely, efficient manner to the near-future flooding
- Make wise decisions about how to recover from flooding, once the threat has passed

In August 2002, the Johnson County SMP retained a project team led by the Peridian Group to complete a study to determine the feasibility of a flood warning/flood forecasting system in Johnson County, Kansas. If the system were determined to be feasible, the next step would be to develop an implementation plan and identify the potential costs.

The result of this work is StormWatch, a website maintained cooperatively by Johnson County with the local communities. The flood warning system feature was not used to formulate alternatives in which there would be a Federal cost share interest. The August 2002 Johnson County SMP study determined that the implementation of a website, StormWatch, maintained cooperatively by Johnson County with the local communities was a feasible plan for a flood warning/flood forecasting system in Johnson County, Kansas.

A dedicated flood warning system for the Turkey Creek watershed was not developed by local governments nor considered for detailed plan formulation, primarily because StormWatch already has precipitation and stream gages in Merriam. There was not a likely Federal interest in further expansion of the system to a Federally cost shared flood warning system. Because of this and the flash flooding occurring in as little as 30 minutes, a dedicated flood warning system solely for the Turkey Creek watershed was not considered practical by the community or the Corps of Engineers.

In addition to StormWatch, the KDOT has developed a smarter traffic control system in the I-35 reach of Johnson County, one that better communicates with the public. KDOT constructed a series of electronic signs to communicate transportation-related messages to travelers on the highways in the entire Kansas City metropolitan area, including I-35 in Johnson County and the City of Merriam. This tool, KC Scout, could be linked with StormWatch to enhance communication techniques, possibly even leveraging KC Scout's website and electronic cameras. Planners have approached KDOT about combining these tools to address flood hazards where Turkey Creek and I-35 overlap. Because KDOT and Johnson County already have significantly advanced these tools, this was not carried further into plan formulation.

Flooding along the I-35 corridor, just upstream of the Wyandotte/Johnson County line, occurs for storms as frequent as the 10 percent AEP event at select portions of the roadway. Flood risk management measures were developed along the portion of I-35 most prone to flooding but were eliminated from

further consideration. Structural measures would not have the ability to significantly reduce flood damages. KDOT's KC Scout and Johnson County's StormWatch are considered by the local agencies as adequate nonstructural measures at this time. The USACE will continue to coordinate with these agencies as this project moves forward and as other opportunities for addressing flood risk may arise.

Limited Floodplain Buyout—Some additional consideration was given to more limited buyout alternatives, focused on areas with the highest concentrations of expected flood damages. It was determined that these alternatives would not offer as much net economic benefit as the structural alternatives and would not be locally acceptable, due to the economic void that would be left in downtown Merriam.

Floodplain Evacuation or "Buyout"—The property buyout alternative is considered a nonstructural flood risk management alternative. The floodplain buyout alternative was carried forward for further consideration in plan formulation. Generally, home buyouts involve those homes located within the flood zone being bought and demolished or transported to a safer location. The associated costs with this alternative are the acquisition of the structure at fair market value and the costs to demolish or relocate these units. There are various benefits that can result from structure buyouts in an affected area: the reduction of damage to public property, the reduction of emergency costs during a flood, the reduction of administrative costs during a flood, reoccupation costs, and the reduction in flood insurance subsidies to communities. Usually, several public meetings are conducted by a watershed-wide coalition to outline the plans and answer residents' specific questions.

Other Nonstructural Measures—The other nonstructural flood risk management measures were considered early in the study and are described above in Section 4.3.1.2, including flood proofing, flood insurance, zoning codes, stream setback ordinances, and public education, but they were not carried further into plan formulation. These measures were not effective at protecting existing development comparable to the protection that would be provided by structural alternatives. As a result, these measures were eliminated from consideration in the development of alternatives. However, through the efforts of this study and other efforts in cooperation with FEMA and Silver Jackets, the education of the community regarding flood risks is ongoing. Johnson County has proactively pursued and implemented stream setback ordinances that encourage wiser use of the floodplain.

The results of the preliminary evaluation of the other nonstructural measures considered and discussed in Section 4.3 include:

- **Dry Flood Proofing**—Features applied to a structure, or adjacent to a structure, to prevent entrance of flood waters. The depth of flooding for the 1 percent AEP event was compared to the first floor elevations of the structures within the Upper Turkey Creek floodplain. A majority of the structures would be subject to a depth of flooding in the 5 foot to 7 foot range. The number of structures within the floodplain and the feasibility of constructing individual ring levees, or erecting permanent flood barriers for each property were determined to be impractical based upon the wide diversity of construction types among structures, the short time of concentration, less than six hours, and flashy nature of the stream and watershed.

- **Wet Flood Proofing**—Features applied to a structure and/or its contents that prevent flooding, or damage from flooding, by allowing flood water to enter the structure. This was also eliminated as a feasible alternative as most of the structures first floors are below flood stage, and again the short time of concentration to peak would not provide sufficient time to remove or raise equipment, above the flood elevation.

- **Elevation**—Lifting of existing structures to an elevation greater than flood elevations using fill material, extended foundation walls, piers, posts or piles. A majority of the structures within the

projects area(s) are light industrial/commercial and have loading docks and floors at ground level for the operations, which would make raising of the structures impractical.

- **Relocation**—Physical movement of at-risk structures out of the flooding area and buying land upon which the structure is located. The water shed is extremely developed and the number of structures which would be required to be re-located exceeds the amount of available vacant land within the immediate project area.

4.5.4 ECOSYSTEM RESTORATION AND RECREATION MEASURES

Ecosystem Restoration Measures—Early in the study process preliminary ecosystem restoration measures were considered throughout the watershed in anticipation of a potential multipurpose project. The ecosystem restoration measures were not carried forward or used to formulate because there was no local sponsor with an interest in cost-sharing ecosystem restoration measures.

Recreation Measures—Recreation measures were not formulated, but consideration was given for accommodation of sponsor recreation features that will not impact project purposes. This primarily applies to accommodation of sponsor desires to maintain or, in some locations, expand a trail along Turkey Creek.

4.5.5 MEASURES SCREENING REVIEW

The preliminary screening of measures allows the planning team to narrow the list of measures most suitable to mitigating the flood hazards. How the study team applied the criteria to various measures allows the reader to better understand the plan formulation conclusions. The process is described below and is provided to show how the study team applied the criteria to various measures prior to development of the preliminary array of alternatives.

Measures that meet the criteria the most received this symbol: ◉

The symbol constitutes (and depicts) a bull's eye and means the measure is "Highly Effective" or "Recommended" in meeting planning objectives and should be formulated into an alternative for this study.

Measures that meet the criteria fairly well received this symbol: ◓

The symbol means the measure is "Effective" in meeting planning objectives.

Measures that may meet the criteria received this symbol: ○

The symbol means the measure is "Neutral" or possibly "Further Evaluation Needed" as to how the measure may meet planning objectives. Study funding often limits the ability to fully evaluate this. Other realities are that a hypothetical model may not exist to allow a determination on the measure's possible performance.

Measures that do not really meet the criteria received this symbol: ◒

The symbol means the measure is "Not Recommended" in meeting planning objectives.

Measures that cannot meet the criteria use this symbol: ●

The symbol means the measure is "Not Recommended" and more definitively defeats or detracts from meeting planning objectives. Specific meaning of each metric is described in the following table.

Table 4-1: Supporting Definitions of Screening Criteria

Screening Criteria	Metric[1]	Notes
Completeness	Highly effective Effective Neutral Not effective Not effective and detracts from objectives	• Extent to which a given measure provides and accounts for all necessary investments or other actions • A complete measure includes all elements necessary to function independently to achieve the planning objectives
Effectiveness	Highly effective Effective Neutral Not effective Not effective and detracts from objectives	• Overall effectiveness of a measure in maintaining an acceptable level of flood risk management in the Upper Turkey Creek project area based on technical analysis, such as with a model, to the USACE mission area, whether flood risk management or ecosystem restoration • Conceptual measures were assessed to determine their potential to contribute substantially to the overall effectiveness of any alternative
Environmental Effects	Highly effective Effective Neutral Not effective Not effective and detracts from objectives	• Produce an environmentally sustainable project • Component of overall effectiveness
Social Effects	Highly effective Effective Neutral Not effective Not effective and detracts from objectives	• Criteria for how this satisfies the project's planning objectives • Component of overall effectiveness
Acceptability	Highly effective (publically acceptable) Effective Neutral Not effective with some social controversy Not effective and detracts from objectives (unacceptable to many stakeholders)	• Indicators of acceptability include controversy and potential effects on community cohesion and compliance with policy
Implementability	Highly effective Effective Neutral Not effective Not effective and detracts from objectives	• This is about compatibility with policies at the local, state or federal level and consideration of issues that could affect the ability to implement the measure or alternative • Constructability with common methods • Ability of local sponsor to support within or without the municipalities boundaries or ability to fund the measure • Degree of inter-local collaboration needed to achieve the measure either on multiple properties or throughout a watershed
Cost	Highly effective (costs are achievable) Effective Further study needed Not effective (costs high and likely not budgetable) Not effective and detracts from objectives	• First cost of project, costs of local operations and maintenance and long-term residual costs • Basis is available funding ability from local, county, state or federal, or a combination • Sponsor capital improvement plan sets the

Screening Criteria	Metric[1]	Notes
	(Costs are too excessive)	neutral threshold around $5.8 million • Federal is variable • Considered in relation to efficiency and acceptability
Risk	Highly effective (reduces risk) Effective Further study needed Not effective Not effective and detracts from objectives	• Uncertainties, vulnerabilities, and potential consequences of the measure • How measure address flood risks • Risk is the probability multiplied by the consequence • Effective measures reduce flood risk, though some risk remains • Workability and viability of a measure as part of a formed alternative are part of the criteria
Separable Mitigation	High effective (mitigatable) Effective Neutral Not effective Not effective and detracts from objectives	• Need for compensatory mitigation under Clean Water Act • Is mitigation possible • Effects to project cost
Cost Effectiveness	Highly effective (costs very low) Effective Further study needed Not effective Not effective and detracts from objectives (costs very high)	• Compares expected economic benefits and estimated costs of alternatives • Primary in consideration of federal interest
Floodway Conveyance Considerations	Highly effective Effective Neutral Not effective Not effective and detracts from objectives	• Avoidance of impacts to established conveyance
Sustainability Considerations	Highly effective Effective Neutral Not effective Not effective and detracts from objectives	• Consideration of sustainable measures and activities for the viability of the community (i.e., health and safety, minimal maintenance, willing project sponsor)

[1]The symbol legend (Highly effective to Not effective and detracts from objectives):

In addition to the evaluation and discussion of the project sites and measures eliminated and project sites and measures carried forward in Sections 4.5.1 through 4.5.4 the table below represents preliminary screening. The table juxtaposes the criteria against the full spectrum of structural and nonstructural measures. Only the flood risk management screening is presented. As the planning process develops, new information is often found. The screening represented conditions found at the time the planning work was done.

Table 4-2: Screening Against Planning Criteria for Flood Risk Management Measures[1]

Measure	Completeness	Effectiveness	Environmental Effects	Social Effects	Acceptability	Implementability	Cost	Risk	Separable Mitigation	Cost Effectiveness	Floodway Conveyance Considerations	Sustainability Considerations	Notes
STRUCTURAL													
Off-line Impoundment / Detention	●	◒$_1$	○	●	◒	●	○	◒	◓	○	⊙	◓	1) Not enough land area and volume available
In-line Impoundment / Detention	◒	◒$_1$	◒	◒	◓	○	○	◒	○	○	⊙	◓	1) No volume available
Levees$_3$	◓	⊙	◓	◓	◓	○	◓	◓	⊙	⊙	◓$_2$	◓	2) No negative change in flood conveyance
Floodwalls$_3$	◓	⊙	◓	◓	◓	◓	○	○	⊙	◓	◓$_2$	◓	2) No negative change in flood conveyance
Bridge Retrofit or Replacement (widening)$_3$	⊙	⊙	◓	⊙	◓	◓	◓	◓	⊙	◒	⊙	◓	(No note)
Channel Modifications (widening)$_3$	◓	◓	◒	◒	◓	○	◒	◓	◒	◒	⊙	◓	(No note)
Flow Diversion	○	◒	●	○	◓	●	●	○	◒	●	○	○	Affects base flow

[1]The symbol legend (Highly effective to Not effective and detracts from objectives): ⊙ ◓ ○ ◒ ●

$_3$ Carried forward in the development of flood risk management alternatives.

Table 4-2: Screening Against Planning Criteria for Flood Risk Management Measures (Continued[1]

Measure	Completeness	Effectiveness	Environmental Effects	Social Effects	Acceptability	Implementability	Cost	Risk	Separable Mitigation	Cost Effectiveness	Floodway Conveyance Considerations	Sustainability Considerations
NONSTRUCTURAL												
Flood Proofing												
Dry flood proofing	○	◒	○	○	◒	●	○	○	NA	○	◉	◉
Wet flood proofing	○	◒	○	○	◒	◒	○	◒	NA	○	◉	◉
Elevation	○	◒	◓	○	○	○	○	○	NA	○	◉	◉
Relocation	●	◓	◓	●	◒	◒	○	◓	◓	○	◓	○
Flood Warning Systems	○	◒	◉	○	◒	○	○	◒	NA	◉	NA	◉
Floodplain Evacuation or "Buyout"[3]	●	◓	◓	●	○	○	●	◓	◓	●	◉	○

[1]The symbol legend (Highly effective to Not effective and detracts from objectives): ◉ ◓ ○ ◒ ●

[3] Carried forward in the development of flood risk management alternatives.

No cost share partner stepped forward for the ecosystem restoration. The study had a significant effort developing ecosystem restoration strategies in the watershed for the purpose of

- Channel bottom armoring (prevent down-cutting)
- Removal of obstructions to fish passage
- Detention basin retrofits for water quality
- Opened up enclosed channels
- Bioengineered stream banks
- Re-establish floodplain to channel connectivity
- Rainfall infiltration

The results appear in two interim reports done for the non-Federal sponsor and the adjacent communities. These reports are located in Appendix J.

4.6 PRELIMINARY ARRAY OF ALTERNATIVE PLANS

Based on the identified problems and opportunities, project goals, objectives, and conditions in this study area, measures with the greatest potential for meeting planning objectives were formulated into alternative plans. The planning steps of formulating, evaluating, and comparing alternative plans were accomplished iteratively as information about the alternatives developed. The product of this process was to establish the alternatives for the evaluation step in the P&G six step planning process.

4.6.1 STRUCTURAL FLOOD RISK PLAN FORMULATION

The capacity of the Turkey Creek channel was evaluated with respect to the hydraulic analyses, watershed urbanization, and structures subject to flood hazards. Structural measures reduce flood risk by modifying the characteristics of the flood. They are often employed to reduce peak flows (flood storage), direct floodwaters away from flood prone property (flood barriers), or facilitate flow of water through or around an area (channel modification or diversions). All of these features have the potential to reduce flood damages; however, not all are likely to be appropriate in every situation.

A flood risk management alternative plan for the study area could involve replacing bridges, retrofitting one bridge, channel widening, channel benching, constructing vertical channel walls where space is too constrained for widening or benching, and making plans for minor evacuation.

Based upon judgment and existing conditions analyses, the structural flood risk management measures retained were used to develop basic series of alternative concepts or “themes” that would be necessary for the alternatives to address the planning objectives.

- Alternative 1 Concepts: Channel Widening
- Alternative 2 Concepts: Levees / Floodwalls
- Alternative 3 Concepts: Combination of Channel Widening and Levees / Floodwalls

4.6.2 NONSTRUCTURAL FLOOD RISK PLAN FORMULATION

The Federal government has endeavored to support nonstructural approaches (such as flood warning systems, flood-proofing of structures, floodplain management, and property buyout). Nonstructural approaches have merit when the site characteristics and the flooding threat are compatible with the nonstructural capabilities and found acceptable to stakeholders. Additionally, it may be possible to

combine nonstructural and structural measures to improve the overall level of flood risk management. The ability for this to be feasible depends on the specific conditions of the area being considered.

Based upon judgment and existing conditions analyses, the nonstructural flood risk management measures retained were used to develop a nonstructural alternative concept or "theme" that would be necessary for the alternatives to address the planning objectives.

- Alternative 4 Concept: Buyout

The planning team conducted a real estate cost analysis for the inundation area of the 1 percent AEP event, or the NFIP base flood extents. This floodplain buyout alternative used the following assumptions.

- Properties within the 1 percent AEP floodplain that were affected by improvements or use were considered a complete take. The minimum land take was estimated at $5,000.
- A cursory examination of the project improvements and lands was completed to determine the Land, Easement, Right-of-Ways, Relocations, and Disposal areas (LERRDs). Some structures were eliminated if not located within the 1 percent AEP floodplain.
- Appraised values were obtained from the County Appraiser's Office. The appraised values are considered consistent with current values. Values missing from appraiser's data were calculated at a value of $50,000/acre if over the $5,000 minimum.
- Relocation was estimated in 2008 and will be recalculated in the Real Estate Plan during the Gross Appraisal.
- A 25 percent contingency was included in the total real estate value.
- Non-Federal sponsor incidental costs associated with acquisition were estimated based on required components, such as appraisals, tract surveys, legal support, and additional Public Law 91-646 cast. Due to level of detail for this alternative, a set amount of 10 percent of total costs including contingency was used.
- No cost for utility, railroad, or road relocations was included based on level of detail of this alternative. Mapping indicated that all three are impacted by the 1-perent AEP flood and could cause significant costs to relocate.

4.6.3 DEVELOPMENT OF FLOOD RISK MANAGEMENT ALTERNATIVES

The study team performed preliminary technical analysis of proposed measures and evaluated these using the screening criteria to focus on the most implementable alternatives. Those measures that appeared to be most viable with respect to planning criteria were refined and further developed. Using the information developed, the study team compared the alternatives to each other to screen out inferior plans and identify the most feasible and beneficial plans. Initial screening results were presented to the non-Federal sponsor in November 2009. This discussion was used to narrow the alternatives further.

Three basic series or concepts of structural alternatives were developed: Channel Widening Alternatives, Levees and Floodwalls Alternatives, and Combination Channel Widening and Levees/Floodwalls Alternatives and one nonstructural alternative was developed, Buyout.

Alternative 1: Channel Widening—Channel widening was considered as a flood abatement measure in areas where overbank expansion was available. Because the majority of the channel currently has a hard slate bottom, channel bottom deepening was minimized. The proposed channel bottom width was kept constant, wherever possible, with a maximum side slope in most areas of 2H:1V (or horizontal: vertical), which allows the channels to be lined with either biostabilization, rip rap or concrete block measures. Areas that require steeper slopes in excess of 1H:1V would be treated with hardened revetments, such as

pre-cast retaining wall block or the local limestone blocking currently used by MDD in the Merriam downtown stream reaches. For the Merriam and Roe Lane Industrial Park reaches, channel widening was considered with rip rap slope protection as well as biostabilization. Bridge modifications were also considered in channel widening alternatives.

Alternative 2: Levees and Floodwalls—A levee is a compacted and engineered earthen embankment. For this study, practical levee dimensions ranged from heights of 2 to 7 feet high and practical proportional footprints ranging from 2 to 3H to 1V. Floodwalls were used when overbank area or proximity to structures precluded a levee footprint. The proposed floodwalls would consist of a reinforced concrete retaining wall generally with a minimum thickness of two feet. Bridge modifications were not considered a part of this alternative.

Alternative 3: Combination of Channel Widening and Levees/Floodwalls—The combination alternative minimizes the required channel width by introducing either a levee or a floodwall where needed. A combination of channel widening and levee walls was considered and could be more cost effective than levees or floodwalls alone, while providing better flood protection than channel widening alone. The channel widening component of the combination alternative included rip rap slope stabilization, biostabilization slope protection, and necessary bridge modifications.

The biostabilization slope protection measures considered in the early development of Alternative 1, Channel Widening; and Alternative 3, Combination were not carried forward for further evaluation due to the excessive cost of operation and maintenance for these features and their lack of reliability at withstanding flows compared to less costly structural alternatives considered. Although not evaluated in detail, it is not expected that the biostabilization would substantially improve the overall environmental quality of the Turkey Creek watershed.

Alternative 4: Non-structural: Buyout—Once structures in the floodplain are removed, they are no longer subject to flood damages. There are many considerations associated with a property buyout including demolition, relocation, and other costs. The floodplain can be considered for restoration after a property buyout would be implemented.

4.7 EVALUATION TOOLS

Evaluation tools are described, as follows, from the feasibility study's quality assurance or review plan. The project delivery team (PDT) used the following planning models in the development of this study:

Table 4-3: Upper Turkey Creek Planning Models

Model Name and Version	Brief Description of the Model and Application
HEC-FDA 1.2.4	The Hydrologic Engineering Center's Flood Damage Reduction Analysis (HEC-FDA) software provides the capability to perform an integrated hydrologic engineering and economic analysis during the formulation and evaluation of flood risk management plans. The HEC-FDA is designed to assist USACE PDT members in using risk analysis procedures for formulating and evaluating flood risk management measures (EM 1110-2-1619, ER 1105-2-101).
IWR-PLAN 1.0.11.0	The Institute for Water Resources' (IWR) Planning Suite is a model that assists with formulating plans, cost-effectiveness, and incremental cost analysis, which are required in ecosystem restoration projects and any compensatory mitigation.
Habitat Suitability Index Models: Green Sunfish	For use in doing cost effectiveness and incremental cost analysis of the Clean Water Act compensatory mitigation for the affected stream.
Habitat Suitability Index	For use in doing cost effectiveness and incremental cost analysis of

Model Name and Version	Brief Description of the Model and Application
Models: Fox Squirrel	the Clean Water Act compensatory mitigation for the affected forested area.

The PDT used the following engineering models in the development of the study:

Table 4-4: Upper Turkey Creek Engineering Models

Model Name and Version	Brief Description of the Model and Application
HEC-1, version 4.1	The PDT used the USACE Hydrologic Engineering Center's model to reevaluate peak flows of Turkey Creek at specified locations, screen out detention basins as possible features in alternatives as a means as reducing peak discharges and resultant water surface elevations; use for load points to HEC-RAS existing conditions analysis and proposed improvements.
HEC-RAS 4.0	The PDT used the USACE Hydrologic Engineering Center's River Analysis System to establish peak water surface elevations for a range of probabilities (8 profiles) for existing and proposed alternatives input for HEC-FDA (see below).

A HEC-RAS model was developed for the project area consistent with the recently adopted Johnson County flood insurance study, and included the addition of the Roe Lane Industrial Park project site in Wyandotte County. Once the storm frequency flood profiles were developed, the extent of flooding was generated and analyzed using a GIS. Software tools for the determination of the discharges were developed and applied. GIS was used to identify the extent of the proposed alternatives, impact on properties and structures, land ownership, easement areas required, existing utility information, and existing and proposed floodplains. GIS also was used as a tool in the development of cost estimates for the various alternatives and ecological restoration measures.

The evaluation and comparison of structural flood risk management alternatives involved the identification of the most critical areas of flooding and occurrence of flood damages and determination of the best alternative for flood risk management. This study focused on the areas where damages and losses are greatest and most amenable to practical damage reduction measures.

Flood frequency analysis is required to identify the flood magnitude for each return period. Therefore, a comprehensive flood frequency analysis has been carried out for the entire project area. The HEC-RAS model was used to determine flood inundation depth in the floodplain areas. The model was developed to predict discharges and water levels of each reach for different return periods of floods in existing situation and mitigation plan alternatives.

Flood damage estimation in inundated areas is one of the key parts of the flood studies. In order to provide an accurate damage amount, a flood damage survey was performed in the most critical areas of the floodplains in addition to gathering historical data of damage from recent floods. Therefore, estimating potential damage must be based on the vulnerability of the region as a method of damage analysis. A GIS database was built using maps and the results from the model.

The planning team conducted physical, habitat, and biological data collection and evaluation in representative reaches throughout Upper Turkey Creek in May and June 2005. These data were then used to develop an overall stream health assessment ranking for approximately 100 reaches on the Upper Turkey Creek and its tributaries. Several additional environmental tools were also used for evaluation of

potential restoration measures. The KDWP's Aquatic Habitat Model and Terrestrial Habitat Model along with the Kansas Stream Mitigation Guidance (KSMG) were used to evaluate aquatic and terrestrial resources. These data were not used for further plan formulation but were used to assess the watershed system and potential effects of flood risk measures.

4.7.1 PERIOD OF ANALYSIS

In addition to the existing conditions of 2012, a base condition and a future condition were analyzed. The base year for the economic analysis, i.e., the year when the project would be completed and operational, is 2018. The future condition year is 2042.

In this analysis, the economic database for the existing condition also was used to characterize the base and future conditions. These conditions initially were defined separately to allow the addition of planned development late in the study completion period based on the most current information about future development. Because economic development plans potentially affecting the future without-project condition tend to be fluid and speculative, assumptions in this area were established as late in the study as possible. Ultimately, however, no imminent projects that met the criteria for inclusion were identified: (a) high likelihood of implementation, (b) firm identification of a location, and (c) availability of information on industrial classification and estimated investment. Therefore, the economic database used in the existing conditions analysis was carried through to the base and future conditions without change.

Annualized estimates of damages, benefits and costs in this analysis assumed the FFY 2012 Federal interest rate of 4.000 percent and a period of analysis of 50 years based on official guidance for evaluation of Federal levees. All estimates are expressed in October 2011 prices unless otherwise noted.

4.7.2 MODELING

A hydrologic model (HEC-1) and a hydraulic model (HEC-RAS) are each combinations of models first begun by Johnson County Public Works models between 2005 and 2009 to update FEMA FIRMs and the USACE around 2005 and 2006 for Turkey Creek reaches within Wyandotte County. The consulting engineer firm, Larkin, contracted with Johnson County creating those models for results presented in the northeast Johnson County watershed study, and Larkin also did similar work for the USACE (as part of work in-kind credit to the sponsor, Merriam) in Wyandotte County. The products received external review with Dr. Parr of the University of Kansas. They are described as combinations because the latest updates were taken by the USACE planning team around 2009 to enhance the modeling tools to evaluate planned alternatives.

The versions of both the hydrologic and hydraulic model are approved and certified according to USACE guidance. The planning team used HEC-1 version 4.1 to reevaluate peak rainfall runoff flows of Turkey Creek at specified locations, screen out detention basins as possible features in alternatives as a means as reducing peak discharges and resultant water surface elevations, and use for the load points to HEC-RAS existing conditions analysis and proposed improvements. The flood risk management alternatives were analyzed using HEC River Analysis System, or HEC-RAS 3.1.3. The HEC-RAS is software developed by the USACE to conduct one-dimensional steady flow river hydraulic calculations. As mentioned in Section 3.2.3, the base of the existing Upper Turkey Creek feasibility study existing condition model was the hydraulic HEC-RAS model. The alternatives were initially formulated for the 10-, 2-, and 1 percent AEP events. For levee and flood wall alternatives and combination alternatives, 0.5- and 0.2 percent AEP events were also considered. Bridge modifications are required for some alternatives and are discussed below.

The flood risk management alternatives were then analyzed using two planning models. The first is FDA (HEC-FDA) software developed by the USACE for doing risk analysis. The second is the Institute for Water Resources' (IWR) Planning Suite, a model that assists with analyzing cost effectiveness.

The HEC-FDA software, version 1.2.4, provides the capability to perform an integrated hydrologic engineering and economic analysis during the formulation and evaluation of flood risk management plans, following Federal and USACE policy regulations (ER 1105-2-100 and ER 1105-2-101). HEC-FDA uses discharge-exceedance probability, stage-discharge, and damage-stage functions and applies Monte Carlo simulation to compute expected damage and account for uncertainty. According to policy, newly constructed Corps levees are essentially assumed to be structurally reliable up to the point of overtopping. For any event in which the levee is overtopped, the overtopping would be enough to exceed the design of the levee and render any associated structural problems moot. After any flood event that damages the levee, there would be a potential need for repair, rehabilitation, and/or replacement; the OMRR&R component of the annual costs is intended to account for costs such as these. Therefore, the HEC-FDA model assumes the newly constructed levees and floodwalls to be structurally reliable throughout the 50-year period of analysis.

Mitigation options to meet requirements for compensatory restoration were evaluated using the USACE Institute for Water Resources IWR Planning Suite software. The IWR Planning Suite software was version 1.0.11.0, and is a Certified Decision Support Software to assist with the formulation and comparison of alternative plans. Specifically the model does cost effectiveness and incremental costs analysis (CE/ICA), identifying the plans which are the best financial investments. IWR Planning Suite can assist with plan formulation by combining solutions to planning problems and calculating the additive effects of each combination, or "plan;" however, the compensatory restoration options that were evaluated for Upper Turkey Creek were viewed as mutually exclusive from one another. So the compensatory restoration options were evaluated only in comparison to each other, without evaluating combinations of restoration options.

4.7.3 PERFORMANCE MEASURES

The economic analysis identifies the extent of the economic impact from flooding with existing and future without project conditions and, on a comparable basis, evaluates the range of plans to reduce flood damages considered in the study. The analysis first requires a risk-based analysis of the flood problem under the existing condition. The future without project condition is then determined and, finally, a risk-based evaluation in terms of benefits, costs, and performance of the various alternatives under the with-project condition is completed. The analysis encompasses all flood-prone properties within the study area.

The process includes damage cost assessment for different flood levels in various plans separately. It was therefore necessary to conduct a cost/benefit analysis for the alternative flood mitigation schemes and select the best alternative by means of flood risk management based analysis and cost assessment.

The HEC-FDA software was used in the benefit analysis for the various mitigation alternatives. A risk-based damage analysis was conducted to identify annual benefits of a certain mitigation alternative, and economic assessment was performed based on cost/benefit analysis to select the best alternatives. HEC-FDA software was used in this study for the following purposes:

- Determination of expected benefits of the proposed flood mitigation plans with regards to expected damage reduction by implementing the plan in comparison with not implementing the plan condition
- Description of the uncertainty of computing probability versus discharge, discharge versus stage, and damage versus stage and determining the effects in reducing the damages

A flood mitigation plan can decrease damages by reducing discharge, stage, or damage susceptibility. The net benefit of these plans can be calculated by a costs/benefits analysis of a project in optimum design flood. The optimum return period of design flood can be determined by a trade-off between construction costs and operational benefits in certain plans considering risk of failure of the structure.

The average annual **without-project damage** is calculated in the HEC-FDA program, using water-surface profile data and floodplain property inventory data. The average annual **with-project damage** (residual damage) is also calculated in HEC-FDA, using water-surface profile data and floodplain property inventory data.

Benefit = Without-Project Damage – With-Project Damage

The average annual **cost** is determined by annualizing the project's initial cost and adding the expected average annual cost of operations and maintenance.

Benefit-Cost (BC) Ratio = Benefit ÷ Cost

Net Benefit = Benefit - Cost

In Figure 4-2 the hypothetical **NED plan** is the plan with the highest **net benefits**.

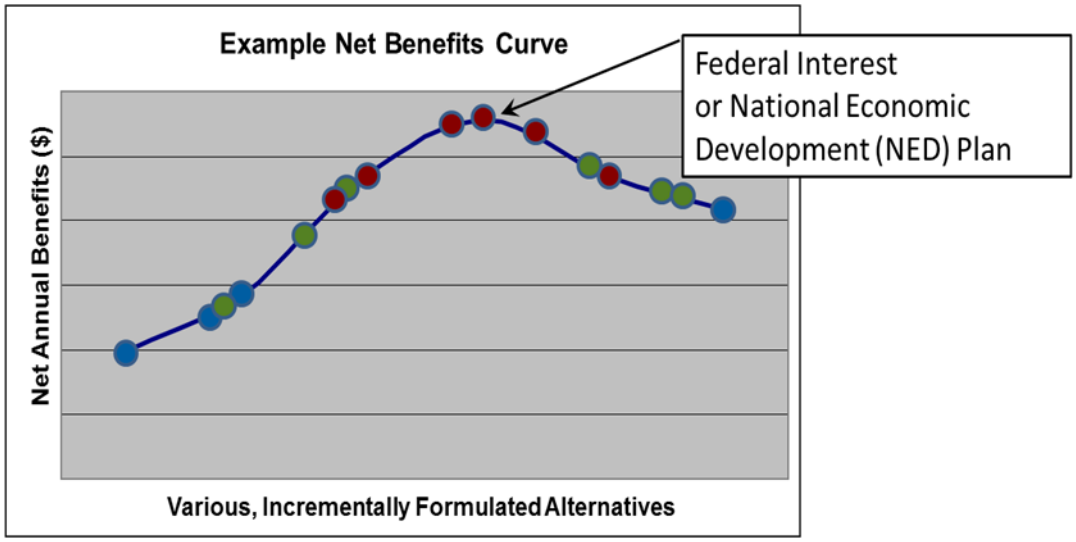


Figure 4-2: Net Benefits Curve

The current document focuses on economic impacts; however, it is important to consider environmental, social, and economic impacts as part of the planning process.

5 CHAPTER 5 – ALTERNATIVE EVALUATION AND COMPARISON

The fourth and fifth steps of the six-step planning process are evaluation and comparison. The process further develops the plan formulation work from the third step. Within this chapter, the planning team determines cost estimates for each alternative based on the measures used to develop that alternative. Benefits, or flood damages prevented, also are taken into account. The process allows the planning team to identify the alternative that maximizes the net annual benefits. The planning team conducted iterative analyses of alternatives and generally what is reflected in the final array were evaluated in the interim step as well, with two slightly modified alternatives added in the final array.

5.1 FORMULATION OF FINAL ARRAY OF ALTERNATIVES

NOTE: At this point in the report we have adopted the term annual chance of exceedance, abbreviated as "ACE", when referring to the magnitude of specific flood events. The term annual exceedance probability, abbreviated as "AEP", is applied to the performance of a project in terms of the risk of the design being exceeded by a flood event. The capacity in the Merriam Reach of the Turkey Creek channel was evaluated and served as a basis for formulation of alternatives for reducing flood risk and damages. The HEC-RAS model indicates that the majority of the Turkey Creek channel that passes through the City of Merriam can contain the 20 percent ACE flood event, although two areas flood at the 50 percent ACE event. It is estimated that the 1 percent ACE-event flows would have to be reduced as much as 45 to 50 percent in order to remain within the channel.

In order to evaluate projects of differing performance levels to serve as an adequate basis for comparison and cost-benefit analysis, several scales of three structural alternative concepts were evaluated that would pass different discharges. Using all of the information developed, conceptual designs and cost estimates were prepared for an array of structural alternatives for the Merriam Reach project site.

The Alternative 1 concept is Channel Widening (Figure 5-1); Alternative 2 concept is Levees and Floodwalls (Figure 5-2); Alternative 3 concept is a Combination of Channel Widening and Levees/Floodwalls (Figure 5-3); and Alternative 4 is the Property Buy-Outs (Figure 5-4). Several flow capacity levels were used to formulate plans within each of the alternative concepts 1 through 3. Alternative 1, Channel Widening, and Alternative 3, Combination of Channel Widening and Levees/Floodwall, were evaluated with and without modifications to major bridge structures within the downtown Merriam area. Table 5-1 includes a description and comparison of the final array of alternatives that were carried forward through the full screening.

Based on a review of the Merriam channel cross section and hydraulic analyses, the planning team observed that levees between approximately two and six feet in height could provide protection for up to the 1 percent ACE event. However, the addition of levees alone would not contain the floodwaters within the channel. The Merriam Drive and Shawnee Mission Parkway culverts create a rise in the water surface elevation of the various storm profiles and result in floodwaters overtopping the roads.

The Merriam Drive and Shawnee Mission Parkway bridges would require modifications because both the 10 percent ACE and 1 percent ACE events overtop the bridge, and the constriction causes a two-foot rise in water surface elevation in the upstream storm profile.

Analysis during formulation revealed that for Alternative 2c (with levees and floodwalls) had 86 percent reliability in passing the 1 percent discharge. It was desirable for this alternative array to consider an additional plan that would have at least a 90 percent or greater reliability in passing the 1 percent ACE discharge, and so an additional alternative plan was developed for that level of performance and evaluated. A description of the alternative arrays evaluated is summarized below and in Table 5-1.

Merriam Alternative 1 Array: Channel Widening

The channel widening alternative array (Figure 5-1) was considered varying levels of design using channel bottom widths ranging from 40 to 100 feet and varying side slopes throughout downtown Merriam. Structural modifications were also considered to the Shawnee Mission and Merriam Drive bridges, including increasing the bridge span across the creek, removing the existing culverts that were replaced with piers, and raising the bridge deck to allow flows to pass without overtopping the bridge decks. The pedestrian bridge at RS 3.568 was modified under Alternatives 1d and 1e to span 160 feet with a vertical clearance height of four feet to help reduce flood levels at the upstream bridge section. The intent of Alternative 1, Channel Widening, was to modify only those sections that could not accommodate specific levels of discharge. Project concept design cross sections for individual projects are included in Appendix B.

The following Channel Widening alternatives were considered for Merriam under the Alternative 1 concept, Channel Widening:

- **Alternative 1**: Channel Widening
  - 1a: Bottom width 40-46 ft, 3:1 side slope, existing bridges, 10,500 cfs flow capacity
  - 1b: Bottom width 60 ft, 2:1 side slope, with existing bridges, 14,700 cfs flow capacity
  - 1c: Bottom width 60 ft, 2:1 side slope, with bridge modifications, 14,700 cfs flow capacity
  - 1d: Bottom width 100 ft, 2:1 side slope, with existing bridges, 15,300 cfs flow capacity
  - 1e: Bottom width 100 ft, 2:1 side slope, with bridge modifications, 15,300 cfs flow capacity

Merriam Alternative 2: Levees/Floodwalls

Alternative 2, Levees/Floodwalls (Figure 5-2), involves the installation of concrete floodwalls and/or earthen levees in the downtown Merriam project area and considered five levels of design using the existing overbank area for floodway flow, thus increasing the distance between the levee walls. The pedestrian bridge at RS 3.568 was modified under the Alternatives 2b, 2c, 2d, 2e, and 2f to span across the new levee walls.

As a result of levees and floodwalls, local drainage systems often back-up and result in localized flooding of stormwater behind the systems. To address this issue, the inclusion of a flap gate on drainage outfalls is necessary. In addition, the development of a ponding area behind the levee system is required. Concept design cross sections for individual projects are included in Appendix B.

The following Levees/Floodwalls alternatives were considered for Merriam under the Alternative 2 concept, Levees/Floodwalls:

- **Alternative 2**: Levees/Floodwalls
  - 2a: 8,500 ft of levee and floodwall up to 4 ft high, top-of-levee (TOL) elevation of 917.11 at RM 3.298
  - 2b: 8,500 ft of levee and floodwall up to 5 ft high, TOL elevation of 920.05 at RM 3.298
  - 2c: 8,500 ft of levee and floodwall up to 6 ft high, TOL elevation of 920.49 at RM 3.298
  - 2d: 8,500 ft of levee and floodwall up to 6 ft high, TOL elevation of 920.98 at RM 3.298
  - 2e: 8,500 ft of levee and floodwall up to 6 ft high, TOL elevation of 921.21 at RM 3.298
  - 2f: 8,500 ft of levee and floodwall up to 8 ft high, TOL elevation of 922.78 at RM 3.298

Merriam Alternative 3: Combination Channel Widening and Levees/Floodwalls

Under Alternative 3, Combination Channel Widening and Levees/Floodwalls rip rap would be used for stabilization. Projects concept design cross sections are included in Appendix B.

Under this alternative, varying levels of design were considered using channel bottom widths ranging from 40 to 120 feet and varying side slopes throughout downtown Merriam. Levee and floodwall systems were used in sections to either contain flood flows or provide a one-foot level of freeboard protection. Protection heights generally remained at or below three feet, including one foot of freeboard. Levee and wall heights are considerably lower than those proposed under Alternative 2 because of the reductions in water surface elevations that occur due to the channel widening described under Alternative 1. Structural modifications were also considered to the Shawnee Mission and Merriam Drive bridges, including increasing the bridge span across the creek, removing the existing culverts that were replaced with piers, and raising the bridge deck to allow flows to pass without overtopping the bridge decks. The pedestrian bridge at RS 3.568 was modified under Alternatives 3b, 3c, 3d, and 3e to help reduce flood levels at the upstream bridge section.

The following Combination Channel Widening and Levees/Floodwalls alternatives were considered for Merriam under the Alternative 3 concept, Combination Channel Widening and Levees/Floodwalls:

- **Alternative 3**: Combination Channel Widening and Levees/Floodwalls
  - 3a: 50 ft channel bottom, 3,600 ft of levee and floodwall up to 3 ft high and TOL elevation of 916.36 at RM 3.298, with existing bridges
  - 3b: 60 ft channel bottom, 9,100 ft of levee and floodwall up to 3 ft high and TOL elevation of 917.80 at RM 3.298, with existing bridges
  - 3c: 60 ft channel bottom, 8,100 ft of levee and floodwall up to 3 ft high and TOL elevation of 916.86 at RM 3.298, with bridge modifications
  - 3d: 100 ft channel bottom, 4,400 ft of levee and floodwall up to 3 ft high and TOL elevation of 916.64 at RM 3.298, with existing bridges
  - 3e: 100 ft channel bottom, 1,700 ft of levee and floodwall up to 3 ft high and TOL elevation of 915.93 at RM 3.298, with bridge modifications

Alternatives of the Alternative 3 concept larger than Alternatives 3d and 3e were not carried through the full screening of alternatives due to diminishing economic benefits. The residual damages in the reach protected by the levee (Reach 3b) with Alternative 2e are only 2.1 percent of the without-project damages.

Merriam Alternative 4: Property Buy-Outs

Consideration was given to nonstructural alternatives that could provide benefits of flood risk management, reduction of future potential flood damages, and lower long-term costs to the federal government.

Floodplain acquisition can be used to retire land that frequently floods to preclude Federal disaster payments, allow levee setbacks, or limit use of the land. However, all measures must be economically, environmentally, and socially defensible and technically sound. All long-term benefits must be weighed against the cost of continued damage on an average annual basis.

Using GIS, the 1 percent ACE event inundation polygon was intersected with property owners for the Merriam Reach project site to determine the affected parcels. If the 1 percent ACE event affected the current use of a property, the entire parcel was considered to be taken, both land and improvements. If an insignificant portion of a parcel was in the 1 percent ACE event, but its current use remained intact, a

minimum estimate of $5,000 was considered to be representative. Values missing from appraisers' data were calculated at a value of $50,000 per acre if over the $5,000 minimum.

Table 5-1: Final Array of Alternatives

Alternative	Channel Widening	Levees/Floodwalls	Bridge Modifications
Alternative 1: Channel Widening			
1a	• Average bottom width = 40-60 feet • Average side slope = 3H:1V	NA	NA
1b	• Average bottom width = 60 feet • Average side slope = 2H:1V	NA	NA
1c	• Average bottom width = 60 feet • Average side slope = 2H:1V • Channel modifications upstream of Shawnee Mission Road to improve the transition of the channel to the wider bridge opening.	NA	Merriam Drive Bridge: • The 53-foot-bridge span was increased to 88 feet with four equally spaced piers. The bottom of the deck was raised 1 foot to accommodate the 2 percent ACE-event flows. Shawnee Mission Road Bridge: • The four existing 14-foot wide culverts were removed and replaced with a 210-foot span supported by six piers spaced at 30-foot intervals.
1d	• Average bottom width = 100 feet • Average side slope = 2H:1V	NA	NA

Alternative	Channel Widening	Levees/Floodwalls	Bridge Modifications
1e	• Average bottom width = 100 feet • Average side slope = 2H:1V • Channel modifications upstream of Shawnee Mission Road to improve the transition of the channel to the wider bridge opening.	NA	Merriam Drive Bridge: • The 53-foot bridge span was increased to 88 feet with four equally spaced piers. The bottom of the deck was raised 1 foot to accommodate the 2 percent ACE-event flows. Shawnee Mission Road Bridge: • The four existing 14-foot wide culverts were removed and replaced with a 210-foot span supported by six piers spaced at 30-foot intervals.
Alternative 2: Levees/Floodwalls			
2a	NA	Left Bank: • 1,500 feet of floodwall (2 to 4 feet high; average 10 feet bottom width) • 1,600 feet of levee (2 to 4 feet high; 20- to 30-foot bottom width) Right Bank: • 4,000 feet of floodwall (2 to 3 feet high; average 10-foot bottom width) • 1,400 feet of levee (2 to 3 feet high; 20- to 25-foot bottom width)	NA

Alternative	Channel Widening	Levees/Floodwalls	Bridge Modifications
2b	NA	Left Bank: • 1,000 feet of levee/floodwall (5 feet high; 35-foot levee bottom width; average 10-foot floodwall bottom width) • 450 feet of levee (4 feet high; 30-foot bottom width) • 1,800 feet of floodwall (4 feet high; average 10-foot bottom width) Right Bank: • 1,500 feet of levee/floodwall (3 to 5 feet high; 25- to 35-foot levee bottom width; average 10-foot floodwall bottom width) • 1,750 feet of levee (5 to 6 feet high; 35- to 40-foot bottom width) • 1,000 floodwall (4 feet high; average 10-foot bottom width) • 1,100 feet of floodwall (3 feet high; average 10-foot bottom width)	NA
2c	NA	Left Bank: • 1,000 feet of levee/floodwall (5 feet high; 35-foot levee bottom width; average 10-foot floodwall bottom width) • 450 feet of levee (4 feet high; 30-footbottom width) • 1,800 feet of floodwall (3 feet high; 10-foot average bottom width) Right Bank: • 1,500 feet of levee/floodwall (3 to 5 feet high; 25- to 35-foot levee bottom width; 10-foot floodwall average bottom width) • 1,750 feet of levee (5 and 6 feet high; 35- to 40-foot bottom width) • 1,000 floodwall (4 feet high; average -foot bottom width) • 1,100 feet of floodwall (3 feet high; average 10-foot bottom width)	NA

Alternative	Channel Widening	Levees/Floodwalls	Bridge Modifications
2d	NA	Left Bank: • 700 feet of levee/floodwall (5 feet high; 35-foot levee bottom width; average 10-foot floodwall bottom width) • 450 feet of levee (4 feet high; 30-foot bottom width) • 280 feet of floodwall (5 feet high; average 10-foot bottom width) • 800 feet of floodwall (6 feet high; average 10-foot bottom width) • 1,800 feet of floodwall (3 feet high; average 10-foot bottom width) Right Bank: • 2,050 feet of levee/floodwall (5 to 6 feet high; 35- to 40-foot levee bottom width; average 10-foot floodwall bottom width) • 1,500 feet of levee/floodwall (4 feet high; 30-foot wide levee bottom width; average 10-foot floodwall bottom width) • 400 feet of levee (5 feet high; 35-foot bottom width) • 1,000 floodwall (4 feet high; average -foot bottom width) • 1,100 feet of floodwall (3 to 5 feet high; average 10-foot bottom width)	Pedestrian Bridge Located at River Mile/Station 3.568: Modification to span 175 feet across the new levee walls
2e	NA	Left Bank: • 1,400 feet of levee (4 to 6 feet high; 30- to 40-foot bottom width) • 3,300 feet of floodwall (4 to 6 feet high; average 10-foot bottom width) Right Bank: • 500 feet of levee (4 to 6 feet high; 30- to 40-foot bottom width) • 6,500 feet of floodwall (4 to 6 feet high; average 10-foot bottom width)	NA

Alternative	Channel Widening	Levees/Floodwalls	Bridge Modifications
2f	NA	Left Bank: • 500 feet of levee (5 to 8 feet high; 35- to 50-foot bottom width) • 4,600 feet of floodwall (5 to 8 feet high; average 10-foot bottom width) Right Bank: • 500 feet of levee (5 to 8 feet high; 35- to 50-foot bottom width) • 6,500 feet of floodwall (5 to 8 feet high; average 10-foot bottom width)	NA
Alternative 3: Combination Channel Widening and Levees/Floodwalls			
3a	• Average bottom width = 50 feet • Average side slope = 3H:1V • Increased channel bottom width of 70 feet to several channel sections downstream of Shawnee Mission Parkway to accommodate mainstem and tributary flows	Left Bank: • 300 feet of levee (2 feet high; 20-foot bottom width) Right Bank: • 3,300 feet of levee/floodwall (1 to 3 feet high; average 10-foot bottom width)	NA
3b	• Average bottom width = 60 feet • Average side slope = 2H:1V • Increased channel bottom width of 90 to 120 feet to several channel sections downstream of Shawnee Mission Parkway to accommodate mainstem and tributary flows	Left Bank: • 3,600 feet of levee/floodwall (1 to 3 feet high; 15- to 25-foot levee bottom width; average 10-foot floodwall bottom width) Right Bank: • 5,500 feet of levee/floodwall (3 to 5 feet high; 25- to 35-foot levee bottom width; average 10-foot floodwall bottom width)	NA
3c	• Average bottom width = 60 feet • Average side slope = 2H:1V • Increased channel bottom width to several channel sections upstream and downstream of Shawnee Mission Parkway to transition to and from the modified 210-foot bridge opening • Increased channel bottom width to 95 feet immediately upstream and downstream of Merriam Drive Bridge 1H:1V side slopes	Left Bank: • 2,900 feet of levee/floodwall (1 to 3 feet high; 15- to 25-foot levee bottom width; average 10-foot floodwall bottom width) Right Bank: • 5,200 feet of levee/floodwall (3 to 5 feet high; 25- to 30-foot levee bottom width; average 10-foot floodwall bottom width)	Shawnee Mission Parkway Bridge: • Enlarged to span 210 feet across 6 piers Merriam Drive Bridge: • Enlarged to span 88 feet across 4 piers Pedestrian Bridge Located at River Mile/Station 3.568: • Modification to span 114 feet across the new levee walls

Alternative	Channel Widening	Levees/Floodwalls	Bridge Modifications
3d	• Average bottom width = 100 feet • Average side slope = 2H:1V • Increased channel bottom width of 90 to 120 feet to several channel sections downstream of Shawnee Mission Parkway to accommodate mainstem and tributary flows	Left Bank: • 900 feet of levee/floodwall (2 to 4 feet high; 20- to 30-foot levee bottom width; average 10-foot floodwall bottom width) Right Bank: • 3,500 feet of levee/floodwall (3 to 5 feet high; 25- to 35-foot levee bottom width; average 10-foot floodwall bottom width)	Pedestrian Bridge Located at River Mile/Station 3.568: • Modification to span 167 feet across the new levee walls
3e	• Average bottom width = 100 feet • Average side slope = 2H:1V • Increased channel bottom width to 200 feet between to accommodate the new bridge openings • Increased channel bottom width to 95 feet immediately upstream and downstream of Merriam Drive Bridge 1H:1V side slopes	Left Bank: • 400 feet of levee/floodwall (2 feet high; 20-foot levee bottom width; average 10-foot wide floodwall bottom width) Right Bank: • 1,700 feet of levee/floodwall (1 to 3 feet high; 15- to 25-foot levee bottom width; average 10-foot floodwall bottom width)	Shawnee Mission Parkway Bridge: • Enlarged to span 210 feet across 6 piers Merriam Drive Bridge: • Enlarged to span 179 feet across 7 piers Pedestrian Bridge Located at River Mile/Station 3.568: • Modification to span 160 feet across the new levee walls

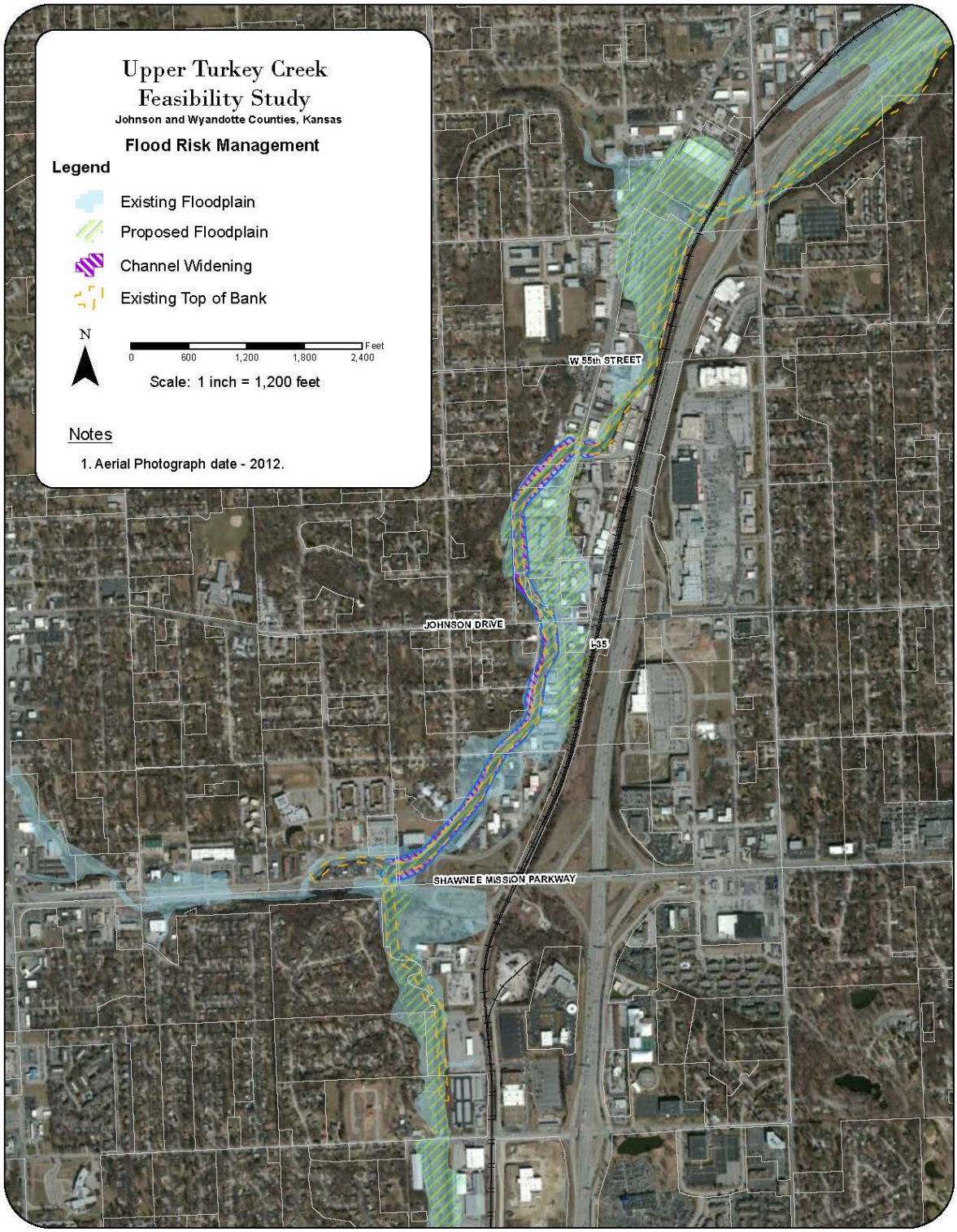


Figure 5-1: Alternative 1: Channel Widening

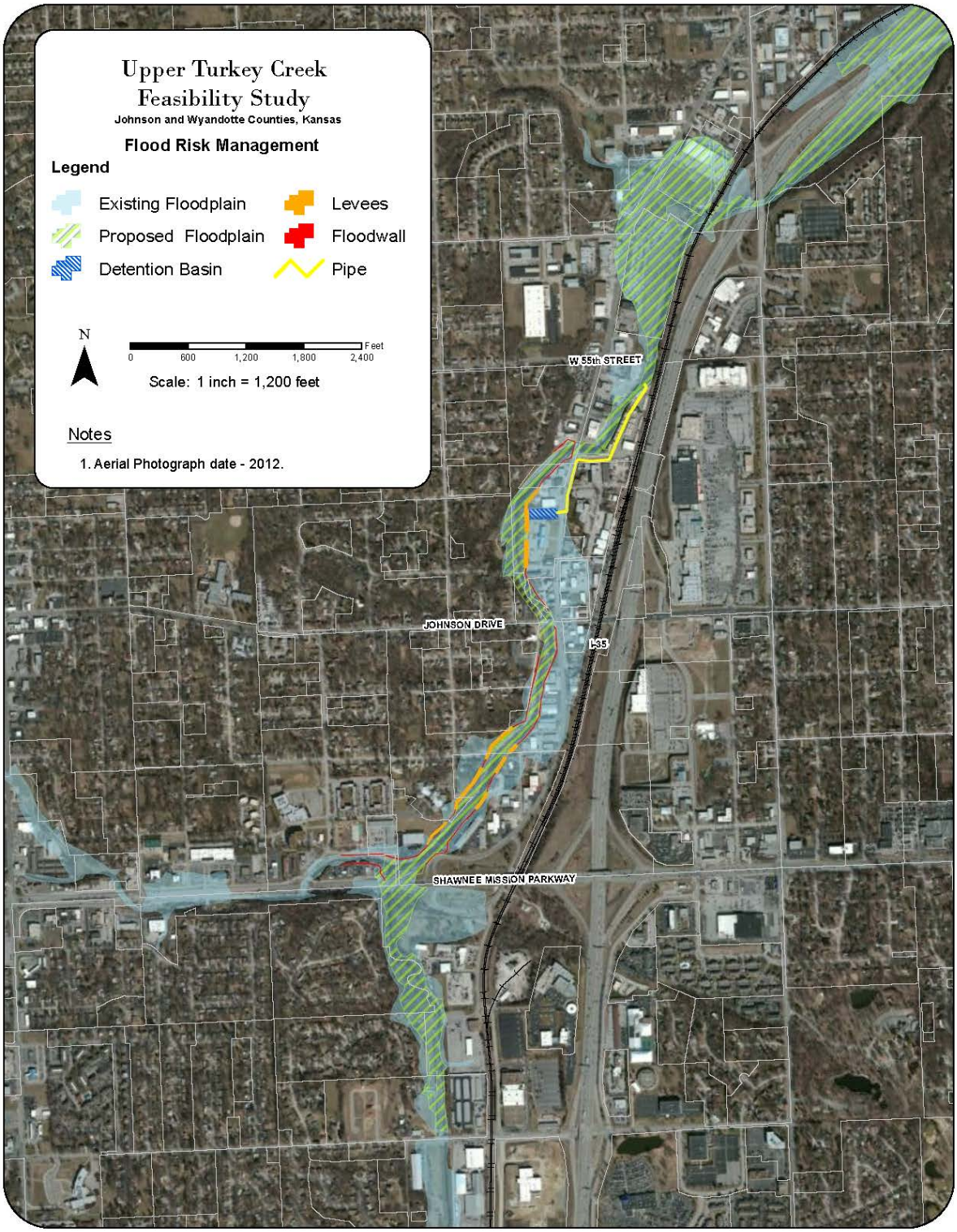


Figure 5-2: Alternative 2: Levees/Floodwalls

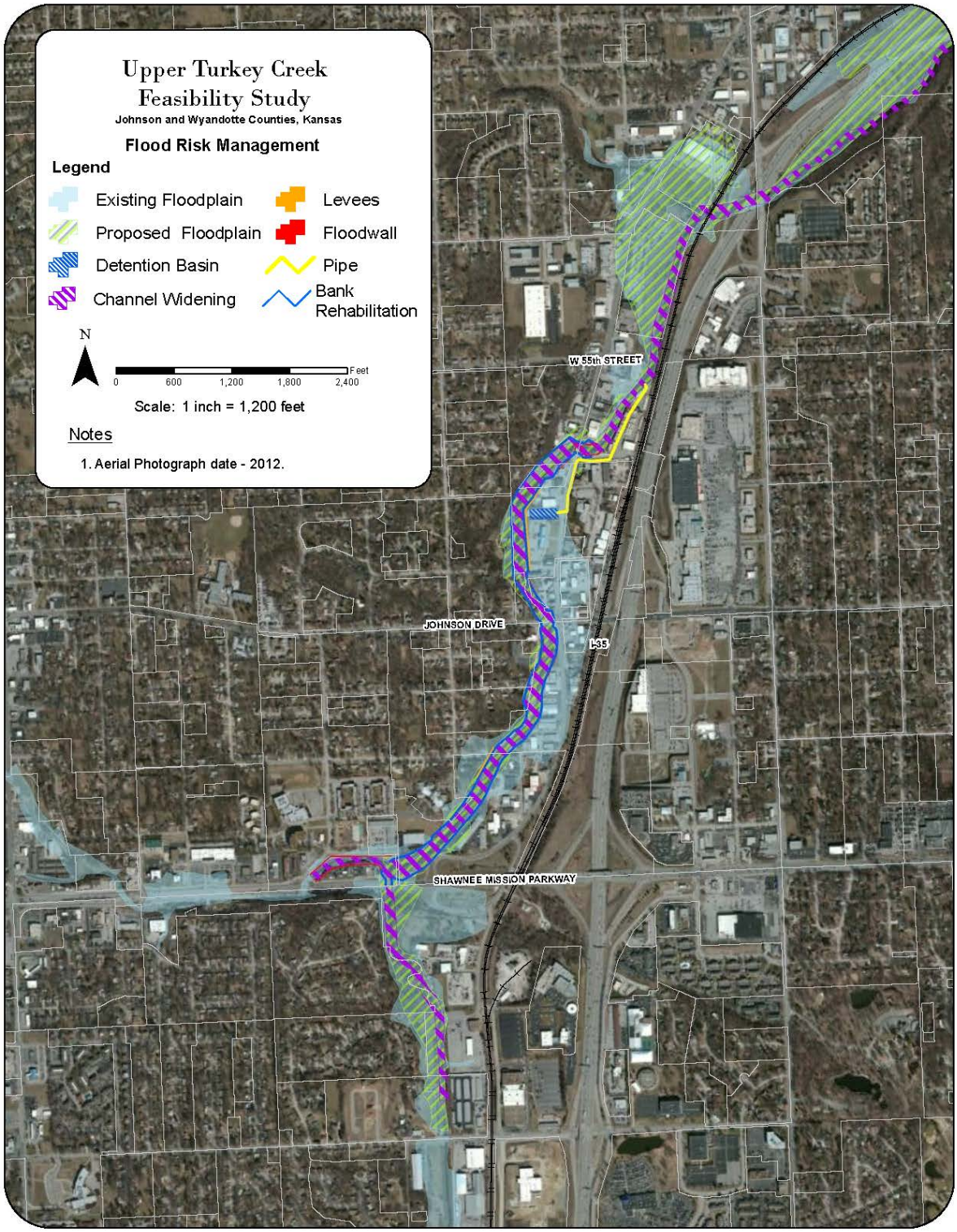


Figure 5-3: Alternative 3: Combination

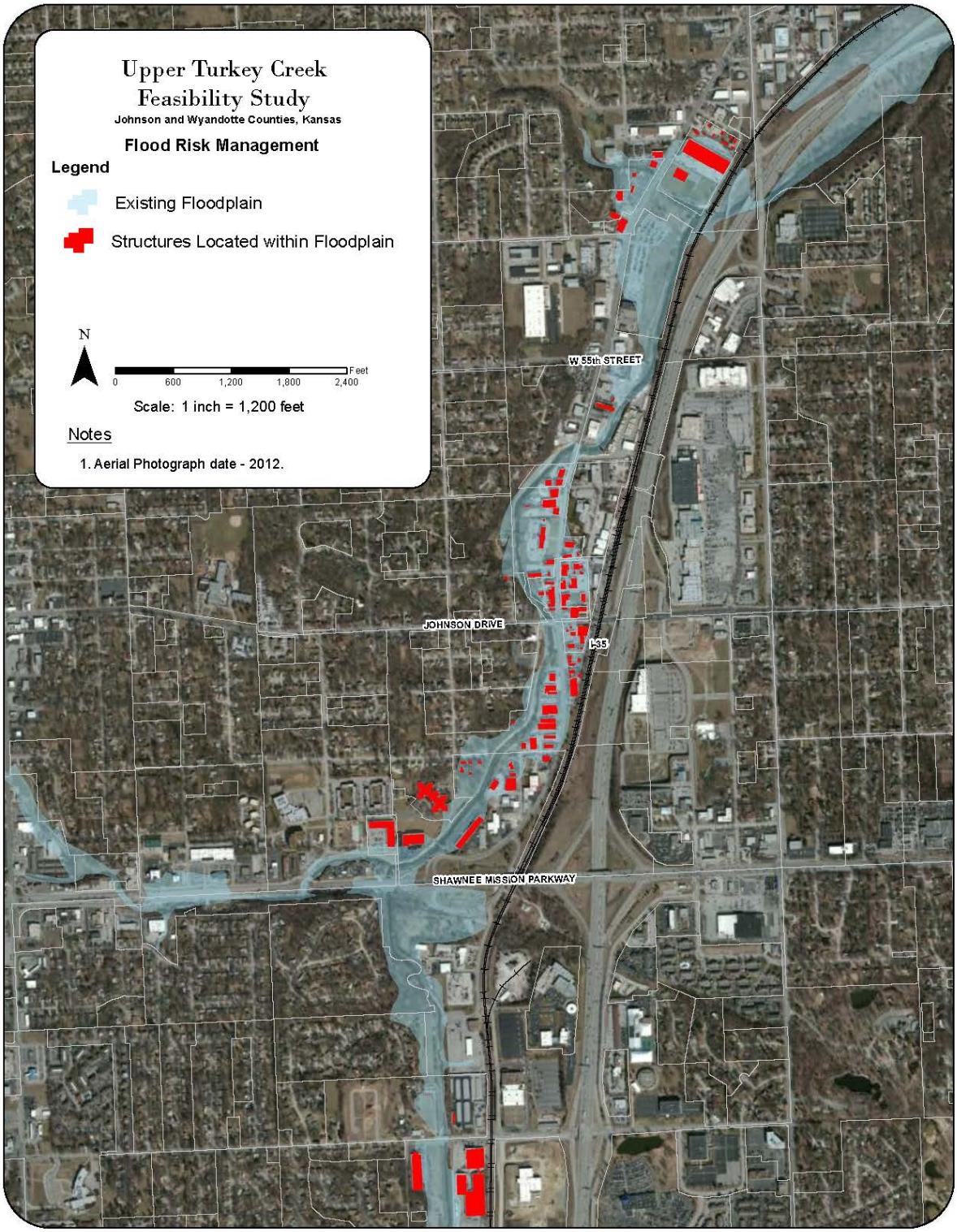


Figure 5-4: Alternative 4: Property Buy-Outs

5.2 EVALUATION OF FINAL ARRAY OF ALTERNATIVES

Alternatives were examined and compared considering the Federal criteria for completeness, efficiency, effectiveness, and acceptability. As alternatives passed through this evaluation and screening process, the economic analysis of each alternative's incremental cost was used as a ranking factor in the final selection. Having passed review for engineering adequacy, environmental and public acceptability, and other evaluation criteria as described below, the remaining alternative with the highest net benefits to the national economy was identified as a component of the overall recommended National Economic Development (NED) Plan.

The development and screening of alternatives involved the consideration of a number of evaluation factors or criteria previously discussed in Section 4.2, *Planning Criteria*.

The following Channel Widening alternatives were considered in the final array for Merriam:

- **Alternative 1**: Channel Widening
  - **Alternative 1a:** Bottom width 40-46 ft, 3:1 side slope, existing bridges, 10,500 cfs flow capacity
  - **Alternative 1b:** Bottom width 60 ft, 2:1 side slope, with existing bridges, 14,700 cfs flow capacity
  - **Alternative 1c:** Bottom width 60 ft, 2:1 side slope, with bridge modifications, 14,700 cfs flow capacity
  - **Alternative 1d:** Bottom width 100 ft, 2:1 side slope, with existing bridges, 15,300 cfs flow capacity
  - **Alternative 1e:** Bottom width 100 ft, 2:1 side slope, with bridge modifications, 15,300 cfs flow capacity

The following Levees/Floodwalls alternatives were considered in the final array for Merriam:

- **Alternative 2**: Levees/Floodwalls
  - **Alternative 2a:** 8,500 ft of levee and floodwall up to 4 ft high, TOL elevation of 917.11 at RM 3.298
  - **Alternative 2b:** 8,500 ft of levee and floodwall up to 5 ft high, TOL elevation of 920.05 at RM 3.298
  - **Alternative 2c:** 8,500 ft of levee and floodwall up to 6 ft high, TOL elevation of 920.49 at RM 3.298
  - **Alternative 2d:** 8,500 ft of levee and floodwall up to 6 ft high, TOL elevation of 920.98 at RM 3.298
  - **Alternative 2e:** 8,500 ft of levee and floodwall up to 6 ft high, TOL elevation of 921.21 at RM 3.298
  - **Alternative 2f:** 8,500 ft of levee and floodwall up to 8 ft high, TOL elevation of 922.78 at RM 3.298

The following Combination Channel Widening and Levees/Floodwalls alternatives were considered for Merriam:

- **Alternative 3**: Combination/Channel Widening and Levees/Floodwalls
  - **Alternative 3a:** 50 ft channel bottom, 3,600 ft of levee and floodwall up to 3 ft high and TOL elevation of 916.36 at RM 3.298, with existing bridges

- **Alternative 3b:** 60 ft channel bottom, 9,100 ft of levee and floodwall up to 3 ft high and TOL elevation of 917.80 at RM 3.298, with existing bridges
- **Alternative 3c:** 60 ft channel bottom, 8,100 ft of levee and floodwall up to 3 ft high and TOL elevation of 916.86 at RM 3.298, with bridge modifications
- **Alternative 3d:** 100 ft channel bottom, 4,400 ft of levee and floodwall up to 3 ft high and TOL elevation of 916.64 at RM 3.298, with existing bridges
- **Alternative 3e:** 100 ft channel bottom, 1,700 ft of levee and floodwall up to 3 ft high and TOL elevation of 915.93 at RM 3.298, with bridge modifications

Alternative 4, Property Buy-Outs, was also considered in the final array of alternatives.

5.2.1 ECONOMIC EVALUATION

NED Analysis of Benefits and Costs

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. 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. NED costs represent the costs of diverting resources from other uses in implementing a flood-risk management project, as well as the costs of economic losses resulting from detrimental effects of a project. Such other detrimental effects of a project could include, for example, induced flooding in areas other than the project study area.

Residual Damages and Benefits of Screening Alternatives

For the screening of alternatives, the future condition with- and without-project equivalent annual damages (EAD) were calculated with risk and uncertainty in the HEC-FDA program reflecting October 2011 prices and the FY 2012 Federal interest rate of 4.000 percent. This section, and the table below, shows the benefits of each alternative and the with-project equivalent residual annual damages that would be expected to occur if each alternative considered were in place. Equivalent annual damages (EAD) under the future without-project condition are also shown for comparison purposes.

Table 5-2: Equivalent Annual Benefits (EAD) and Residual Damages With and Without Project

(October 2011 Prices, 4.000% Interest Rate, 50-Year Period of Analysis, $1,000s)

Alternative	EAD Reach 3a[a]	EAD Reach 3b[b]	EAD Reach 3c[c]	Total EAD Reaches 3a 3b, and 3c	EAD reduced by FRM Alternatives in Merriam
Future Without Project	$ 426.4	$ 2,881.6	$ 148.6	$ 3,456.7	NA
Alternative 1, Channel Widening					
Alternative 1a	$ 426.0	$ 1,965.9	$ 148.6	$ 2,540.5	$ 916.2
Alternative 1b	$ 426.4	$ 1,928.4	$ 148.6	$ 2,503.4	$ 953.3
Alternative 1c	$ 426.4	$ 1,203.5	$ 148.4	$ 1,778.2	$ 1,678.5
Alternative 1d	$ 426.4	$ 850.6	$ 148.4	$ 1,425.4	$ 2,031.3
Alternative 1e	$ 426.4	$ 381.2	$ 148.4	$ 955.9	$ 2,500.8

Alternative	EAD Reach 3a[a]	EAD Reach 3b[b]	EAD Reach 3c[c]	Total EAD Reaches 3a 3b, and 3c	EAD reduced by FRM Alternatives in Merriam
Alternative 2, Levees and Floodwalls					
Alternative 2a	$ 426.4	$ 1,130.7	$ 148.6	$ 1,705.7	$ 1,751.0
Alternative 2b	$ 426.4	$ 230.2	$ 148.6	$ 805.2	$ 2,651.5
Alternative 2c	$ 426.4	$ 225.2	$ 148.6	$ 800.2	$ 2,656.5
Alternative 2d	**$ 426.4**	**$ 69.6**	**$ 148.6**	**$ 644.6**	**$ 2,812.1**
Alternative 2e	$ 426.4	$ 47.8	$ 148.6	$ 622.8	$ 2,833.9
Alternative 2f	$ 426.4	$ 7.0	$ 148.6	$ 582.1	$ 2,874.6
Alternative 3, Combination of Channel Widening and Levees/Floodwalls					
Alternative 3a	$ 426.0	$ 559.1	$ 148.6	$ 1,133.7	$ 2,323.0
Alternative 3b	$ 426.4	$ 390.0	$ 148.6	$ 965.0	$ 2,491.7
Alternative 3c	$ 426.4	$ 327.7	$ 148.4	$ 902.5	$ 2,554.2
Alternative 3d	$ 426.4	$ 87.0	$ 148.4	$ 661.7	$ 2,795.0
Alternative 3e	$ 426.4	$ 61.9	$ 148.4	$ 636.6	$ 2,820.1
Alternative 4, Property Buy-Outs	$ 14.6	$ 32.9	$ 12.1	$ 59.7	$ 3,397.0

Notes: Any discrepancies are due to rounding.
[a] Reach 3a = River Mile (RM) 2.035 to RM 2.593; downstream of potential levee.
[b] Reach 3b = RM 2.594 to RM 3.825; potential levee area.
[c] Reach 3c = RM 3.826 to RM 5.394; upstream of potential levee.

Annual Project Costs

Screening cost estimates (October 2011 price level) and estimated construction periods for each of the alternatives were developed using level of detail appropriate to this phase. Interest during construction (IDC) for each alternative was calculated based on the total first cost for each alternative, the starting and completion dates for each phase, assumed equal monthly expenditures during each phase, and the FY12 federal interest rate of 4.000 percent. Ongoing federal funding issues were not considered in the starting and completion dates of the phases; appropriate funding was assumed available for each phase. Total first cost for each alternative includes the estimated construction cost, cost for lands, easements and rights-of-way, PED cost, environmental mitigation cost, supervision and administration cost, and contingencies. The construction costs shown in Table 5-3 include engineering during construction, as well as supervision and administration, but not PED, which is shown in a separate column. 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 based on a 50-year life and a 4.000 percent interest rate. More detailed information on project costs are included Appendix A and Appendix B, Chapter 1.

Table 5-3: Detailed Breakdown of Project First Costs by Alternative

(October 2011 Prices, 4.000% Interest Rate, 50-Year Period of Analysis, $1,000s)

Alternative	Construction Cost (includes EDC and S&A)	PED Cost	LERRD Cost	Mitigation Cost (Compensatory Restoration)	Total First Cost
Future Without Project	NA	NA	NA	NA	NA
Alternative 1, Channel Widening					
Alternative 1a	$ 6,616.4	$ 615.5	$ 3,241.1	$ 29.3	$ 10,502.3
Alternative 1b	$ 8,235.6	$ 766.1	$ 4,744.7	$ 29.3	$ 13,775.7
Alternative 1c	$ 15,249.9	$ 1,418.6	$ 4,744.7	$ 29.3	$ 21,442.5
Alternative 1d	$ 10,984.2	$ 1,021.8	$ 5,652.2	$ 29.3	$ 17,687.5
Alternative 1e	$ 19,178.1	$ 1,784.0	$ 5,652.2	$ 29.3	$ 26,643.6
Alternative 2, Levees and Floodwalls					
Alternative 2a	$ 8,360.6	$ 777.7	$ 2,369.3	$ 24.0	$ 11,531.6
Alternative 2b	$ 9,618.5	$ 894.7	$ 3,943.3	$ 24.0	$ 14,480.5
Alternative 2c	$ 11,631.2	$ 1,082.0	$ 3,963.5	$ 24.0	$ 16,700.7
Alternative 2d	**$ 12,232.1**	**$ 1,137.9**	**$ 3,963.5**	**$ 24.0**	**$ 17,357.5**
Alternative 2e	$ 12,641.6	$ 1,176.0	$ 3,963.5	$ 24.0	$ 17,805.1
Alternative 2f	$ 15,239.9	$ 1,417.7	$ 3,963.5	$ 24.0	$ 20,645.1
Alternative 3, Combination of Channel Widening and Levees/Floodwalls					
Alternative 3a	$ 9,071.6	$ 843.9	$ 3,901.6	$ 29.3	$ 13,846.4
Alternative 3b	$ 16,355.3	$ 1,521.4	$ 4,191.7	$ 29.3	$ 22,097.7
Alternative 3c	$ 21,176.7	$ 1,969.9	$ 4,168.6	$ 29.3	$ 27,344.5
Alternative 3d	$ 14,173.0	$ 1,318.4	$ 4,872.8	$ 29.3	$ 20,393.5
Alternative 3e	$ 21,136.5	$ 1,966.2	$ 5,189.2	$ 29.3	$ 28,321.2
Alternative 4, Property Buy-Outs	$ -	$ -	$ 58,232.5	$ -	$ 58,232.5

Notes: Any discrepancies are due to rounding.

Annual OMRR&R Costs

The costs for operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) were estimated in October 2011 prices for each alternative and were based on a life cycle cost analysis. The analysis includes only new OMRR&R costs (net of present without-project costs) that the sponsors would be expected to incur based on the new proposed alternative. The analysis considered and accounted for the OMRR&R in each year of occurrence and then computed a present worth value of the future OMRR&R costs. The present worth value was then annualized using a Federal interest rate of 4.000 percent and a 50-year period of analysis.

Induced Damages

Induced damages created by a proposed flood risk alternative must be included as costs in the economic screening; however, based on results from HEC-FDA, the alternatives evaluated for Upper Turkey Creek do not have significant induced damages on adjacent stream reaches.

Total Annual Costs

The total annual cost of each alternative that are compared with the benefits of the project is the sum of the direct project costs: annual economic cost and annual OMRR&R cost. Table 5-4 provides a detailed breakdown of costs for the alternatives considered. (Reminder: These are screening phase costs that will not match the later more detailed total project cost estimate developed for the recommended plan as is often the case in this type of study.)

Table 5-4: Detailed Cost Breakdown for Screening Alternatives for Merriam

(October 2011 Prices, 4.000% Interest, 50-Year Period of Analysis, $1,000s)

Alternative	Project First Cost	Interest During Constr.	Total Investment Cost	Annual Economic Cost	Annual OMRR&R Cost	Annual Induced Damages	Total Average Annual Cost
Future Without Project	NA	NA	NA	NA	NA	NA	NA
Alternative 1, Channel Widening							
Alternative 1a	$ 10,502.3	$ 497.4	$ 10,999.7	$ 512.0	$ 100.9	$ 0.0	$ 612.9
Alternative 1b	$ 13,775.7	$ 853.3	$ 14,629.0	$ 681.0	$ 126.5	$ 0.0	$ 807.5
Alternative 1c	$ 21,442.5	$ 1,516.8	$ 22,959.3	$ 1,068.8	$ 133.7	$ 0.0	$ 1,202.5
Alternative 1d	$ 17,687.5	$ 1,135.1	$ 18,822.6	$ 876.2	$ 152.5	$ 0.0	$ 1,028.7
Alternative 1e	$ 26,643.6	$ 2,344.0	$ 28,987.6	$ 1,349.4	$ 162.5	$ 0.0	$ 1,511.9
Alternative 2, Levees and Floodwalls							
Alternative 2a	$ 11,531.6	$ 520.8	$ 12,052.4	$ 561.0	$ 179.9	$ 0.0	$ 740.9
Alternative 2b	$ 14,480.5	$ 897.3	$ 15,377.8	$ 715.8	$ 198.9	$ 0.0	$ 914.7
Alternative 2c	$ 16,700.7	$ 1,007.7	$ 17,708.4	$ 824.3	$ 210.8	$ 0.0	$ 1,035.1
Alternative 2d	**$ 17,357.5**	**$ 1,040.1**	**$ 18,397.6**	**$ 856.4**	**$ 212.1**	**$ 0.0**	**$ 1,068.5**
Alternative 2e	$ 17,805.1	$ 1,306.4	$ 19,111.5	$ 889.6	$ 215.3	$ 0.0	$ 1,104.9
Alternative 2f	$ 20,645.1	$ 1,760.4	$ 22,405.5	$ 1,043.0	$ 229.4	$ 0.0	$ 1,272.4
Alternative 3, Combination of Channel Widening and Levees/Floodwalls							
Alternative 3a	$ 13,846.4	$ 642.5	$ 14,488.9	$ 674.5	$ 187.6	$ 0.0	$ 862.1
Alternative 3b	$ 22,097.7	$ 1,284.3	$ 23,382.0	$ 1,088.4	$ 247.0	$ 0.0	$ 1,335.4
Alternative 3c	$ 27,344.5	$ 1,897.5	$ 29,242.0	$ 1,361.2	$ 245.0	$ 0.0	$ 1,606.2
Alternative 3d	$ 20,393.5	$ 1,232.1	$ 21,625.6	$ 1,006.7	$ 252.2	$ 0.0	$ 1,258.9
Alternative 3e	$ 28,321.2	$ 2,435.7	$ 30,756.9	$ 1,431.7	$ 252.0	$ 0.0	$ 1,683.7

Alternative	Project First Cost	Interest During Constr.	Total Investment Cost	Annual Economic Cost	Annual OMRR&R Cost	Annual Induced Damages	Total Average Annual Cost
Alternative 4, Property Buy-Outs	$ 58,232.5	$ 0.0	$ 58,232.5	$ 2,710.7	$ 0.0	$ 0.0	$ 2,710.7

Note: Any discrepancies are due to rounding.

Summary of Economic Screening of Alternatives Considered

Table 5-5 displays a summary of total annual costs (including OMRR&R costs), annual benefits, residual damages, and net benefits for each alternative evaluated. The benefit/cost ratio and the net benefits for the alternatives considered are also shown.

Table 5-5: Screening Summary With-Project Annual Benefits, Costs, and Net Benefits

(October 2011 Prices, 4.000% Interest Rate, 50-Year Period of Analysis, $1,000s)

Reach Alternative	Total Annual Costs of Project [a]	Annual Benefits	Residual Damages	Benefit/ Cost Ratio	Net Benefits
Future Without Project	NA	NA	$ 3,456.7	NA	NA
Alternative 1, Channel Widening					
Alternative 1a	$ 612.9	$ 916.2	$ 2,540.5	1.5	$ 303.3
Alternative 1b	$ 807.5	$ 953.3	$ 2,503.4	1.2	$ 145.8
Alternative 1c	$ 1,202.5	$ 1,678.5	$ 1,778.2	1.4	$ 476.0
Alternative 1d	$ 1,028.7	$ 2,031.3	$ 1,425.4	2.0	$ 1,002.6
Alternative 1e	$ 1,511.9	$ 2,500.8	$ 955.9	1.7	$ 988.9
Alternative 2, Levees and Floodwalls					
Alternative 2a	$ 740.9	$ 1,751.0	$ 1,705.7	2.4	$ 1,010.1
Alternative 2b	$ 914.7	$ 2,651.5	$ 805.2	2.9	$ 1,736.8
Alternative 2c	$ 1,035.1	$ 2,656.5	$ 800.2	2.6	$ 1,621.4
Alternative 2d	$ 1,068.5	$ 2,812.1	$ 644.6	2.6	$ 1,743.6
Alternative 2e	$ 1,104.9	$ 2,833.9	$ 622.8	2.6	$ 1,729.0
Alternative 2f	$ 1,272.4	$ 2,874.6	$ 582.1	2.3	$ 1,602.2
Alternative 3, Combination of Channel Widening and Levees/Floodwalls					
Alternative 3a	$ 862.1	$ 2,323.0	$ 1,133.7	2.7	$ 1,460.9
Alternative 3b	$ 1,335.4	$ 2,491.7	$ 965.0	1.9	$ 1,156.3
Alternative 3c	$ 1,606.2	$ 2,554.2	$ 902.5	1.6	$ 948.0
Alternative 3d	$ 1,258.9	$ 2,795.0	$ 661.7	2.2	$ 1,536.1
Alternative 3e	$ 1,683.7	$ 2,820.1	$ 636.6	1.7	$ 1,136.4

Reach Alternative	Total Annual Costs of Project [a]	Annual Benefits	Residual Damages	Benefit/ Cost Ratio	Net Benefits
Alternative 4, Property Buy-Outs	$ 2,710.7	$ 3,397.0	$ 59.7	1.3	$ 686.3

Notes: Any discrepancies are due to rounding.
[a] Includes PED, LERRD, construction, environmental mitigation measures, interest during construction, and OMRR&R.
**

Economic Performance with Uncertainty for Screening Alternatives Considered

The economic performance and effectiveness of the alternatives are compared in Table 5-6 below. The table displays the expected value and probabilistic values of EAD and EAD reduced, thus showing the impact of uncertainty in evaluation of project benefits. The damages reduced represent the project benefits and are shown in terms of annualized equivalent values as computed in the HEC-FDA program.

Table 5-6: Economic Performance with Uncertainty

(October 2011 Prices, 4.000% Interest Rate, 50-Year Period of Analysis, $1,000s)

Plan	Top of Levee/ Floodwall Elevation (feet)	Expected Value and Probabilistic Values of EAD and EAD Reduced					
		Equivalent Annual Damage			Probability EAD Reduced Exceeds Indicated Amount		
		Without Plan	With Plan	Damage Reduced	.75	.50	.25
Future Without Project	NA	$ 3,456.7	$ 3,456.7	NA	NA	NA	NA
Alternative 1, Channel Widening							
Alternative 1a	NA	$ 3,456.7	$ 2,540.5	$ 916.2	$621.0	$964.1	$1,224.7
Alternative 1b	NA	$ 3,456.7	$ 2,503.4	$ 953.3	$604.2	$953.2	$1,275.4
Alternative 1c	NA	$ 3,456.7	$ 1,778.2	$ 1,678.5	$921.4	$1,544.2	$2,267.7
Alternative 1d	NA	$ 3,456.7	$ 1,425.4	$ 2,031.3	$1,085.4	$1,863.6	$2,765.3
Alternative 1e	NA	$ 3,456.7	$ 955.9	$ 2,500.8	$1,176.3	$2,194.4	$3,395.8
Alternative 2, Levees and Floodwalls							
Alternative 2a	917.11	$ 3,456.7	$ 1,705.7	$ 1,751.0	$1,001.5	$1,564.2	$2,391.6
Alternative 2b	920.05	$ 3,456.7	$ 805.2	$ 2,651.5	$1,222.3	$2,250.6	$3,653.5
Alternative 2c	920.49	$ 3,456.7	$ 800.2	$ 2,656.5	$1,231.1	$2,261.4	$3,665.0
Alternative 2d	920.98	$ 3,456.7	$ 644.6	$ 2,812.1	$1,256.0	$2,291.8	$3,791.9
Alternative 2e	921.21	$ 3,456.7	$ 622.8	$ 2,833.9	$1,262.1	$2,299.2	$3,800.6
Alternative 2f	922.78	$ 3,456.7	$ 582.1	$ 2,874.6	$1,289.3	$2,332.4	$3,839.9
Alternative 3, Combination of Channel Widening and Levees/Floodwalls							
Alternative 3a	916.36	$ 3,456.7	$ 1,133.7	$ 2,323.0	$1,162.1	$ 2,132.1	$3,071.3
Alternative 3b	917.80	$ 3,456.7	$ 965.0	$ 2,491.7	$1,209.1	$2,206.1	$3,317.3
Alternative 3c	916.86	$ 3,456.7	$ 902.5	$ 2,554.2	$1,215.6	$2,231.1	$3,412.3

Plan	Top of Levee/ Floodwall Elevation (feet)	Expected Value and Probabilistic Values of EAD and EAD Reduced					
		Equivalent Annual Damage			Probability EAD Reduced Exceeds Indicated Amount		
		Without Plan	With Plan	Damage Reduced	.75	.50	.25
Alternative 3d	916.64	$ 3,456.7	$ 661.7	$ 2,795.0	$1,252.1	$2,287.0	$3,786.5
Alternative 3e	915.93	$ 3,456.7	$ 636.6	$ 2,820.1	$1,267.2	$2,305.5	$3,808.4
Alternative 4, Property Buy-Outs	NA	$ 3,456.7	$ 59.7	$ 3,397.0	$1,503.5	$3,715.7	$4,590.1

5.3 COMPARISON OF FINAL ALTERNATIVES Note: Any discrepancies are due to rounding.

From the array of final alternatives, the planning team chose the alternative from each concept (Alternative 1, Channel Widening; Alternative 2, Levees and Floodwalls; Alternative 3, Combination of Channel Widening and Levees/ Floodwalls) with the highest net annual benefits for further consideration as a refinement to the screening. The alternatives range from downstream of the Merriam Drive Bridge over Turkey Creek to the upstream face of the Shawnee Mission Parkway culvert. The neighborhoods protected in all alternatives included in the final array are proceeding north to south; Merriam downtown or Farmers' Market area, Industrial and Railway Drive, and the Parkway vicinity.

Planners conducted an economic analysis, which is an iterative process that reveals the alternative with the highest net annual benefits with corresponding higher orders of magnitude of protection (see Section 5.2). Table 5-7 outlines the costs and economic performance of each alternative.

Table 5-7: Total Project Costs and Economic Performance for Final Array of Alternatives

Alternative	1d	2d	3d	4 Property Buy-Outs
Construction (including S&A)	$10,984,200	$12,232,100	$14,173,000	$ 000
PE&D	$ 1,021,800	$ 1,137,900	$ 1,318,400	$ 000
LERRD	$ 5,652,200	$ 3,963,500	$ 4,872,800	$58,232,500
Environmental mitigation	$ 29,300	$ 24,000	$ 29,300	$ 000
Total First Cost	$17,687,500	$17,357,500	$20,393,500	$58,232,500
Interest during construction	$ 1,135,100	$ 1,040,100	$ 1,232,100	$ 000
Total investment cost	$18,822,600	$18,397,600	$21,625,600	$58,232,500
Annual economic cost	$ 876,200	$ 856,400	$ 1,006,700	$ 2,710,700
OMRR&R	$ 152,500	$ 212,100	$ 252,200	$ 000
Residual damages with project	$ 1,425,400	$ 655,600	$ 661,700	$ 59,700
Average annual costs	$ 1,028,700	$ 1,068,500	$ 1,258,900	$ 2,710,700
Average annual benefits	$ 2,031,300	$ 2,812,100	$ 2,795,000	$ 3,397,000
Net annual benefits	$ 1,002,600	$ 1,743,600	$ 1,536,100	$ 686,300
B/C ratio	2.0	2.6	2.2	1.3

The following alternatives from each plan formulation concept with the highest net annual benefits from the final array of alternatives were carried forward and were evaluated under plan formulation and under NEPA:

- No Action
- Alternative 1d: Channel Widening
- Alternative 2d: Levees/Floodwalls
- Alternative 3d**:** Combination/Channel Widening and Levees/Floodwalls
- Alternative 4: Property Buy-Outs

A summary of project features for the alternatives considered with the highest net annual benefits from the final array of alternatives is included as Table 5-8. Project design cross sections for individual projects are included in Appendix B.

No Action Alternative

The District is required to consider the No Action Alternative in order to comply with the requirements of the NEPA. Under the No Action Alternative, it is assumed that no project would be implemented by the District to achieve the planning objectives. The No Action Alternative forms the basis against which all other alternatives are measured.

No additional flood risk management would be provided under the No Action Alternative. Without modification to the existing flood risk management system, the study area would continue to be at significant risk from frequent dangerous and damaging floods and the affected community would be faced with continued life safety and economic development concerns. The problem would likely worsen with time if no action is taken because flood insurance rates could rise and force existing development out of the study area.

Alternative 1d: Channel Widening

Alternative 1d (see Figure 5-1) in downtown Merriam downtown or the Farmers' Market area would widen Upper Turkey Creek to a 90-foot average channel bottom width with a 170-foot average channel top width and 2H:1V side slopes between Merriam Drive and Johnson Drive. Within the Industrial and Railway Drive area, Upper Turkey Creek would be widened to a 100-foot average channel bottom width with a 160-foot average channel top width and 2H:1V side slopes between Johnson Drive and West 61st Street. Within the Parkway vicinity, Upper Turkey Creek would be widened to a 110-foot average channel bottom width, a 175-foot average channel top width, and 3H:1V side slopes between West 61st Street to just south of Shawnee Mission Parkway, and from south of Shawnee Mission Parkway to approximately 0.2 mile upstream the channel would be widened to a 200-foot average channel bottom width to accommodate new bridge openings. Rip rap would be used for stabilization under this alternative.

For the purpose of achieving lower water surface elevations in through the Merriam Reach, modifications would be made to both the Shawnee Mission Parkway and Merriam Drive Bridges. The Merriam Drive Bridge would be enlarged to conform to the new channel shape. The proposed bridge spans 179 feet across seven piers. The lower bridge deck elevation also would be raised by 1 foot. The Shawnee Mission Parkway Bridge would be enlarged to span 210 feet across six piers. The lower bridge deck would be raised 2.85 feet to ensure that the deck would not obstruct storm flows. Between RS 3.855 and RS 3.665, the channel bottom width would transition to 200 feet to accommodate the new bridge openings. This

proposed bridge and channel configuration would reduce the upstream water surface by approximately 6 feet and reduce overtopping the road. The pedestrian bridge at RS 3.568 would be modified to span 160 feet with a vertical clearance height of 4 feet to reduce flood levels by 6.87 feet at the upstream bridge section.

Table 5-8: Comparison of Features for the Final Action Alternatives

Features	Alternative 1d: Channel Widening	Alternative 2d: Levees/Floodwalls	Alternative 3d: Combination
Levees/floodwalls: left bank	NA	Merriam Downtown: • 280 feet of floodwall (5 feet high) upstream of Merriam Drive Industrial and Railway Drive: • 800 feet of floodwall (4 to 6 feet high) begins at 300 feet upstream of Johnson Drive to 500 feet upstream of West 60th Street • 440 feet of levee (5 feet high) along the bike path to 100 feet north of West 61st Street Parkway Vicinity: • 725 feet of floodwall (5 feet high) from 100 feet south of West 61st Street along the bike path to Knox Avenue where it joins West 62nd. Street • 700 feet of levee (3 to 5 feet high) from West 62nd Street to West 62nd Terrace • 930 feet of floodwall (3 feet high) from West 62nd Terrace to Shawnee Mission Parkway	Merriam Downtown: • 80 feet of floodwall (3 feet high) upstream of Merriam Drive Parkway Vicinity: • 400 feet of levee (2 feet high) from 100 feet south of W. 61st Street to 300 feet north of W. 61st Street • 930 feet of floodwall (2 to 3 feet high) along W. 62nd Terrace to Shawnee Mission Parkway
Levees/Floodwalls: Right Bank	NA	Merriam Downtown: • 550 feet of floodwall (5 to 6 feet high) from Merriam Drive upstream to West 57th Street, then • 900 feet of levee (6 feet high) then • 550 feet of floodwall (6 feet high) downstream of Johnson Drive Industrial and Railway Drive: • 1,100 feet of floodwall (4 to 6 feet high) south of Johnson Drive to 400 feet north of West 61st Street • 400 feet of levee (5 feet high) to West 61st Street Parkway Vicinity: • 1,000 feet of floodwall (5 feet high) from West 61st Street to 400 feet north of Shawnee Mission Parkway, then • 300 feet of levee (5 feet high) • 100 feet floodwall (4 feet high) to Shawnee Mission Parkway	Merriam Downtown: • 500 feet of floodwall (3 feet high) from Merriam Drive to point approximately 300 feet north of Farmers' Market • 950 feet of levee (3 to 5 feet high) along bank at Farmers' Market, then • 600 feet of floodwall (5 feet high) downstream of Johnson Drive Industrial and Railway Drive: • 850 feet of floodwall (ranging from 1 to 4 feet high) from Johnson Drive to 300 feet south of West 60th Street Parkway Vicinity: • 850 feet of floodwall (2 feet high) along Shawnee Mission Parkway

Features	Alternative 1d: Channel Widening	Alternative 2d: Levees/Floodwalls	Alternative 3d: Combination
Channel Widening	Merriam Downtown: • Average bottom width = 90 feet • Average top width = 170 feet • Average side slope = 2H:1V Industrial and Railway Drive: • Average bottom width = 100 feet • Average top width = 160 feet • Average side slope = 2H:1V Parkway Vicinity: From West 61st Street to just downstream of Shawnee Mission Parkway • Average bottom width = 110 feet • Average top width = 175 feet • Average side slope = 3H:1V From just downstream of Shawnee Mission Parkway to 0.2 mile upstream of Shawnee Mission Parkway. • Average bottom width = 200 feet • Average top width = 175 feet • Average side slope = 3H:1V	NA	Merriam Downtown: • Average bottom width = 90 feet • Average top width = 170 feet • Average side slope = 2H:1V Industrial and Railway Drive: • Average bottom width = 100 feet • Average top width = 160 feet • Average side slope = 2H:1V Parkway Vicinity: • Average bottom width = 110 feet • Average top width = 175 feet • Average side slope = 3H:1V
Flap Gates	NA	Merriam Downtown: • Flap gates on all drainage structures discharging to creek (total of 2 gates) Industrial and Railway Drive: • 3 flap gates on triple culvert south of Johnson Drive • Flap gates on all drainage structures (total of 2 gates) Parkway Vicinity: • Flap gates on all drainage structures discharging to creek (total of 6 gates)	Merriam Downtown: • Flap gates on all drainage structures discharging to creek (total of 2 gates) Industrial and Railway Drive: • 3 flap gates on triple culvert south of Johnson Drive • Flap gates on all drainage structures (total of 2 gates) Parkway Vicinity: • Flap gates on all drainage structures discharging to creek (total of 6 gates)
Bridge Modifications/ Headwalls	Merriam Downtown: • Merriam Drive Bridge – modification to span 179 feet across 7 piers Parkway Vicinity: • Shawnee Mission Bridge – modification to span 210 feet across 6 piers and lower bridge deck raised 2.85 feet • Modification to pedestrian bridge at RM 3.568 to span 160 feet across the new channel	Merriam Downtown: • Merriam Drive Bridge – approximately 4 foot high headwall Parkway Vicinity: • Pedestrian Bridge located at River Mile/Station 3.568 - modification to span 175 feet across the new levee walls	Merriam Downtown: • Merriam Drive Bridge – approximately 4 foot high headwall Parkway Vicinity: • Pedestrian Bridge located at River Mile/Station 3.568 – modification to span 175 feet across the new levee walls

Features	Alternative 1d: Channel Widening	Alternative 2d: Levees/Floodwalls	Alternative 3d: Combination
Modified Storm sewer	NA	Merriam Downtown: • 500 feet of storm drainage replacement • Interior drainage system, including 2.14 acre-foot (80 feet wide by 360 feet long) grass detention basin • 830 feet of pipe rework • 2,100 feet of storm sewer trunk line	Merriam Downtown: • 500 feet of storm drainage replacement • Interior drainage system, including 2.14 acre-foot (80 feet wide by 360 feet long) grass detention basin • 830 feet of pipe rework • 2,100 feet of storm sewer trunk line
Utility Impacts/ Relocations	Merriam Downtown: • Sanitary sewer line reconstruction at crossing south of Farmers' Market. Industrial and Railway Drive: • Water line reconstruction south of Johnson Drive Parkway Vicinity: • Sanitary sewer line reconstruction at Shawnee Mission Parkway • Water line reconstruction near Shawnee Mission Parkway	Merriam Downtown: • Sanitary sewer line reconstruction at crossing south of Farmers' Market. Industrial and Railway Drive: • Water line reconstruction south of Johnson Drive Parkway Vicinity: • Sanitary sewer line reconstruction at Shawnee Mission Parkway • Water line reconstruction near Shawnee Mission Parkway	Merriam Downtown: • Sanitary sewer line reconstruction at crossing south of Farmers' Market. Industrial and Railway Drive: • Water line reconstruction south of Johnson Drive Parkway Vicinity: • Sanitary sewer line reconstruction at Shawnee Mission Parkway • Water line reconstruction near Shawnee Mission Parkway
Real Estate	Temporary Easement: 6.23 acres Permanent Easement: 24.94 acres	Temporary Easement: 10.15 acres Permanent Easement: 5.21 acres	Temporary Easement: 8.03 acres Permanent Easement: 25.58 acres

Alternative 2d: Levees/Floodwalls

Alternative 2d (see Figure 5-2) involves the installation of concrete floodwalls and earthen levees in the project area. The Merriam downtown or Farmers' Market area would require construction of 280 feet of floodwall 5 feet high upstream of Merriam Drive on the left bank of Upper Turkey Creek. On the right bank of the creek, the alternative includes 550 feet of floodwall 5 to 6 feet high from Merriam Drive upstream to West 57th Street, then 990 feet of levee 6 feet high, and 550 feet of floodwall 6 feet high downstream of Johnson Drive. Two flap gates would be required on drainage structures discharging to the creek, and the Merriam Drive Bridge would require the incorporation of an approximately 4-foot high headwall. Storm sewer modifications would include 500 feet of storm drainage replacement, and an additional 830 feet of pipe rework, a 2,100-foot storm sewer trunk line, and a 2.14-acre/feet grass detention basin approximately 80 feet wide by 360 feet long located east of the Farmers' Market for internal drainage. Impacts to utilities would include reconstruction of a sanitary sewer line at the crossing south of the Farmers' Market.

The Industrial and Railway Drive area would require construction of 800 feet of floodwall 4 to 6 feet high beginning 300 feet upstream of Johnson Drive to 500 feet upstream of West 60th Street, then 440 feet of levee 5 feet high along the bike path to 100 feet north of West 61st Street on the left bank of the creek. On the right bank of the creek, the alternative includes 1,100 feet of floodwall 4 to 6 feet high south of Johnson Drive to 400 feet north of West 61st Street, then 400 feet of levee 5 feet high to West 61st Street. Three flap gates would be required on the triple culvert south of Johnson Drive.

The Parkway vicinity would require construction of 725 feet of floodwall 5 feet high from 100 feet south of West 61st Street along the bike path to Knox Avenue where it joins West 62nd Street, then 700 feet of

levee 3 to 5 feet high from West 62nd Street to West 62nd Terrace, and 930 feet of floodwall 3 feet high along West 62nd Terrace to Shawnee Mission Parkway on the left bank of the creek. On the right bank of the creek, the alternative includes 1,000 feet of floodwall 5 feet high from West 61st Street to 400 feet north of Shawnee Mission Parkway, then 300 feet of levee 5 feet high, and 100 feet of floodwall 4 feet high to Shawnee Mission Parkway. Six flap gates would be required on drainage structures discharging to the creek, and the pedestrian bridge near West 62nd Terrace would require modification to span 175 feet. Impacts to utilities would include reconstruction of a sanitary sewer and water line at and near Shawnee Mission Parkway.

Alternative 3d: Combination Channel Widening and Levees/Floodwalls

Alternative 3d (see Figure 5-3) involves the installation of concrete floodwalls and/or earthen levees in the project area along with channel widening with the same flap gates, headwall, and detention basin as discussed under Alternative 2d. Levee and floodwall heights would be considerably lower than those proposed under Alternative 2d as a result of reductions in water surface elevations that would occur due to the channel widening described under Alternative 1d. Rip rap would be used for stabilization under this alternative.

Under Alternative 3d (see Figure 5-3), in the Merriam downtown or Farmers' Market area, Upper Turkey Creek would be widened to a 90-foot average channel bottom width with a 170-foot average channel top width and 2H:1V side slopes between Merriam Drive and Johnson Drive. The left bank of the creek in the Merriam downtown or Farmers' Market area would require construction of 80 feet of floodwall, 3 feet high upstream of Merriam Drive. On the right bank of the creek, the alternative includes 500 feet of floodwall 3 feet high from Merriam Drive upstream to approximately 300 feet north of the Farmers' Market, then 950 feet of levee 3 to 5 feet high along the bank at the Farmers' Market, and 600 feet of floodwall 5 feet high downstream of Johnson Drive. Two flap gates would be required on drainage structures discharging to the creek, and the Merriam Drive Bridge would require the incorporation of an approximately 4-foot-high headwall. Storm sewer modifications would include 500 feet of storm drainage replacement, and an additional 830 feet of pipe rework, a 2,100-foot storm sewer trunk line, and a 2.14-acre-foot grass detention basin, approximately 80 feet wide by 360 feet long located east of the Farmers' Market, for internal drainage. Impacts to utilities would include reconstruction of a sanitary sewer line at the crossing south of the Farmers' Market.

Within the Industrial and Railway Drive area, Upper Turkey Creek would be widened to a 100-foot average channel bottom width with a 160-foot average channel top width and 2H:1V side slopes between Johnson Drive and West 61st Street. The left bank of the creek in the Industrial and Railway Drive area does not include levees or floodwalls. On the right bank of the creek, the alternative includes construction of 850 feet of floodwall ranging from 1 to 4 feet high from Johnson Drive to 300 feet south of West 60th Street. Three flap gates are required on the triple culvert south of Johnson Drive.

Within the Parkway vicinity, Upper Turkey Creek would be widened to a 110-foot average channel bottom width with a 175-foot average channel top width and 3H:1V side slopes between West 61st Street to Shawnee Mission Parkway. The left bank of the creek in the Parkway vicinity would require construction of 400 feet of levee 2 feet high from 100 feet south of West 61st Street to 300 feet north of 61st Street, then 930 feet of floodwall 2 to 3 feet high along West 62nd Terrace to Shawnee Mission Parkway. On the right bank of the creek, the alternative includes 850 feet of floodwall 2 feet high along Shawnee Mission Parkway. Six flap gates would be required on drainage structures discharging to the creek and the pedestrian bridge near West 62nd Terrace would require modification to span 175 feet. Impacts to utilities would include reconstruction of a sanitary sewer and water line at and near Shawnee Mission Parkway.

Alternative 4: Property Buy-Outs

Under Alternative 4, Property Buy-Outs (see Figure 5-4), 222 parcels affecting approximately 135 acres would be purchased and relocated for which the current use of the property would be impacted by the 100-year floodplain in the Merriam Reach project area. The buy-out would include the entire parcel, both land and improvements. If an insignificant portion of the parcel is located within the floodplain, but its current use would remain intact, a minimum amount of compensation would be provided, estimated at $5,000 for the economic analysis. Existing utility, railroad or roads would not be relocated; therefore, future flood damages to this infrastructure would continue into the future.

5.3.1 TRADE-OFF ANALYSIS

Three alternatives from the screening array Alternative 2 series, all levee and floodwall plans, are very similar in terms of net annual economic benefits, those being 2b, 2d, and 2e. They also would have very similar effects and requirements for implementation. Throughout several iterations of analyses conducted in the process of adjusting economic and cost data, they have remained very close and Alternative 2d has consistently remained the plan with the maximum net annual benefits. For these reasons, it is highly unlikely that future changes in interest rates and price levels would alter the relative ranking of these three plans. Alternative 2d would pass the 1 percent ACE event through downtown Merriam with an estimated assurance (conditional non-exceedance probability) of 95.7 percent. In comparing the three alternatives, 2b would be approximately $2.88 million less in first cost, but would provide less flood risk reduction and allow greater risk, providing an estimated assurance of passing the 1 percent ACE event of 84.7 percent and allowing more structures to be damaged at a higher level. Alternative 2e would be higher in cost than Alternative 2d by $447,600, but would provide an estimated 97.1 percent assurance in passing the 1 percent ACE event. It would provide very similar flood risk reduction to the structures in the City of Merriam relative to Alternative 2d. Table 5-2 shows that selection of Alternative 2b would reduce annual damages to $230,200, which is about 8 percent of without-project condition damages. Alternative 2d, while entailing higher project costs, would reduce residual damages to $69,600, or 2.4 percent of without-project damages, and Alternative 2e, the most expensive of these three alternatives, would further reduce residual damages to 1.7 percent of without-project damages ($47,800).

Alternative 2d would provide significantly greater net annual benefits in reduction of flood damages than would Alternatives 1d, 3d, and 4 (see Table 5-9). The study analysis shows that channel modifications and levees and floodwall combined with channel modifications would be less efficient than alternatives consisting solely of low height levees and floodwalls. The nonstructural buy-out Alternative 4 would have significantly more costs and less net annual benefits and would be a complete disruption of the economic integrity of the city of Merriam. Other smaller configurations of buyout plans were considered and had significantly less net annual benefits than the NED Plan (Alternative 2d). Additionally, not all costs that would be necessary were included in the buy-out alternatives were they to be actually implemented.

The No Action Alternative would allow for significant and unacceptable flood risk and economic flood damage susceptibility to persist in the city of Merriam. It would not meet the planning objectives of this study. Significant flood damages and risk to life would be significantly greater absent a Federal flood risk management project.

5.3.2 TENTATIVE SELECTION OF PLANS

NED Plan

The NED Plan is Alternative 2d, which would maximize the net annual benefits while significantly reducing flood risk. Economic justification for the NED Plan project is relatively strong with a benefit-

cost ratio of 2.6. This finding of economic justification is strong enough that it is unlikely to be overthrown by changes in purely economic variables, such as year-to-year changes in federal interest rates or subsequent updates of the economic floodplain inventory that might identify abnormally high changes in occupancy. In order for economic justification to be challenged, a significant change in the engineering parameters of the project probably would be required. This could involve a major shift in estimated project costs or a revision of hydrologic/hydraulic data pertaining to flood flows and overbank stages, including uncertainty estimates. But within the context of the existing engineering parameters for the study, the benefit-cost ratio of the selected plan should not be fundamentally affected.

Because the top three alternatives in the NED screening, 2b, 2d, and 2e, were close in economic efficiency (net annual benefits of the three plans differ by only 0.8 percent), it might be expected that changes in any variable could affect rankings of alternatives, possibly overthrowing the NED plan identification. However, in this case all three alternatives are similar structural projects involving levees/floodwalls, distinguished only by differing project scales and the costs associated with these scales. For that reason, changes in cost estimates or other factors would most likely have a similar effect on all of the top alternatives rather than challenging the rankings in terms of NED outputs.

The current NED Plan after the screening evaluation is Alternative 2d, which would provide an estimated $2,812,100 in annual benefits and $1,743,600 in net annual benefits and has a benefit-cost ratio of 2.6 (October 2011 price level and Federal interest rate of 4.0 percent). The plan includes 6,035 feet of floodwall up to 6 feet in height, 2,740 feet of levees up to 5 feet in height, a total 3,340 feet of storm drainage work, and a 2.14 acre-foot detention area. It has a total estimated first cost of $17,863,267, and annual costs are estimated at $1,068,500. The plan has a general cost of $11,611,123, non-Federal cost of $6,252,143, and from that a lands, easements, rights-of-way, relocations and disposal areas (LERRD) requirement of $4,149,489, and estimated annual O&M costs of $212,100. Compensatory mitigation pursuant to environmental compliance is estimated at $24,000.

Federal Interest

A Flood Risk Management Project in the city of Merriam, Kansas, provides significant flood risk reduction and economic damages reductions, meets the planning objectives, and also provides significant benefits in a priority mission area of USACE. The NED Plan, Alternative 2d is in the federal interest for cost sharing in implementation.

5.3.3 ENVIRONMENTAL EVALUATION OF ALTERNATIVES

To evaluate the need for any compensatory mitigation that may be required for CWA Section 404 Authorization, the HEP method was used. Specific HSI models used for this method were the green sunfish (*Lepomis cyanellus*) and the fox squirrel (*Sciurus niger*). Using the green sunfish model, it was determined that no compensatory mitigation would be needed for any of the alternatives evaluated for in-stream impacts. Two of the alternatives, Channel Widening and Channel Widening with Levees and Floodwalls, would actually increase the amount of aquatic habitat resulting in an overall net gain in the number of average annual habitat units (AAHUs) for this species. However, compensatory mitigation would be necessary for impacts to the riparian corridor as indicated by the fox squirrel model. The amount of mitigation necessary would vary depending on the alternative implemented. Mitigation options considered include planting hard mast tree species to provide enough AAHUs to meet or exceed the number of AAHUs that would be lost as a result of implementing a particular alternative. A detailed evaluation of environmental impacts is presented in Chapter 6.

5.4 ATLAS 14 UPDATE

In late 2013 the study's Independent External Peer Review (IEPR) brought to light that the National Oceanographic and Atmospheric Administration (NOAA) had recently published updated rainfall frequency information in the document titled "*Hydrometeorological Design Studies Center Frequency Data Server Atlas 14* (NOAA 2013)", replacing the TP-40 document, which would change the probability of flooding in the Upper Turkey Creek study area. Corps of Engineers guidance requires that the most up-to-date NOAA rainfall information be utilized for hydrology in the formulation and design of flood risk management plans. Given the potential change in discharge accounted for in this new rainfall data, the Corps of Engineers vertical team determined that the opportunity to evaluate the plans under Atlas 14 should be taken during the feasibility phase of the project. The Atlas 14 rainfall estimates were formally adopted at this point in the study. An updated HEC-RAS model was developed incorporating Atlas 14 in the hydrology with a resultant revised hydraulic model. The Atlas 14-based model showed flood probabilities that were generally higher than previous estimates. This meant that any with-project alternative would have both greater benefits and greater residual damages than previously estimated. The alternatives were reevaluated under the Atlas 14 conditions using the Federal criteria for completeness, efficiency, effectiveness, and acceptability. It was reaffirmed that levees and floodwalls (Alternative 2 array) better meets the criteria than channelization either singly or in combination with levees and floodwalls, the sensitivity analysis focused on whether or not a levee and floodwall project was still justified and what the recommended levee/floodwall height should be. A summary of these results can be found in Table 5-11.

Table 5-9: Screening Alternatives Against Planning Criteria[1]

Measure	Completeness	Effectiveness	Efficiency	Acceptability
STRUCTURAL				
Alternative 1, Channel Widening	◓	◓	○	◓
Alternative 2, Levees and Floodwalls	◓	◉	◓	◓
Alternative 3, Combination of Channel Widening and Levees/Floodwalls	◓	◓	○	◓
NON- STRUCTURAL				
Alternative 4, Property Buyouts	●	◓	◒	○

[1]The symbol legend (Highly effective to Not effective and detracts from objectives): ◉ ◓ ○ ◒ ●

Table 5-10 shows a comparison of flows under previous hydrology, and under the new Atlas 14 hydrology for selected locations in the Merriam project reach. More detailed information regarding hydraulic analyses is contained in the Engineering Appendix.

Table 5-10: Comparison of Flows from Original (TP-40 based) to Atlas 14 Based Hydrology

Channel Location	Original 1 percent ACE Discharge cfs	Atlas 14 1 percent ACE Discharge cfs	Original 0.2 percent ACE Discharge cfs	Atlas 14 0.2 percent ACE Discharge cfs
Shawnee Mission Parkway Bridge	9,210	10,380	11,250	13,360
Johnson Drive Bridge	15,670	17,691	19,100	22,290

The following is a comparison of flow depths and velocities for the 1 percent ACE event under original and Atlas 14 based flows at selected locations in Merriam, without project condition:

Shawnee Mission Parkway Bridge: **Original**- 0.22 ft at 6.3 fps; **Atlas 14 -** 1.32 ft at 5.3 fps

Merriam Marketplace: O**riginal-** 3.67 ft at 8.1 fps; **Atlas 14-** 4.67 ft at 7.8 fps

West 61st Street: **Original-** 3.0 ft at 11.8 fps; **Atlas 14-** 3.0 ft at 12.3 fps

Merriam Drive Bridge: **Original**- 1.73 ft at 9.1 fps; **Atlas 14-** 2.9 ft at 8.3 fps

Based upon these findings, a new plan - "**Alternative 2g**" - was formulated to accomplish a sensitivity analysis. Alternative 2g was intended to achieve a level of reliability equivalent to what had been previously estimated for the NED Plan. The NED Plan (Alternative 2d) happens to have been a plan that met Corps of Engineers requirements for National Flood Insurance Program (NFIP) certification under the previous hydrology and hydraulics. Thus, for comparison Alternative 2g was developed such that it would meet Corps of Engineers and FEMA criteria for NFIP certification against the 1 percent ACE event discharge under Atlas 14. This would also serve as a likely upper bound for the updated benefit-cost analysis. The updated benefits and costs of the NED Plan (with top-of-levee elevation of 920.98 at the index point) were compared against the Alternative 2g (with top-of-levee elevation of 922.69 at the index point), and both plans were compared against the future without-project condition, using the updated Atlas-14-based discharge-frequency data.

Alternative 2g was developed with costs estimated at the same level of detail as the NED Plan (Alternative 2d). Table 5-13 depicts a summary comparison of primary features for the NED Plan (Alternative 2d) and Alternative 2g. The required height of levees and floodwalls for Alternative 2g was on average 2-3 feet higher throughout the project area than for Alternative 2d. The increase in the 1 percent ACE discharge caused a significant hydraulic challenge at the Merriam Drive Bridge at the downstream end of the project. It was determined in analysis that in addition to raising the parapet walls at that bridge from 4 feet to 8 feet high, a triple box 5x5 RCB hydraulic diversion structure 320 feet long would be required to successfully pass the design discharge. This configuration was determined to be optimal in performance versus cost after several alternative box and culvert combinations were modeled. The replacement of the Merriam Drive Bridge would be more costly than any of the bypass alternatives evaluated, and would still not address significant hydraulic inefficiency at that location. At the Johnson Drive Bridge, where no modifications to the bridge were deemed necessary with Alternative 2d, the hydraulic analysis showed that under Alternative 2g, parapet walls 7 feet high would be required. The length of floodwall and levee for Alternative 2g was less than the NED Plan (Alternative 2d). This is

because in Reach 3, in order to achieve successful hydraulic tie-in to high ground under the Atlas 14 design flow, the tie-in point would have to be well downstream of the Shawnee Mission Parkway Bridge, just downstream of the pedestrian bridge.

Revised Screening to Verify NED Plan. In order to sufficiently verify the plan having the highest net annual economic benefits under Atlas 14 flow conditions, it was determined that there was a need to reevaluate certain screening level plans in comparison to Alternatives 2d and 2g. In reviewing the results of the initial screening and Atlas 14 sensitivity analyses, it was determined that the narrow difference in net benefits between Alternatives 2b, 2c and 2d in the initial screening necessitated an additional step to confirm the plan with highest net benefits in the Atlas 14 flow regime. The comparison was limited to these three alternatives from the original screening array because Alternative 2d appeared to represent a peak in net benefits – i.e., net benefits for the next largest alternative, 2e, dropped slightly. The comparison of Alternatives 2b and 2c with the NED Plan (Alternative 2d) required that 2b and 2c be updated in a manner reasonably consistent with the updating of Alternative 2d and Alternative 2g. Therefore, in addition to refinement of features and costs for Alternative 2d and development of features and costs for Alternative 2g, alternatives 2b and 2c were also updated to reflect current estimates of features and costs and were also analyzed under the Atlas 14 flow regime for comparison to Alternative 2d and Alternative 2g. The floodwall and levee profiles for Alternatives 2b and 2c were determined in the refined analysis on average only 1 foot and 0.5 feet lower than Alternative 2d. The engineering features required for Alternatives 2b and 2c were virtually the same and in the same lengths as those required in Alternative 2d, except the heights were lower than 2d, as stated. As such, the features for those plans as estimated were virtually identical to Alternative 2d, only lower in overall average height.

Engineering and Cost Updates. As is often encountered during refinement of alternative plan details, certain engineering refinements were deemed necessary in updating the array of plans compared at this phase of study. During the engineering analysis for the Atlas 14 Update, it was determined that the existing stacked rock wall lining the channel in most locations was not adequately reliable to support a cantilever T-type reinforced concrete floodwall without a foundation ground modification. This is because of the relatively close proximity of the floodwall foundation to the existing channel walls. The geotechnical engineers decided to design an array of auger cast grout piles for a suitable ground modification to ensure floodwall foundation stability. This was necessary for the final engineering refinement to the Alternatives 2b, 2c, 2d, and 2g. This required that there be over 12,300 total for Alternative 2d, a similar number of piles for Alternatives 2b and 2c, and a greater number was required for Alternative 2g. Additionally, the team determined that due to the number of storm drainage pipes and utilities, that there would be more relocations required than originally estimated. The engineers also re-routed and consolidated the larger storm sewers into junction boxes with flap gates. All of these improvements were necessary engineering changes that affected the most cost effective plans and Alternative 2g in a similar manner. The team also determined that for Alternative 2d the maximum height from ground in one location was actually 6.5 instead of 6 feet. In the refined analysis and in applying consideration of actual site conditions and features, experience from other similar projects, the OMRR&R and mitigation costs were estimated to be lower than in previous screening analysis and essentially the same for all plans considered in this comparison. The additional box culverts in Alternative 2g could result in somewhat higher annual OMRR&R costs, but those were not included for the purposes of this comparison. After revised cost estimates were developed and the new array of plans was evaluated in HEC-FDA economic analysis, the team's economist verified that Plan 2d is the plan with the highest net annual economic benefits.

Table 5-11: Comparison of Features - Alternatives 2d and 2g

Alternative	Alternative Plan 2d	Alternative 2g
Primary Features Comparison	- 6,822 ft floodwall 3-6.5 ft high - 3,383 ft levee 3-6 ft high - 4 ft high parapet wall on upstream and downstream sides of Merriam Drive Bridge	- 5,565 ft floodwall 6-8' high - 2,300 ft levee 7-8 ft high - 320 ft. long triple 5x5 box culvert hydraulic diversion at downstream of project under Merriam Drive Bridge - 8 ft high parapet wall on upstream and downstream sides of Merriam Drive Bridge - 7 ft high parapet wall on upstream and downstream sides of Johnson Drive Bridge

Tables 5-12 through 5-16 compare the updated NED Plan, Alternative 2g , and Alternatives 2b and 2c with the Future Without-Project Condition, using the same metrics used for the initial screening in Tables 5-2 through 5-6. Table 5-14 shows the benefits of each alternative and the with-project equivalent residual annual damages that would be expected to occur if each alternative considered were in place.

Table 5-12: Equivalent Annual Benefits and Residual Damages With and Without Project

(October 2014 Prices, 3.375% Interest Rate, 50-Year Period of Analysis, $1,000s)

Alternative	Equivalent Annual Flood Damages in Reach 3a	Equivalent Annual Flood Damages in Reach 3b	Equivalent Annual Flood Damages in Reach 3c	Total Equivalent Annual Damages/Residual Damages in Reaches 3a, 3b, and 3c	Total Benefits from FRM Alternatives in Merriam
Future Without Project	$ 702.9	$ 3,709.6	$ 337.2	$ 4,749.6	NA
Alternative 2b	$ 702.9	$ 549.0	$ 337.2	$ 1,589.0	$ 3,160.6
Alternative 2c	$ 702.9	$ 397.4	$ 337.2	$ 1,437.5	$ 3,312.1
Alternative 2d (NED Plan)	$ 702.9	$ 264.9	$ 337.2	$ 1,304.9	$ 3,444.7
Alternative 2g	$ 702.9	$ 6.7	$ 337.2	$ 1,046.7	$ 3,702.9

Note: Any discrepancies are due to rounding.

Table 5-13 shows project first costs for each of the alternatives. The construction costs shown include "engineering during construction" and "supervision & administration," but not PED. The LERRD costs shown include "lands & damages," as well as "relocations."

Table 5-13: Detailed Breakdown of Project First Costs by Alternative

(October 2014 Prices, 3.375% Interest Rate, 50-Year Period of Analysis, $1,000s)

Alternative	Construction Cost (includes EDC and S&A)	PED Cost	LERRD Cost	Mitigation Cost (Compensatory Restoration)	Total First Cost
Future Without Project	NA	NA	NA	NA	NA
Alternative 2b	$ 23,883.0	$ 2,712.0	$ 10,122.0	$ 15.0	$ 36,732.0
Alternative 2c	$ 24,261.0	$ 2,748.0	$ 10,122.0	$ 15.0	$ 37,146.0
Alternative 2d (NED Plan)	$ 24,655.0	$ 2,787.0	$ 10,122.0	$ 15.0	$ 37,579.0
Alternative 2g	$ 29,771.0	$ 3,287.0	$ 9,954.0	$ 15.0	$ 43,026.0

Note: Any discrepancies are due to rounding; EDC – Engineering During Construction, LERRD – Land, Easement, Rights-of-way, Relocations, and Disposal, PED – Preconstruction Engineering and Design, S&A – Supervision and Administration

Table 5-14 provides a detailed breakdown of the average annual cost of each alternative. For this updated, each annual cost (as well as IDC) was calculated using a federal interest rate of 3.375 percent and a 50-year period of analysis.

Table 5-14: Detailed Cost Breakdown for Screening Alternatives for Merriam

(October 2014 Prices, 3.375% Interest, 50-Year Period of Analysis, $1,000s)

Alternative	Project First Cost	Interest During Constr.	Total Investment Cost	Annual Economic Cost	Annual OMRR&R Cost	Annual Induced Damages	Total Average Annual Cost
Future Without Project	NA	NA	NA	NA	NA	NA	NA
Alternative 2b	$ 36,732.0	$ 2,946.4	$ 39,678.4	$ 1,653.7	$ 40.8	$ 0.0	$ 1,694.5
Alternative 2c	$ 37,146.0	$ 2,974.1	$ 40,120.1	$ 1,672.1	$ 40.8	$ 0.0	$ 1,712.9
Alternative 2d (NED Plan)	$ 37,579.0	$ 3,003.9	$ 40,582.9	$ 1,691.4	$ 40.8	$ 0.0	$ 1,732.2
Alternative 2g	$ 43,026.0	$ 4,021.1	$ 47,047.1	$ 1,960.8	$ 40.8	$ 0.0	$ 2,001.6

Note: Any discrepancies are due to rounding.

Table 5-15 displays a summary of total annual costs (including OMRR&R costs), annual benefits, residual damages, and net benefits for each alternative. The benefit/cost ratio and the net benefits for the alternatives considered are also shown.

Table 5-15: Screening Summary With-Project Annual Benefits, Costs, and Net Benefits

(October 2014 Prices, 3.375% Interest Rate, 50-Year Period of Analysis, $1,000s)

Reach Alternative	Total Annual Costs of Project[a]	Annual Benefits	Residual Damages	B/C Ratio	Net Benefits
Future Without Project	NA	NA	$ 4,749.6	NA	NA
Alternative 2b	$ 1,694.5	$ 3,160.6	$ 1,589.0	1.9	$ 1,466.1
Alternative 2c	$ 1,712.9	$ 3,312.1	$ 1,437.5	1.9	$ 1,599.2
Alternative 2d (NED Plan)	$ 1,732.2	$ 3,444.7	$ 1,304.9	2.0	$ 1,712.5
Alternative 2g	$ 2,001.6	$ 3,702.9	$ 1,046.7	1.8	$ 1,701.3

Note: Any discrepancies are due to rounding.
[a] Includes PED (Preconstruction Engineering and Design); LERRD (Lands, Easements, Rights-of-way, Relocations, and Disposal); construction; EDC (Engineering During Construction); S&A (Supervision and Administration); environmental mitigation; interest during construction; and OMRR&R (Operation, Maintenance, Repair, Rehabilitation, and Replacement).

Table 5-16 shows expected values and probabilistic values of equivalent annual damage and reduction in equivalent annual damage for each of the alternatives.

Table 5-16: Economic Performance With Uncertainty for Merriam Alternatives

(October 2014 Prices, 3.375% Interest Rate, 50-Year Period of Analysis, $1,000s)

Plan	Top of Levee/ Floodwall Elev. (feet)	Expected Value and Probabilistic Values of EAD and EAD Reduced					
		Equivalent Annual Damage			Probability EAD Reduced Exceeds Indicated Amount		
		Without Plan	With Plan	Damage Reduced	.75	.50	.25
Future Without Project	NA	$ 4,749.6	$ 4,749.6	NA	NA	NA	NA
Alternative 2b	920.05	$ 4,749.6	$ 1,589.0	$ 3,160.6	$ 1,706.4	$ 2,835.7	$4,262.1
Alternative 2c	920.49	$ 4,749.6	$ 1,437.5	$ 3,312.1	$ 1,727.0	$ 2,938.8	$4,445.8

Plan	Top of Levee/ Floodwall Elev. (feet)	Expected Value and Probabilistic Values of EAD and EAD Reduced					
		Equivalent Annual Damage			Probability EAD Reduced Exceeds Indicated Amount		
		Without Plan	With Plan	Damage Reduced	.75	.50	.25
Alternative 2d (NED Plan)	920.98	$ 4,749.6	$ 1,304.9	$ 3,444.7	$ 1,749.1	$ 2,986.1	$4,620.3
Alternative 2g	922.69	$ 4,749.6	$ 1,046.7	$ 3,702.9	$ 1,811.3	$ 3,062.2	$4,891.1

Notes: Any discrepancies are due to rounding.

EAD – equivalent annual damages

Annual Performance and Equivalent Long-Term Risk

Long-term risk indicates how successfully the project would protect against flooding given the uncertainties and over a long period. Table 5-17 shows (for each alternative) the long-term risk or probability of the target stage/top-of-project being exceeded in a 10-, 30-, and 50-year period, given uncertainties.

Table 5-17: Annual Performance and Equivalent Long-term Risk for Merriam Reach 3b

Plan	Top of Levee/ Floodwall Elevation (feet)	Annual Performance (expected annual probability of design being exceeded)	Equivalent Long-term Risk (probability of exceedance over the indicated time period)		
			10 Years	30 Years	50 Years
Future Without Project	NA	0.283	0.9640	0.9998	1.0000
Alternative 2b	920.05	0.011	0.1086	0.2498	0.4371
Alternative 2c	920.49	0.008	0.0777	0.1831	0.3326
Alternative 2d (NED Plan)	920.98	0.005	0.0507	0.1220	0.2292
Alternative 2g	922.69	0.0001	0.0011	0.0028	0.0055

Conditional Probability of Design Non-Exceedance

Table 5-18 shows the probability that the target stage associated with each plan will not be exceeded, given the occurrence of the 1 percent ACE event.

Table 5-18: Conditional Probability of Design Non-Exceedance

Plan	Top of Levee/ Floodwall Elevation (feet)	Conditional Probability of Design Containing 1% ACE Event
Future Without Project	NA	0.001
Alternative 2b	920.05	0.644
Alternative 2c	920.49	0.740
Alternative 2d (NED Plan)	920.98	0.829
Alternative 2g	922.69	0.995

The original NED Plan (Alternative 2d), analyzed under the Atlas 14 flow regime was shown to have higher annual benefits than Alternative 2g, Alternative 2b, and Alternative 2c. Alternative 2g is very close to Alternative 2d in net annual benefits, but has significantly higher in cost. Alternative 2d has an estimated 83 percent reliability against the Atlas 14 1 percent ACE event, but will physically contain the nominal 1 percent ACE event Atlas 14 profile.

Sensitivity analyses conducted using Atlas 14 flows indicated that levee and floodwall heights between Alternative 2d and Alternative 2g elevations will require an additional parapet wall at the Johnson Drive Bridge, a parapet wall at the Merriam Drive Bridge, and a very large flow bypass conveyance at the Merriam Drive Bridge, all features incurred in Alternative 2g. Thus, increasing plan elevations above Alternative 2d will incur the significant cost impact. Our analysis indicated that there are not reasonable increments of plan elevation between Alternative 2d and 2g that would be more cost effective or affordable than Alternative 2d. Any plan above Alternative 2d in height would cross a hydraulic threshold and require walls very similar to the 7-foot parapet wall at the Johnson Drive Bridge and the 8-foot high parapet wall at the Merriam Drive Bridge. Any plan above Alternative 2d in height would also require a large diversion / conveyance similar in size and cost to the triple box configuration needed for Alternative 2g at the Merriam Drive Bridge. Attempting to formulate plans in between these would be an excessively costly exercise that would not result in a positive outcome.

Sponsor Preference. During the formulation of Alternative 2g, the Sponsor, City of Merriam was engaged in the evaluation process. The City staff and City Council carefully evaluated the comparative cost, features, performance, and residual risk associated with the Alternatives 2d and 2g. The City has requested that Plan 2d be the Recommended Plan, even though they are fully aware that it is has an 83 percent conditional probability of containing the 1 percent ACE event, versus 99.5 percent associated with Alternative 2g. Alternative 2d would significantly decrease flood risk to life and average annual damages to economic investment. Alternative 2d is affordable to the City, and the City does not consider Alternative 2g to be affordable or practical for construction. The City's staff has advised the Corps of Engineers of their opinion that the Corps of Engineers has likely underestimated costs to bridges for Alternative 2g. They believe that parapet walls above 4 feet (i.e. 7 feet at Johnson Drive and 8 feet at Merriam Drive) would be impractical, and that other more costly modifications to the bridges would likely be required. The impact of raising the levees and floodwalls to 7 and 8 feet, as is the case for Alternative 2g, is considered to be an unacceptable impact to the stream corridor, trail, and aesthetics by the City's elected officials, and this was also reflected in the citizen feedback indicated in the last public meeting held in 2014 to update the community of study findings. The City, County, and State agencies have established a response process for flood risk management and preparedness. This includes a system of rain and stage gages in the Turkey Creek basin, known as "Stormwatch," used for real time flood warning and response activities. The Sponsor is committed to managing residual risk and has good confidence in their ability to do so, working in established close relationships with their partner agencies.

1 CHAPTER 6 – ENVIRONMENTAL EFFECTS

An environmental analysis was conducted for the No-Action Alternative, three structural alternatives, and one non-structural alternative. It should be noted that within each of the three structural concepts only the alternative that provided the greatest National Economic Development (NED) benefit was evaluated for environmental effects. Only slight differences in the project footprint occur under the alternatives considered; therefore, similar impacts would occur under the alternatives considered.

United States Fish and Wildlife Service (USFWS) has reviewed the project alternatives and provided comments meeting Fish and Wildlife Coordination Act requirements during the public comment period (Appendix H). USFWS did not elect to provide comments earlier in the study process because the project is in an area in which the ecosystem is already highly degraded (See Appendix H).

6.1 HABITAT MODELING

To evaluate the need for any compensatory mitigation that may be required for Clean Water Act (CWA) Section 404 Authorization and to better compare alternatives, the Habitat Evaluation Procedure (HEP) method was used. HEP describes habitat for selected wildlife species as an Habitat Suitability Index (HSI) with a value ranging from 0.0 to 1.0, with values closer to 0.0 representing poor habitat and values closer to 1.0 representing good habitat. The HSI value is multiplied by the area of available habitat to obtain Habitat Units (HUs). To calculate habitat value over a period of time, such as 50-year period of analysis, HUs are averaged on a yearly basis to provide an Average Annual Habitat Units (AAHU). Specific HSI models used for this method were the green sunfish (*Lepomis cyanellus*) and the fox squirrel (*Sciurus niger*).[1] The HEP method and the USFWS HSI models have been approved for use for USACE planning projects in accordance with EC 1105-2-412, Assuring Quality of Planning Models. Details of the HEP analysis are found in Appendix M, *Compensatory Mitigation Determination*.

6.2 EFFECTS ON RESOURCES OF CONCERN

Primary resources of concern identified for evaluation include geology, soils and geomorphology, climate, hydrology, water quality, aquatic habitat, wetlands and waters of the United States, terrestrial habitat, fish and wildlife, threatened and endangered species, HTRW, floodplain, land use, socioeconomics, environmental justice, transportation, recreation, and cultural resources.

6.2.1 GEOLOGY, SOILS, AND GEOMORPHOLOGY

No-Action: The existing geology, soils, or geomorphology would not change within the project area under this alternative.

Alternative 1d—Channel Widening: Under this alternative, minor, long-term impacts to the geomorphology of Turkey Creek would occur within the project area. The channel bottom would be widened to a width of approximately 100 feet with a side slope of 2H:1V. These changes would allow for a greater conveyance of water during flood events when compared to the No-Action Alternative. Existing soils would be removed from locations where the channel would be widened, resulting in minor, long-term impacts. Additionally, construction activities would cause short-term impacts to the soil. Dust from construction activities may also lead to a short-term minor impact to air quality. The project is located in an

[1] These models are available online at http://el.erdc.usace.army.mil/hsi/GreenSunfish.pdf and http://el.erdc.usace.army.mil/hsi/FoxSquirrel.pdf.

area of air quality attainment in accordance with the National Ambient Air Quality Standards and these short-term construction related impacts are not expected to change this status. This alternative would not affect the geology of the project area.

Alternative 2d—Levees and Floodwalls: Constructing levees and floodwalls would cause minor, long-term impacts to the geomorphology of the Turkey Creek floodplain from the physical presence of the levee and floodwall structures. Because the banks of the creek are armored with limestone blocks, it is not likely that any changes would occur to the geomorphology of the creek channel. A grass detention basin approximately 2.1 acre in size would be constructed north of the Merriam Marketplace and would cause minor, long-term impacts to soils and geomorphology at this particular location. Ground disturbance necessary for construction would cause additional minor, short-term impacts to soils. Dust from construction activities may also lead to a short-term minor impact to air quality. The project is located in an area of air quality attainment in accordance with the National Ambient Air Quality Standards and these short-term construction related impacts are not expected to change this status. The existing geology of the project area would not be affected under this alternative.

Alternative 3d—Channel Widening with Levees and Floodwalls: This alternative would cause minor, long-term impacts to the geomorphology of Turkey Creek within the project area from widening the channel bottom and sloping the sides of the channel. Additionally, the levees and floodwalls would constitute a change in the geomorphology of the Turkey Creek floodplain. A grass detention basin approximately 2.1 acre in size would be constructed on the east side of the Merriam Marketplace and would cause minor, long-term impacts to soils and geomorphology at this particular location. Ground disturbance necessary for construction would cause additional minor, short-term impacts to soils. Dust from construction activities may also lead to a short-term minor impact to air quality. The project is located in an area of air quality attainment in accordance with the National Ambient Air Quality Standards and these short-term construction related impacts are not expected to change this status. The existing geology of the project area would not be affected under this alternative. These changes would allow for a greater conveyance of water during flood events when compared to the other alternatives.

Alternative 4—Property Buy-Outs: This alternative would not change the geology or geomorphology of the project area. There may be minor, long-term beneficial impacts to soils within the project area if buildings and parking lots were to be removed and the project area left in a more natural condition. In total, 222 parcels of property, affecting about 135 acres, would be purchased. These properties are currently used for industrial, retail, and residential purposes.

6.2.2 CLIMATE

No-Action: The No-Action Alternative would not improve flood risk management along Turkey Creek. If the region continues to see increases in rainfall, and in particular any increase in the intensity of storm events, the risk of flooding would increase even more than the current risk level.

Alternative 1d—Channel Widening, Alternative 2d—Levees and Floodwalls, **Alternative 3d—Channel Widening with Levees and Floodwalls, and Alternative 4—Property Buy-Outs:** All of these alternatives would improve flood risk management along Turkey Creek compared to the No-Action Alternative. Changes in precipitation patterns could impact the level of flood risk management provided by these alternatives. These changes would not affect any features associated with these alternatives.

6.2.3 HYDRAULICS AND HYDROLOGY

No-Action: Under the No-Action Alternative, there would not be any foreseeable changes to the hydraulics or hydrology of Turkey Creek. The City of Merriam would not see any improvements to flood risk management compared to its current level of risk.

Alternative 1d—Channel Widening: This alternative would cause minor, long-term impacts to the hydraulics of Turkey Creek. The width of the channel bottom would be more than doubled under this alternative, allowing for greater water conveyance during flood events. Water velocity during baseflow conditions would be similar under this alternative compared to the No-Action Alternative, but the depth of water would be reduced. Construction equipment operating in the creek channel also may cause minor, short-term impacts to the hydraulics of the Creek. This alternative is not expected to have any substantial impact on the hydrology of the Turkey Creek watershed. The hydraulic modeling results show no increase in flooding upstream or downstream of the project reach. These results give reasonable confidence that the project will not induce additional damages upstream or downstream of its limits. The project reach consists of an urban watershed in which flood waters move rapidly through the overbank floodplain area. See Appendix B, Chapter 3 for detailed hydrologic and hydraulic conditions and analysis and Figure 5-1 for the proposed floodplain upstream and downstream of the project area.

Alternative 2d—Levees and Floodwalls: This alternative would cause minor, long-term impacts to the hydraulics of Turkey Creek. During flood events, it would constrain more water within the channel and reduce the likelihood of flooding adjacent to the channel. A grass detention basin approximately 2.1 acre in size would be constructed on property that is north of the Merriam Marketplace. About 4,000 linear feet of replacement and new stormwater drainage lines would be associated with the detention basin. Construction equipment operating in the creek channel also may cause minor, short-term impacts to the hydraulics of the creek. The recommended detention basin should not result in significant changes to the peak flows downstream of the Merriam Marketplace reach. This alternative is not expected to have any substantial impact on the hydrology of the Turkey Creek watershed. The hydraulic modeling results show no increase in flooding upstream or downstream of the project reach. These results give reasonable confidence that the project will not induce additional damages upstream or downstream of its limits. The project reach consists of an urban watershed in which flood waters move rapidly through the overbank floodplain area. See Appendix B, Chapter 3 for detailed hydrologic and hydraulic conditions and analysis and Figure 5-2 for the proposed floodplain upstream and downstream of the project area.

Alternative 3d—Channel Widening with Levees and Floodwalls: This alternative would have minor, long-term impacts to the hydraulics of Turkey Creek, as described under Alternatives 1d and 2d. A grass detention basin approximately 2.1 acre in size would be constructed on property that is part of the Merriam Marketplace. About 4,000 linear feet of replacement and new stormwater drainage lines would be associated with the detention basin. Construction equipment operating in the creek channel also may cause minor, short-term impacts to the hydraulics of the creek. The recommended detention basin should not result in significant changes to the peak flows downstream of the Merriam Marketplace reach. This alternative is not expected to have any substantial impact on the hydrology of the Turkey Creek watershed. The hydraulic modeling results show no increase in flooding upstream or downstream of the project reach. These results give reasonable confidence that the project will not induce additional damages upstream or downstream of its limits. The project reach consists of an urban watershed in which flood waters move rapidly through the overbank floodplain area. See Appendix B, Chapter 3 for detailed hydrologic and hydraulic conditions and analysis and Figure 5-3 for the proposed floodplain upstream and downstream of the project area.

Alternative 4—Property Buy-Outs: This alternative is not expected to change the hydraulics or hydrology of Turkey Creek. However, if structures were to be removed as part of the buy-out, there would be less resistance to water flow during flood events, which would be expected to reduce flood elevations. In addition to reducing property damage, this alternative would reduce the threat to human health and safety during flood events by removing people and property away from flood prone locations. Appendix B contains a more detail hydraulic and hydrologic analysis.

6.2.4 WATER QUALITY

No-Action: Under the No-Action Alternative, the water quality of Turkey Creek would not change. Turkey Creek water quality would continue to be negatively impacted by point and non-point sources of pollution.

Alternative 1d—Channel Widening: The channelization of Turkey Creek within the project area would cause minor, short-term impacts to water quality due to construction activities occurring within the creek channel and on the creek banks. Additionally, two sewer lines and two waterlines that currently cross under Turkey Creek would be replaced. During construction, downstream waters could see a temporary increase in turbidity. Construction activities under this alternative would require a CWA Section 401 State Water Quality Certification. Additionally, the construction contractor would be required to obtain a Section 402 NPDES permit from Kansas Department of Health and Environment (KDHE) prior to beginning any construction activities. Best management practices (BMPs) would be implemented to minimize the incidental fallback of material into the waterway and to minimize the introduction of fuel, petroleum products, or other deleterious material from entering the waterway. Such measures could include the using 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. Once construction is complete, the water quality of Turkey Creek would return to its pre-construction state. This alternative would not cause significant, adverse, long-term impacts to water quality.

Alternative 2d—Levees and Floodwalls: Alternative 2d, the Recommended Plan, would have minor, short-term construction related impacts to water quality due to activities occurring within the creek channel and on the creek banks in order to construct the levees and floodwalls. Additionally, two sewer lines and two waterlines that currently cross under Turkey Creek would be replaced. During construction, downstream waters would experience an increase in turbidity. However, it is expected that these short-term increases in turbidity would be less than would occur under either Alternative 1 or Alternative 3 because the amount of construction activity occurring in the creek channel would be less. The detention basin may result in minor, long-term beneficial impacts to water quality by removing some suspended sediment from stormwater runoff before it would enter Turkey Creek. CWA Section 401 State Water Quality Certification has been obtained from the KDHE (Appendix D). . Additionally, the construction contractor would be required to obtain a Section 402 NPDES stormwater permit from KDHE prior to beginning any construction activities. BMPs would be implemented as described for Alternative 1d. This alternative would likely result in a minor long-term benefit to water quality by limiting the amount of trash and debris that enters the stream from surrounding industrial/commercial properties during storm events.

Alternative 3d—Channel Widening with Levees and Floodwalls: This alternative would cause similar minor, short-term, construction-related impacts as identified in Alternative 1, Channel Widening. As with the other construction alternatives, this alternative would require CWA Section 401 and 402 permits prior to beginning construction. This alternative would likely result in a minor long-term benefit to water quality by limiting the amount of trash and debris that enters the stream from surrounding industrial/commercial properties during storm events.

Alternative 4—Property Buy-Outs: This alternative is not expected to cause any impacts to water quality. It is unlikely that any CWA Section 404 authorization or Section 401 permits would be required. A Section 402 NPDES stormwater permit would be necessary to remove existing buildings.

6.2.5 AQUATIC HABITAT

No-Action: The No-Action Alternative would not change the aquatic habitat within the project area. The aquatic habitat would remain in a degraded condition, due to large portions of Turkey Creek being

channelized within the project area providing little habitat for benthic or invertebrate populations. The HEP method was used to evaluate the existing number of HUs for green sunfish within the project area, as an indicator of the condition of the aquatic habitat. Over a 50-year period of analysis, there would be 3.8 AAHUs for green sunfish within the project area. More detailed information on the HEP analysis is provided in Appendix M, *Compensatory Mitigation Determination*.

Alternative 1d—Channel Widening: Widening the Turkey Creek channel would cause short-term, construction-related impacts to the aquatic habitat. Long-term widening would cause a slight decrease in habitat quality but would result in an overall increase in the number of AAHUs for green sunfish because the amount of aquatic habitat within the project area would increase from 7 acres to 20 acres, an increase of approximately 13 acres. This alternative would result in 8.5 AAHUs, a net gain of 4.7 AAHUs when compared to the No-Action Alternative for green sunfish.

Alternative 2d—Levees and Floodwalls: Constructing levees and floodwalls would cause short-term, construction-related impacts to the aquatic habitat of Turkey Creek as a result of disturbances from heavy equipment operating in the creek to access the bank. After the project construction is complete, the aquatic habitat would be expected to return to its existing state, providing 3.8 AAHUs for green sunfish over the 50-year period of analysis. Long-term benthic or invertebrate populations would be similar to the no action alternative.

Alternative 3d—Channel Widening with Levees and Floodwalls: This alternative would have similar short-term, construction-related impacts to the aquatic habitat as Alternative 1. This alternative would result in 8.5 AAHUs for green sunfish, a net gain of 4.7 AAHUs compared to the No-Action Alternative.

Alternative 4—Property Buy-Outs: This alternative would not likely affect aquatic habitat. Over a 50-year period of analysis, there would be 3.8 AAHUs for green sunfish within the project area.

6.2.6 WETLANDS AND WATERS OF THE UNITED STATES

No-Action: The No-Action Alternative would not adversely impact any wetlands or jurisdictional waters of the United States. No wetlands are located within or adjacent to the project area.

Alternative 1d—Channel Widening: This alternative would not affect wetlands. This alternative would result in the widening of a jurisdictional water of the United States, Turkey Creek. This alternative would require a CWA Section 404 Authorization and a CWA Section 401 State Water Quality Certification for the project prior to the commencement of any construction activities.

To evaluate the need for any compensatory mitigation that may be required for CWA Section 404 Authorization, the HEP method was used. Specific HSI models used for this method were the green sunfish and the fox squirrel. This alternative would result in a net gain of 4.7 AAHUs for green sunfish. However, it would result in a habitat loss of 3.9 AAHUs for fox squirrel as a result of removing 6 acres of riparian trees along the bank of Turkey Creek. Fox squirrel habitat loss would be compensated for by planting 290 hard mast producing trees within the Turkey Creek watershed over an 11-acre area, as this type of mitigation would closely replicate the open-canopy mast producing trees with little underbrush habitat that would be lost. The City of Merriam would be responsible for providing lands to plant these trees as part of the cost sharing agreement. There have been preliminary discussions with the city to use open parklands owned by the city for mitigation locations. It has been assumed that any lands provided by the city would not have any existing fox squirrel habitat. No trees would be planted within 15 feet of any levee or floodwall, complying with Engineering Technical Letter 1110-2-571 Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures (April 10, 2009). Detailed information concerning this compensatory mitigation is found in Appendix M, *Compensatory Mitigation Determination*.

Alternative 2d—Levees and Floodwalls: Alternative 2d, the Recommended Plan, would not affect wetlands. This alternative would cause minor, short-term impacts to Turkey Creek, a jurisdictional water of the United States, as a result of construction to build portions of the levees and floodwalls. To evaluate the need for any compensatory mitigation that may be required for CWA Section 404 Authorization, green sunfish and the fox squirrel HSI models were utilized. Alternative 2 would not result in any habitat loss for green sunfish. However, it would result in a loss of 2.7 AAHUs for fox squirrel by removing approximately 3.6 acres of trees along the bank of Turkey Creek. This habitat loss would be compensated for by planting 185 hard mast producing trees over a 7-acre area, as this type of mitigation would closely replicate the open-canopy mast producing trees with little underbrush habitat that would be lost. The City of Merriam would be responsible for providing lands to plant these trees as part of the cost sharing agreement. There have been preliminary discussions with the city to use open parklands owned by the city for mitigation. It has been assumed that any lands provided by the city would not have any existing fox squirrel habitat. No trees would be planted within 15 feet of any levee or floodwall, complying with Engineering Technical Letter 1110-2-571 Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures (April 10, 2009). Additional information concerning compensatory mitigation is found in Appendix M, *Compensatory Mitigation Determination*.

CWA Section 404 Authorization has been prepared for the Recommended Plan and is included in Appendix D. CWA Section 401 State Water Quality Certification has also been obtained and is also included in Appendix D.

Alternative 3d—Channel Widening with Levees and Floodwalls: Alternative 3d would not affect wetlands. Under this alternative, Turkey Creek, a jurisdictional water of the United States, would be widened, requiring CWA Section 404 Authorization and CWA Section 401 State Water Quality Certification for the project prior to the commencement of any construction activities. As under Alternative 1, this alternative would result in a net gain of 4.7 HUs for green sunfish. It would result in a loss of 4.2 AAHUs for fox squirrel from removing 7 acres of riparian trees from along the bank of Turkey Creek. This habitat loss would be compensated for by planting 290 hard mast producing trees over an 11-acre area, as this type of mitigation would closely replicate the open-canopy mast producing trees with little underbrush habitat that would be lost. The City of Merriam would be responsible for providing lands to plant these trees as part of the cost sharing agreement. There have been preliminary discussions with the city to use open parklands owned by the city for mitigation. It has been assumed that any lands provided by the city would not have any existing fox squirrel habitat. No trees would be planted within 15 feet of any levee or floodwall, complying with Engineering Technical Letter 1110-2-571 Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures (April 10, 2009). Additional information concerning compensatory mitigation is found in Appendix M, *Compensatory Mitigation Determination*.

Alternative 4—Property Buy-Outs: Alternative 4 would not adversely impact any wetlands or jurisdictional waters of the United States. No wetlands are located within or adjacent to the project area. This alternative would not result in any changes to the AAHUs for green sunfish. Because of limited resources and the size of the project footprint for this alternative, AAHU for fox squirrel were not determined. However, it would be expected that there would be an increase in the number of AAHUs for this species over the long-term assuming that the area where properties would be bought out would be converted to green space.

6.2.7 TERRESTRIAL HABITAT

No-Action: The No-Action Alternative would not affect the existing terrestrial habitat within the project area.

Alternative 1d—Channel Widening: Widening Turkey Creek would convert approximately 13 acres of urban terrestrial habitat into aquatic habitat. In total, this alternative would result in the removal of riparian trees that provide about 6.3 acres of canopy cover. This cover is patchy in distribution and contains little overall connectivity due to urban development along Turkey Creek. Most of the project area contains manicured grass, parking lots, and buildings with little woody understory vegetation. As previously described, approximately 290 hard mast producing trees would be replanted over an 11-acre area for compensatory mitigation for CWA Section 404 compliance for the loss of riparian trees resulting from this alternative. The mitigation would closely replicate the open-canopy mast producing trees with little underbrush habitat that would be lost. Because the trees would take time to mature, this alternative would cause minor, long-term impacts to terrestrial habitat.

Alternative 2d—Levees and Floodwalls: Alternative 2d, the Recommended Plan, would result in the removal of riparian trees that provide approximately 3.6 acres of canopy cover. These trees are patchy in distribution and contain little overall connectivity. There is limited woody understory vegetation. Approximately 185 hard mast producing trees, such as oaks and walnut, would be planted over a 7-acre area for compensatory mitigation for CWA Section 404 compliance for the loss of riparian trees that would occur with the Recommended Plan. The mitigation would closely replicate the open-canopy mast producing trees with little underbrush habitat that would be lost. A map of potential mitigation planting sites is located in Appendix M. Because these trees would take time to mature, this alternative would cause minor, long-term impacts to the terrestrial habitat.

Alternative 3d—Channel Widening with Levees and Floodwalls: This alternative would convert approximately 13 acres of urban terrestrial habitat into aquatic habitat. In total, trees would be removed that provide approximately 6.4 acres of canopy cover. These riparian trees are patchy in distribution and contain little overall connectivity. The remaining project area contains manicured grass, parking lots, and buildings. Approximately 290 hard mast producing trees would be planted over an 11-acre area for compensatory mitigation for CWA Section 404 compliance for the loss of riparian trees. The mitigation would closely replicate the open-canopy mast producing trees with little underbrush habitat that would be lost. Because the trees would take time to mature, this alternative would cause minor, long-term impacts to the terrestrial habitat.

Alternative 4—Property Buy-Outs: Buying out and removing properties within designated locations subject to frequent flooding would likely result in more green space providing an improvement to the existing terrestrial habitat resulting in a minor, long-term benefit to terrestrial habitat.. Because of limited resources and the size of the project footprint for this alternative, AAHU for fox squirrel were not determined. However, it would be expected that there would be an increase in the number of AAHUs for this species over the long-term in the location where properties would be bought out and converted to green space.

6.2.8 FISH AND WILDLIFE

No-Action: The No-Action Alternative would not adversely impact any fish or wildlife. Fish and wildlife tolerant of an urban landscape would continue to persist. Over a 50-year period of analysis, there would be 3.8 AAHUs for green sunfish within the project area, and from 3.2 to 4.2 AAHUs for fox squirrel, varying by the size of the project footprint evaluated.

Alternative 1d—Channel Widening: This alternative would cause minor, short-term construction related impacts to fish and wildlife from construction noise, direct displacement of organisms, and potential decreases in water quality from excavation of the creek banks that may negatively impact species that are not tolerant of temporary increases in turbidity. BMPs, as described in Section 6.2.4, would help minimize impacts to water quality. Any organisms that would leave the project area as a result of noise or direct

displacement would be expected to either return to the area after construction has been completed or use similar habitat types in locations adjacent to the project. In the long term, this alternative would result in minor benefits to aquatic resources. Two barriers to fish movement would be removed under this alternative. These barriers are approximately 3 to 4 feet in height. One is a utility crossing that runs perpendicular to the creek channel that has been encased in concrete. The second is a vertical drop in the bedrock of the channel bottom that is probably the result of channelizing Turkey Creek in the past. Widening the channel would also increase the amount of habitat available to aquatic species by approximately 13 acres. Another minor, long-term benefit under this alternative would be the removal of limestone blocks that have been placed along most of the creek channel within the project area, creating vertical banks. The banks would be sloped from 2H:1V to 3H:1V and stabilized with quarry run rock. While quarry run rock would not be a desirable habitat for most wildlife species, the reduced slope of the channel banks would improve access to Turkey Creek for some wildlife such as squirrels and rabbits. One minor, long-term impact to wildlife would be the removal of riparian trees that provide approximately 6.3 acres of canopy cover. To offset the removal of these trees, approximately 290 hard mast producing trees would be planted within the Upper Turkey Creek watershed. To comply with the Migratory Bird Treaty Act, the taking of migratory birds, their eggs, and nests would be avoided by conducting field surveys if construction were to take place during the migratory bird nesting season, generally considered to be from April 1 to July 15. If active nests were identified during the survey that could not be avoided, either temporally or spatially, USFWS would be consulted.

Alternative 2d—Levees and Floodwalls: Alternative 2d, the Recommended Plan, would cause minor, short-term construction-related impacts to fish and wildlife from the construction noise, direct displacement of organisms, and potential decreases in water quality during construction that may negatively impact species that are not tolerant of these changes. BMPs, as described in Section 6.2.4, would help minimize impacts to water quality. Any organisms that would flee the project area as a result of noise or direct displacement would be expected to either return to the area after construction has been completed or use similar habitat types in locations adjacent to the project. One minor, long-term impact to wildlife would be the removal of riparian trees that provide approximately 3.6 acres of canopy cover. To offset the removal of these trees, approximately 185 hard mast producing trees would be planted in the Upper Turkey Creek watershed. A map of potential mitigation planting sites is located in Appendix M. A minor, long-term impact to wildlife would be that the levees and flood walls may physically restrict access to Turkey Creek. However, the 15- to 20-foot vertical drop along the creek banks due to the channelization with limestone blocks already limits wildlife access to Turkey Creek. To comply with the Migratory Bird Treaty Act, the taking of migratory birds, their eggs, and nests would be avoided by conducting field surveys if construction were to take place during the migratory bird nesting season, generally considered to be from April 1 to July 15. If active nests were identified during the survey but could not be avoided, either temporally or spatially, USFWS would be consulted.

Alternative 3d—Channel Widening with Levees and Floodwalls: As with the other alternatives that involve construction, this alternative would cause minor, short-term construction-related impacts from construction noise, direct displacement of organisms, and potential decreases in water quality during construction that may negatively impact species that are not tolerant of these changes. BMPs, as described in Section 6.2.4, would help minimize impacts to water quality. Any organisms that would flee the project area as a result of noise or direct displacement would be expected to return to the area after construction has been completed or use similar habitat types in locations adjacent to the project. In the long term, this alternative would result in minor benefits to aquatic resources within the project area. The two barriers to fish movement, previously described for Alternative 1, would be removed under this alternative. Widening the channel also would increase the amount of habitat available to aquatic species by approximately 13 acres. One minor, long-term impact to wildlife would be the removal of riparian trees that provide

approximately 6.4 acres of canopy cover. To offset the removal of these trees, approximately 290 hard mast producing trees would be planted in the Upper Turkey Creek watershed. A minor, long-term impact to wildlife would be that the levees and flood walls may physically restrict access to Turkey Creek. However, most of the creek banks along Turkey Creek in the project area consist of a vertical limestone wall that is 15 to 20 feet in height. These vertical banks already limit wildlife access to Turkey Creek. Actions to comply with the Migratory Bird Treaty Act would be the same as those described for Alternatives 1d and 2d.

Alternative 4—Property Buy-Outs: Buying properties in locations subject to frequent flooding, and subsequently removing any structures, would likely result in more green space that may provide some minor, indirect benefits to fish and wildlife. This alternative would not cause any long-term, negative impacts to fish and wildlife. This alternative would not result in any changes to the AAHUs for green sunfish. Because of limited resources and the size of the project footprint for this alternative, AAHUs for fox squirrel were not determined. However, it would be expected that there would be an increase in the number of AAHUs for this species over the long-term assuming that the area where properties would be bought out would be converted to green space.

6.2.9 THREATENED AND ENDANGERED SPECIES

No-Action: The No-Action Alternative would have no effect on any Federally-listed threatened or endangered species.

Alternative 1d—Channel Widening, Alternative 2d—Levees and Floodwalls, **Alternative 3d—Channel Widening with Levees and Floodwalls, and Alternative 4—Property Buy-Outs:** These alternatives would have no effect on any federally-listed threatened or endangered species, candidate species, or designated critical habitat. No federally listed species, candidate species, or designated critical habitats are located in or adjacent to the project area. A copy of the USFWS and Kansas Department of Wildlife, Parks, and Tourism (KDWPT) letters concurring that no affect has been placed in the appendix H of this report.

6.2.10 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTES

No-Action: This alternative would involve any ground disturbance; therefore, there would not be any impacts to HTRW sites.

Alternative 1d—Channel Widening, Alternative 2d—Levees and Floodwalls, **Alternative 3d—Channel Widening with Levees and Floodwalls, and Alternative 4—Property Buy-Outs:** Based on a records search, these alternatives are not expected to affect HTRW sites. However, because of the urban nature of the project site, any construction specifications developed for the alternative would include provisions to develop a contingency plan if any hazardous wastes or contaminated soils are encountered during construction.

6.2.11 FLOODPLAIN

No-Action: The No-Action Alternative would not change the existing characteristics or uses of the floodplain.

Alternative 1d—Channel Widening: Under this alternative, the greater conveyance of flood waters through the main channel and under the Merriam Drive and Shawnee Mission Bridges would cause minor, long-term impacts to the floodplain due to a reduction in floodplain area and the frequency of overbank flows. Because the floodplain has already been completely developed, it is not expected to induce any additional development.

Alternative 2d—Levees and Floodwalls: Under Alternative 2d, constraining more floodwater within the main channel would cause minor, long-term impacts to the floodplain. Because the floodplain has already been developed, this alternative is not expected to induce any additional development.

Alternative 3d—Channel Widening with Levees and Floodwalls: Under Alternative 3d, increasing the conveyance of flood waters and also constraining more flood water within the main channel would cause minor, long-term impacts to the floodplain. This alternative is not expected to induce any additional development within the floodplain.

Alternative 4—Property Buy-Outs: Property buy-outs would result in minor, long-term beneficial impacts to the floodplain. In total, 222 parcels of property, affecting about 135 acres, would be purchased. These properties are currently used for industrial, retail, and residential purposes.

6.2.12 LAND USE

No-Action: The No-Action Alternative would not change land use within the property area. The negative impacts of flooding would remain at current levels.

Alternative 1d—Channel Widening: This alternative would have a minor, long-term impact on land use adjacent to the Turkey Creek channel within the project area because additional land would be required on both sides of the creek to expand the width of the channel from its current width of approximately 50 feet to a top width of approximately 160 to 175 feet, depending on location. Implementation of this alternative would require obtaining approximately 31.17 acres of land immediately adjacent to the creek channel that is currently used for commercial and industrial developments and city parks. The two pedestrian bridges over Turkey Creek in the project area would be modified to span the width of the new channel.

Alternative 2d—Levees and Floodwalls: This alternative would have minor, long-term impacts on land use adjacent to the Turkey Creek channel within the project area. About 15.4 acres of land adjacent to the Turkey Creek channel would be needed to construct the levees and floodwalls, including about 30 feet of land from the existing Turkey Creek top of bank. Implementation of Alternative 2d also could require minor modifications, such as moving parking areas and existing industrial and commercial properties adjacent to the channel. Additionally, the property located to the north of the Merriam Marketplace would need to be acquired to construct a detention basin to collect stormwater runoff coming from locations landward of the levees and floodwall. It is not anticipated that any businesses would need to be bought out or relocated under this alternative. To minimize impacts to land use, floodwalls would be used in locations where there is not enough room between the channel and existing buildings to construct a levee. The two pedestrian bridges that span Turkey Creek in the project area would be increased in length so that they would extend over the new levee.

Alternative 3d—Channel Widening with Levees and Floodwalls: This alternative would have a long-term impact on land use adjacent to the Turkey Creek channel in the project area. Additional land would be required on both sides of the creek to expand the width of the channel from its current width of approximately 50 feet to a top width of approximately 160 to 175 feet, depending on location. Additional land would also be needed for levees and floodwalls. Implementation of this alternative would require obtaining approximately 33.6 acres of land immediately adjacent to the creek channel that is currently used for commercial and industrial developments and city parks. The two pedestrian bridges that span Turkey Creek in the project area would be increased in length so that they would extend over the new levee.

Alternative 4—Property Buy-Outs: Under Alternative 4, property buy-outs would result in long-term impacts to existing land use in locations along the Turkey Creek channel within the project area. In total, 222 parcels of property, totaling about 135 acres, would be purchased. These properties are currently used for industrial, retail, and residential purposes. Potentially, these locations could be returned to green space.

6.2.13 SOCIOECONOMICS

No Action: The future without a flood risk management project would not be expected to have any foreseeable impacts on the population or employment of the Turkey Creek project area or surrounding areas. Existing flood risk to the homes and business properties in the floodplain (approximately $4.7 million per year, based on Atlas-14, see Chapter 5, Table 5-12) would continue over the period of analysis.

Alternative 1d—Channel Widening: The future with a channel widening project flood risk management project would not be expected to have any foreseeable adverse impacts on the population or employment in the Turkey Creek project area or surrounding areas. This channel widening project would reduce the expected damage to the homes and business properties in the floodplain by an average of approximately $2.0 million per year over the period of analysis (estimate based on TP-40, see Chapter 5, Table 5-5) and decrease the likelihood that families and businesses would be forced to relocate outside the floodplain. This alternative would contribute to the safety of those working or residing within the floodplain by decreasing the probability of floodwater inundating the floodplain. During the period of construction, some noise would occur during normal daytime construction hours. With the construction occurring in an area that is primarily commercial and industrial, the noise impact on the community would probably be minimal.

Alternative 2d—Levees and Floodwalls: The future with the levee and floodwall project would slightly reduce employment in the Turkey Creek project area but not have any foreseeable adverse impacts on the population of the Turkey Creek project area or surrounding areas. This levee and floodwall project would reduce the expected damage to the homes and business properties in the floodplain by an average of approximately $3.4 million per year over the period of analysis (based on Atlas-14, see Chapter 5, Table 5-12) and decrease the likelihood that families and businesses would be forced to relocate outside the floodplain. This alternative would contribute to the safety of those working or residing within the floodplain by decreasing the probability of floodwater inundating the floodplain. This alternative would require relocating three businesses in the floodplain. These businesses have a combined estimated employment between 19 and 29 people. It is uncertain whether or not these businesses would relocate within the city of Merriam. For a couple of weeks during the period of construction, a culvert would be placed along Merriam Drive (the road that runs most prominently through the Merriam floodplain, with an average daily traffic count of 4,610), creating some delay. The likely impact would be Merriam Drive shutting down to one lane at a time. Also during the period of construction, some noise would occur during normal daytime construction hours. With the construction occurring in an area that is primarily commercial and industrial, the noise impact on the community would probably be minimal.

Alternative 3d—Channel Widening with Levees and Floodwalls: The future with a flood risk management project that combines channel widening with levees and floodwalls would slightly reduce employment in the Turkey Creek project area but not have any foreseeable adverse impacts on the population of the Turkey Creek project area or surrounding areas. Similar to Alternative 2, this flood risk management project would reduce the expected damage to the homes and business properties in the floodplain by an average of approximately $2.8 million over the period of analysis (estimate based on TP-40, see Chapter 5, Table 5-5) and decrease the likelihood that families and businesses would be forced to relocate outside the floodplain. This alternative would contribute to the safety of those working or residing within the floodplain by decreasing the probability of floodwater inundating the floodplain. This alternative would require relocating at least two businesses in the floodplain. It is uncertain whether or not these businesses would relocate within the city of Merriam. For a couple of weeks during the period of construction, a culvert would be placed along Merriam Drive (which has an average daily traffic count of 4,610), creating some delay. The likely impact would be Merriam Drive shutting down to one lane at a time. Also during the period of construction, some noise would occur during normal daytime construction hours.

With the construction occurring in an area that is primarily commercial and industrial, the noise impact on the community would probably be minimal.

Alternative 4—Property Buy-outs: The future with a property buyout of the floodplain would reduce the population and employment of the Turkey Creek project area. Under a future condition with this non-structural alternative, the bought-out homes and business properties would no longer incur any of their expected average annual damage of approximately $3.4 million (estimate based on TP-40, see Chapter 5, Table 5-5). A future under this alternative would result in families and businesses currently within the project area floodplain relocating outside the floodplain. Some businesses and residents would likely relocate within the city of Merriam; however, some businesses could move out of the study area if they cannot find suitable locally available facilities. This probability is particularly high under Alternative 4 because of the larger number of structures involved. If businesses move outside Merriam, the city would lose the associated jobs and tax revenue. This alternative would contribute to public safety by decreasing the consequences of floodwater inundating the floodplain.

6.2.14 ENVIRONMENTAL JUSTICE

No Action: The future without a flood risk management project would not be expected to have any disproportionate impacts on minority or low-income groups in the Turkey Creek project area or surrounding areas. **Alternative 1d—Channel Widening, Alternative 2d—Levees and Floodwalls, Alternative 3d—Channel Widening with Levees and Floodwalls, and Alternative 4—Property Buy-Outs:** These alternatives would not be expected to have any disproportionate impacts on minority or low-income groups in the Turkey Creek project area or surrounding areas. The minority populations for the overall study area and the Merriam project area are lower than the national averages. The percentage of the population below poverty level, on the other hand, is slightly higher in the Merriam project area (17.5 percent) than the national average of 13.8 percent. However, all of the alternatives would provide socioeconomic benefits by improving flood risk management within the project area.

6.2.15 TRANSPORTATION

No Action: The future without a flood risk management project would not be expected to have any foreseeable permanent impacts on transportation activity or infrastructure in the Turkey Creek project area or surrounding areas.

Alternative 1d—Channel Widening: A future with a channel widening flood risk management project would reduce the expected average annual damage to roads in the floodplain by approximately $14,000. Under this alternative, minor, short-term impacts to local traffic would occur during project construction.

Alternative 2d—Levees and Floodwalls: A future with a levee and floodwall project would reduce the expected average annual damage to roads in the floodplain by more than $16,000. Under this alternative, minor, short-term impacts to local traffic would occur during project construction.

Alternative 3d—Channel Widening with Levees and Floodwalls: A future with a flood risk management project that combines channel widening with levees and floodwalls would also reduce the expected average annual damage to roads in the floodplain by more than $16,000. Under this alternative, minor, short-term impacts to local traffic would occur during project construction.

Alternative 4—Property Buy-Outs: The future with a floodplain property buyout would not have a significant impact on the expected physical damages to roads in the floodplain. Removing the homes and businesses from the floodplain would likely reduce use of Merriam Drive and other roads in the floodplain.

6.2.16 RECREATION

No-Action: The No-Action Alternative would not impact recreation.

Alternative 1d—Channel Widening: This alternative would cause minor, long-term impacts to recreation resources along Turkey Creek. It would require using approximately 2 to 3 acres of the Merriam Marketplace, Campbell Park, and Werner Park to make room for a larger channel. Additionally, there may be impacts to the Turkey Creek Streamway Park. However, efforts would be made during the more detailed engineering and design phase of the project to retain a trail adjacent to Turkey Creek throughout the project area. Additionally, implementation of this alternative would cause minor, short-term impacts to the parks during project construction because these areas may not be available for public use.

Alternative 2d—Levees and Floodwalls: This alternative would cause minor, long-term impacts to recreation along Turkey Creek. It would require using a total of approximately 1 acre of the Merriam Marketplace and Campbell Park to make room for the levees and floodwalls. Additionally, there may be impacts to the Turkey Creek Streamway Park. However, efforts would be made during the more detailed engineering and design phase of the project to retain a trail adjacent to Turkey Creek throughout the project area. Implementation of this alternative may also cause minor, short-term impacts to the parks during project construction because these areas may not be available for public use.

Alternative 3d—Channel Widening with Levees and Floodwalls: This alternative would have minor, long-term impacts to recreation along Turkey Creek. It would require using approximately 2 to 3 acres of the Merriam Marketplace, Campbell Park, and Werner Park to make room for a larger channel and levees and floodwalls. Turkey Creek Streamway Park also would be impacted. However, efforts would be made during the more detailed engineering and design phase of the project to retain a trail adjacent to Turkey Creek throughout the project area. Additionally, implementation of this alternative would cause minor, short-term impacts to the parks during project construction because these areas may not be available for public use.

Alternative 4—Property Buy-Outs: Property buy-outs would not have any long-term adverse impacts on recreation in the project area. Potentially, the City of Merriam could convert the locations where properties have been bought out into additional city parks.

6.2.17 CULTURAL RESOURCES

No Action: The No-Action Alternative would not impact any cultural resources.

Alternative 1d—Channel Widening, Alternative 2d—Levees and Floodwalls, Alternative 3d—Channel Widening with Levees and Floodwalls, and Alternative 4—Property Buy-Outs: Because no cultural resource sites were recorded in the project area or identified during an archeological survey and because the area has been heavily disturbed by surrounding urban development, these alternatives would not adversely impact cultural resource sites. If in the unlikely event that archeological material is discovered during project construction, work in the area of the discovery would cease until the discovery is investigated by a qualified archeologist and the find is coordinated with the State Historic Preservation Officers (SHPO) and the Tribes.

6.2.18 SUMMARY OF ENVIRONMENTAL AFFECTS

A matrix was developed to summarize the impacts that each of the alternatives would have on each of the resources that were evaluated (Table 6-1). None of the alternatives would result in any significant adverse impacts to the human environment.

Table 6-1: Summary of the Environmental Impacts for the Alternatives

(Because there would not be any impacts to climate, wetlands, threatened and endangered species, HTRW, environmental justice, and cultural resources, these resource areas were omitted from the table.)

	No Action	Alternative 1d	Alternative 2d	Alternative 3d	Property Buy-Outs
Geology, Soils, and Geomorphology	O	□ (Soil disturbance) ▲ (Geomorphic ↑ in channel capacity)	□ (Soil disturbance) ■ (Levees in floodplain) ▲(2.1-acre detention basin)	□ (Soil disturbance) ■ (Levees in floodplain) ▲ (Geomorphic ↑ in channel capacity, 2.1-acre detention)	▲ (Potential to convert impervious cover to more natural soil type)
Hydraulics and Hydrology	O	□ (Construction equipment in channel) ▲(↑ in channel capacity)	□ (Construction equipment in channel) ■ (Constrained channel capacity)	□ (Construction equipment in channel) ■ (Constrained channel capacity) ▲(↑ in channel capacity)	▲(Potential for less resistance for flood waters)
Water Quality	O	□ (↑ in turbidity)	□ (↑ in turbidity)	□ (↑ in turbidity)	O
Aquatic Habitat	O	□ (Physical disturbance) ▲(↑ of 13 acres of habitat)	□ (Physical disturbance)	□ (Physical Disturbance) ▲(↑ of 13 Acres of Habitat)	O
Terrestrial Habitat	O	□ (Physical disturbance) ■ (6 acres of trees removed)	□ (Physical disturbance) ■ (4 acres of trees removed)	□ (Physical disturbance) ■ (6 acres of trees removed)	▲(Potential to restore more natural floodplain habitat)
Fish and Wildlife	O	□ (Physical disturbance) ■ (6 acres of trees removed) ▲(↑ of 13 acres of aquatic habitat)	□ (Physical disturbance) ■ (4 acres of trees removed)	□ (Physical disturbance) ■ (6 acres of trees removed) ▲(↑ of 13 acres of aquatic habitat)	▲(Potential to restore more natural floodplain habitat)
Floodplain	O	▲(↑ in channel capacity)	■ (Constrained channel capacity)	■ (Constrained channel capacity) ▲(↑ in channel capacity)	▲ (135 acres of developed properties removed from floodplain)
Land Use	O	■ (31.17 acres of developed properties needed for widening channel)	■ (15.4 acres of developed properties needed for widening channel)	■ (33.6 acres of developed properties needed for widening channel)	■ (135 acres of developed properties removed from floodplain)
Socioeconomics	O	▲ (Reduction of property damages by $2.7 million/year)	▲ (Reduction of property damages by $3.0 million/year) ■ (Relocation of 3 businesses)	▲ (Reduction of property damages by $3.0 million/year) ■ (Relocation of at least 2 businesses)	▲ (Reduction of property damages by $3.7 million/year) ■ (Relocation of 28 businesses and 9 residences)
Transportation	O	□ (Traffic delays, potential detours) ▲(Reduced road damage estimated at $14,000/year)	□ (Traffic delays, potential detours) ▲(Reduced Road Damage Estimated at $16,000/year)	□ (Traffic delays, potential detours) ▲(Reduced Road Damage Estimated at $16,000/year)	O
Recreation	O	□ (Restricted access to parks and trails) ■ (Removal of 2-3 acres of park lands)	□ (Restricted access to parks and trails) ■ (Removal of approximately 1 acre of park lands)	□ (Restricted access to parks and trails) ■ (Removal of 2-3 acres of park lands)	▲ (Potential to develop additional parkland or flood resilient recreational facilities in vacated floodplain)

Notes: O – No impact; □ – Minor, short-term negative impact resulting from construction; ■ – Minor, long-term negative impact; ▲ – Minor, long-term beneficial impact

6.3 ALTERNATIVE FORMULATION FOR COMPENSATORY MITIGATION

To evaluate the need for any compensatory mitigation that may be required for CWA Section 404 Authorization, the HEP method was used. Specific HSI models used for this method were the green sunfish (*Lepomis cyanellus*) and the fox squirrel (*Sciurus niger*). Screening level costs were utilized to identify appropriate mitigation plans for each study alternative. The cost for the final mitigation plan was updated prior to finalization of the study. Using the green sunfish model, it was determined that no compensatory mitigation would be needed for any of the alternatives evaluated for in-stream impacts (Table 6-2). Two of the alternatives—Alternative 1d, Channel Widening, and Alternative 3d, Channel Widening with Levees and Floodwalls—would increase the amount of aquatic habitat, resulting in an overall net gain in the number of AAHUs for this species. However, compensatory mitigation would be necessary for impacts to the riparian corridor as indicated by the fox squirrel model (Table 6-3). The amount of mitigation necessary would vary depending on the alternative implemented.

Table 6-2: Summary of Results from Green Sunfish HSI Model for Each Alternative

Alternative	Green Sunfish AAHU Future Without Project	Green Sunfish AAHU Future With Project	Mitigation Required
No-Action Alternative	3.77	3.77	No
Alternative 1d: Channel Widening	3.77	8.47	No
Alternative 2d: Levees and Floodwalls	3.77	3.77	No
Alternative 3d: Combination Widening and Levees and Floodwalls	3.77	8.47	No
Alternative 4: Property Buy-Outs	3.77	3.77	No

Notes: AAHU – Average annual habitat unit, HSI – Habitat Suitability Index, NA – Not applicable

Table 6-3: Summary of Results from Fox Squirrel HSI Model for Each Alternative

Alternative	Fox Squirrel AAHU Future Without Project	Fox Squirrel AAHU Future With Project	Mitigation Required
No-Action Alternative[a]	3.2 to 4.2	3.2 to 4.2	No
Alternative 1d: Channel Widening	3.94	0	Yes
Alternative 2d: Levees and Floodwalls	2.74	0	Yes
Alternative 3d: Combination Widening and Levees and Floodwalls	4.23	0	Yes
Alternative 4: Property Buy-Outs[b]	See footnote b	See footnote b	No

Notes: AAHU – Average annual habitat unit, HSI – Habitat Suitability Index, NA – Not applicable

[a] The AAHU varied based by the size of the project footprint evaluated for comparison with Alternatives 1d, 2d, or 3d.

[b] Due to limited resources and the size of the project footprint for this alternative, AAHUs for fox squirrel were not determined. However, it would be expected that there would be an increase in the number of AAHUs for this species over the long-term.

To compensate for riparian habitat lost as a result of implementing a structural alternative, various mitigation options were developed. Each of these mitigation options would require planting hard mast producing trees, such as oak, walnut, and/or pecan. No trees would be planted within 15 feet of any levee or

floodwall, complying with Engineering Technical Letter 1110-2-571, Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures (April 10, 2009). Variables that were manipulated to develop various mitigation options included the initial size of the tree that would be planted, the density of the trees, and the size of the planting area. As shown in Table 6-4, a total of 24 mitigation options were developed.

Table 6-4: Mitigation Options Formulated to Compensate for Impacts to the Riparian Habitat as a Result of Implementing a Structural Alternative

Mitigation Option	Caliper of Tree When Planted	Density of Trees	Number of Acres Planted
Mitigation Option 1	5/8 inch	35 foot x 35 foot	5
Mitigation Option 2	5/8 inch	40 foot x 40 foot	5
Mitigation Option 3	5/8 inch	45 foot x 45 foot	5
Mitigation Option 4	1 inch	35 foot x 35 foot	5
Mitigation Option 5	1 inch	40 foot x 40 foot	5
Mitigation Option 6	1 inch	45 foot x 45 foot	5
Mitigation Option 7	5/8 inch	35 foot x 35 foot	7
Mitigation Option 8	5/8 inch	40 foot x 40 foot	7
Mitigation Option 9	5/8 inch	45 foot x 45 foot	7
Mitigation Option 10	1 inch	35 foot x 35 foot	7
Mitigation Option 11	1 inch	40 foot x40 foot	7
Mitigation Option 12	1 inch	45 foot x45 foot	7
Mitigation Option 13	5/8 inch	35 foot x 35 foot	9
Mitigation Option 14	5/8 inch	40 foot x 40 foot	9
Mitigation Option 15	5/8 inch	45 foot x 45 foot	9
Mitigation Option 16	1 inch	35 foot x 35 foot	9
Mitigation Option 17	1 inch	40 foot x 40 foot	9
Mitigation Option 18	1 inch	45 foot x 45 foot	9
Mitigation Option 19	5/8 inch	35 foot x 35 foot	11
Mitigation Option 20	5/8 inch	40 foot x 40 foot	11
Mitigation Option 21	5/8 inch	45 foot x 45 foot	11

Mitigation Option	Caliper of Tree When Planted	Density of Trees	Number of Acres Planted
Mitigation Option 22	1 inch	35 foot x 35 foot	11
Mitigation Option 23	1 inch	40 foot x 40 foot	11
Mitigation Option 24	1 inch	45 foot x 45 foot	11

The future condition of variables in the fox squirrel HSI model was predicted for each of the mitigation options, Appendix M. Selection of the most appropriate mitigation option was then determined through the CE/ICA process using IWR-Planning Suite. An additional criterion for selecting a mitigation option is that it must provide enough AAHUs to meet or exceed the number of AAHUs that would be lost as a result of implementing a particular alternative.

Each of the mitigation options was mutually exclusive from the others. Therefore, no additional permutations or combinations of options were evaluated under CE/ICA. IWR Planning Suite was used to determine which of the options were "cost effective" and which options were "best buys." Cost effective options are those options for which there is no other option that achieves greater output at a lesser cost (identified in Table 6-5). Best buy options are the array of cost effective options for which the average cost for the *incremental* output is strictly increasing (identified in Table 6-6). The output used for CE/ICA was the Fox Squirrel AAHU. The cost used for CE/ICA was average annual cost, including the cost of purchasing trees, installation, PED, and real estate. The full calculation of costs can be found in Appendix M. In addition to Tables 6-5 and 6-6, the results of CE/ICA are also displayed graphically in Figures 6-1 and 6-2.

Table 6-5: Results of IWR Planning Suite Cost Effectiveness Analysis

Mitigation Option	Total Cost	Average Annual Cost[a]	Fox Squirrel AAHU Gain	Cost Effective?
No Mitigation	$0	$0	0.00	Yes
Mitigation Option 1	$14,802	$689	2.26	Yes
Mitigation Option 2	$13,851	$645	2.23	Yes
Mitigation Option 3	$13,323	$620	2.18	Yes
Mitigation Option 4	$30,483	$1,419	2.78	No
Mitigation Option 5	$25,612	$1,192	2.71	No
Mitigation Option 6	$22,906	$1,066	2.58	No
Mitigation Option 7	$20,722	$965	3.16	Yes
Mitigation Option 8	$19,392	$903	3.12	Yes
Mitigation Option 9	$18,652	$868	3.06	Yes
Mitigation Option 10	$42,676	$1,987	3.89	No
Mitigation Option 11	$35,857	$1,669	3.80	No
Mitigation Option 12	$32,069	$1,493	3.61	No
Mitigation Option 13	$26,643	$1,240	4.06	Yes

Mitigation Option	Total Cost	Average Annual Cost[a]	Fox Squirrel AAHU Gain	Cost Effective?
Mitigation Option 14	$24,932	$1,161	4.01	Yes
Mitigation Option 15	$23,982	$1,116	3.93	Yes
Mitigation Option 16	$54,870	$2,554	5.00	No
Mitigation Option 17	$46,102	$2,146	4.88	No
Mitigation Option 18	$41,232	$1,919	4.64	No
Mitigation Option 19	$32,564	$1,516	4.97	Yes
Mitigation Option 20	$30,473	$1,419	4.90	Yes
Mitigation Option 21	$29,311	$1,364	4.80	Yes
Mitigation Option 22	$67,063	$3,122	6.12	Yes
Mitigation Option 23	$56,347	$2,623	5.97	Yes
Mitigation Option 24	$50,394	$2,346	5.67	No

Note: IWR – Institute of Water Resources
[a] The average annual cost was determined using an October 2011 price level and the FY 2012 federal interest rate of 4.000% over a 50-year period of analysis.

Table 6-6: Results of IWR Planning Suite Incremental Cost Analysis

Mitigation Option	Average Annual Cost	Fox Squirrel AAHU Gain	Best Buy?
No Mitigation	$0	0.00	Yes
Mitigation Option 1	$689	2.26	No
Mitigation Option 2	$645	2.23	No
Mitigation Option 3	$620	2.18	No
Mitigation Option 7	$965	3.16	No
Mitigation Option 8	$903	3.12	No
Mitigation Option 9	$868	3.06	Yes
Mitigation Option 13	$1,240	4.06	No
Mitigation Option 14	$1,161	4.01	No
Mitigation Option 15	$1,116	3.93	Yes
Mitigation Option 19	$1,516	4.97	No
Mitigation Option 20	$1,419	4.90	Yes
Mitigation Option 21	$1,364	4.80	Yes

Mitigation Option	Average Annual Cost	Fox Squirrel AAHU Gain	Best Buy?
Mitigation Option 22	$3,122	6.12	Yes
Mitigation Option 23	$2,623	5.97	Yes
Mitigation Option 24	$2,346	5.67	No

Note: IWR – Institute of Water Resources

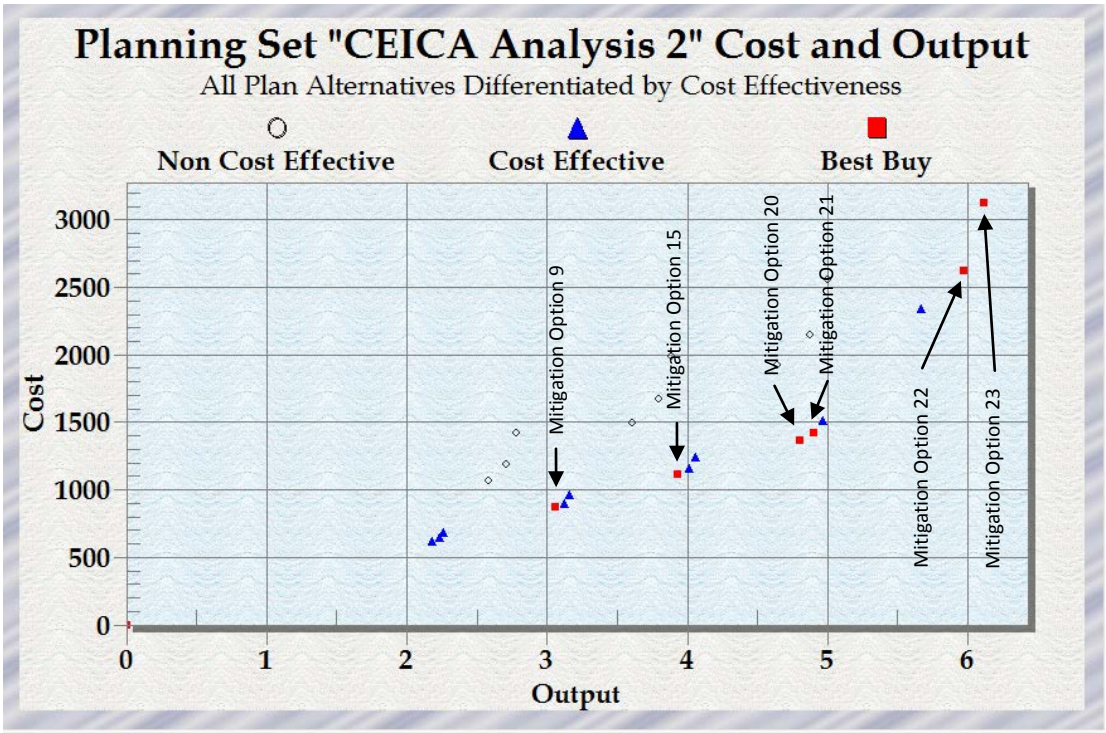


Figure 6-1: Planning Set "CE/ICA Analysis 2" Cost and Output

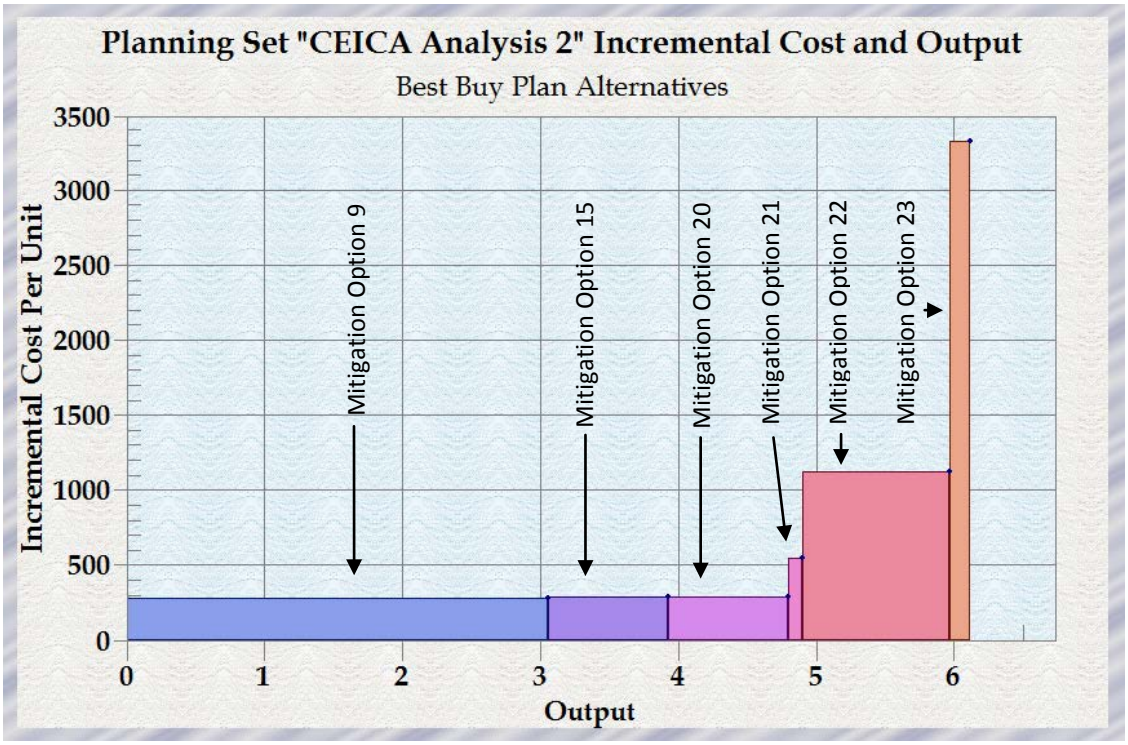


Figure 6-2: Planning Set "CE/ICA Analysis 2" Incremental Cost and Output

***output is in Average Annual Habitat Units (AAHUs),**
****each color bar represents a mitigation option alternative**

The criteria for determining which mitigation option(s) would be used in the economic screening were that the option:

1. Is a best buy option as determined by CE/ICA
2. Meets the minimum mitigation requirement for a given alternative
3. Is the lowest-cost option of the options that meet criteria 1 and 2

The best buy options are evaluated for criteria 2 in Table 6-7. The final results of all criteria are shown in Table 6-8.

Table 6-7: Evaluation of Best Buy Options against Minimum Mitigation Requirement

Mitigation Option (Re-ordered by ascending cost and output)	Fox Squirrel AAHU Gain	Meets Minimum Mitigation Requirement for Alt 1d (3.94)	Meets Minimum Mitigation Requirement for Alt 2d (2.74)	Meets Minimum Mitigation Requirement for Alt 3d (4.23)	Meets Minimum Mitigation Requirement for Alt 4 (0.00)
No Mitigation	0.00	No	No	No	Yes
Mitigation Option 9	3.06	No	Yes	No	Yes
Mitigation Option 15	3.93	No	Yes	No	Yes
Mitigation Option 21	4.80	Yes	Yes	Yes	Yes
Mitigation Option 20	4.90	Yes	Yes	Yes	Yes

Mitigation Option (Re-ordered by ascending cost and output)	Fox Squirrel AAHU Gain	Meets Minimum Mitigation Requirement for Alt 1d (3.94)	Meets Minimum Mitigation Requirement for Alt 2d (2.74)	Meets Minimum Mitigation Requirement for Alt 3d (4.23)	Meets Minimum Mitigation Requirement for Alt 4 (0.00)
Mitigation Option 23	5.97	Yes	Yes	Yes	Yes
Mitigation Option 22	6.12	Yes	Yes	Yes	Yes

Table 6-8: Mitigation Options and Mitigation Costs Used in Economic Screening

Alternative	Mitigation Option Used in Economic Screening	Total Cost[a]
Alternative 1d: Channel Widening	Mitigation Option 21	$29,311
Alternative 2d: Levees and Floodwalls	Mitigation Option 9	$18,652
Alternative 3d: Combination Widening and Levees and Floodwalls	Mitigation Option 21	$29,311
Alternative 4: Property Buy-Outs	No Mitigation	$0

[a] Screening level costs were utilized to identify appropriate mitigation plans for each study alternative. The cost for the final mitigation plan was updated prior to finalization of the study.

6.4 CUMULATIVE IMPACTS

The CEQ 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 within the Turkey Creek watershed.

Much of the original Turkey Creek floodplain has been developed for urban uses, including industrial, commercial, and residential areas. Turkey Creek originally flowed into the Missouri River, but a major flood in the 1800s moved its mouth from the Missouri River to the Kansas River. Since that time, Turkey Creek has been channelized, moved and filled, and placed in a tunnel for some of its length. The lower reach of the creek was originally channelized before 1920, during the construction of the tunnel bypass. In addition, the construction of I-35 and the railroad through the Turkey Creek valley has also impacted the creek channel and floodplain. Urban development of the floodplain has included fill activity, channelization of drainages including concrete lining and enclosures, and development of numerous buildings, parking lots, roads, and utilities. Within the Merriam project area, Merriam Drainage District (MDD) has channelized Turkey Creek from 63rd Street downstream to 51st Street in the late 1960s and early 1970s. MDD has produced a channel of nearly uniform width, deepened to bedrock, through the Merriam project area.

The recommended plan in this study is not expected to result in cumulative impacts with past actions that have occurred in the watershed. The location that the project would provide socioeconomic benefits too is highly urbanized and area is fully developed with residential, commercial, and industrial land uses. The project would provide socioeconomic benefits to the area, but is not expected to contribute to future development that could result in any additional environmental impacts. Space within the project area limits any additional development.

In addition to the alternatives evaluated in this Integrated Feasibility Report and EA, USACE is currently constructing another flood risk management project on Turkey Creek under a separate authorization. Construction of this project, Lower Turkey Creek, began in 2004 and is expected to be completed in 2016. The Lower Turkey Creek project is being constructed along the downstream 8,700 feet of Turkey Creek before it enters the Kansas River. The project is being constructed in several phases. Work completed to date includes a realignment and widening of the channel immediately adjacent to I-35 for approximately 4,000 feet, rehabilitation of a 1,200-foot-long tunnel, construction of an engineered channel for 1,500 feet, replacement of a railroad bridge, construction of a levee 2,500 feet long, and development of an 18-acre environmental enhancement area. Future work will include replacement of a bridge, widening and benching of 1,800 feet of channel, replacement of a second railroad bridge, and construction of a series of hillside interceptors to direct water from upland areas directly to Turkey Creek.

Another major construction activity occurring in the Turkey Creek watershed and relatively close to the creek in some locations is numerous construction projects along I-35. These projects are part of a phased plan to widen I-35 and redo numerous interchanges along the interstate in Johnson County to meet future traffic demands. The I-35 construction projects are scheduled to be completed by 2015.

A project that replaced a traffic bridge on Antioch Road and a railroad bridge over Turkey Creek was completed in the year 2000. These bridges are both located within Merriam, Kansas. These bridges were designed to reduce channel constrictions along Turkey Creek. Additionally, gabion revetments were used to stabilize the banks of the creek in the vicinity of the bridges. Other construction activities within the Turkey Creek watershed are expected to continue indefinitely into the future as development and redevelopment continues in the highly urbanized watershed.

Turkey Creek has relatively poor water quality as the result of urban runoff and effluent from a waste water treatment plant. In addition, the aquatic community in the creek lacks diversity and is dominated by species that are tolerant of polluted waters. Much of Turkey Creek has only limited riparian habitat due to the presence of industrial properties, fencing, roads, and other intensive land use practices. Intensive development within the Turkey Creek watershed has resulted in a narrow to non-existent riparian corridor along the channel. As part of this study, potential measures to benefit the ecosystem were developed early in the study process as part of a systems approach and are included in Appendix J. However, there was not support from the local sponsor to further develop these measures into implementable plans because they would not have any measurable benefits for flood risk management on a scale that would be able to be reasonably implanted. It is hoped that these plans could be refined at some point in the future by either the sponsor or some other interested entity and implemented. The current project is not expected preclude or inhibit any efforts that may be undertaken in the future to improve water quality or benefit fish and wildlife habitat.

In the past, watershed planning efforts have been initiated to improve the environment within the Upper Turkey Creek watershed. In 2005 and 2006, EPA contracted the Watershed Institute, Inc. to prepare background research as the first phase of a Special Area Management Plan (SAMP) for the Upper Turkey Creek watershed. The goal of SAMP is to achieve a balance between aquatic resource conservation, infrastructure maintenance, and sound economic development to minimize the individual and cumulative impacts of future projects. Implementation for the remaining three phases of the SAMP has not occurred. At this time, it seems unlikely that SAMP will be further developed or implemented for Turkey Creek. However, if one is ever implemented in the future, the SAMP would not be impacted by the current project.

The sponsor will prepare the Floodplain Management Plan (FMP) during design phase. Any action items developed as part of FMP will be a local responsibility and will have specific timeframes identified for

implementation to ensure not only the longevity of the project identified in this report but also to improve public understanding of flood risks and reduce future damages and threats to public safety.

The recommended plan is not expected to result in cumulative impacts with other past, ongoing projects or projects that may occur in the future. The primary environmental impact associated with the recommended plan is to riparian trees. This impact would be mitigated at part of the project. Other minor impacts, primarily related to short-term construction related impact and long-term geomorphic changes would occur in locations that have already been modified in the past. These impacts are similar in intensity to past disturbances and are typical in context with other activities in the area and are not expected to have long-term cumulative adverse effects to the human environment. The recommend plan would not prevent future efforts to improve environmental conditions with the watershed.

7 CHAPTER 7 – THE RECOMMENDED PLAN

The USACE Planning Guidance Notebook, ER 1105-2-100, states, "A plan that reasonably maximizes net national economic development benefits, consistent with the Federal objective, is to be formulated. This plan is to be identified as the National Economic Development (NED) plan." The Environmental Assessment for this study has been integrated into the following Feasibility Report in accordance with ER 1105-2-100. Sections of the report that are required for compliance with the National Environmental Policy Act (NEPA) are noted by an asterisk (*) in the Table of Contents.

The feasibility study's project delivery team identified Alternative 2d as the NED Plan and selected Alternative 2d as the Recommended Plan. Alternative 2d is the plan that reasonably maximizes the net NED benefits (as shown in the initial screening of alternatives in Section 5.3 and post-Atlas-14 sensitivity-analysis described in Section 5.4), while also being environmentally acceptable (as shown in Chapter 6). Alternative 2d would pass the 1 percent Annual Chance of Exceedance (ACE) event through downtown Merriam with an estimated assurance (conditional non-exceedance probability) of 82.9 percent, provide greater net annual benefits in reduction of flood damages than the other alternatives, and meet the needs of the local community.

The cost of the NED Plan Alternative 2d increased significantly during development of the detailed plan analysis. This is not uncommon when considering the proposed selected/NED Plan in more detail that the costs will increase as more engineering and cost estimating effort is applied. The sensitivity analysis completed in Section 5.4 utilizing updated features and costs for the most economically effective plans 2c, 2b and the Atlas 14 Plan confirmed Plan 2d as the plan with the highest net annual benefits.

A Cost and Schedule Risk Analysis (CSRA) was performed on the Recommended Plan (Alternative 2d). The project cost including the contingency estimate that resulted from CSRA for Alternative 2d is $37,579,000 (price level date 1 Oct 2014). There is also an additional economic cost of interest during construction (IDC) of $3,003,900, for a total investment cost of $40,582,900. Total annual NED cost is $1,732,200. Total annual benefits are $3,444,700. The benefit-cost ratio is 2.0 to 1, with net benefits of $1,712,500.

7.1 PLAN ACCOMPLISHMENTS

The Recommended Plan meets the objectives identified in Chapter 2, Section 2.4. The Principles and Guidelines for Water and Related Land Resources Studies (P&G) define effectiveness as a measure of the extent to which a plan achieves its objectives. The Recommended Plan meets the criteria of effectiveness, because it reduces risk to the City business district and public facilities, and allows these facilities to remain functional during all but the largest flood events. Additionally, through the systems approach used by USACE throughout the study numerous collaborative planning achievements were met. These include working jointly with the cities and counties on watershed based tools to reduce flood hazards, developing environmental restoration strategies, integrating recreational trails, and working with numerous stakeholder groups within the watershed.

Given the cost, the Recommended Plan is estimated to provide the greatest level of damage reduction of approximately 73 percent of total equivalent annual damages within the Upper Turkey Creek watershed to the city of Merriam with residual damages of 27 percent of the future without-project damages.

Because of the area of the City that is susceptible to flooding and the velocity of the flood waters, there is a risk for loss of life during flood fighting and other emergency measures. The flood of July 1993 caused one fatality and resulted in damages estimated at $3.4 million in Merriam, and $20 million in the lower basin areas. The flood of October 1998 caused an estimated $12 million of damages in Merriam, and

damages in the lower basin equivalent to those of 1993. The flood peak occurred in the late evening, and if the peak had occurred during rush hour, loss of life would have been very likely for travelers on I-35, which was overtopped by flood waters at multiple locations. The Recommended Plan would substantially reduce flood risk in the City of Merriam to 69 commercial/industrial structures and nine residential structures and would also likely reduce the risk of loss of life from flooding, due to the decreased probability of a flood event inundating the floodplain with short warning time.

There is one critical facility in the floodplain, the nursing home located at 62nd Street. The property is subjected to potential flooding in the without-project condition and it will be protected by the recommended plan.

The planners and hydraulic engineers developed inundation maps for the without and with-project conditions to depict estimates of flooding and the effects of the Recommended Plan. Those are located in plates at the beginning of Section 7.2.

7.2 CONSTRUCTION FEATURES

The Recommended Plan is a levee and floodwall plan in the city of Merriam. These features would extend approximately from Shawnee Mission Parkway to Merriam Drive, which is a 1.5-mile stretch that includes Merriam's main downtown reach. Most of the protected area is on the right bank of Turkey Creek while much of the left bank remains as an unoccupied floodplain. The features are designed for a small urban watershed and include levees no more than 6.5 feet high. The Recommended Plan includes 6,822 feet of floodwall up to 6.5 feet high, 3,383 feet of levees up to 6 feet high, utility modifications, approximately 12,427 Auger Grout Piles, and a 2.14 acre-foot detention area (Figures 7-1 through 7-6). These figures are plates depicting the primary features of the project in plan view by reach of the creek. In addition, Figures 7-7 and 7-8 are plates showing the inundation from flooding for the nominal 1 percent-ACE and the 0.2 percent-ACE events in the without project and with-project conditions. The blue hatching overlay shows the 1 percent-ACE event flooding extent, and the 0.2 percent-ACE event is shown by the lighter blue shading.

An overview of major construction features is included in sections below, and a summary of the Recommended Plan features is included in Table 7-1 by reach.

- Levees and floodwalls
- Ground Modification
- Bridge modifications/headwalls
- Utility modifications
- Environmental mitigation

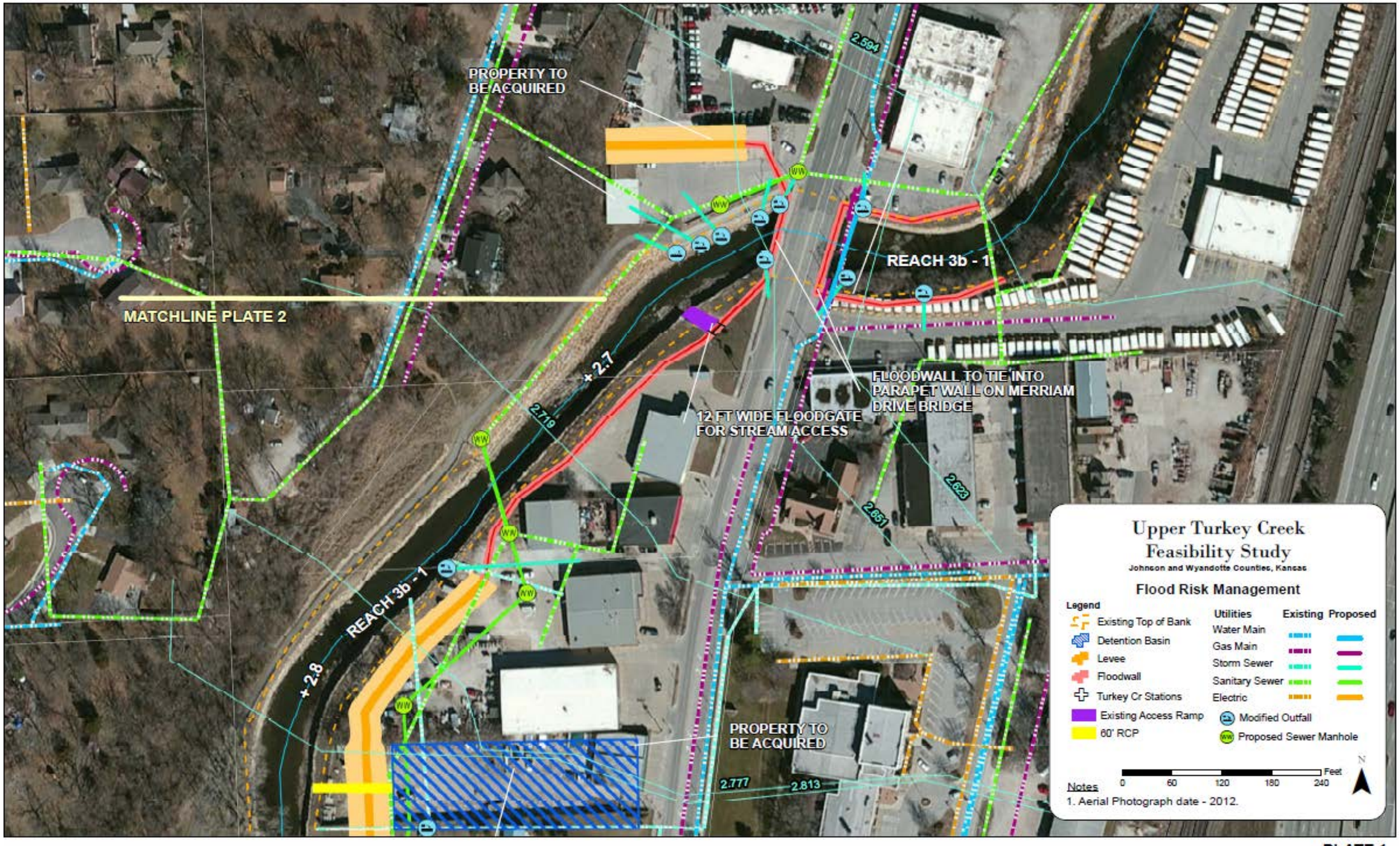


Figure 7-1: Recommended Plan (Alternative 2d) - Plate 1

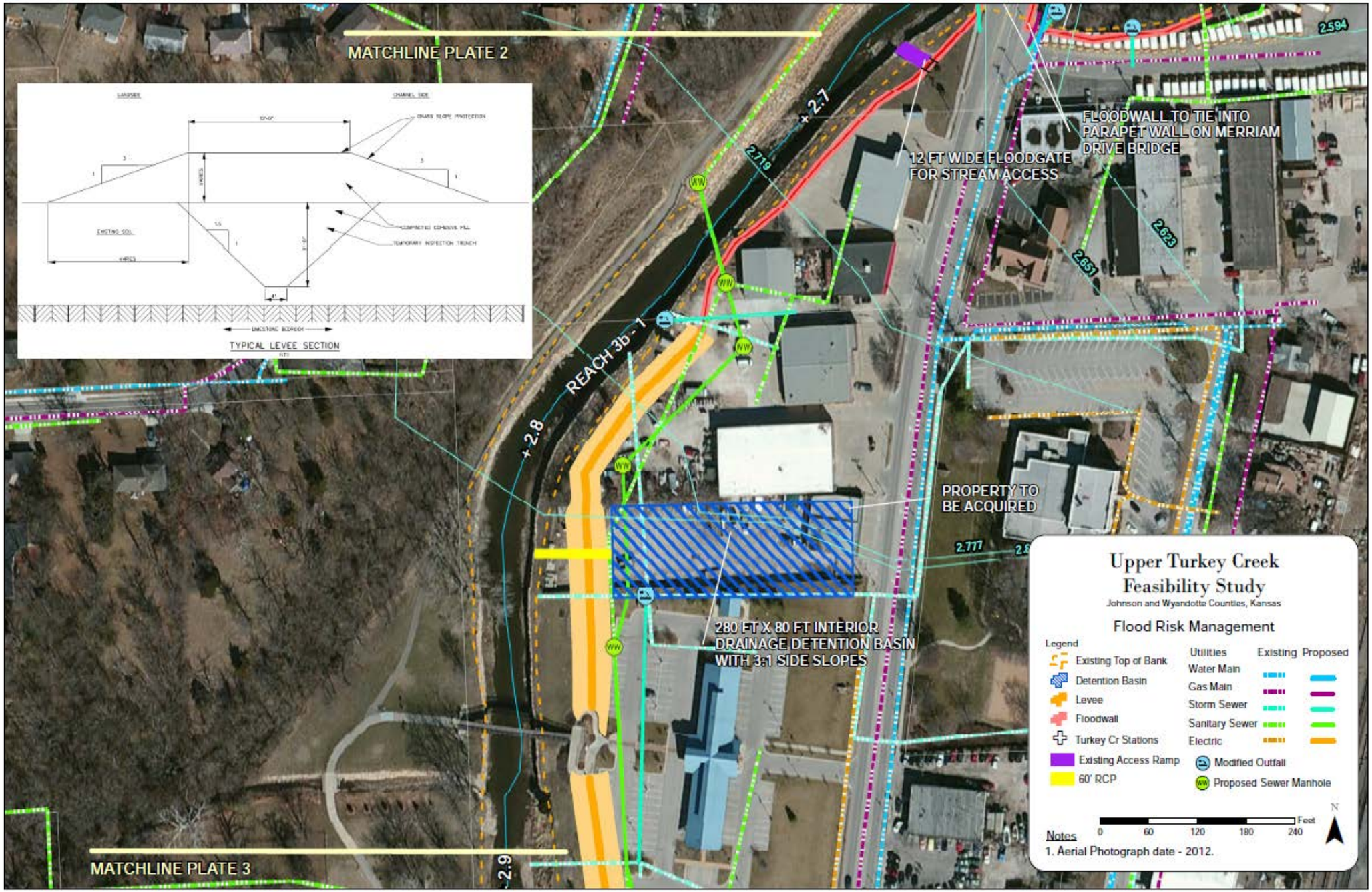


Figure 7-2: Recommended Plan (Alternative 2d) - Plate 2

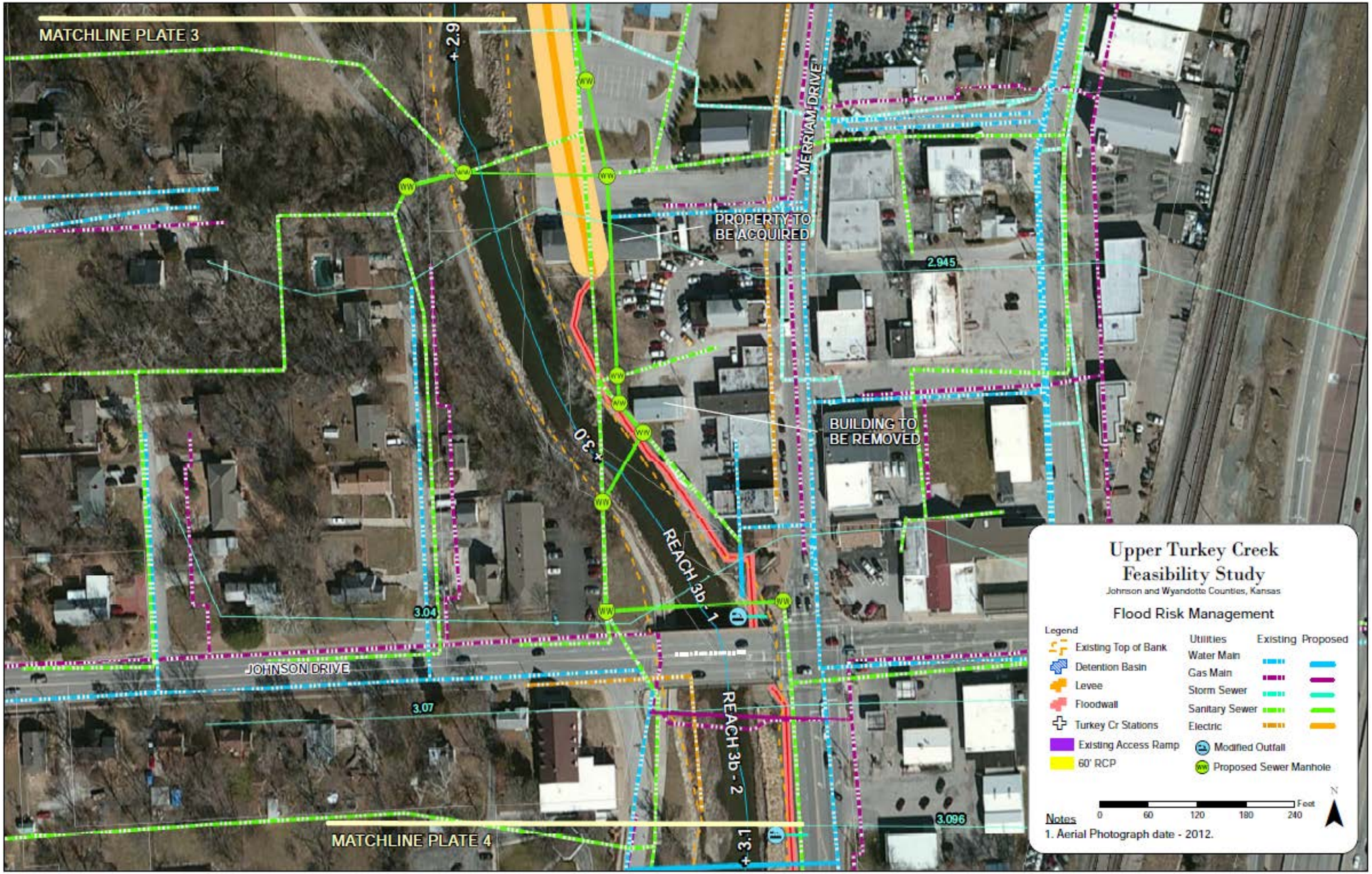


Figure 7-3: Recommended Plan (Alternative 2d) - Plate 3

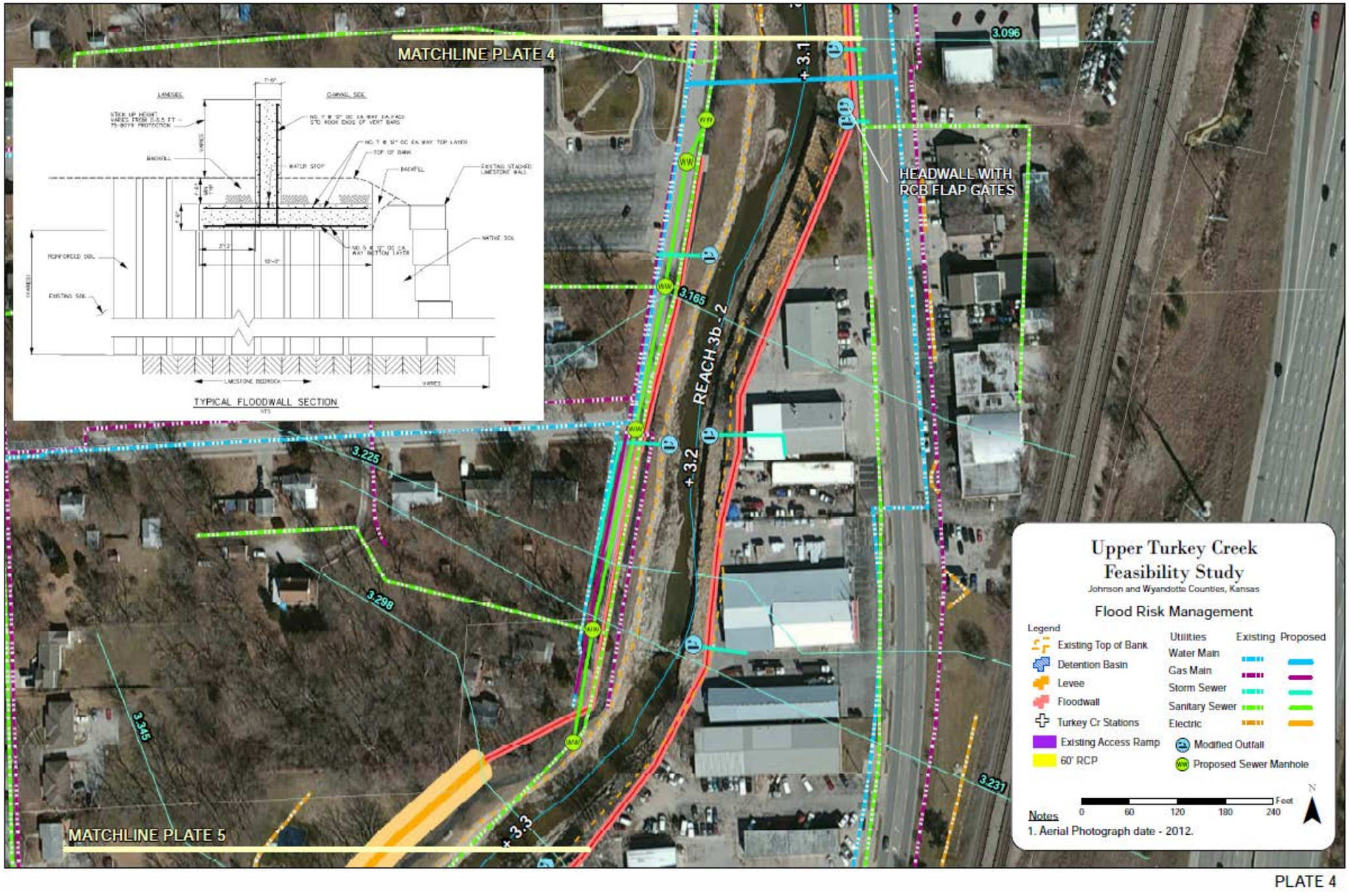


Figure 7-4: Recommended Plan (Alternative 2d) - Plate 4

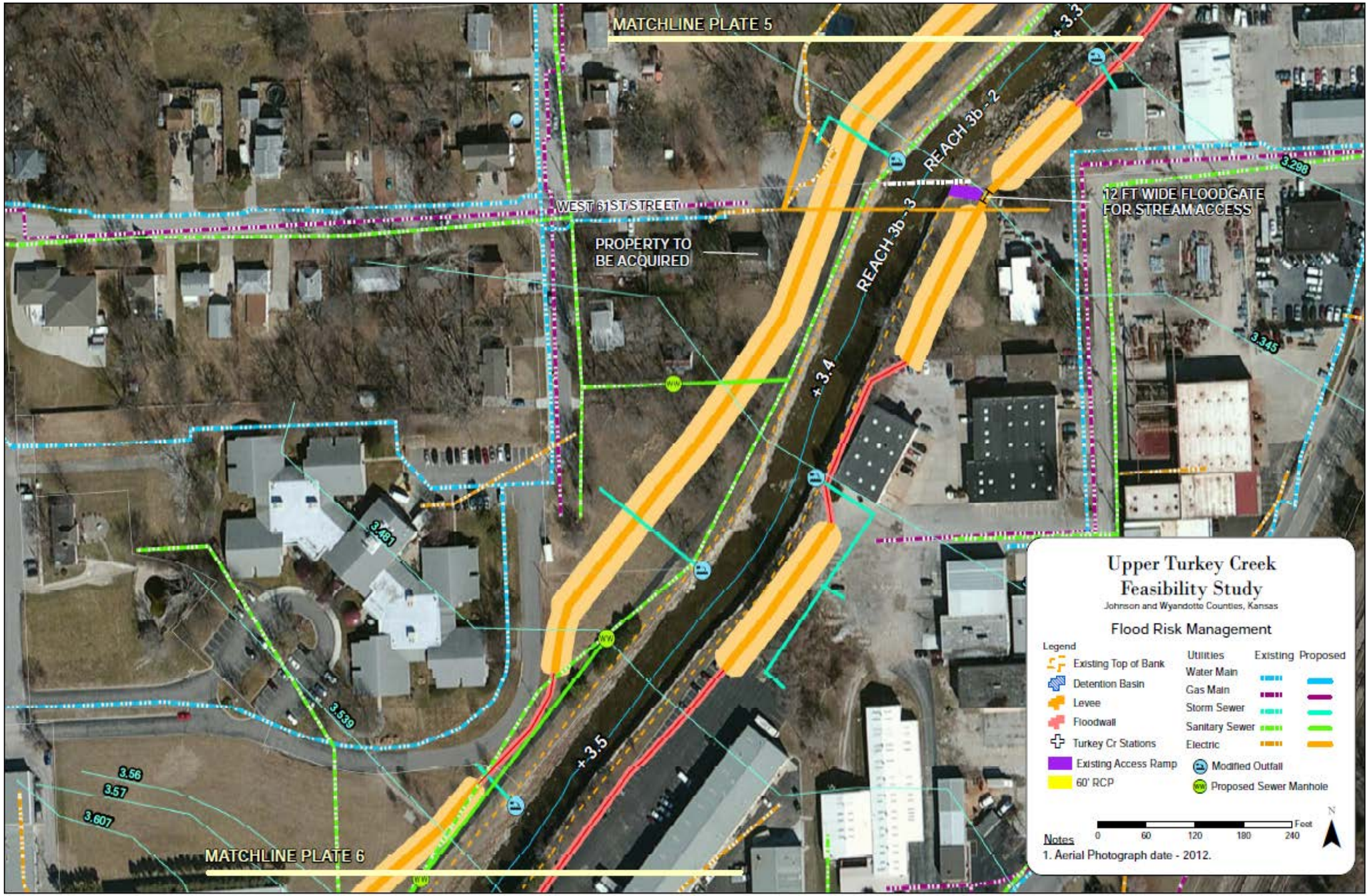


Figure 7-5: Recommended Plan (Alternative 2d) - Plate 5

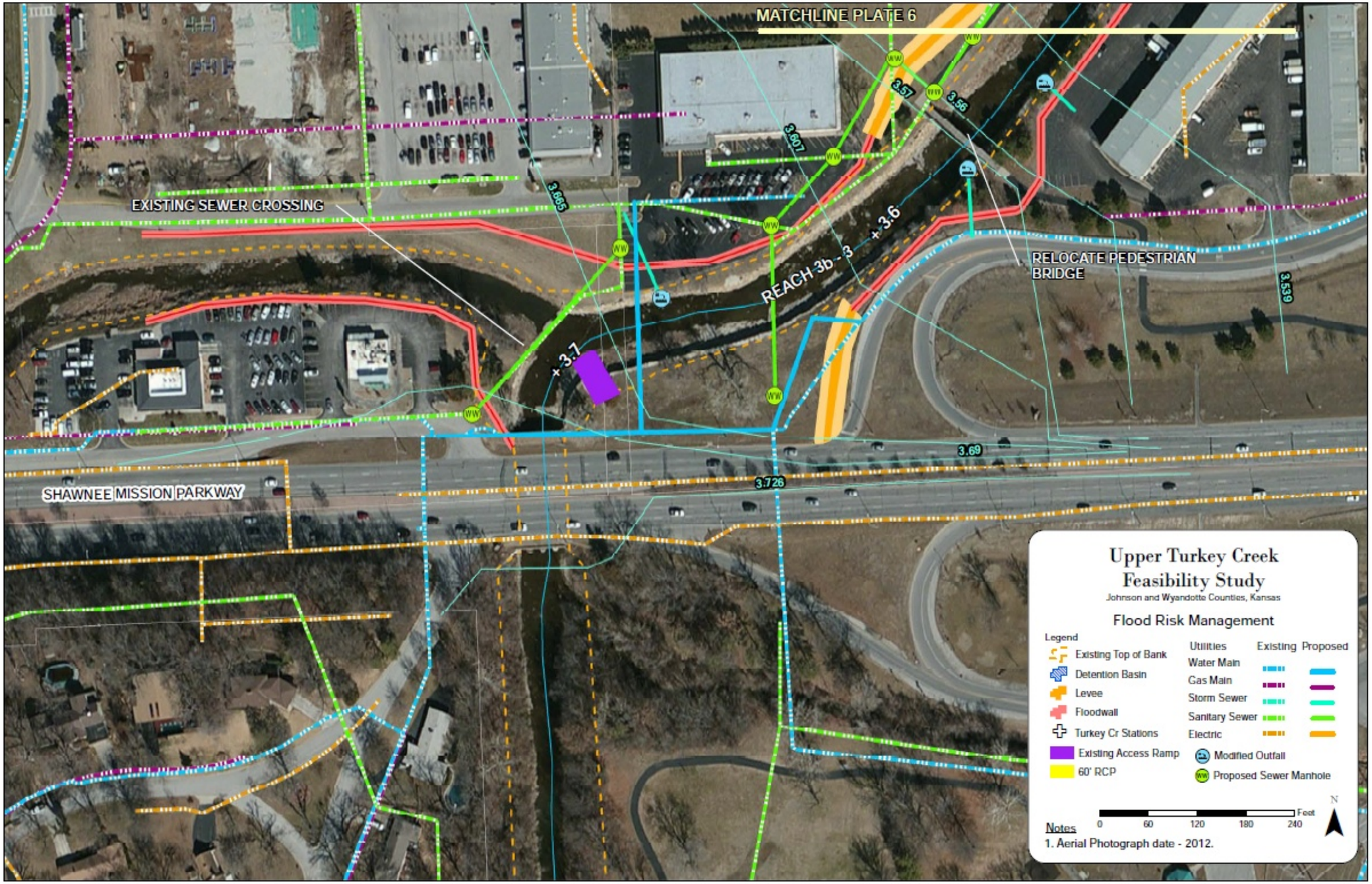


Figure 7-6: Recommended Plan (Alternative 2d) - Plate 6

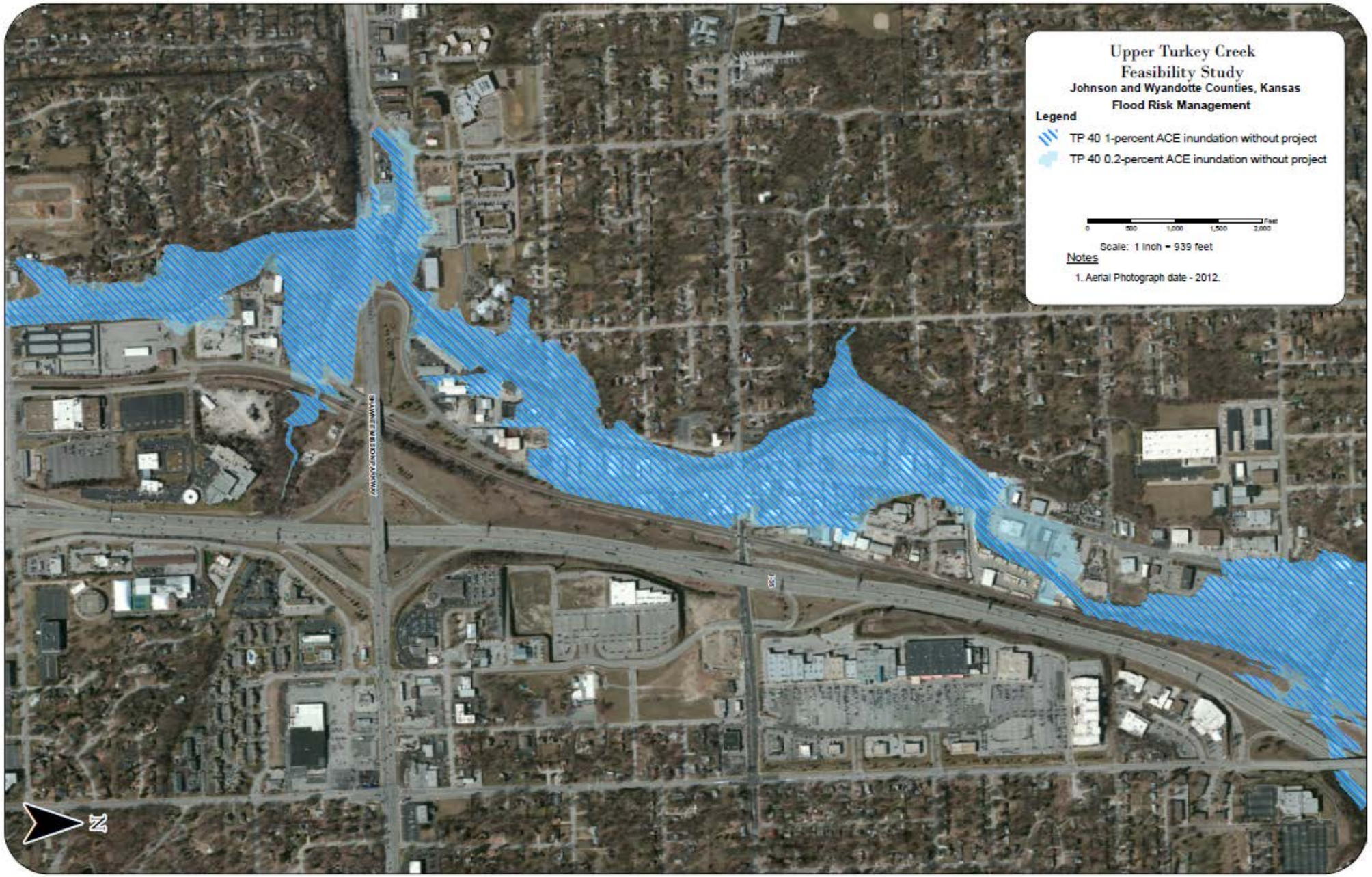
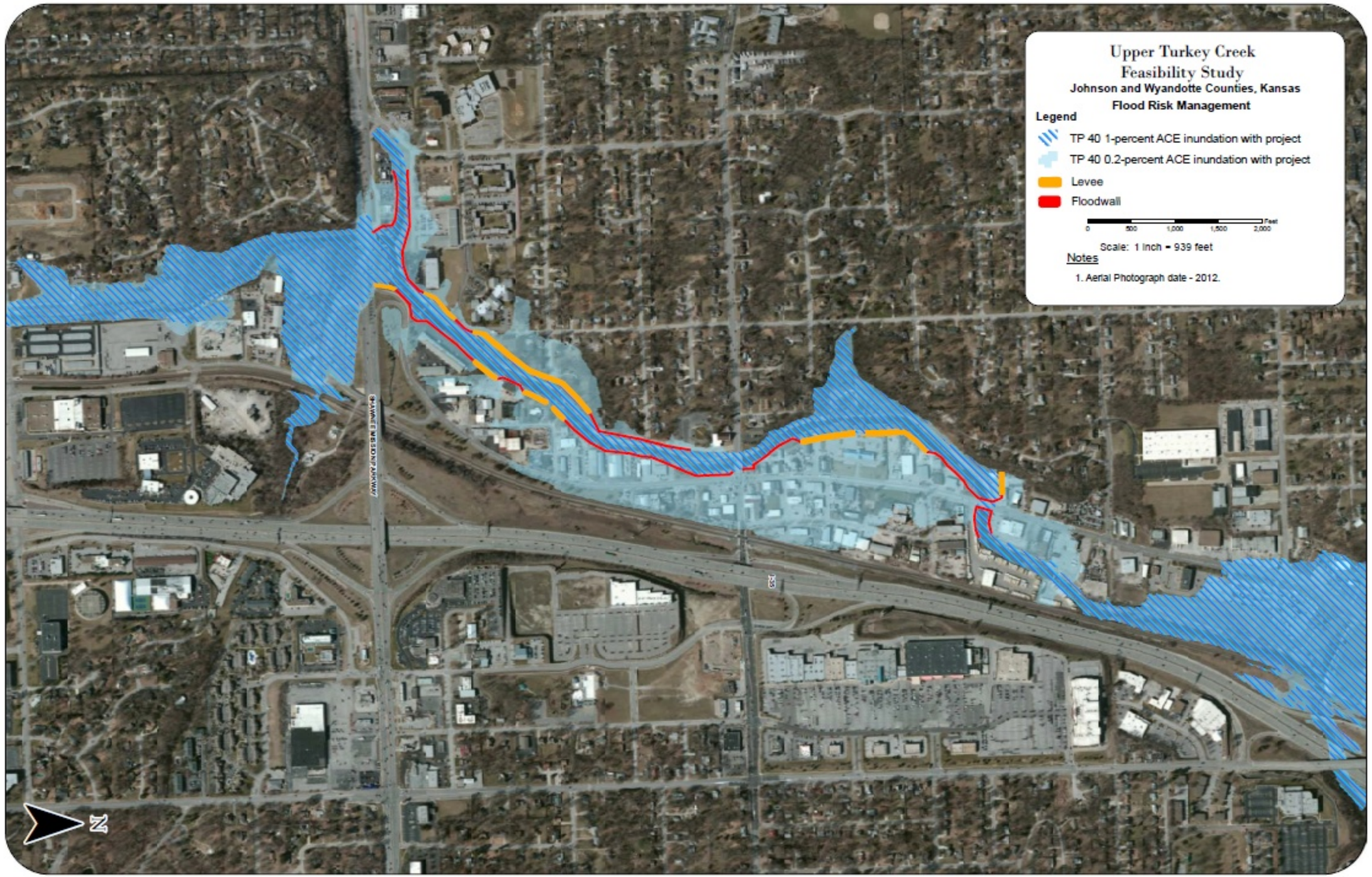


Figure 7-7: Inundation Map Without Project (TP-40) - Plate 7



7-8: Inundation Map With Project (TP-40) - Plate 8

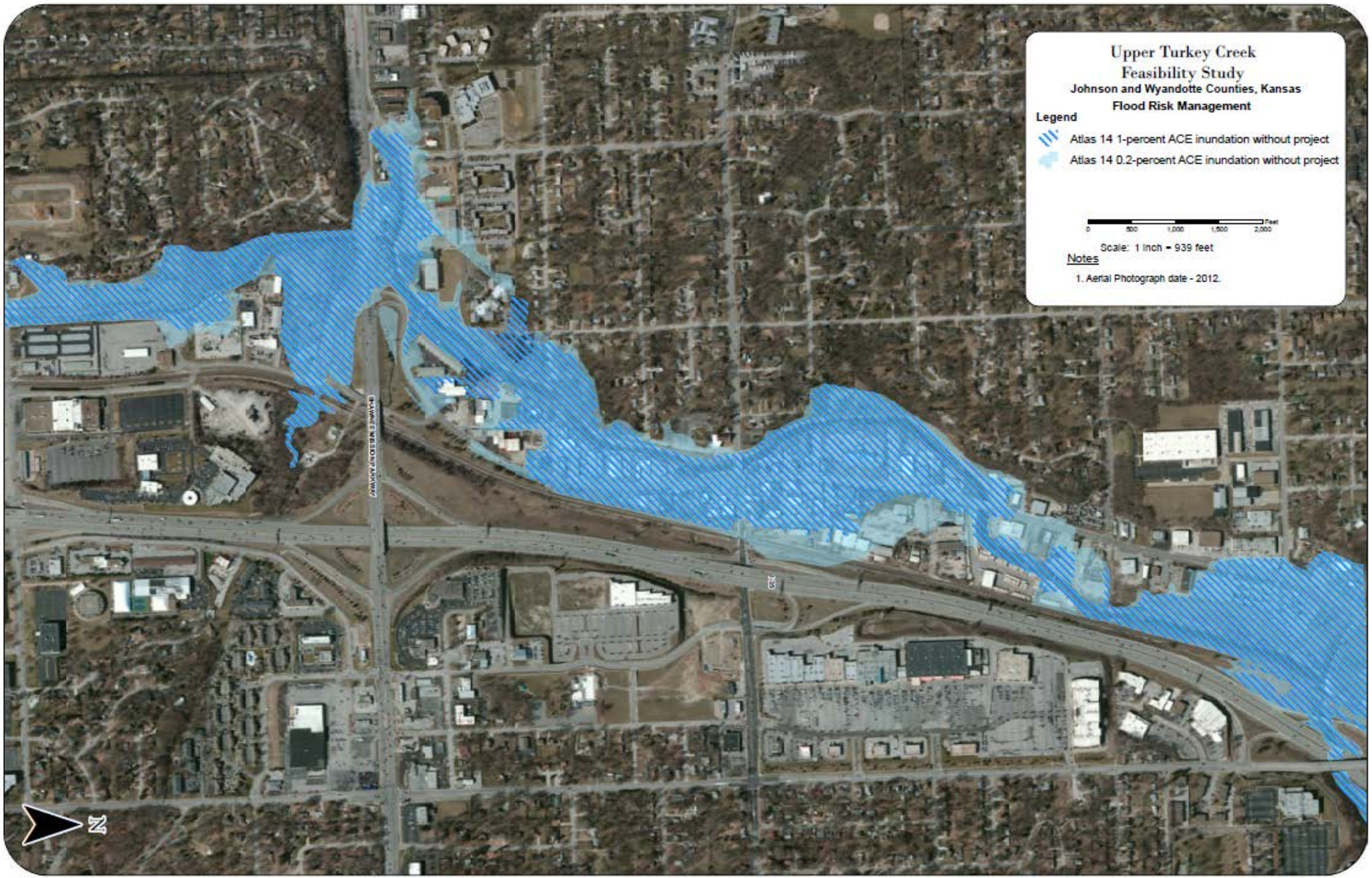


Figure 7-9: Inundation Map Without (Atlas 14) - Plate 9

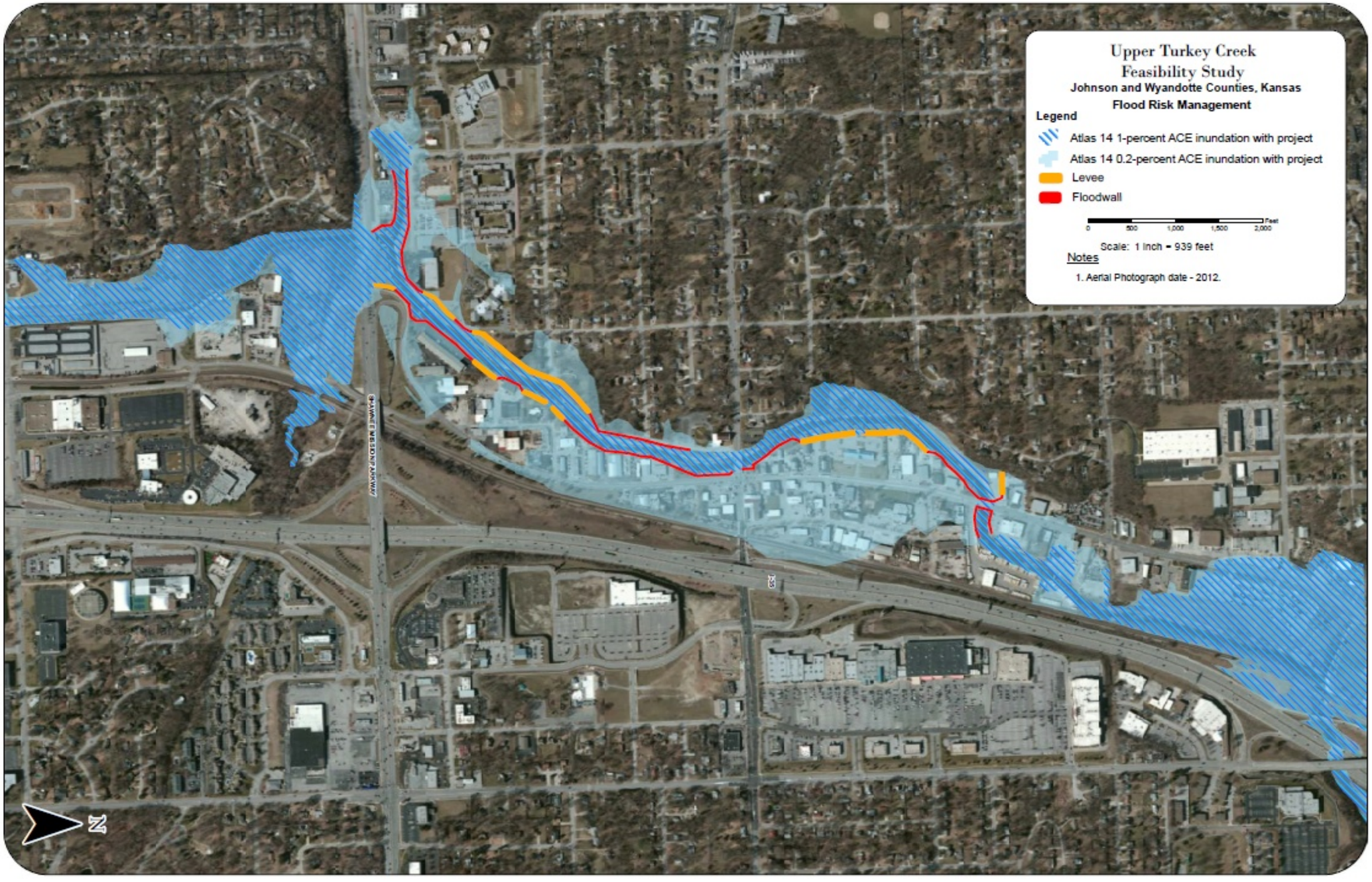


Figure 7-10: Inundation Map With (Atlas 14) - Plate 10

Table 7-1: Recommended Plan Features

Construction Features*	
Levees/Floodwalls: Left Bank	Reach 3b-1 - Merriam Downtown : • 160 feet floodwall downstream of Merriam • 75 feet of floodwall upstream of Merriam Drive • 168 feet of levee upstream of Merriam Drive Reach 3b-2 - Industrial and Railway Drive (West 61st Street): • 840 feet of floodwall begins at 300 feet upstream of Johnson Drive to 500 feet upstream of West 60th Street • 290 feet of levee from 500 feet upstream of West 60th Street to West 61st Street Reach 3b-3 - Parkway Vicinity: • 744 feet of levee from West 61st Street to 70 feet downstream of West 62nd Street • 200 feet of floodwall from 70 feet downstream of West 60th Street to 20 feet upstream of West 62nd Street • 320 feet of levee from 20 feet upstream of West 62nd Street to 60 feet upstream of pedestrian bridge (North side of Skate World Parking Lot) • 1,070 feet of floodwall from 60 feet upstream of pedestrian bridge , to south side of Skateland Parking lot, then along west 62nd Terrace
Levees/Floodwalls: Right Bank	Reach 3b-1 - Merriam Downtown: • 220 feet of floodwall downstream of Merriam Drive to Merriam Drive Parapet wall • 532 feet of floodwall from Merriam Drive Parapet wall to West 57th Street • 1051 feet of levee from West 57th Street to 180 feet South of Farmers Market Parking Lot • 595 feet of floodwall downstream of Johnson Drive Reach 3b-2 - Industrial and Railway Drive (West 61st Street): • 1,390 feet of floodwall south of Johnson Drive to 70 feet north of West 61st Street • 150 feet of levee to West 61st Street Reach 3b-3 - Parkway Vicinity: • 240 feet of levee from W 61st Street to190 feet north of W 62nd Street • 290 feet of floodwall from 190 feet north of W 62nd Street to W 62nd Street • 240 feet of levee from 62nd Street to 240 feet south of W 62nd Street • 890 feet of floodwall from 240 feet south of W 62nd Street to 130 feet north of Shawnee Mission Parkway • 180 feet of levee to Shawnee Mission Parkway • 560 feet of floodwall on W Side of Turkey Creek extending to North of Shawnee Mission Parkway and running along South side of drainage ditch the runs parallel to W. 62nd Terrace
Bridge Modifications/ Headwalls	Reach 3b-1 - Merriam Downtown: • Merriam Drive Bridge – approximately 4.5 to 6 foot high headwall (upstream/downstream) Reach 3b-3 - Parkway Vicinity: • Pedestrian Bridge located at River Mile/Station 3.568 - modification to span 175 feet across the new levee walls

Storm Sewer Modifications	Reach 3b-1 - Merriam Downtown: 7 Outfalls modified with flap gates. 4 Outfalls abandoned and combined with outfalls modified Detention Basin, including 2.14 acre-foot (80 feet wide by 250 feet long) grass detention basin and 60 in RCP outfall with flap gate, located in property north of the outdoor farmers' market. 3 Outfalls abandoned and combined with Detention Basin. Reach 3b-2 - Industrial and Railway Drive: 6 Outfalls modified with flap gates 2 Outfalls combined with outfalls modified 2 Headwall modifications with flap gates Reach 3b-3 - Parkway Vicinity: 7 Outfalls modified with flap gates 3 Outfalls combined with outfalls modified
Utility Impacts/ Relocations	Reach 3b-1 - Merriam Downtown: • 2 Domestic Water reconstructions • 1 Natural Gas reconstruction • 3 Sanitary Sewer reconstructions Reach 3b-2 - Industrial and Railway Drive: • 1 Domestic Water reconstruction • 2 Natural Gas reconstructions • 1 Sanitary Sewer reconstructions • 1 Overhead electric reconstruction Reach 3b-3 - Parkway Vicinity: • 1 Domestic Water reconstruction • 3 Sanitary Sewer reconstructions • 1 Domestic Water reconstruction
Notes: Merriam Downtown (includes farmers' market called Merriam Market Place) = Merriam Drive to Johnson Drive, RM/RS 2.623 to 3.05, *Reach 3b-1; Industrial and Railway Drive = Johnson Drive to West 61st Street, RM/RS 3.05 to 3.345, *Reach 3b-2; Parkway Vicinity = West 61st Street to Shawnee Mission Parkway, RM/RS 3.345 to 3.726 with the exception of Alternative 1 which extends from RM/RS 3.345 to RM/RS 3.855, *Reach 3b-3	

7.2.1 LEVEES AND FLOODWALLS

Earthen levees and concrete floodwalls will be constructed in the Merriam study area. Levees have been selected where existing structures have allowed flood protection to be placed greater than 1V on 2H behind the toe of the existing creek bank. Levee heights throughout the study area range from 3 to 6 feet and vary dependent upon location and water level protection needs. The levees were designed using Engineering Manual (EM) 1110-2-1913, which specifies that the minimum levee section shall have a crown width of at least 10 feet and a side slope flatter than or equal to 1V on 2H, and that 1V on 3H slope is the steepest slope that can be conveniently traversed with conventional mowing equipment and walked on during inspections. A homogeneous embankment (levee) is recommended with the landside slope at 3.0H: 1.0V and riverside slope at 3.0H: 1.0V, with vegetation or synthetic erosion control elements to protect the levee embankment side slopes. The general configuration of the levee is shown in Figure 7-9. The total amount of low to medium plasticity clay material needed for the levee is estimated to be 17,231 cubic yards. Landside seepage berms were not included due to the limited land area and the flashy nature

of Upper Turkey Creek. The flashy nature would not result in prolonged periods of flood impoundment, and as such, would not contribute significant seepage through the levee.

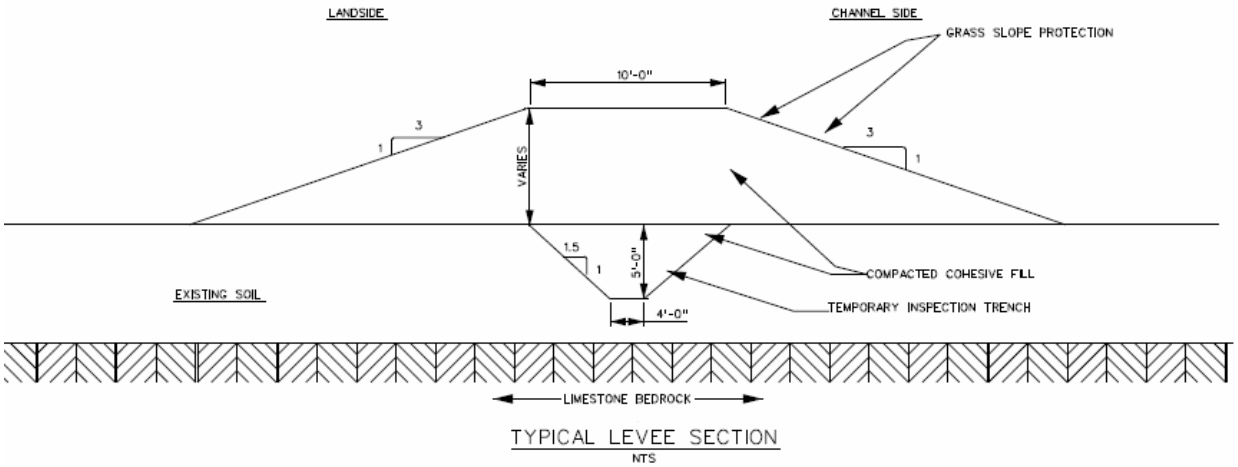


Figure 7-11: Typical Levee Cross Section

In areas where real estate acquisition was constrained because of the existing structures adjacent to Upper Turkey Creek, floodwalls were selected. The floodwall considered is a cantilevered T-type reinforced concrete floodwall with an 18-inch top width. The general configuration of the floodwall is shown in Figure 7-10. The soil beneath the floodwall will be modified with unreinforced auger cast piles, in sections of floodwall where the protected slope is steeper than 1:2 from the toe of the floodwall to the edge of the creek bed. This ground modification will provide improved global stability when the adjacent creek bank wall requires repair. An inspection trench will be completed below flood wall sections not supported on ground modified soil during construction phase. Where this inspection trench indicates soil that is inadequate to support the floodwall, it will be over-excavated and replaced with low plasticity clay. Based on the anticipated bearing elevation and the subsurface information, shallow foundations are adequate to provide bearing support for the flood wall. EM 1110-2-2502 was used for standard dimensions and construction materials. The proposed floodwall height varies depending on location.

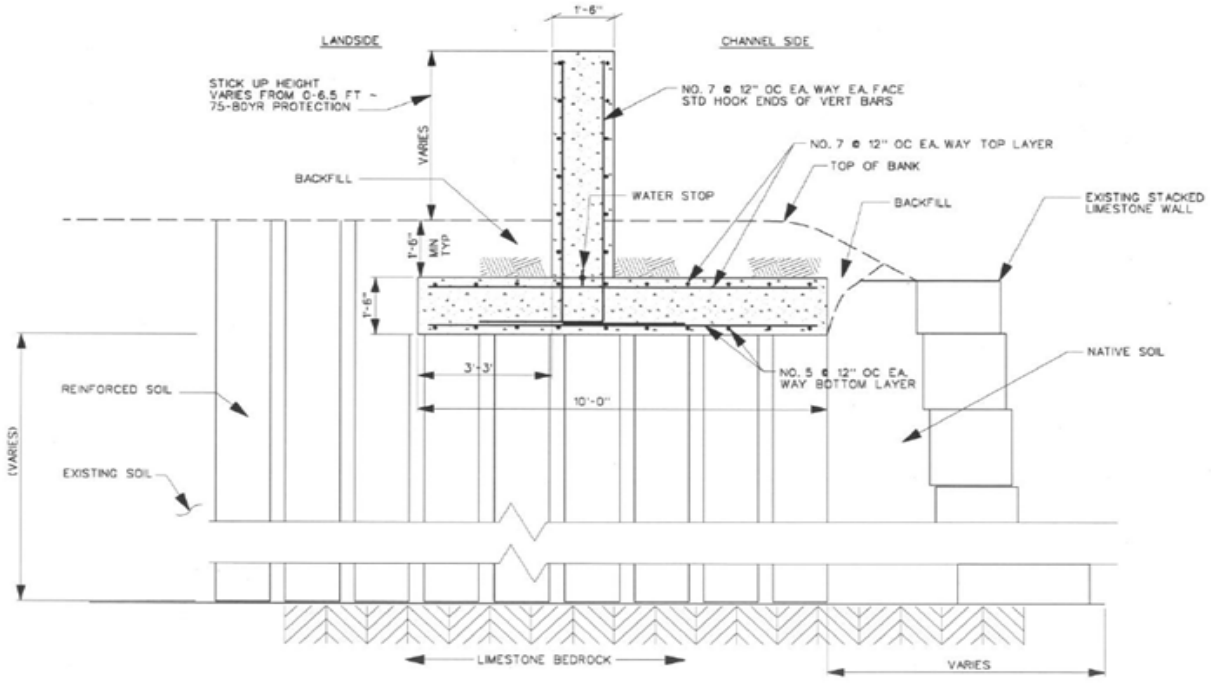


Figure 7-12: Typical Flood Wall

7.2.2 BRIDGE MODIFICATIONS

The proposed project area is bounded by the Shawnee Mission Parkway and Merriam Drive bridges. Major bridge modifications are not implemented under the Recommended Plan because there would be no additional benefit to this action. However, a 4.5 to 6-foot-high headwall (i.e., bridge parapet support structure) would be installed at the Merriam Drive Bridge crossing to maintain the flows in the river channel.

This bridge will require the installation of reinforced headwalls as a supplement to the levee and floodwall protection measure reducing the risk of overtopping at this bridge crossing during the higher intensity storm events. The planned project modifications raise the possibility of scour at the Merriam Drive Bridge. Pressure flow conditions which will occur under Merriam Bridge will have the potential to cause scour. Based on the one-dimensional steady state modeling which uses Atlas 14 flows, velocities will nearly double under pressurized conditions when compared to pre-project conditions. However, the bed material under Merriam Bridge is mostly exposed bedrock. Although the formation of a scour hole under the bridge is possible, it will take long term sustained high flows and velocities to form it and Turkey Creek is characterized mainly for its short duration floods. It is expected that if a scour hole under the bridge develops in the future, its formation will be slow and countermeasures to mitigate it would be implemented before placing the bridge stability in danger. The current surveillance program in the channel and at the bridges due to local maintenance requirements is performed periodically and is very diligent. Regular surveillance would continue and improve after project construction, being reinforced by the federal project sponsorship requirements and the project O&M Manual. The concern of contraction scour is also possible, and the addition of revetment upstream and downstream from the Merriam Drive Bridge was included in the cost risk analysis. During final design, a detailed analysis of the effects of increased velocities and potential scour as a result of the pressure flow through the bridges and downstream of the bridges will be performed in accordance with Federal Highway Administration Hydraulic Engineering Circular No. 18 Evaluating Scour at Bridges Fifth Edition, 2012, appropriate

bridge scour countermeasures consistent with FHWA Hydraulic Engineering Circular No. 23 Bridge Scour and Stream Instability Countermeasures Experience, Selection and Design Guidance Volumes 1 and 2, Third Edition 2009 and USACE EM 110-2-1601 Hydraulic Design of Flood Control Channels (1994). During the final design phase, a refined hydraulic model should be developed along this reach to confirm the effects of the pressurized flow condition and the velocity changes which may occur.

To minimize the induced damages upstream of Shawnee Mission Parkway, it was determined no headwall or parapet wall will be proposed for this bridge. Overtopping of the bridge will be required to prevent a rise in upstream water surface elevations. The bridge actually is lower in elevation than either abutment, as such the overtopping flow will remain within confines of the bridge and in the channel proper, and areas protected by levees and floodwalls in this vicinity will be protected as intended. At the 1 percent ACE event, in the without-project condition it is estimated that the bridge will overtop by approximately 3.5 feet at a velocity of approximately 4 feet per second. In the with-project condition, the overtopping depth at the bridge is estimated to be 3.6 feet at a velocity of approximately 4.1 feet per second. During final design, a reevaluation of the hydraulic model will be required if modifications to the bridge to prevent overtopping is desired. In addition, during final design an updated detailed topographic survey will be performed to assess any residual ponding on the downstream side of the Shawnee Mission Parkway bridge. The pedestrian bridge at RS 3.568 will be modified as part of the project to span 175 feet

7.2.3 DETENTION BASIN

A detention basin would be installed just north of the Farmers' Market in Merriam for internal drainage containing localized drainage during the peak stages of Upper Turkey Creek. The stored runoff volume would be released once the peak flow has progressed downstream from the study area. The detention basin is sized to hold 2.14 acre-feet of water, approximately 80 feet wide by 250 feet long, and have a maximum slope of 3:1 on all sides. Re-grading these areas will be necessary to provide drainage and ensure a ponding level of 905.5 feet, providing 0.5 foot of freeboard from the pond level to the road elevation. This amount of freeboard will be refined during design to ensure full compliance with the City of Merriam regulations.

7.2.4 UTILITY IMPACTS

Utilities impacted by this project include electric, domestic water, natural gas, sanitary sewers, and storm sewers. A summary of these impacts is presented below; complete descriptions are presented in Appendix B Chapter 1.

Overhead electrical lines require relocation when power poles conflict with project feature footprints or when lines cross with project features. When power poles conflict with project features and project features cannot be adjusted, power poles are relocated. When power lines cross project features vertical clearance required by the utility provider may not be maintained. This requires modification of the electric line relocation.

Domestic water lines located within the area subject to flooding or within the project features footprint were evaluated for modification. Where domestic water lines cross levees or floodwalls the lines are routed over the feature. This modification of the pressurized domestic water lines complies with Kansas City District criteria for utilities crossing flood protection. Appurtenances including vacuum breakers and manholes shall comply with Kansas City District criteria. Limited information is known about the construction material used in existing water lines within the flood corridor. The civil engineer and lead planner assumed that water lines will be replaced with ductile iron pipe. During the design phase additional investigations will be performed which may reduce the amount of waterline to be replaced.

Natural Gas lines located within the area subject to flooding or within the project features footprint were evaluated for modification. Where natural gas lines cross levees or floodwalls the lines are routed over the feature. This modification of the pressurized domestic water lines complies with Kansas City District criteria for utilities crossing flood protection. Welded steel pipe will be used for modified natural gas lines.

Pressurized sanitary sewer lines are not present within the limits of the recommended plan. Gravity sanitary sewer lines are within the proposed project limits. Sanitary sewer lines located under project feature footprints or within the flood corridor were considered for modification. The preferred location for relocated sanitary lines is landward of levees and floodwall. Where this is not possible, bolted manhole lids will be installed. Limited information is known regarding pipe material or condition throughout the plan limits. With limited information known regarding pipe material type and condition it is assumed that all lines would be replaced. During the design phase it may be determined that some lines may remain in service.

Only gravity storm sewer lines are located within selected plan limits. Storm sewer outfalls under proposed levee and flood walls require modification to ensure high water flows in Turkey Creek do not back flow through storm sewer systems. The back flow prevention system will include manholes installed on the landward side of the levee or floodwall. The storm sewers under the levee or floodwall will be replaced with reinforced concrete pipe (RCP) and on the creek side of the protection and junction boxes will be installed. Flap gates will be used within the junction boxes to prevent back flow. Throughout this reach there are cases of multiple storm sewer outfalls in close proximity. In these cases, the storm sewer lines will be combined landward of levees or floodwall and one outfall will be provided. The remaining inactive outfalls will be abandoned in place. Other lines will be routed to the detention basin. Replaced pipe will be RCP and have a minimum diameter of 24 inches. EM 1110-2-2902 recommends a minimum diameter of 48 inches for storm sewer lines under levees to facilitate installation, maintenance, and inspection. However, for this project, engineering judgment determined a minimum size of 24 inches is acceptable. Installation and inspection of 24 inch diameter pipes is readily performed using modern construction and inspection equipment. Manholes will be installed at the project limits to further facilitate inspection and maintenance activities. Storm sewer lines located under project feature footprints or within the flood corridor were considered for modification. As with sanitary sewer lines limited information is known about pipe material or condition. With limited information known regarding pipe material type and condition it is assumed all lines would be replaced. During the design phase further investigations should be made into the status of existing lines.

7.2.5 ENVIRONMENTAL MITIGATION

Mitigation actions for footprint impacts were based on the concept of replacing the value of the habitat lost with an equal or greater value of restored or improved habitat value. To evaluate the need for any compensatory mitigation that may be required for CWA Section 404 Authorization, the Habitat Evaluation Procedure (HEP) method was utilized. Specific Habitat Suitability Index (HSI) models used for this method were the green sunfish (*Lepomis cyanellus*) and the fox squirrel (*Sciurus niger*). Using the green sunfish model, the environmental specialist determined that no compensatory mitigation would be needed for the Recommended Plan for in-stream impacts. However, compensatory mitigation would be necessary for impacts to the riparian corridor as indicated by the fox squirrel model.

Numerous species are present in the project area that are tolerant of urban conditions and utilize the overall Turkey Creek riparian corridor. However, within the study area, most of the existing habitat consists of manicured grass and mast producing trees, primarily dominated by black walnut. The environmental specialist and planning team noted no large areas with undergrowth vegetation within the study area. Selection of the fox squirrel model best captures the habitat type, mast producing trees, which

would be impacted by the project. Other habitat models were reviewed, and environmental specialist determined that they would not pick up impacts caused by the project.

To compensate for riparian habitat lost as a result of implementing the Recommended Plan, hard mast producing trees, such as oak, walnut, and/or pecan would be planted. No trees would be planted within 15 feet of any levee or floodwall, complying with Engineering Technical Letter 1110-2-571, *Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures* (April 10, 2009).

The Recommended Plan would result in the removal of riparian trees that provide approximately 3.6 acres of canopy cover. Most of the canopy cover is overstory, with limited woody understory vegetation. Approximately 185 hard mast producing trees, such as oaks and walnut, would be planted over a 7-acre area to compensate for the loss of trees. For addressing environmental effects on the project, including cost effectiveness and incremental cost analysis (CE/ICA), Section 6.3 and Appendix M, *Clean Water Compensatory Mitigation CE/ICA*, contain a detailed analysis of the mitigation measures. Figures 3 and 4 in Appendix M show the locations that were coordinated with the sponsors.

Mitigation will occur concurrently with project construction within each construction contract. Trees will be planted during the first suitable planting season following award of the construction contract. Further details on planting rates, ensuring survival, monitoring and maintenances are located in Appendices M and O of this report. The planted trees will be monitored by the sponsor during an annual inspection by the project sponsor, and maintenance or replacement will be as specified in accordance with the project O&M manual which will be prepared during design phase. The inspection reports the survival and overall health of the trees, and whether the success goals are being met to ensure long-term success of mitigation planning. A mitigation plan is included as Appendix O.

7.3 DETAILED COST ESTIMATE (MCACES II)

The detailed construction cost estimate has been developed based a conceptual design of the Recommended Plan using the USACE Micro-Computer Aided Cost Estimating System MII (MCACES 2nd Generation) in accordance with guidance contained in ER 1110-2-1302, Civil Works Cost Engineering. The costs are allocated between the project's purposes. These costs, along with annual costs, annual benefits, net economic benefits and the benefits-to-cost ratios are shown in Table 5-9. These values are based on October 2014 price levels, an interest rate of 3.375 percent and a 50-year period of economic analysis. See Appendix L, *Cost Estimate and Cost and Schedule Risk Analysis*, for the MII construction cost estimate and output reports.

The MII costs, initial costs, investment costs, OMRR&R, and annual costs are discussed in detail in the sections below and are summarized in Table 7-2 and Table 7-3.

Table 7-2: Cost Estimate Summary (including contingencies)

Cost Account	Estimated Cost
Lands and Damages	$4,854,000
Relocations	$5,268,000
Fish & Wildlife Facilities (Mitigation Costs)	$15,000
Levee & Floodwalls (excluding EDC)	$22,565,000
Planning, Engineering, and Design (including EDC)	$3,066,000

Construction Management	$1,811,000
Project Cost Totals (Effective Price Level Date 1 Oct 14)	**$37,579,000**

Table 7-3: Annual Cost Calculation

Cost Account	Estimated Cost
Project Implementation Cost	$37,579,000
Interest During Construction	$3,003,900
Total Investment	$40,582,900
Annual Economic Cost	$1,691,400
Annual OMRR&R	$40,800
Total Average Annual Cost	**$1,732,200**

7.3.1 INITIAL COSTS

The NED costs of the recommended plan include the project first costs that will occur with project implementation. These costs include $2,787,000 for PED (excluding Engineering During Construction [EDC]), $24,655,000 for construction (including EDC and Supervision and Administration [S&A]), $15,000 for environmental mitigation, and $10,122,000 for lands, easements, right-of-way, relocations and disposal areas (LERRD).

7.3.2 INVESTMENT COSTS

All of the initial costs are included in the economic analysis. In addition to these costs interest during construction (IDC) ($3,003,900) was computed to describe the opportunity cost of the dollars spent on the project prior to its completion. The total investment cost of $40,582,900 was used in calculating the annual economic cost ($1,691,400) at the current FY15 Federal interest rate of 3.375 percent, October 2014 price level, and 50-year period of analysis. (This annual economic cost total is exclusive of annual OMRR&R costs.)

7.3.3 OPERATION, MAINTENANCE, REPAIR, REPLACEMENT, AND REHABILITATION COSTS

The analysis also includes all OMRR&R costs that the sponsors would be expected to incur based on any new proposed alternative. For the annual operations and maintenance (O&M) cost, unit costs and quantities for each alternative were estimated based on past project experience, and assumptions were made for quantities of line items for channel clearing and loading, hauling, and debris disposal. The unit costs for the drainage system maintenance were based on 10 percent of the particular drainage system costs for that level of intensity. Additionally, repairs, rehabilitation, and replacement unit costs were examined for each alternative. The planning team assumed that these percentages of the Recommended Plan would be repaired every 10 years, rehabilitated every 25 years, and replaced every 50 years. A specific percentage for each line item of each alternative in the initial screening is given in Appendix B, Chapter 4, paragraph 8. The OMRR&R costs for the recommended plan were then updated to the OCT 2014 price level using an appropriate index factor (CWCCIS 11: Levees & Floodwalls). A summary of these costs and how frequently they occur can be found in Table 7-4 below. The present value and the

average annual cost of each RR&R cost that would occur over the 50-year period of analysis was calculated using the FY2015 discount rate of 3.375 percent, and that value was added to the annual O&M cost ($28,000) to arrive at the average annual OMRR&R cost ($40,800) for the Recommended Plan. The existing channel and rock wall is maintained by the Merriam Drainage District (MDD), a district formed and constituted under Kansas state law for this purpose. This maintenance will continue in the with-project condition. The floodwall foundation and other features of the federal project are not dependent upon this rock wall for function. The City as project sponsor has agreed to all responsibilities that a Project Partnership Agreement (PPA) will require in order to maintain the federal project functional, safe and in good condition. Our knowledge of the City in working with them and in observing their relationship with MDD, both entities have demonstrated their ongoing ability to cooperate and have stated their intent to continue and increase their cooperation in maintenance of features in the project reach.

Table 7-4: OMRR&R Cost Summary

Items	Cost	Frequency
Operations and Maintenance	$28,000	Every year
Repairs	$49,000	Every 10
Rehabilitations	$104,000	Every 25
Replacements	$748,000	Every 50

7.3.4 ANNUAL COSTS

The total average annual cost of the Recommended Plan (including annual economic cost and annual OMRR&R costs) is $1,732,200.

7.3.5 COST ESTIMATE UNCERTAINTIES

A full CSRA was completed for the Recommended Plan. Contingencies used are intended to identify an estimated construction cost amount that is not likely to be exceeded, given the current project scope. Uncertainties that have been identified that could affect project costs and designs could affect design assumptions, pending a detailed design, include the following:

- Detailed design level soil and topography information (two borings and limited LiDAR are available);
- Unanticipated construction and phasing requirements;
- Variation in estimated quantities;
- Seasonal working condition uncertainties and extended schedule;
- Unanticipated utilities;
- Unexpected geotechnical issues;
- New design requirements;
- Delays in property, utility, and easement acquisition;
- Unexpected buried debris or unsuitable material

CSRA was performed for this project to determine the appropriate contingency factors for project features and is being coordinated with the Directory of Expertise for Civil Works Cost Engineering (Walla Walla District). The project CSRA is presented in Appendix L.

The screening alternative derivation of contingency included a general contingency of 20 percent plus construction risks associated with each alternative resulting in a range of 2 to 7 percent additional difference. Using CSRA on the selected plan, additional external risks were identified that would be consistent across all alternatives if adopted. The original construction related differences were accounted for in the alternative screening, and if CSRA was performed on the screening alternative, the additional associated risks would be relative across all alternatives.

7.4 DESIGN AND CONSTRUCTION CONSIDERATIONS

The creek along the study area is located a minimum of 15 feet from the existing residential and commercial properties, thus its impact to the existing structures during and after construction of the floodwall is expected to be minimal, if any. The majority of the structures along the creek bank are mostly one-story, warehouse-type structures. A Design Documentation Report will be completed during the development of plans and specifications with appropriate surveys and design-level detail to adjust exact proximity of features as needed. For this phase we have captured the major components, design criteria, features, and cost risks and contingencies as needed for a feasibility report.

Specific design and construction considerations for the Recommended Plan can be found in the individual engineering appendices. The design parameters used for floodwall design are considered to be reasonable at this planning stage. Site-specific subsurface conditions are based on visual observations given in boring logs. For the future design work, designers must conduct additional borings and laboratory testing to drive geotechnical design parameters, and a preliminary boring plan. A borrow site is not specifically located for this project; however, the volume of material to be imported for construction is relatively small. Based upon experience in this region on projects of a similar nature, and preliminary inquiries made specifically for this project, it was determined that it would be most cost effective to use a commercial borrow source. A local material supplier with an established permitted commercial borrow area within the 10 mile haul distance utilized for the baseline cost estimate would be able provide the volume of material that meets a design specification developed for the project contract.

Construction of the project, including land acquisition, will not begin until Congress authorizes and appropriates funds for it.

7.5 RISK AND UNCERTAINTY

Areas of risk and uncertainty are analyzed and described below so that decisions can be made with knowledge of the degree of reliability of the estimated benefits and costs of the effectiveness of alternative plans.

7.5.1 COST AND SCHEDULE RISK ANALYSIS

In compliance with Engineering Regulation (ER) 1110-2-1302 Civil Works Cost Engineering dated May 17, 2009, and developed by the Directory of Expertise for Civil Works Cost Engineering (Walla Walla District), CSRA was conducted on the Recommended Plan. CSRA was facilitated by CENWK-ED-DC with assistance from the study team and non-Federal sponsor. The purpose of this assessment was to establish an overall project contingency by identifying and measuring the cost and schedule impact of project uncertainties with respect to the estimated total project cost.

The draft CSRA report, as contained within the Appendix L, *Cost Estimate and Cost and Schedule Risk Analysis*, resulted in a contingency amount of 25 percent. The cost and schedule risk assessment for the

Recommended Plan was completed during the feasibility study. The most likely project cost (October 2014 price level) is estimated at approximately $37,579,000. The key cost risk drivers identified through sensitivity analysis were Market Conditions and Site Access. The key schedule risk driver identified through sensitivity analysis was Project Purpose – Height/Pump Plants, Site Access, and Numerous Separate Contracts. Details of CSRA are located in Appendix L, *Cost Estimate and Cost and Schedule Risk Analysis*. Significant effort and emphasis was placed in the development of the Recommended Plan details on determining the key features and cost factors for the project including foundation stability measures, drainage features, utility modifications, and relocations.

Recommendations to address cost and schedule risk include the implementation of cost and schedule contingencies, further iterative study of risks through the project life-cycle, potential mitigation throughout the design phase, and proactive monitoring and control of risk identified in this study.

7.5.2 RESIDUAL RISK

Although floodplain users and occupants may desire total protection from flooding, the planning team has emphasized that this is an unachievable goal during public outreach. Residual flood risk will remain after implementation of the Recommended Plan. The primary source of residual flood risk will be infrequent and extreme flood events that would overtop and/or flank the flood protection. The project will be designed using appropriate measures and factors of safety to ensure that the constructed system is robust and resilient. However, the City of Merriam, Merriam Drainage District, and Johnson County will express to the community on a periodic basis that a residual risk of exceedance of the system's design capacity exists, and this may be placed as a recurring action item in the floodplain management plan.

In the case of a flood event that exceeded the design capacity of the system, the levees and/or floodwalls of the Recommended Plan could be overtopped, allowing a sudden influx of flood water within the protected area. An overtopping or breach of a levee or failure of a control structure would allow flood water into the protected area during any subsequent flood event during which the breach remains unrepaired. The effects of the failure could be catastrophic depending on the magnitude and timing of the stage increases within the protected area. While the Recommended Plan is expected to reduce the risk of life loss from flooding due to the decreased probability of a flood event inundating the floodplain with short warning time, a residual risk to public safety associated with large flood events that could overtop the levees and/or floodwalls will remain.

Residual risk can be expressed by the probability of the project being exceeded over a certain number of years. Long-term risk indicates how well the project will contain floods under conditions of uncertainty and over a long period of time. The annual exceedance probability (AEP) of the NED plan design (probability of flooding in any given year with the project in place) in Reach 3b is 0.5 percent. Over a 10-year period, the probability of the top of project being exceeded is approximately 5.1 percent in Reach 3b. Over a 30-year period, the long-term risk is 12.2 percent, and it is 22.9 percent over a 50-year period. Additional information is included in Appendix F, *Socio-Economics*.

The planning team has assumed during formulation of the Recommended Plan that, during less frequent floods larger than the 1 percent ACE event, the local sponsor would continue operating the existing flood risk management features (such as the creek channel, storm sewer, bridges, etc.) and emergency preparedness and response measures within the protected area. In addition, an emergency action plan is important for the local sponsor to prepare and implement, including communication of this residual risk and the appropriate emergency measures to take during a flood event. An emergency action plan (EAP) is not the same as a floodplain management plan, and local creation of EAP is actually one action to be documented in the action items of a floodplain management plan. The local sponsor will prepare a floodplain management plan during design that will be useful as a flood risk management tool. This living

document will benefit the city by explaining numerous action items needed on a recurring basis, including risk communication, understanding roles and responsibilities of various departments at the city and the Merriam Drainage District. The floodplain management plan provides a framework for continued public outreach and information regarding flood risk, as well as reinforcement for ordinances and best practices for the City in the improved management of risk.

Communities in Johnson County, Kansas have an existing flood warning system called "Stormwatch." Originally developed by the City of Overland Park, but now utilized by many of the cities, the Stormwatch system and website presents users with data collected from a flood warning system consisting of remote weather stations located throughout the Kansas City Metropolitan area. The majority of the stations report real-time rainfall. Some stations also report stream levels, temperature, relative humidity, wind, pavement temperature, pavement state, and other weather data. All data is collected and stored into a database. The earliest stations were installed in the 1980s and information from those sites can be queried directly from this website. The City of Merriam, Johnson County, and the Kansas Department of Transportation (KDOT), as well as other responder agencies, local businesses and citizens monitor this system for rainfall data and flood threat. When the forecasts call for conditions of high risk, and rainfall intensities reach certain levels, this triggers a coordinated response by the City, County and KDOT for deployment of emergency response staff, emergency responder agencies, and closure of high risk streets and roads. KDOT manages traffic through the Kansas City Scout regional traffic management system. The KDOT System Manager will contact the Kansas State Highway Patrol based upon rainfall and stage data thresholds in the Stormwatch system in Turkey Creek watershed, and coordinate a response to include monitoring and closure of the high risk low lying locations, as appropriate. This robust and well coordinated response process supported by complementary plans in each jurisdiction, supported by the Stormwatch system, represents a significant measure in place to address current and residual risk. As such, at the end of this feasibility planning process, the final combination of flood risk management measures along with the formulation, design, construction and maintenance of the Recommended Plan components, constitute the decision process and public consensus for how floodwaters and the floodplain are being managed. The combination of these measures represents this community's decided approach and will serve to further reduce the risks associated with future flooding.

This Upper Turkey Creek feasibility study project manager is the Lead Silver Jackets Coordinator in Kansas and Missouri and has encouraged state attention to flood risks on Turkey Creek. The Silver Jackets Coordinator has participated regularly on the Kansas Hazard Mitigation Team since 2009, and worked closely with the state floodplain manager and state hazard mitigation officer through the interagency Silver Jackets Program to address flood risk management needs, including long-term local planning initiatives, risk identification and analysis, public awareness and outreach, and potential future nonstructural measures. Several USACE Silver Jackets interagency projects are currently underway in other areas of the state focused on the following:

- Flood inundation mapping for all levels of risk
- 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.

These projects and coordination with the state floodplain manager at the Kansas Department of Agriculture Division of Water Resources (KDWR) has renewed focus on the full menu of measures for flood risk management. Several of the projects have emphasized the importance of presenting the flood risk management story regarding decisions on managing floodwaters and floodplains in a floodplain

management plan, especially tuned to having the public involved in the decision process for possible nonstructural, as well as structural, measures. The City of Merriam is also interested in establishing a floodplain management plan for the project, recognizing that the entire plan formulation process from the feasibility study is major piece of the community's floodplain management plan. This tool is considered a viable and essential component of an overall flood risk management planning effort by the State, including the ensemble of structural and nonstructural measures as unique to Turkey Creek. The floodplain management plan will further assist in driving down the risk for the protected areas and is also a vehicle through which USACE works in partnership to address residual risk. The floodplain management plan is also useful in clarifying the roles and responsibilities, which will be especially useful with the city's partnership with the Merriam Drainage District in sharing the responsibility of managing the flood risks. The appropriate state agencies have been kept aware of and have participated in planning meetings and discussions including regarding the Upper Turkey Creek flood risk management study and residual risk in Merriam, Kansas as well as areas up and downstream. This cooperation has set the stage very well for ongoing work involving the state floodplain manager at KDWR and state hazard mitigation officer at the Kansas Department of Emergency Management in working with the local partners, Johnson County, the City of Merriam and the Merriam Drainage District, in enhancing the engagement on all of the effective flood risk management measures going forward, in concert with the floodplain management plan development and implementation.

7.5.3 PRELIMINARY DESIGN UNCERTAINTY

The main source of uncertainty in the results of the hydraulic analysis is the absence of USGS stream gages on Turkey Creek. The base of this analysis is a HEC-RAS model which was originally provided by Johnson County. This model was initially produced by the Larkin Group Inc. for the Storm Management Program of Johnson County (JOCO Report) and the flows modeled were obtained from the Johnson County FEMA Flood Insurance Study (FIS). This model was reviewed and accepted by USACE engineers during the early stages of this feasibility study. Additional details about this study are provided in Appendix B, Chapter 3, Hydrologic and Hydraulic Conditions. For future design work, requirements to update the analysis for any changes in the watershed and or confirm the hydrology and hydraulic analysis are still valid are detailed in EM 1110-2-1416, Appendix C. Specific to this project, collection of detailed topographic surveys during design would provide an opportunity to update and or verify that the hydraulic model geometry and corresponding water surface profiles are still valid. Additionally, as the design progresses, final levee and floodwall configurations may also need to be updated in the hydraulic model to verify the water surface profiles and corresponding top of levee design is still valid. Due to the lack of stream gages in Turkey Creek, no further statistical analyses could be conducted to add validity to flow-frequency published in the Johnson County FIS and as updated in this study to include the updated precipitation frequency estimates from NOAA Atlas 14. However, another large flood event, if it were to occur during design, could provide an opportunity to collect additional data that can be used for hydrologic and or hydraulic model validation, and if warranted, re-calibration.

Limited preliminary geotechnical information is available on the soils in the region. Site-specific subsurface condition information on compactness/consistency and stratification of the soils is based on a generalized description given in boring logs based on visual observations of the subsurface deposits. The slope stability performed of the Upper Turkey Creek stream embankment determined general ideas of soil strengths and seepage potential in the study area. The Engineering Appendix (Appendix B) includes a list of preliminary design parameters and the assumed values necessary for the slope stability and the evaluation of the stability of the floodwalls. To compensate for this, the parameters as noted are on the conservative end, and likely a more economical design could be developed during the design phase after conducting additional geotechnical, survey, and site-specific hydrographic data. For the future design work, it is essential to conduct additional borings and laboratory testing to drive geotechnical design

parameters. Details on the types of geotechnical data that should be collected during design are included in Appendix B.

The information available for the existing stormwater system (ESS) located in the study area is limited. USACE requested ESS storm sewer plans from the City of Merriam, but these plans are not available. The only related information available is a GIS schematic illustrating the location of a fraction of pipelines and inlets. Not only is this a concern when determining the project cost and schedule, ESS was not considered in the hydrologic analysis of effective runoff and time of concentration due to lack of detailed information. However, not considering ESS for planning in this case is considered a conservative approach because its capacity was not included to estimate the detention volume. ESS will likely offer a small detention volume plus it will add some travel time to the flows potentially changing the time of concentration. Including ESS into a design analysis will most likely reduce the required size of the detention pond. ESS will be surveyed and detailed to a much greater degree during design phase. However the current cost and performance assumptions are considered reasonable for identification of the project cost and performance for a decision document

HTRW: An HTRW investigation of the study area was conducted consisting of a records search of past and present environmental activities and enforcement actions at properties adjacent to the creek. Based on findings from the records search performed, there are no known hazardous waste sites that will impact the proposed work. The property located north of the Merriam Market Place (or farmer's market) in downtown Merriam (5730 Merriam Drive) had three 560 gallon gasoline underground storage tanks removed from the property. There was no contamination observed during the underground storage tank removal and the site was remediated successfully so the likelihood of encountering fuel contamination is low. In addition, there is the possibility that properties along the channel may have buried debris, although there is no specific data or subsurface information to indicate such. If buried debris is excavated during construction activities, it will need to be properly disposed of at an off-site facility permitted to accept the material. Any specifications for work should include provisions to develop a contingency plan to address any hazardous waste encountered during construction. Based upon experience on other projects, provisions for the removal of some debris was included in the cost estimate and it was addressed in the cost risk analysis.

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.

Climate Change Consideration and ECB No. 2014-10

Climate change information for hydrologic analyses includes direct changes to hydrology through changes in temperature, precipitation, and other climate variables, as well as subsequent basin responses such as sedimentation loadings potentially altered by changes in those primary climate drivers. ECB No. 2014-10 includes consideration of both past (observed) changes as well as potential future (projected) changes to relevant hydrologic inputs. In order to comply with ECB No. 2014-10, a qualitative analysis of available data was conducted. Two main sources of information were evaluated. A report published by NOAA National Environmental Satellite, Data and Information Service (NESDIS) and a long-term period of record weather station in the Kansas City, MO area.

NOAA NESDIS Model Report

Results from this model of future conditions for the central plains of the United States were published by NOAA NESDIS 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 Fahrenheit and a precipitation trend slightly toward wetter conditions can be expected through the next 50 years, but significant uncertainty is associated with these estimates. The NESDIS and other literature proffer slightly wetter future conditions in NE Kansas which could lead to slightly higher flood stages.

Long-Term Period of Record Weather Station

Daily total precipitation and daily maximum and minimum temperature data were obtained for NOAA weather station GHCND: USW00093972. The period of record extends from 1893 to 2014 and the data was obtained from the National Centers for Environmental Information formerly known as the National Climatic Data Center. The data from these 121 years were analyzed for linear trends that could indicate a discernible tendency in the annual maximum precipitation and in the temperature annual extremes.

The trend evaluation of the daily precipitation data was performed using four different sets: annual daily maximum, annual 2-day maximum, annual 3-day maximum and annual 5-day maximum. No definite trends were identified in any of the sets. Monthly daily maximum sets were briefly evaluated but the mild trends that could be identified were not consistent from month to month or season to season so the findings of this analysis were not considered relevant. A more defined trend was observed when analyzing daily maximum and minimum temperatures for the same period of record but at this time there is no clear correlation between the available precipitation and temperature data.

Additional Considerations

Although not prepared to address climate change, NOAA National Weather Service recently updated their precipitation atlas titled Hydro-meteorological Design Studies Center Frequency Data Server Atlas 14 (NOAA 2013). This document was published three months after the Recommended Plan was selected. The rainfall data used for analysis was based on a 2002 study completed by the University of Kansas working with the American Public Works Association (APWA) of Kansas City. A sensitivity analysis using the recently published updated rainfall atlas has been performed to help understand the implications of potentially increased extreme precipitation in the future and corresponding increases in peak flows. Based on a preliminary analysis, including re-running the hydrologic and hydraulic models with the 24-hr rainfall depths from Atlas 14 with an appropriate rainfall distribution, the team determined that Atlas 14 rainfall will result in increased flows (increased water surface elevations), increased damages in the without-project condition, and increased benefits in the with-project condition as compared to analysis performed with the 2002 precipitation study. Based on the alternatives analysis, the economic outputs were determined to be optimized for levee heights of alternative 2d. Taller levees will require significant changes and or full scale replacement of existing bridge, utility and road infrastructure. As documented in Chapter 5, economic outputs and benefit cost ratios are reduced for levees higher than the recommended plan for both precipitation frequency studies. Additionally, shorter levee heights were also shown to have reduced economic outputs from the recommended plan with both precipitation frequency studies. Therefore, based on the analysis of approximately a 15% increase in precipitation, future increases in precipitation frequency, if they were to occur due to climate change, are not expected to alter the

recommended plan. Residual risks could increase over time if climate change leads to an increased frequency of extreme precipitation events.

The data available and the results of plan formulation in this study indicate that increasing the level of structural risk reduction or altering structural project features to address the potential effects of climate change in the future is not warranted at this time. Periodic review of floodplain management activities, active and robust flood risk planning, preparedness and response, which is a characteristic in this study area that will be sustained and improved is the most appropriate response measure to account for uncertainties associated with climate change. The floodplain management plan to be developed pursuant to the project will greatly support this recommendation.

Conclusions

The results of this qualitative and semi-quantitative analysis do not indicate a direct tendency in expected precipitation changes but may suggest a future tendency of temperature increases in the future. The lack of USGS gages in Turkey Creek prevents from a direct analysis of the effect of any potential climate change trend of the stream discharges. The impacts of a potential climate change trend are not expected to increase the current range of uncertainty considered in the hydrologic analysis.

7.6 REAL ESTATE REQUIREMENTS

7.6.1 LAND ACQUISITION – CATEGORIES

Required estates for project purposes will include permanent easements for flood protection, temporary work area easements, utility easements, and fee acquisition. The entire project will affect 121 tracts.

The non-federal sponsor will be responsible for providing information on property boundaries, specific estates to be acquired, facilities to be relocated, number of affected property owners, and zoning information for the area affected by the proposed project.

7.6.1.1 FEE

ER405-1-12 states that uneconomic remnants are required to be purchased in fee under Section 301 (9) of Public Law 91-646 (para 2-20) “If the acquisition of only a portion of a property would leave the owner with an uneconomic remnant, the head of the federal agency concerned shall offer to acquire that remnant. For the purposes of this Act, an uneconomic remnant is a parcel of real property in which the owner is left with an interest after the partial acquisition of the owner's property and which the head of the Federal agency concerned has determined has little or no value or utility to the owner.” ” During the Gross Appraisal process, four properties were identified as requiring a full take of the land and building that will require fee simple acquisition: parcels JP35000000-0009, JP28000033-0024D and JD241212-3003 will need to be acquired in fee due to the location of the buildings and the need for space for the levee/floodwall system. Parcel JF241212-3005 is where the detention basin will be constructed. The elevation of this property will be adjusted and will require removal of the building. The appraiser also identified a shed that will have to be acquired, but the remaining portion of the property will retain its highest and best use as a downtown row store. Details for the four properties are listed below:

- Property JP35000000-0009: This property described as a general office building.
- Property JD241212-3003: This property is a combination shop/warehouse structure.
- Property JF241212-3005: This property is a warehouse structure.
- Property JP28000033-0024D: This property is a residential house.

7.6.1.2 PERMANENT FLOOD PROTECTION EASEMENT

Permanent flood protection easement will be acquired for any land required for levees, floodwalls, and other permanent structures along with area needed for operation and management. The team's real estate specialist estimated that 8.6 acres will be required for the flood protection easement.

7.6.1.3 TEMPORARY EASEMENT

Temporary easements will be needed to provide adequate area for construction of the project and access to the work area. The real estate specialist estimated that 4.59 acres of temporary easement will be required for construction of the flood control structures of the project. All temporary easements were valued as 3-year easements.

7.6.1.4 MITIGATION LANDS

The team's environmental specialist has determined that 7 acres of mitigation land will be required for the project. Ideally the mitigation will be done on City-owned land; the City has stated public park land will be available for use.

7.6.2 LAND ACQUISITION – IDENTIFICATION OF LANDOWNERS

The real estate specialist determined that 121 parcels of land will be affected by the project. The City of Merriam owns in fee approximately 7.5 acres within the project footprint. The Merriam Drainage District (MDD) owns in fee more than 9.2 acres along the channel. The lands owned by the City of Merriam and MDD are available for use on the project. Most of the properties within the area are a mix of commercial/industrial businesses. The businesses include auto parts stores, used car sales lots, warehouses, car rental agencies, and other locally owned retail stores. The Real Estate Plan will list the landowners and easement requirements in more detail. Fee acquisition for project structures is approximately 1.5 acres, and permanent utility easement required is approximately 2.15 acres.

7.6.3 LAND ACQUISITION – IDENTIFICATION OF ACQUISITION ISSUES

The planning team determined that there will not be any issues with acquisition of lands, easements, and rights-of-ways for the project. USACE has worked with the non-federal sponsor to complete the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capabilities Checklist, and the non-Federal sponsor has been identified as being fully capable of acquiring the lands, easements, and rights-of-way for the project. The non-Federal sponsor 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. At this time, the non-federal sponsor will not require USACE assistance with acquiring real estate. Financial capability is addressed in Appendix I.

7.6.4 RELOCATION ASSISTANCE (PUBLIC LAW 91-646)

Relocation assistance will be required for the four properties being acquired in fee and the acquisition of one shed. The non-federal sponsor has been provided information on P.L. 91-646 and is aware of the obligation to ensure compliance. An estimate of the relocation costs has been included in the LERRDs cost estimate.

7.6.5 INDUCED DAMAGES

This alternative is not expected to have any substantial impact on the hydrology of the Turkey Creek watershed. The hydraulic modeling results show no increase in flooding upstream or downstream of the project reach. Upstream of Shawnee Mission Drive there is no appreciable increase in flooding in the with-project condition compared to without. Downstream of the Merriam Drive Bridge, the analysis showed that the flow with-project will remain within the channel. These results give reasonable confidence that the project will not induce additional damages upstream or downstream of its limits.

7.7 OPERATION AND MAINTENANCE CONSIDERATIONS

Section 3 of the Flood Control Act of 1936 and Section 103 of the Water Resource Development Act of 1986 (WRDA 1986) require that the non-federal sponsor (the City of Merriam), pay 100 percent of the costs for all OMRR&R of project features. The responsibilities of the non-federal sponsor in this regard are detailed in the OMRR&R Manual, which will be furnished to the non-federal sponsor at the completion of construction. Operation is those activities required for the safe and efficient functioning of the project to achieve the intended project benefits. Maintenance is the performance of those activities needed for proper care and efficient operation of the project. Repair is generally defined as including those activities that are of a routine nature and will maintain the project in a well-kept condition. Replacement covers those activities required to replace all or a portion of a worn out project element. Rehabilitation refers to those activities that are required to bring a deteriorated project back to original condition.

The following are typical operation requirements:

- Continual updating of the OMRR&R Manual and emergency response plans, including accounting for any modifications made to the system and updating all emergency contacts and suppliers
- Suggesting annual review of roles and responsibility between the City of Merriam and the Merriam Drainage District

The following are typical maintenance requirements:

- Regular mowing of grass areas
- Maintaining a 15-foot clear zone out from the toe of levees and face of floodwalls
- Eradicating burrowing animals and repairing any damage
- Spraying and removing woody brush and trees in riprap areas
- Removing siltation in drainage ways and detention pond
- Repairing any identified deficiencies pertinent to the project

For the annual O&M cost, unit costs and quantities for each alternative were estimated based on past project experience, and assumptions were made for quantities of line items for channel clearing and loading, hauling, and debris disposal. The unit costs for the drainage system maintenance were based on 10 percent of the particular drainage system costs for that level of intensity.

Additionally, repairs, rehabilitation, and replacement unit costs were estimated for each alternative. The team assumed that repairs would be required every 10 years, rehabilitation every 25 years, and replacement every 50 years. Details of how these costs were determined can be found in Appendix B, Chapter 4, paragraph 8. The OMRR&R costs for the recommended plan were then updated to the 1 Oct 2014 price level using an index factor from the current Civil Works Construction Cost Index System or CWCCIS (account 11: levees and floodwalls).

The present value and the average annual cost of each RR&R cost that would occur over the 50-year period of analysis was calculated using the FY2015 discount rate of 3.375 percent, and that value was added to the annual O&M cost to arrive at the average annual OMRR&R cost for each alternative.

Standard USACE procedures will be used to control invasive species. All District construction contracts contain language to prevent the spread of invasive species, and the OMRR&R Manual will contain information of controlling invasive species. Selection and use of any herbicides will be in accordance with all applicable laws, regulations, policies, and best management practices.

Continual inspections are required throughout the life of the project. All inspections of the system serve to identify any deficiencies that may have occurred since the last inspection. Inspections determine if the system is being maintained at an acceptable level. Types of inspection include the following:

- Annual inspections. An annual inspection is conducted by the USACE that results in a report. The annual inspection report identifies any deficiencies found during the inspection and provides individual and overall ratings.
- Mid-year inspections performed between each year's annual inspections. This inspection is conducted solely by the non-federal sponsor.
- Visual inspection by the non-federal sponsor of all discharge pipes every 5 years.
- Inspection by the non-federal sponsor before and after major flood events.

The non-federal sponsor would be responsible for coordinating all project modifications subsequent to completion of the construction project. Modifications to the system include any plans that impact the function or physical footprint. This includes any work not coordinated before its placement. All modifications impacting the system shall be submitted from the non-federal sponsor to USACE for review. Impacts include physical changes to the system, encroachments, and drainage system disruption.

The non-federal sponsor would be responsible for funding and carrying out annual operation and maintenance of the system and perform or ensure all relocations. Annual operations and maintenance costs that the non-federal sponsor would take on for the Recommended Plan were estimated based on past project experience, and assumptions were made for quantities on line items for channel clearing and loading, hauling, and debris disposal. The unit costs for the drainage system maintenance were based on 10 percent of the particular drainage system costs. Annual repairs, rehabilitation, and replacement costs assumed that repairs would occur every 10 years, rehabilitation every 25 years, and replacement every 50 years. Additional information is included in Appendix B. Their estimates include all labor, materials, and contracts necessary to maintain the system at an acceptable level.

The Recommended Plan has a total length of approximately 10,205 feet that comprises 6,822 feet of floodwalls and 3,383 feet of earthen levee. Existing pavement and mowing activities will minimize any new maintenance requirements by the non-federal sponsor in these areas.

7.8 SUMMARY OF ACCOUNTS

Implementation of the Recommended Plan would provide average annual NED benefits of approximately $3,444,700 in the form of reduced flood damages in the area protected by the levees and floodwalls. Average annual NED costs (including construction, LERRD, PED, S&A, EDC, environmental mitigation, IDC, and OMRR&R) would be approximately $1,732,200, resulting in net average annual NED benefits of $1,712,500.

Implementation of the Recommended Plan would also provide favorable Regional Economic Development (RED) effects due to the decreased probability of flood events inundating the floodplain. Existing businesses would be expected to continue their existing occupancy, and new businesses and investment would be more easily attracted to the area in the future if vacancies occur, resulting in a

stronger tax base. With decreased probability of flooding, business activity would be expected to remain relatively stable, barring unforeseen impacts from other sources. Additionally, temporary increases in employment would be expected during construction. The temporary presence of construction workers for the project may bring a temporary increase in demand for some services in the local area, but also a temporary increase in business volume, profits, and sales tax receipts at the local retail and service establishments.

The Recommended Plan would also likely reduce the risk of life loss from flooding, due to the decreased probability of a flood event inundating the floodplain with short warning time.

7.9 PROJECT IMPLEMENTATION REQUIREMENTS

To implement the Recommended Plan, several steps related to project authorization, funding, and regulatory approval need to be taken, including institutional requirements, division of responsibilities, a fully funded cost estimate, and permits.

7.9.1 INSTITUTIONAL REQUIREMENTS

PROJECT AUTHORIZATION

Project authorization will require approval of the feasibility report by Headquarters USACE, resulting in the transmission of the recommendation in the Report of the Chief of Engineers to the Office of the Assistant Secretary of the Army for Civil Works (ASA-CW), and then to the Office of Management and Budget (OMB) for approval. Then, the report is available to be authorized by inclusion by the United States Congress in a Water Resources Development Act that authorizes USACE Civil Works projects. The project would be considered for inclusion in the President's budget based upon national priorities, magnitude of the federal commitment, economic and environmental feasibility, level of local support, willingness of the non-federal sponsor to fund their share of the project cost, and the budget constraints that may exist at the time of funding.

PROJECT PARTNERSHIP AGREEMENT

Once Congress appropriates Federal construction funds, USACE and the non-federal sponsors would enter into a project partnership agreement (PPA), as required for all Civil Works design and construction projects. This PPA would define the federal and non-federal responsibilities for implementing, operating and maintaining the project. Items for cooperation under PPA can vary, depending on the mission area, or authorized purpose, of the project. This report is for the flood risk management mission area, also known as flood damage reduction. Recreation pieces can be accounted for under this, not requiring a separate or more detailed recreation authorization.

Items of cooperation for a structural flood damage reduction (single purpose) project that will be specifically authorized federal implementation of the Recommended Plan would be subject to the non-federal sponsor agreeing to comply with applicable federal laws and policies, including but not limited to the following basic items, where additional ones may also apply if any elements of the project were to change after the approval of the final report:

a. Provide a minimum of 35 percent, but not to exceed 50 percent of total project costs as further specified below:
    1. Provide the required non-federal share of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

2. Provide, during the first year of construction, any additional funds necessary to pay the full non-federal share of design costs;
3. Provide, during construction, a contribution of funds equal to 5 percent of total project costs;
4. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the project;
5. Provide, during construction, any additional funds necessary to make its total contribution equal to at least 35 percent of total project costs;

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

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

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

e. Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), which requires a non-federal interest to prepare a floodplain management plan within one year after the date of signing a project cooperation agreement, and to implement such plan not later than one year after completion of construction of the project;

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

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

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

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

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

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

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

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

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

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

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

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

CERTIFICATION OF REAL ESTATE

USACE would officially request the non-federal sponsor to acquire the necessary real estate immediately after signing of the PPA and engineering and design has progressed to the point that all real estate

required can be identified. The non-Federal sponsor has been issued a risk letter explaining the risks of acquiring lands prior to the execution of the PPA and been advised to wait on coordination of the acquisition plan and notice to proceed with acquisition from the USACE Real Estate Office. The advertisement of the construction contracts would follow the certification of the real estate.

IMPLEMENTATION SCHEDULE

Subject to project authorization, funding, and regulatory approval, construction is scheduled to be completed in April 2024. The PED phase can begin once the Division Commander's transmittal has been sent, the Design Agreement has been signed by the City of Merriam as the non-Federal sponsor, and funds are available. The estimated schedule for project implementation is shown in Table 7-5.

Table 7-5: Project Implementation Schedule

Milestone	Start Date	Finish Date
PED	October 2016	September 2018
Initial Real Estate Acquisition	October 2018	September 2019
Project Construction		
Contract 1	October 2019	April 2021
Contract 2	May 2021	October 2022
Contract 3	November 2022	April 2024

The project team developed a detailed project schedule as part of this project, and this is included in Appendix L, *Cost Estimate and Cost and Schedule Risk Analysis*.

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.

7.9.2 PROJECT REVIEW PLAN

Project reviews are about comprehensive quality control and quality assurance of products. The USACE policy is that planning, engineering and scientific work will undergo an open, dynamic, and rigorous review process. Technical, scientific and engineering information that is relied upon to support recommendations in decision documents or form the basis of designs, specifications, and/or O&M requirements will be reviewed to ensure technical quality and practical application. This report has undergone extensive review, and a similar quality review is mandatory for the design and construction phase.

The EC 1165-2-209 "Civil Works Review Policy" establishes an accountable, comprehensive, life-cycle review strategy for Civil Works products by providing a seamless process for review of all Civil Works projects from initial planning through design, construction, and OMRR&R. EC provides the procedures for ensuring the quality and credibility of USACE decision, implementation, and O&M documents and work products.

This policy addresses OMB peer review requirements under the "Information Quality Act" and the Final Information Quality Bulletin for Peer Review by the OMB (referred to as the "OMB Peer Review

Bulletin"). It also provides guidance for the implementation of both Sections 2034 and 2035 of the WRDA of 2007 (P.L. 110-114).

7.9.3 PUBLIC-PRIVATE PARTNERSHIPS

The Merriam Drainage District (MDD) is a state authorized entity per the Kansas Watershed District Act. A three-person board of directors is elected periodically, and their mission is to apply funds collected from a mill levy to maintain a very small portion of Turkey Creek that is located entirely within the City of Merriam, Kansas. The city has no authorized control of this entity, but together MDD and the City's floodplain manager manage the floodplain. Additionally, the City is enrolled in the Federal Emergency Management Agency's National Flood Insurance Program (NFIP), and as a requirement, the City must fulfill the role of floodplain management, including actively reaching out to the MDD to satisfy conditions of enrollment in NFIP. Each of these watershed or drainage districts in Kansas is required to have a General Plan describing MDD's mission. Therefore, this public partnership is planning to use the floodplain management plan to cover the decision processes reached with this feasibility study, including the public outreach to the private land owners in the project area.

7.9.4 FULLY FUNDED COST ESTIMATE

The fully funded estimate for the Recommended Plan includes price escalation using Office of Management and Budget inflation factors. Project inflation factors, midpoint of construction features, and fully funded costs can be found in the total project cost summary in Table 7-6.

Table 7-6: Total Project Cost Summary

		Estimated Cost			Project First Cost	Total Project Cost (Fully Funded)		
WBS Number	**Feature Description**	**Cost ($K)**	**CNTG ($K)**	**CNTG (%)**	**Program Year (Budget EC): FY 2015 Effective Price Level Date: 1 Oct 14 ($K)**	**Cost ($K)**	**CNTG ($K)**	**Fully Funded plus CNTG ($K)**
01	Lands and Damages	$4,096	$758	19	$4,854	$4,557	$843	$5,400
02	Relocations	$4,214	$1,054	25	$5,268	$4,860	$1,215	$6,075
06	Fish & Wildlife Facilities	$12	$3	25	$15	$13	$3	$17
11	Levee & Floodwalls	$18,052	$4,513	25	$22,565	$20,810	$5,203	$26,013
30	Planning, Engineering, and Design	$2,453	$613	25	$3,066	$3,042	$761	$3,803
31	Construction Management	$1,449	$362	25	$1,811	$1,911	$478	$2,389
Project Cost Totals		**$30,276**	**$7,303**	**24**	**$37,579**	**$35,195**	**$8,502**	**$43,697**
Notes: All costs in the thousands ($1,000)								

7.9.5 DIVISION OF RESPONSIBILITIES

The non-federal sponsor will be required to sign a design agreement and PPA for implementation of the project. Pursuant to that, the sponsors shall provide 35 percent of the implementation cost of the project, which includes design, construction, project/construction management, and acquisition of all LERRDs, as required for implementation of the project. This will be a combination of cash and LERRD acquisition, with the sponsor required to provide a minimum of 5 percent of total project cost. The sponsor is directly responsible for all LERRD acquisition costs. The local sponsor shall be required to operate and maintain the project to provide the authorized performance for the life of the project.

USACE will provide for 65 percent of the implementation costs of the project and will generally solicit, award, and manage design and construction contracts for implementation. Upon notice by the District Commander to the sponsor of completion of construction of the project, the sponsor will assume the obligation to operate, maintain, repair, replace, and rehabilitate the project.

The apportionment of fully funded costs is shown in Table 7-7 (PED is preconstruction engineering and design).

Table 7-7: Apportionment of Cost

COST APPORTIONMENT	
Total Cost	$37,579,000
Federal Share	$24,426,000
Non-federal Share	$13,153,000
LERRD	$9,652,000
Non-federal Cash	$3,501,000

Price Level 1 Oct 2014

COST SHARING OF CONSTRUCTION AND LAND COSTS

The Federal share of the project will be limited to 65 percent of the Recommended Plan for the flood risk management features. This results in a federal cost of $24,426,000 which is 65 percent of the Recommended Plan for fully funded costs of $37,579,000. The non-federal sponsor is responsible for the costs of the lands, easements, right-of-way, relocations, and disposal areas (LERRDs), not to exceed 50 percent of the total project cost, and for a minimum cash contribution of 5 percent. LERRDs for the Recommended Plan are anticipated to cost $9,652,000 which is less than the project minimum 35 percent contribution that is required. The remaining non-federal share will be a cash contribution of $3,501,000; this exceeds the minimum cash contribution meaning no additional cash in needed. The statement of financial capability from the City is included as Appendix I. NOTE: LERRD costs include the Lands and Damages account and approximately 91% of the Relocations account. Costs not included from the Relocations account include pavement demolition and replacement.

Part of the Turkey Creek channel in the study area is operated and maintained by the Merriam Drainage District (MDD) under a state charter that provides MDD authorities independent of the City of Merriam or Johnson County. MDD has institutional responsibilities and real estate holdings in and near the Turkey Creek channel, where channel erosion repairs have been, and may be in the future, needed; therefore, involvement of MDD is a key element in assessing of future planning for Turkey Creek.

7.9.6 PERMITS

As part of implementing this project, the non-federal sponsors will be required to obtain all appropriate permits. The construction contractors will be responsible for acquiring all local licenses/permits required to comply with state and municipal laws, codes, and regulations (road, borrow, construction, etc.) and for acquiring the National Pollutant Discharge Elimination System (NPDES) permit from the Kansas Department of Health and Environment.

7.9.7 VIEWS OF NON-FEDERAL SPONSOR

The City of Merriam has continually expressed strong support for this project. The City of Merriam has expressed the desire to implement the project and sponsor project construction in accordance with the items of local cooperation set forth in Chapter 11. The non-federal sponsor has completed the necessary financial self-certifications to complete the feasibility report and enter into a Design Agreement. These certifications indicate that they are financially capable of moving forward with the selected plan. Additional financial certification will be necessary prior to beginning construction.

Johnson County, Kansas, has also expressed a desire to support the implementation of this project using funds from the county's Stormwater Management Program (SMP). SMP assists all of the cities in the county in planning, designing, and constructing large stormwater projects. This is an important funding mechanism for smaller cities in the county, such as Merriam. While the annual budget ranges between 10 and 20 million dollars, projects are carefully selected on specific criteria. Merriam's position downstream of several major cities has the burden of addressing resulting floodwaters, and this is one reason Merriam has received funding aid. This program is a significant part of the local cost share of this project.

MDD will also be an important cooperative and also likely a financial partner with the City in supporting future phases of design, construction, and especially the operation and maintenance of a federal cost-shared project on Upper Turkey Creek.

8 CHAPTER 8 – PUBLIC INVOLVEMENT, REVIEW AND CONSULTATION

8.1 PUBLIC INVOLVEMENT PROGRAM

A Public Involvement Program was developed by the Project Delivery Team (PDT) to help meet the requirements of ER 1105-2-100 and NEPA scoping requirements. The Upper Turkey Creek Feasibility Study PDT has regularly engaged the local sponsors and stakeholders throughout the entire process. Public input was sought during the Reconnaissance Phase (Appendix C, Exhibit 1), at the initiation of the Feasibility Study (Appendix C, Exhibit 2), and mid-way through Phase 2 of the Feasibility Study to receive feedback about identified alternatives. The public involvement goals have been to inform, engage and solicit input from stakeholders and the public to increase public awareness of the risk of flooding from Upper Turkey Creek in the City of Merriam and so that the Recommended Plan reflects that input, thus making the alternative acceptable to the public. The Recommended Plan reflects the views of the public and consultative input received from the local sponsor, other Federal and non-Federal agencies, and other affected stakeholders.

8.2 INSTITUTIONAL INVOLVEMENT

8.2.1 STUDY TEAM

A number of disciplines were represented on the PDT: engineering, biology, economics, real estate, planning and public outreach. Team members have interacted with their counterparts at non-Federal and Federal agencies as well as with local government officials and staff.

8.2.2 AGENCY PARTICIPATION

USACE and the project team have maintained regular contact throughout the study with the local sponsor, the City of Merriam. The City of Merriam established inter-local agreements with Johnson County, Kansas, and with the Unified Government of Wyandotte County and Kansas City, Kansas (e.g. Unified Government or UG) to cost-share the non-Federal portion of the study costs. External engagement has included interactions with elected officials as well as with professional staff from each interested jurisdiction.

The Merriam Drainage District operates and maintains part of the Upper Turkey Creek Channel under a state charter that gives the Drainage District Board authority independent of the City of Merriam and Johnson County. The District did not fund the study, but it was included in briefings and was informed of public meetings.

During the Reconnaissance phase, USACE had contact with numerous Non-Federal as well as Federal agencies (see Appendix C, Exhibit 5 for the complete list).

8.2.3 LOCAL AND REGIONAL INTERESTS

The Upper Turkey Creek study area includes numerous businesses along Merriam Drive, parallel to Upper Turkey Creek. The Downtown Merriam Partnership is an association of those businesses and it has been involved throughout the study process.

The Turkey Streamway Bike Trail parallels a section of Upper Turkey Creek between Johnson Drive and Antioch Road. Under the auspices of the Mid America Regional Council's (MARC) Metro Green Bike and Trail initiative, a coalition of public and private organizations have organized as the Turkey Creek Coalition. The coalition is an informal association interested in trail development along this segment of the creek. USACE is a member of the Coalition.

MARC, through other environmental programs, also has interests and acts as a convener of local governments in the region about stormwater and other water quality issues. MARC staff has participated in study briefings and public meetings.

8.3 INFORMATIONAL MATERIALS

The Public Involvement Program included media notices, public meetings, and outreach activities. The goal of the District was to increase public awareness of the risk of flooding and to focus media notices and public attention on the study at key points in the process. Outreach activities for the study were designed to educate the public of the existing flood hazard and associated flood damages and to provide the public with important project information and keep them informed about project activities and milestones and receive feedback. This feedback was then considered and used in the analysis of the study alternatives. The PDT utilized several communication tools to provide the public with study information including:

- Open Houses
- Workshops
- Public Meetings
- Press Releases
- Project Brochures
- Web Page

Information about the project was also made available on the Kansas City District's website at http://www.nwk.usace.army.mil/projects/utc/. The website is a mechanism to provide general information about the project and details about public meetings.

8.4 MEDIA RELEASES

Media releases were distributed to inform the public of upcoming events and of study milestones. Media releases throughout the study include:

- Reconnaissance Study, Notice of Initiation, July 2001 (Appendix C, Exhibit 1)
- Feasibility Study, Notice of Initiation, August 2002 (Appendix C, Exhibit 2)
- Turkey Creek Awareness Workshop, June 2003 (Appendix C, Exhibit 3)
- Upper Turkey Creek Concepts Workshop, September 2004 (Appendix C, Exhibit 4)
- Upper Turkey Creek Basin Feasibility Study, Notice of Public Meeting, September 2011 (Appendix C, Exhibit 6)
- Upper Turkey Creek Basin Feasibility Study, Public Notice of the Draft Feasibility Study with Integrated Environmental Assessment, June 2013 (Appendix C, Exhibit 7)

8.5 PUBLIC OPEN HOUSE AND MEETINGS

A series of meetings were held within the project area. The meetings allowed the PDT to present the existing flood risks and associated flood damages and to show the public flood risk management study alternatives and gather input on any issues that needed to be addressed prior to study initiation and throughout the study process.

- July 25, 2001 – a public workshop was held at Merriam City Hall in the City of Merriam to inform the public of the scope of the reconnaissance study. The workshop included a presentation of the existing flood risk, purpose of the analysis, potential benefits, and possible environmental impacts.
- July 17, 2003 –the Turkey Creek Awareness Workshop was held at the Antioch Public Library in Shawnee Mission, Kansas to inform the public of ongoing activities of the City, State, Federal, and other types of organizations to gather information for the future management of Turkey Creek.
- September 16, 2004 –the Upper Turkey Creek Concepts Workshop was held at the Community Center in the City of Merriam (Appendix C, Exhibit 6). The District presented the concepts developed at that time as opportunities for flood risk management for public consideration. The workshop was an opportunity for the public to ask questions and provide suggestions for improvement.
- October 19, 2011 – a public meeting was held at the Community Center in the City of Merriam to inform and receive input from the public about the identified alternatives. The public was informed about the planned meetings through numerous mechanisms: a 3 panel brochure describing the project, meeting information made available on the USACE District Website, postcards mailed to property owners within 1/8 mile of the creek and key partners, and on the City of Merriam's Facebook account.

  The meeting included a formal presentation titled "Solutions for Flood Hazard on Upper Turkey Creek" which included a discussion of study background, understanding flood risks (i.e. extent of floodwaters, velocity, proximity of population at risk, warning time, rate of rise) (Figure 8-1), , conceptual alternatives, other planning considerations, and next steps (Appendix C, Exhibit 6). The District presented its planning process, the alternatives evaluated, and the screening process used to arrive at the Recommended Plan for flood risk management. A question and answer period was held after the presentation where the project study team captured public comments made at the informational displays. Input was also collected from the public on comment cards provided to attendees in order to provide written feedback. The input collected allowed the project study team the opportunity to address any issues prior to the selection of the Recommended Plan.

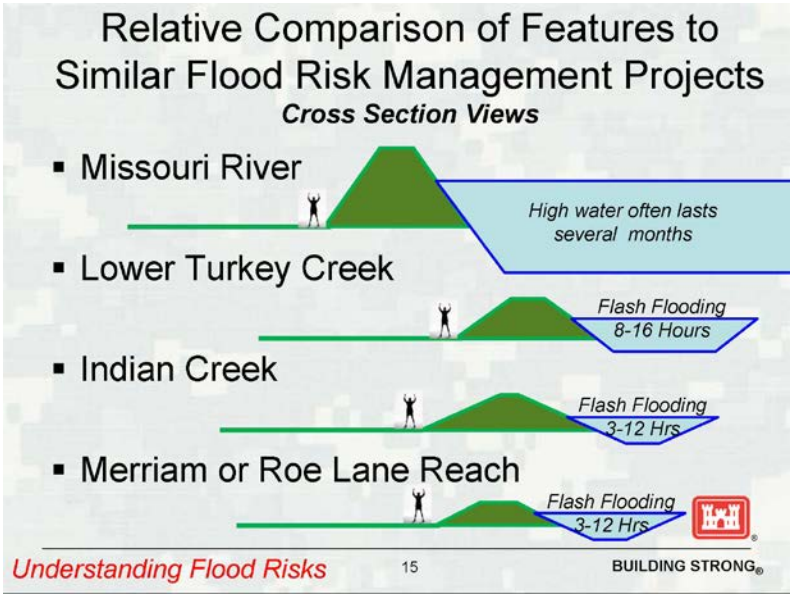


Figure 8-1: Public Hearing PowerPoint Slide 'Understanding Flood Risks"

- August 14, 2013 – a public meeting was held at the Merriam City Hall during the public review period of the Study to inform and receive input from the public about the Recommended Plan. This meeting explained the District's Recommended Plan for FRM. Comments were received on the draft report and are included in Appendix H.
- October 14, 2014 – The city held a meeting on the preliminary design. The USACE showed the levee/floodwall designed and explained how higher rainfall intensities called for a more robust approach over the last year. This was tied to an update from NOAA, National Weather Service, in their precipitation atlas called Atlas 14. This new flood risk was known in April 2013. The USACE

decided to address this in the design in November 2013. The meeting described the performance ability of the proposed low, 6-foot high levees and floodwall. Approximately ten people attended and offered good comments.

Upon the release of the Draft Feasibility Study with Integrated Environmental Assessment, a Public Notice was issued (see Appendix C Exhibit 7), the Study was made available for public review and another public meeting was held to obtain input on the recommended alternative.

8.6 PUBLIC VIEWS AND RESPONSES

A complete list of public comments and responses regarding the scoping process is contained in Appendix C, Public Outreach and Involvement. A complete list of public and private comments and responses to comments regarding the Draft Environmental Assessment is contained in Appendix H, Comments and Correspondence.

8.7 AGENCY CORRESPONDENCE

Agency correspondence and communications initiated during the scoping process and the views of the resource agencies are included in Appendix H, Comments and Correspondence.

The Draft Feasibility Report with Integrated Environmental Assessment was available by Public Notice for a 30 day public review period on June 27, 2013. The review period closed on August 21, 2013 after being extended by 26 days. The review period generated questions and comments on the Draft Feasibility Report with Integrated Environmental Assessment that covered a range of topics. These comments are provided in Appendix H, Comments and Correspondence.

The following is a list, summarizing the comments received during the review period for the Public Notice. Generally, they appear in the order in which they were received, and each is followed by the District response. Many of the responses provide a general overview and then direct the reader to the location within the Draft Feasibility Report with Integrated Environmental Assessment where more detailed information can be found.

1. **Letter from Kansas State Historic Preservation Office, Jennie Chinn, Executive Director and State Historic Preservation Officer, dated August 1, 2013**

   COMMENTS/CONCERNS

   A. The agency had previously reviewed the project and had cleared it in a letter to the USACE dated May 15, 2012. The agency concurred that the project should have no effect on properties listed in the National Register of Historic Places or otherwise listed in their files. The office continues to have no objection to implementation of the Upper Turkey Creek Basin Flood Risk Management Project.

   Response: Noted

2. **Electronic message from Kansas Department of Wildlife, Parks, and Tourism, Jason Luginbill, Aquatic Ecologist, Aquatic Services Section dated August 13, 2013**

   COMMENTS/CONCERNS

   A. The agency responded that no state-listed threatened or endangered species or crucial wildlife habitats should be significantly affected. No Department of Wildlife and Parks permits or special authorizations are needed.

   Response: Noted

   B. The agency provided the following design criteria:

- Avoidance of impacts to non-impacted riparian zones, wetlands, and native prairie and woodland areas
- Minimization of further instream construction activities particularly during general spawning dates of May 1 and August 31
- Incorporation of principles of Low Impact Development
- Implementation and maintenance of standard erosion control Best Management Practices
- Reseeding and landscaping of disturbed areas with indigenous species

Response: Each of these recommendations will be evaluated for incorporation in the design phase of the project.

3. Letter from U.S. Environmental Protection Agency, Larry Shepard, NEPA Reviewer, dated August 21, 2013

COMMENTS/CONCERNS

Floodplain Management

A. Comments ask for the inclusion of high water marks and projected flood levels on constructed flood walls, and signage to address flood hazards in the protected area. They also have asked for Floodplain Management Plan (FMP) deadlines to be completed in the PPA.

Response: The decision to provide water marks on floodwalls and signage in the protected area is a non-Federal sponsor decision. In addition to encouraging measures such as these, during the preparation and implementation of the FMP and project implementation, we will work with the sponsor to assist them with a range of flood risk management measures including continued risk information disclosure, flood preparedness and flood response. There are provisions in the clauses of the USACE Flood Risk Management PPA that requires preparation of a FMP including stipulation that it be completed prior to completion of construction. The FMP has been initiated during feasibility phase and it will be completed prior to project construction.

B. Comments ask for a City of Merriam commitment to identify structures and properties within the floodplain to acquire from willing sellers to further reduce flood risk in the area.

Response: We studied and identified the areas of highest flood risk to property and life along Upper Turkey Creek. The area identified as highest risk was located within the City of Merriam. As part of the feasibility report's consideration of alternatives, we evaluated evacuation of structures or buy-out from the floodplain as a detailed alternative (see Chapter 4, Section 4.6.2, Chapter 5, and Chapter 6. It was not selected as it was not the NED Plan. The City of Merriam as part of the FMP will be required to have in place or establish procedures that manage flood risk and protect Federal investment in this project. The FMP is discussed in Chapter 2, Section 2.6.3 and further discussion was added to Chapter 7, section 7.5.2. If the City of Merriam has justification, authority, and funding to implement property buy-outs in the future (which are beyond the scope of the Federal project), they will likely do so as they have done in the past.

C. Comments request the development of an FMP in a broader geographic context in order to provide a more "systems approach in the watershed".

Response: The USACE policy guidance expressly requires the non-Federal sponsor (City of Merriam) to prepare an FMP specifically for the study area. We are allowed to assist with it and are doing so. The capacity building and opportunities for participation in the FMP was presented to the key stakeholders, and included the importance of having a watershed

perspective and a systems approach. All planning work has been done in a watershed context, and the importance of this perspective will be part of the scope of the FMP. We will coordinate the FMP development with Johnson County and other stakeholders including FEMA, and the State of Kansas. We welcome this comment and would be pleased to include USEPA in the process.

Purpose and Need for Action

D. Comments expressed lack of a clearly-stated project purpose in the document. Comment questions whether the report is consistent with the charge to USACE in the Study Resolution from Congress, states the purpose of the report is addressed in the document but not the purpose of the project. The report addressed to a limited extent flood risk in the vicinity of the project, does not address fundamental causes of flood risk, nor flood risk remaining upstream and downstream of the project area.

Response: The study authority is for the Upper Turkey Creek basin, but it is not a watershed study authority. In scope it allows for basin wide flood risk planning in a watershed context. It asks the USACE to recommend modifications in the form of flood damage reduction (flood risk management) projects in the basin. We evaluated flood risk in the upper basin, and identified to the best of our ability the three most vulnerable areas with significant risk to life and property. Of these, one location was found to have technical and economic feasibility with a non-Federal sponsor willing to cost share in a project. However, that does not obviate the watershed based analyses that the study included, and the fact that the Recommended Plan was formulated and evaluated in a watershed context. The report, to a large degree, is a chronological summary of the study and its findings. The study was initiated by evaluating a broad array of flood risk management measures basin wide, including nonstructural measures, and also ecosystem restoration opportunities. As the study progressed, measures and alternatives were screened for feasibility and sponsorship.

In formulating, comparing, evaluating and selecting alternatives for the Upper Turkey Creek project, the purpose, or performance goal, that we have pursued has simply been to maximize flood risk reduction (or minimize residual risk) within the broader goals and constraints of economic efficiency, environmental considerations, and sponsor finances. Further clarification of the project purpose was added to the introduction section of Chapter 4.

The report in Sections 2.1 and 2.3.1 identifies the fundamental causes of increased flood risk and flood history, and identifies the significant flood hazard in Section 2.3.2. The project will not address the other areas of significant flood risk to life and property that were identified. However, those three areas are identified in Sections 4.1 and 4.3. Section 7.5 relates the residual flood risk which has also been disclosed at public meetings.

E. Comments asked for modification of objective one stated in Chapter 2, Section 2.4.1 to reflect the reduction of flood risk in the City of Merriam rather than in the watershed.

Response: The report is arranged largely in chronological sequence. Planning objective one in Section 2.4.1 was developed prior to screening and evaluation of measures and plans which is documented in Chapters 4 and 5 of the report. The USACE evaluated the threat to life and property in the watershed, and we found three areas of significant flood risk (see Chapter 4, Section 4.3.1). One area (City of Merriam) remained after screening criteria and sponsorship requirements were considered. The evaluation is included in Chapter 4, Section 4.5.1. The planning objective has been reviewed and approved at all levels in USACE as well

as formal Independent External Peer Review, and revision of the objective is not considered warranted.

Future Without Project Conditions

F. The study references existing channel capacity describing its capabilities at various AEP flows. It appears the study characterized channel capacity as conveying or containing the 20% AEP and in another place the 10% AEP (p. 2-5 and 2-6).

The report states that the 1-percent AEP flow would need to be reduced by 45-50 percent in order to remain within the existing channel. This indicates that the USACE could approach flood risk reduction by reducing the 1-percent AEP flow or expanding channel capacity. This concept is important to public understanding of design choices by the USACE but is under-emphasized throughout the report.

Response: The report evaluated measures in the watershed to reduce flood flows early in the study as discussed in Chapter 4, Section 4.5. The watershed is highly urbanized and our engineering analysis revealed that with the areas remaining that are undeveloped it is not feasible to control sufficient flows to have any meaningful flood peak reduction in the flood threatened areas as discussed in Chapter 4, section 4.5.2. The USACE has no authority to formulate watershed BMPs or stormwater reduction measures for implementation in the attempt to reduce peak flows. Our hydrologic modeling and experience indicates the effect of such measures on the magnitude of peak flood flows for large floods would be very limited. The results of evaluation and screening of measures are documented in Chapter 4, Section 4.5. Channel widening was retained and considered in detailed plan evaluation and was not the most cost effective or least impacting alternative, screening of channel widening is documented in Chapter 5. The study has resulted in a recommendation for a project to protect downtown Merriam from dangerous flash flooding, but this area was not the sole focus of the study.

At the Johnson Drive gage the channel capacity is able to convey approximately the 10-percent AEP at the top of bank. Elsewhere in the project reach the channel can pass up to the 20-percent AEP flow, with two areas limited to the 50-percent AEP (2-year event).

G. Section 3.3.11 recognizes the possibility that local businesses might move out of the floodplain as a result of repeated flooding without the recommended project, but does not include the possibility under “future without project conditions”.

Response: Paragraph 3.3.11 states that the future without a flood risk management project would not be significantly different than that described under existing conditions. However, some business and industry may make the decision to move to other locations if flooding problems become too burdensome. There is a historic likelihood that individual businesses that move will be replaced by others.

Alternatives Analysis and Recommended Plan

H. The watershed still possesses some potential for precipitation retention (approximately 30% impervious surface) on a small scale, it is disappointing that the FR/IEA repeatedly references watershed approaches while quickly resorting to small-scale, localized alternatives based solely on "flood prevention" structures. A comprehensive, integrated solution to flood risk basin-wide with modular components addressing more localized issues should be developed, so as to find a full range of alternatives (including upstream and offline storage), and impacts to areas outside the City of Merriam would be fully considered. The notion of comprehensive, watershed-scale design for flood risk reduction should not be constrained by labeling it as "ecosystem restoration measures", as the FR/IEA appears to do.

Response: This project is expected to provide net annual benefits of approximately $1.7 million over the 50-year life of the project. The USACE recognizes that comprehensive watershed planning can make significant contributions to reducing flood risk while improving the environment in some instances. We did apply a watershed approach in formulation and did not unduly limit formulation in this study. The study started out being multi-purpose (ecosystem restoration and flood risk management) in approach using a watershed perspective. The watershed was evaluated for wetland and stream restoration sites while also being evaluated for various types of detention and storage opportunities. Opportunities for restoration sites that could also accomplish flood peak reduction were evaluated through site visits, evaluation of GIS and mapping, and in our hydrologic and hydraulic modeling. Detention or storage-type measures evaluated did not demonstrate capability of significantly reducing flood peaks at the damage areas in and downstream of Merriam and, therefore, would not provide significant flood risk management benefits. Similarly limited sites were available to provide significant wetland restoration opportunities. Any detention or storage measures that would be large enough to significantly reduce flood peaks would require costly buy-outs in improved areas, and / or disruptive construction of costly features in very adverse terrain, and would be very disruptive to the community as well. Ecosystem restoration measures were formulated that would have significant riparian and aquatic benefits, and are documented in Appendix J of the report. There were no sponsors willing to cost share and acquire land to implement these measures, but they could be implemented in the future. We recognize that recommending traditional structural flood risk management measures raises concerns about ensuring that a full range of alternatives were considered. In this case, a full-range of alternatives was considered, but in a very urbanized and impacted watershed the practical opportunities are limited. Measures and alternatives that could adequately address the flash flood threat were identified jointly by USACE and the cost-share sponsor, and were carried forward for full evaluation, including buyout of the floodplain. Incremental or partial buyouts were also evaluated but were not economically competitive with the recommended plan.

I. The document should have projected a 50-year (project life) increase following current precipitation trends to determine whether the recommended plan would provide adequate protection in the project area for the project's life.

Response: The USACE followed accepted practice and procedures in USACE and in the engineering profession for conduct of hydrologic analyses. We have incorporated consideration of the full period of flood history into our analyses and assessment of the flash flood risk. We did seek out the best information available regarding rainfall-runoff data during the study, and evaluated a 2002 University of Kansas update study. This study showed very close approximation of our hydrologic estimates which used traditional TP-40 methodology, and nothing in our investigation indicated that we should use alternative relationships or trends. Utilizing information from available climate trend reports and reasonable engineering assumptions, our best assessment is that there may be a slight increase in precipitation events and associated discharge frequency over the next 50 years, but these increases were considered to be within the bands of uncertainty in the hydrology analysis in this study. The National Weather Service has just published new precipitation frequency estimates in their Atlas 14 in March of 2013 which represents a very significant, long term and specialized body of work on this topic. Governmental agencies across the region must now consider what effect it will have and how to utilize it. It shows increases in the rainfall runoff relationships for some precipitation events. It would require significant effort in hydrologic analyses for us to determine definitive effects on the Recommended

Plan. Our preliminary evaluation indicates that more economic flood reduction benefits would result from a project, but that level of protection for the Recommended Plan could be lower. This recent information and the potential risk and uncertainty was raised and discussed at our August public meeting, and is discussed in the report in Chapter 7 under the section entitled "Risk and Uncertainty". We will consider more detailed design features during implement that are within the project scope and authority and that may be able to address new conditions based upon more detailed hydrologic analyses using Atlas 14 data. Flood risk management measures included in the FMP including public information and outreach, risk disclosure, flood response planning and risk management will continue through project implementation.

Environmental Consequences

J. Upstream and downstream impacts of constraining flood flows within the channel through the project site and possible elevation of flood stages outside of the project site have not been fully defined or analyzed to support the "no effects" statements. In addition, the study does not provide any analysis of how the recommended plan would affect the performance, present and future, of the USACE project in Lower Turkey Creek.

Response: Engineering analysis indicates that the project will not result in significant increases to water surface elevations upstream or downstream of the project area nor result in any noticeable effects to the Lower Turkey Creek project. Section 6.2.3 is being updated to better clarify our analysis of effects. The hydraulic analyses are summarized in Appendix B of the report.

K. The proposed structures will reduce public interaction with the Turkey Creek channel. The study should identify any reductions in recreational opportunities and aesthetics resulting from the installation of flood walls and levees.

Response: Impacts to recreation are described in Chapter 6 of the Draft Feasibility Study with Integrated Environmental Assessment. The public will continue to have access to the creek along the hiking and biking trail and pedestrian bridges, which were important considerations study. Most of the levee and floodwalls are on the bank opposite of the trail, and where required the project will accommodate the trail alignment.

Cumulative Impacts Analysis

L. The study should document in more detail the actions and impacts of each major change to the channel and floodplain. This project, although limited in scope, is one more alteration which contributes to the long-term decline in the quality and sustainability of the watershed. The study needs to account for each of these changes and their cumulative impacts.

Response: In our opinion the report addresses the environmental effects and cumulative impacts of the Recommended Plan sufficiently in Chapter 6, Section 6.4, and is in accordance with CEQ and USACE regulations. The proposed modifications are in a reach of previously modified channel with large limestone rock lining for most of its length, with a rock bottom in a fully urbanized area with heavy development and park like features. The existing conditions in the project area are documented in Chapter 6.

4. Electronic message from Delia Garcia, Ph.D., and Eliodora Chamberlain, Ph.D., dated August 21, 2013

COMMENTS/CONCERNS

A. The commenter expressed opposition to the recommended plan and the use of levees and floodwalls as flood control measures in place of management techniques that would provide more benefits to the ecosystem.

Response: Ecosystem restoration measures were considered early in the study and found to have merit for restoring habitat and channel stability. However there were no local sponsors identified with an interest in cost sharing ecosystem restoration features, and the study authority is for flood risk management. These measures remain available for further consideration by others and are documented in Appendix J of the report.

B. Recommendations were made to the Merriam Drainage District to work with other agencies and nongovernmental organizations to implement greener solutions to alleviate flood risk and promote workshops (e.g. rain gardens, rain barrels, pervious pavement) to homeowners and business organizations.

Response: Noted. The USACE will reinforce sound flood risk management beyond solely the construction of structural features through the development and implementation of the FMP in partnership with the City of Merriam and the MDD.

C. The recommended plan as proposed would lead to the further degradation of an already badly degraded environment.

Response: Impacts to natural resources for the entire area of impacts are described in Chapter 6 of the Draft Feasibility Study with Integrated Environmental Assessment. Unavoidable impacts will be offset by the proposed mitigation.

D. The commenter expressed concerns that the increased containment of flows with the Upper Turkey Creek will lead to increased water velocities to the Lower Turkey Creek and may create damages to the recently improved Lower Turkey Creek project.

Response: Engineering analysis indicates that the project will not result in significant increases to water surface elevations upstream or downstream of the project area nor result in any noticeable effects to the Lower Turkey Creek project. The hydraulic analyses are summarized in Appendix B of the report.

5. Letter from U.S. Fish and Wildlife Service, Heather Whitlaw, Field Supervisor, dated August 21, 2013

COMMENTS/CONCERNS

A. The U.S. Fish and Wildlife Service concurred with the USACE preliminary determination that the project will not affect species designated as threatened and endangered or adversely affect critical habitat and no Federally-listed threatened and endangered species occur in the project area.

Response: Noted

B. We believe that the description of current environmental conditions and Federal trust species, as well as the affects of the project on those resources, in the Draft Feasibility Study with Integrated Environmental Assessment is adequate.

Response: Noted

C. The project is likely to increase thermal pollution in Turkey Creek and downstream receiving waters increasing water temperatures that may further reduce habitat for aquatic and semi-aquatic species.

Response: The project area is located in a highly altered urban environment. There is very little shading of the channel occurring from existing vegetation as very few riparian trees are adjacent to the stream which has been heavily modified and lined with large rock as discussed in Chapter 3 and explained further in Chapter 6, Section 6.2.3. We believe the proposed project would not result in any significant change to the stream water temperatures relative to existing condition.

D. The mitigation plan does not adequately account for the removal of riparian vegetation, including trees, and the loss of the function of riparian vegetation to the health of the stream. Trees planted for mitigation for the loss of riparian vegetation should be along streams, preferably along Turkey Creek or tributaries to Turkey Creek.

Response: The proposed project will result in no significant loss of riparian vegetation as there is very limited riparian habitat or trees close to the stream. A majority of the riparian trees that are in the existing project footprint are located in park-like setting with manicured turf grass which provide very little habitat. In addition, the existing banks are very steep and comprised of large limestone blocks over much of the reach, which doesn't allow for significant riparian vegetation. By changing from the large limestone blocks to rip rap will allow for more growth of stream bank vegetation. Trees planted for mitigation will be planted near the stream when possible. Final locations for the planting will occur in the design phase. The existing conditions in the project area are documented in Chapter 3, Section 3.2. The effects of the project are located in Chapter 6, Section 6.2, and the project mitigation that is justified given project effects and allowable within USACE authority is documented in Section 6.3.

E. The agency recommends the use of the Kansas Stream Mitigation Guidance for the project.

Response: USACE Planning regulations requires the use of certified models in water resource planning studies. The KSMG has not been certified for use in USACE planning studies. The USFWS HEP that are certified for use in USACE planning studies were utilized as a means of comparing habitat units to determine mitigation needs. The HSI models used for HEP are more robust than the KSMG. As stated in the KSMG documentation, the KSMG is to be utilized when a more robust evaluation is not practical.

F. If mitigation is required for aquatic resources the mitigation plan should be developed in accordance with 33 CFR, Part 332 and 40 CFR 230, also known as the Mitigation Rule, and include the recommended sections.

Response: A 404(b)(1) analysis was performed and is included in Appendix B. USACE planning regulations require the replacement of an equal amount of habitat value, typically based on a Habitat Unit or equivalent which is annualized over the life of a project (i.e. AAHU). This process was used in the calculation of mitigation amounts for this project. As determined using a USFWS HSI model, no aquatic habitat mitigation would be required for the Recommended Plan.

G. The agency urges the USACE 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.

Response: The USACE followed all applicable laws and regulations, including CEQ "Principles and Guidelines for Federal Water Resources Projects", P&Gs, and the USACE Planning Guidance Notebook (ER 1105-2-100), among others to develop and evaluate alternatives, including mitigation and restoration opportunities. Environmental impacts, both

positive and negative are utilized as a factor in the planning and selection of project alternatives. Chapter 6 presents the environmental effects of the Recommended Plan. The Recommended Plan will not result in additional significant degradation, either directly or cumulatively, of natural riverine processes in Turkey Creek.

H. If channel widening is considered again in the future, project planning should include the construction of a low flow/base flow channel which should emulate the natural stream pattern, profile, and dimensions.

Response: Noted. The USACE will continue to consider environmental design features during preliminary and final design of the project. The rock bed, confinement, and channel stability will likely limit construction of a low flow channel, but this will be considered as an option.

I. Recommend the use of native species planted on the levees.

Response: The use of native species for planting on the levees will be evaluated during the design phase to determine if and where it may be appropriate use of native vegetation.

J. The project should include erosion control that include BMPs to ensure sediment originating from the project does not enter the stream or migrate downstream. Additionally, instream sediment controls should be considered in sensitive areas or where upland controls may not be adequate.

Response: A stormwater pollution prevention plan will be developed as part of the Section 402 land disturbance permit. The appropriate BMPs will be incorporated into that plan to avoid sediment and other pollutants from entering Turkey Creek.

K. At a minimum the following should be included as a permit condition:

- All equipment brought on the 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 by thoroughly cleaned with hot water greater than 140 degrees F and dried for a minimum of five days before being used at this project site.
- 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 procedures.

Response: USACE construction specifications include those provisions as well as other conditions to prevent the spread of invasive species.

9 CHAPTER 9 – LIST OF PREPARERS

Name	Discipline	Experience	Role in Preparing Report
Brian Rast	Plan Formulation	20 years	Project Manager/Planner
Thomas Topi	Economics	6 years	Economics/Social
Meredith Harmon	Real Estate	6 years	Real Estate
Jesse Granet	Environmental Resources	15 years	EA Preparation, Impact Assessment and Mitigation Planning
Curtis Hoagland	Environmental Resources	17 years	EA Preparation, Impact Assessment and Mitigation Planning
William Otero	Hydraulic Engineering	14 years	Hydraulic and Hydrology Appendix
Timothy Meade	Archeologist/Cultural Resources	24 years	Cultural/Historical Section
Paul Speckin	Civil Engineer	27 years	HTRW Support
Eddie Fernandez	Structural Engineer	10 years	Lead Technical and Structural Engineering
Jim Mehnert	Geotechnical Engineer	25 years	Foundations
Jared Mewmaw	Civil Engineer	10 years	Civil / Site Development and Utilities
Lisa Hook	Geospatial Analysis	10 years	GIS and map-figures
Pat Miramontez	Cost Engineer	20 Years	Construction cost estimating and cost and schedule risk analysis
Lou Ragozzino	Civil Engineering/Hydraulic Analysis	29 years	Contractor/Civil Engineering/Hydraulic Analysis
Laura Totten	Ecologist/Project Management	14 years	Contractor/Project Manager/Main Report and Environmental Appendix
Michael Snyder	Environmental Scientist	13 years	Contractor/Main Report
David Halpern	Civil Engineer/Cost Estimator	10 years	Contractor/Cost Estimator
Dincer Egin	Geotechnical Engineer	30 years	Contractor/Geotechnical Engineer
Aaron Sylvia	Civil Engineering	9 years	Contractor/Cost Estimator/Engineering Appendix
Julie MacLachlan	Public Involvement/Facilitator	20 years	Contractor/Public Involvement Chapter and Appendix
Samantha Hogan	Environmental Scientist	6 years	Contractor/Preparing Maps and Figures
Coreen Johnson	Technical Editor	21 years	Contractor/Editorial Review

10 AGENCY COMPLIANCE WITH OTHER ENVIRONMENTAL LAWS

10.1 COMPLIANCE WITH OTHER ENVIRONMENTAL LAWS

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
Environmental Justice (Executive Order 12898)	Full Compliance
Estuary Protection Act, 16 U.S.C. 1221, et seq.	Not Applicable
Farmland Protection Policy Act, 7 U.S.C. 4201, et. seq.	Full Compliance
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
Floodplain Management (Executive Order 11988, see Section 10.2)	Full Compliance
Invasive Species (Executive Order 13122)	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, as amended, 16 U.S.C. 703-712	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
Protection & Enhancement of the Cultural Environment (Executive Order 11593)	Full Compliance
Protection of Wetlands (Executive Order 11990)	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

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.

10.2 COMPLIANCE WITH EXECUTIVE ORDER 11988

Under this Executive Order, the USACE is required to provide leadership and take action to

- Avoid development in the base flood plain unless it is the only practicable alternative;
- Reduce the hazard and risk associated with floods;
- Minimizes the impact of floods on human safety, health and welfare; and
- Restore and preserve the natural and beneficial values of the base floodplain.

Preauthorization studies, or feasibility studies, are one of the areas of the USACE Civil Works Program that must comply with the Executive Order. Where a floodplain may be affected, the policy and procedures of this regulation shall be incorporated in the multi-objective planning process (ER 1105-2-20, ER 1105-2-30) from the outset, to a scope and level of detail appropriate for preauthorization studies.

The project team followed the eight step decision-making process for helping to avoid long and short-term adverse impacts per the proposed actions that are in and that affect the floodplain in Merriam, Kansas. These eight steps are bulleted below and followed with project specific statements and should not be confused with the Six Step Planning Process used through the first seven chapters:

1. **Determine if the proposed action is in the base floodplain**.

The Selected Plan is in the base floodplain. The features also redefine the boundary of the floodway.

2. **Identify and evaluate practicable alternatives to locating in the base floodplain, including alternative sites outside of the floodplain**.

The project team considered a buyout of all structures and a greener floodplain. This is discussed in Section 4.6. After much discussion with the city and several meetings with stakeholders like Merriam Downtown Partners between 2006 and 2009, this is not acceptable to these businesses. If a portion of the channel happened to be owned by the city, this may have been an alternative worth pursuing. None of the property except at road rights-of-way belongs to the city. The conclusion was this is not a practicable alternative.

Another consideration is widening bridges. But two issues defeat this measure of wider bridge openings. First, a wider bridge typical requires commensurate widening of the channel, or the channel capacity

would become the next limiting factor for conveying the floodwaters. The real estate associated with widening the channel makes the bridge widening more costly. In addition, the Merriam Drive Bridge has a particularly high skew or a bend in the stream's alignment. Reducing the effects of the skew require more real estate as well. Also, benefits for improving just this one bridge are hard to realize when, during a flood, another bridge crossing is nearby that acts as an alternate and safer route for traffic.

3. **Provide for public review and involve the public in the decision process**.

Study finds that no other measure to alleviate the consequences of flooding will work, other than a feature built in the floodplain, and several opportunities, for the public to be involved the process leading to this realization, occurred. The public involvement chapter outlines this in detail. The stakeholders were engaged several times and with various tools, beginning in 2001. A full list of meetings is in Section 8.5. The project team organized a public meeting on October 19, 2011 to present a menu of measures and involve the public in the development of the alternatives from those measures. The project team was careful to clearly layout this menu of measures for reducing impacts of flooding. The measures covered tools for addressing floodplain management as well as those that adjust the floodwaters. The results for conducting plan formulation with the measures are presented in Section 4.5.5. The floodplain management measures discussed included both activities by the city and Merriam Drainage District and features, such as flood proofing and flood warning. Floodplain management measures will be continued in the floodplain management plan with the city's leadership. A list of action items will be maintained in the floodplain management plan.

4. I**dentify beneficial and adverse impacts of the proposed action**.

    a. Impacts will vary depending on the Federal action

    b. Impacts on lives, property, and floodplain values

    c. Positive and negative; concentrated and dispersed; and short and long term

The negative impacts can be divided into floodwater and environmental impacts.

Regarding floodwater, the features of the Selected Plan will protect areas in the reach of stream that are on the same bank of the creek. Properties on banks without the levee or floodwall features will see a rise in water surface elevations and a change in the location of the floodway. The advancement of the floodwaters on to each property depends on topographic conditions: for example, a flat piece of land will see minimal advancement into the property for a similar property with steeper land slopes. A review of the lands, especially on the west bank of the creek, showed no structures will be impacted and risk of loss of life would not change.

Environmentally, the negative impacts are under the footprint of the features and the floodplain lands within the protected area that are cutoff from the water body. Ideally, the buyout alternative would offer the chance to return to a more vibrant stream corridor, however the private property owners are not on board with that. All of that land is developed behind the proposed levee. The land use has impervious surfaces. Thus no additional loss to the floodplain ecosystem is quantified. The project team was careful to assess needed compensatory mitigation for the terrestrial habitat impacted, and this is addressed in Appendix M.

Positive impacts are more notable. The area will not have impacts from the more frequent flood events. This includes damage, loss of life, and the suffering during recovery phases after flood events. The levee and flood walls require an interior drainage pond that offers an opportunity to improve water quality and water infiltration. Currently, Downtown Merriam discharges this stormwater directly. The dry pond area will act as a stormwater detention basin. Water held during the drainage holding time can percolate into

the soil. The green space alone offers and improvement compared to the amount of impermeable land cover currently in the area. If the city agrees to plant native plants, this could improve groundwater recharge. The same green area could be a recreational amenity as well, being used for removable soccer or volleyball equipment, directly compatible with the Merriam Downtown Marketplace park environment. This is a good example of the wise use of the floodplain.

With the levee in place, any poor water quality will be directed and controlled and routed to the interior drainage dry pond, which offers an opportunity for treatment if the city desires to pursue that with its own funding to address possible EPA requirements (NPDES).

5. **Examine the possibility of inducing development.**

The possibility of further inducing development is unlikely. The primary reason is that the area is already developed. The community leaders are focused on maintaining a stream corridor for the existing trail for pedestrians and bikers. The preference they have is that business re-development occurs at the tops of the nearby hills along the I-35 corridor and that the park setting be maintained.

6. **Revaluate the alternatives to minimize impacts**.

The re-evaluation has been done. Property owners wish to remain, and funds are not available to afford a buyout alternative. The study team considered means that other agencies offer. The team used the state hazard mitigation team network, through USACE Silver Jackets and looked at FEMA mitigation grants and HUD resiliency competitions. No funds were available through these, or the community simply was not eligible. The team considered a green way in conjunction with the EPA mechanisms, including the SAMP. Cost of bioengineering stream banks is high and the risk of failure during the root growth is too great. The solution to flooding is needed in the near term by 2020 according to the capital improvement plan.

7. **Issue findings and a public explanation**.

The study team looked at many possible solutions for years (2002-2014). The study has tried many different alternatives, from local to watershed-wide, from one agency to many. The Selected Plan is the result of a more than ten-year search. After including the public in the planning process, the city and USACE have presented updates, including one update focused on the increased flood risk found after applying the NOAA National Weather Service Atlas 14 higher rainfall intensities. The public understands the findings and has expressed desires to be worked into the design, such as preserving the trail.

8. **Recommend the plan most responsive to the planning objectives**.

The best plan was recommended per the requirements of the Executive Order 11988. The planning process established objectives and planning criteria for the decision process in Section 2.2 and Section 4.2, respectively. This planning effort sought to avoid the floodplain per measures evaluated in Section 4.5.2. As the only practicable alternative, the selected plan, Alternative 2d as modified for Atlas 14 flows, emerged in Section 5.3.2 and finalized in Chapter 7 as the best solution. That plan reduces the flash flood hazard and risk associated with floods in the best way. In alignment with the objectives of Executive Order, that plan minimizes the impact of floods on human safety, health, and welfare, as the proposed feature reduce the potential for loss of life and property damages. Finally, the planning process sought to restore and preserve the natural and beneficial values of the base floodplain. Specifically, environmental improvement was looked at to the degree possible under this study's authority, including identifying significant plan formulation of more than ten best management practices based on a watershed perspective (see Appendix J, Section 2 and 3). The final plan also includes environmental mitigation to meet the Executive Order's objectives on natural and beneficial values of the base floodplain (see Appendix M).

STATEMENT OF FINDINGS

The proposed levees and floodwalls are the best action for managing the flood risks for Merriam, Kansas, because of these features best address the flash flood risk in the this well developed area. The report documents the decision process that lead to this conclusion, and the reasons for why the proposed action must be located in the floodplain. The plan formulation process considered many alternatives before narrowing plans down to the determination to locate in the floodplain, and the many alternative sites and actions considered are presented in first several chapters of this report. The selected plan conforms to applicable State or local floodplain protection standards, including those of the National Flood Insurance Program as administered by the City of Merriam and the Kansas Department of Agriculture, Division of Water Resources, and the design phase will continue that effort. The selected plan will temporarily disrupt the natural and beneficial values of the floodplain, and the plan will also mitigate that environment. The plan will include steps to design or modify the proposed action to minimize potential harm to stakeholders in the area and within the floodplain, and much of this will be guided through a floodplain management plan. The City of Merriam and the Kansas Department of Agriculture, Division of Water Resources, the Lower Kansas River WRAPs, and the Turkey Creek Coalition have all been involved in the development of this plan.

11 CHAPTER 11 – RECOMMENDATIONS

As District Engineer, I have considered the environmental, social, and economic effects, the engineering feasibility, and comments received from the other resource agencies, the non-Federal sponsor, and the public, and have determined that the Recommended Plan presented in this report is in the overall public interest and is technically sound, environmentally acceptable, and economically feasible. I recommend that the Recommended Plan and associated features described in this report be authorized for implementation as a Federal project.

The Recommended Plan is the NED Plan, which is Alternative 2d, as generally described in this report. The plan includes flood risk management features including 6,822 feet of floodwall up to 6.5 feet in height, 3,203 feet of levees up to 6.5 feet in height, with associated storm drainage modification and relocation work, and a 2.14 acre-foot detention area. These features are in the City of Merriam and extend approximately from Shawnee Mission Parkway to Merriam Drive, which is a stretch that includes Merriam's main downtown reach, as well as a commercial and industrial area just south of Johnson Drive. Most of the protected area is on the right bank of Turkey Creek. The total estimated first cost estimate at October 2014 price levels is $37,579,000, and a fully funded cost of $43,697,000, with the Federal and non-Federal shares of the total estimated at $28,403,000 and $15,294,000, respectively, and from that a LERRD requirement of $10,934,000, and estimated annual OMRR&R costs of $40,800. The selected plan has an overall benefit to cost ratio (BCR) of 2.0 to 1.

These recommendations are made with the provision that, prior to implementation, the non-Federal sponsor will agree to comply with the following requirements:

Federal implementation of the Recommended Plan 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 flood risk management costs as further specified below:

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

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

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

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

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

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

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

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

e. Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), which requires a non-Federal interest to prepare a floodplain management plan within one year after the date of signing a project cooperation agreement, and to implement such plan not later than one year after completion of construction of the project;

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

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

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

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

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

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

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

m. Comply with all applicable Federal and state laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled

"Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c et seq.);

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

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

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

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

This plan is being recommended with such modifications thereof as in the discretion of the Commander, HQUSACE, may be advisable.

The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It does 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 before it is transmitted to the Congress as a proposal for authorization and implementation funding. However, prior to transmittal to Congress, the non-Federal sponsor, the State of Kansas, interested Federal agencies, and other parties will be advised of any modifications and will be afforded the opportunity to comment further.

Andrew D. Sexton
Colonel, Corps of Engineers
District Commander

12 CHAPTER 12 – LIST OF RECIPIENTS

The following Federal, State, County, local and regional agencies; environmental organizations; and interested groups received notice of availability of this document:

- Kansas Division of Emergency Management (KDEM)
- Kansas Division of Water Resources, Kansas Department of Agriculture
- City of Merriam, Kansas
- Kansas House of Representatives
- USACE, Kansas City District
- Lower Kansas WRAPS
- Kansas Department of Health and Environment (KDHE)
- The Watershed Institute
- U.S. Environmental Protection Agency
- Downtown Merriam Partnership
- Merriam Drainage District
- Unified Government
- Kansas Department of Transportation (KDOT)
- Federal Emergency Management Agency (FEMA), Region VII
- Mid-America Regional Council
- Johnson County, Kansas
- Johnson County Public Works and Infrastructure-Urban Services Division
- City of Shawnee, Kansas
- City of Lenexa, Kansas
- City of Overland Park, Kansas
- City of Mission, Kansas
- City of Fairway, Kansas
- U.S. Geological Survey
- U.S. Fish and Wildlife Service
- Kansas Department of Wildlife, Parks, and Tourism
- Kansas State Historical Society (SHPO)
- Natural Resources Conservation Service (NRCS)
- Burrows Audubon Society
- Ducks Unlimited
- Federal Highway Administration
- Iowa Tribe of Kansas and Nebraska
- Kansas Water Office
- Kickapoo Tribe in Kansas
- Kansas Chapter Sierra Club
- Osage Tribe
- Ponca Tribe of Nebraska
- Pawnee Nation
- Sac and Fox Nation of Missouri in Kansas and Nebraska
- The Nature Conservancy

13 CHAPTER 13 – REFERENCES

13.1 PRIOR STUDIES AND REPORTS

The following previously conducted or ongoing studies are related to the Upper Turkey Creek Basin:

Design Memorandum No. 2, General Design Memorandum, Turkey Creek Diversion, USACE, Kansas City District, January 1956. The memorandum documents a proposed plan to raise the right bank levee on Turkey Creek by four feet from a point 200 feet upstream from the Turkey Creek Tunnel entrance to a point 4,000 feet upstream of the tunnel entrance. Also proposed was widening the bottom width of the channel to 90 feet with 1-on-2 side slopes from the Southwest Boulevard bridge to a point 100 feet downstream from the Frisco Railroad bridge. The design features discussed in the proposed plan were never constructed.

Flood Protection Project, Turkey Creek, Merriam, Kansas, USACE, September 1962. This Design Memorandum reevaluated the economic justification of a flood protection plan developed in 1946. The project was designed to alleviate flooding along Turkey Creek in Merriam, Kansas. The plan of improvement called for constructing levees along the banks, a short section of floodwall, a new channel through the entire length of the improvement area, and the modification of several bridges and roads. The report revised the recommendations for conditions, as of 1962, and provided a map of improvements and typical channel sections. This project was not constructed.

Letter Report for Proposed Inclusion of Turkey Creek Improvements, Modification of Local Protective Works, Kansas River, Kansas City, Kansas (Flood Control Act of 1962), USACE, Kansas City District, May 1968. The report described the Turkey Creek Flood Problem and proposed a solution for addressing flood hazards. The report recommended a new 28-foot-diameter tunnel to be driven adjacent to the existing tunnel, and an enlarged and deepened channel extending 11,400 feet upstream from the existing tunnel entrance. The proposed plan was never authorized or constructed.

Flood Plain Information Report for Turkey Creek in Metropolitan Kansas City, USACE, January 1974. The report was authorized by Section 206 of the 1960 Flood Control Act (Public Law 86-645) as amended. The report included an evaluation of the flooding hazards associated with Turkey Creek in the metropolitan Kansas City area. The report was prepared at the request of the Cities of Kansas City, Merriam, and Overland Park, Kansas, the Kansas Water Resources Board, and Kansas City, Missouri.

Turkey Creek Improvement, 75th Street and I-35 Interchange, January 1983. The report detailed the design for the improvement of 75th Street at the I-35 interchange. The design called for raising the grade of 75th Street 22 feet at the Turkey Creek crossing. The study examined the hydraulic feasibility of constructing the crossing on an embankment with a suitably sized culvert. The Kansas Department of Transportation (KDOT) chose to proceed with the channel improvements, the new structure at 75th Street, and the use of a reach upstream of the BNSF Railway bridge as both a borrow site and a detention basin.

Planning Aid Report for the Turkey Creek Basin, Kansas and Missouri Reconnaissance Study, U.S. Fish and Wildlife Service (USFWS), Kansas State Office, Manhattan, September 1987. During a reconnaissance phase to determine potential measures for managing flood risks within the Turkey Creek Basin, this report to the USACE provided five recommendations to conserve fish and wildlife habitat and two recommendations to enhance habitats.

Reconnaissance Report: Turkey Creek Basin, Kansas and Missouri, USACE, December 1987. The reconnaissance report presented the results of a reconnaissance study that examined various alternatives for flood damage reduction in the Turkey Creek Basin. The report included an assessment of the Federal Interest and local support for flood reduction measures. The report concluded that one or more plans to reduce flood damages and hazard to human life in the lower Turkey Creek basin had potential economic feasibility and therefore recommended a feasibility phase study.

Flood Insurance Study, City of Kansas City, Kansas, FEMA revision of January 1995. A study was performed to convert the City of Kansas City, Kansas, to the regular FEMA program of flood insurance. The program was then used by local and regional planners in their efforts to promote sound land use and flood plain management. Hydraulic analysis for the study was performed by the USACE, Kansas City District, and was completed in September 1977.

Design Concept Report Supplement: Burlington Northern Railroad at Turkey Creek, HNTB Corporation, August 1996. The report supplemented an earlier Design Concept Report that evaluated new alternatives for lowering flood levels along Turkey Creek near Merriam's Industrial Park. The report included new discharge values developed since the original report (1995). Based on the new discharge data, the investigation determined that the most feasible course of action was to widen the channel 20 feet downstream of the I-35 bridges, improve the channel between the existing railroad bridges and the I-35 bridges, and acquire four properties in the industrial park.

Draft Fish and Wildlife Coordination Act Report for the Turkey Creek, Kansas City, Kansas, and Kansas City, Missouri, Local Flood Protection Project, USFWS, Kansas State Office, Manhattan, April 1997. This report to the USACE identified the loss of 18 acres of riparian habitat and the physical alteration and channelization of 4,000 feet of Turkey Creek as the primary impacts caused by proposed flood risk management measures. The USFWS provided six recommendations to minimize and offset fish and wildlife habitat losses. The report was authorized under Section 205 of the Flood Control Act of 1948 and was designed to accompany the USACE Feasibility Study.

Use Attainability Analysis of Turkey Creek, Johnson and Wyandotte Counties, Kansas, Gary E. Welker and Dr. Donald G. Huggins, USEPA, Environmental Services Division, Kansas City, Kansas and the Kansas Biological Division, University of Kansas, Lawrence, Kansas, July 1997. The study included chemical and biological analyses of Turkey Creek to determine the use attainability for aquatic life and recreation use, future use attainment, and potential causes of non-attainment for Turkey Creek.

Final Fish and Wildlife Coordination Act Report for the Turkey Creek Flood Damage Reduction Project, Kansas City, Kansas, and Kansas City, Missouri, USFWS, Kansas State Office, Manhattan, October 1998. This report to the USACE identified the loss of 5.6 acres of riparian habitat and the physical alteration and channelization of 4,100 feet of Turkey Creek as the primary impacts caused by proposed flood risk management measures. USFWS provided six recommendations to minimize and offset fish and wildlife habitat losses. The report was authorized under Section 205 of the Flood Control Act of 1948 and was designed to accompany the USACE Feasibility Study.

Feasibility Report and Environmental Assessment, Turkey Creek Basin, Kansas City, Kansas and Missouri, Kansas City District, USACE, December 1998. The report included a recommendation for the construction of a downstream project consisting of a combination of channel modification and hillside interceptors. The preferred plan was authorized for construction in Section 101(a)(24) of Public Law 106-53, the Water Resources Development Act of 1999.

TMDLs for the Kansas - Lower Republican Basin, Kansas Department of Health & Environment, June 30, 1999. The report included the USEPA approved Total Maximum Daily Loads (TMDL) or

quantitative objectives and strategies needed to achieve water quality standards to fully support designated uses for the Kansas-Lower Republican River Watersheds, including Turkey Creek.

Upper Turkey Creek Basin, Johnson and Wyandotte Counties, Kansas: Section 905(b) Analysis, USACE, July 2001. This report evaluated the potential Federal interest in solutions to recurring flood damages, environmental degradation, and related water and land resource needs and opportunities in the Upper Turkey Creek Basin. A positive determination of Federal interest and recommended approval by the USACE District Engineer led to development of the 2002 Project Management Plan (PMP).

Draft Supplemental Final Fish and Wildlife Coordination Act Report for the proposed General Reevaluation Report and revised Environmental Assessment, Lower Turkey Creek flood damage reduction project – Kansas City, Kansas and Missouri, USFWS, March 29, 2002, Kansas State Office, Manhattan. This report is the draft supplement to the 1998 Final Fish & Wildlife Coordination Act Report and General Reevaluation Report. Due to the occurrence of a flood event exceeding the containment capability of the proposed channel modifications (1998 Feasibility Report), the USACE expanded the proposed project (General Reevaluation Report). Based on the proposed project expansion, the USFWS added four recommendations to the six previously identified measures to minimize and offset fish and wildlife habitat losses. USFWS also included one recommendation to enhance fish and wildlife habitat.

Final Supplemental Final Fish and Wildlife Coordination Act Report for the proposed General Reevaluation Report and revised Environmental Assessment, Lower Turkey Creek flood damage reduction project – Kansas City, Kansas and Missouri, USFWS, September 9, 2002, Kansas State Office, Manhattan. This report is the final supplement to the General Reevaluation Report. No changes were made from the previous "draft."

Stormwater Management Ordinance, Chapter 7, Article 1 of City code of ordinances, City of Merriam, June 24, 2002. This article establishes the stormwater run-off management criteria and standards for the city's secondary or major drainage system and its components. (Ord. No. 1400, §1, 3-26-01). The secondary or major system includes the primary/minor system, its overflow elements and all Turkey Creek tributaries and drainage structures both public and private that are not identified as part of the Turkey Creek regulatory floodplain located within the City of Merriam, Kansas.

Johnson County Flood Warning/Flood Forecasting: Feasibility Study, Johnson County Stormwater Management Program (SMP), August 2002. The Johnson County SMP completed a study to determine the feasibility of a flood warning/flood forecasting system in Johnson County, Kansas – and if determined to be feasible, develop an implementation plan and to identify the potential costs to develop such a system. The basis for the study was the existing rain and stream gage network in Johnson County. In 1999 the Johnson County SMP initiated a significant expansion to the existing rain and stream gage network that at the time was located primarily in Overland Park, Kansas and Jackson County, Missouri. The expansion covered a significant portion of Johnson County and was completed to provide a data collection system and the foundation for developing and implementing a flood warning system, if desired or required. The report concluded that based on the significant interest by Johnson County communities combined with the extent and capabilities of the existing rain and stream gage network in Johnson County, a flood warning/flood forecasting system is feasible and should be considered for Johnson County. The study identified several recommended system enhancements.

General Reevaluation Report and Environmental Assessment, Turkey Creek Basin, Kansas City, Kansas and Kansas City, Missouri, USACE, January 2003. This report presents the findings of a reevaluation of potential measures to reduce flood damages identified in USACE's 1998 Feasibility Report and Environmental Assessment. Reevaluation was necessary to include updated information from

a severe flood in October 1998. This report extends modification of the Turkey Creek channel an additional 4,000 feet upstream, widens the channel modifications approved in 1998, and upgrades the Turkey Creek tunnel. The plan provides flood damage reduction benefits to the same locations identified in the 1998 document**.**

Upper Turkey Creek Basin Environmental Restoration Report: Feasibility Phase – Draft, USACE, August 2004. The Upper Turkey Creek Basin Environmental Restoration Report-Feasibility Phase was prepared by HNTB and Kabbes Engineering. The purpose of the report was to identify strategies for environmental restoration within the basin. Nine strategies for environmental restoration were developed:

1. Stopping and possibly reversing the downcutting of the stream banks
2. Removing fish blockages or finding alternatives to divert fish around the blockages
3. Retrofitting stormwater basins and swales to improve water quality
4. Acquiring open space pertinent to aquatic resources
5. Removing enclosures on tributaries
6. Removing retaining walls and using bioengineering solutions to improve those locations and other eroded areas
7. Reconnecting the channel and the floodplain
8. Emphasizing stormwater and flood water storage and infiltration systems over stormwater and flood water conveyance systems
9. Implementing a public information and awareness campaign addressing regulatory programs, potential regulatory strategies, and negative environmental impacts on downstream flooding of stream enclosures and channel modifications, and available alternatives

The study provided designs for thirteen projects at twelve sites to address seven of the above-mentioned strategies. The report identifies the potential water quality, habitat, and benefits from flood risk management measures plus estimated restoration costs for each design.

Northeast Johnson County Watershed Study, Johnson County, Kansas. 2005. Johnson County Public Works is conducting a watershed study of the major creeks and streams in the Northeast corner of the County. The Northeast watershed is approximately 38.5 square miles and contains 5 watersheds (Brush Creek, Dykes Branch, Lake Quivira, Rock Creek, and Turkey Creek). The project includes data collection—channels, culverts, bridges, and low opening elevations on houses and business structures in or near flood-prone areas—public meetings, and development of a plan addressing future stormwater issues. The study will generate new floodplain maps, identify flood prone areas and other problems (stream erosion), alternative solutions will be considered.

Effects of Contaminant Sources on Streamwater Quality in Johnson County, Northeastern Kansas, October 2002 through June 2004, C.J. Lee, D.P. Mau, and T.J. Rasmussen. U.S. Geological Survey (USGS), Fact Sheet 2005–3080, August 2005. This fact sheet summarizes the results of a water-quality investigation conducted in Johnson County from October 2002 through June 2004. A minimum of three stormflow samples were collected from six sites located in the Blue River, Cedar Creek, Indian Creek, Kill Creek, Mill Creek, and Turkey Creek watersheds.

Effects of Nonpoint and Selected Point Contaminant Sources on Stream-Water Quality and Relation to Land Use in Johnson County, Northeastern Kansas, October 2002 through June 2004, C.J Lee, D.P. Mau, and T.J. Rasmussen, 2005, USGS, Scientific Investigations Report 2005–5144. USGS collected water and sediment samples in 12 Johnson County watersheds to determine the effects of nonpoint and selected point contaminant sources on stream-water quality and their relation to varying land use. The streams studied were located in urban areas of the county (Brush, Dykes Branch, Indian, Tomahawk, and Turkey Creeks), developing areas of the county (Blue River and Mill Creek), and in more rural areas of the county (Big Bull, Captain, Cedar, Kill, and Little Bull Creeks). Two base-flow synoptic surveys (73 total samples) were conducted in 11 watersheds, a minimum of three stormflow samples were collected in each of six watersheds, and 15 streambed-sediment sites were sampled in nine watersheds from October 2002 through June 2004.

Special Area Management Plan (SAMP), Upper Turkey Creek Watershed, Watershed Institute, Inc., 2007. The goal of a SAMP is to attain a balance between aquatic resource conservation, infrastructure maintenance, and sound economic development to minimize the individual and cumulative impacts of future projects. This report documents the first phase of the SAMP process for Upper Turkey Creek, which included documentation of past and present projects and planning efforts, existing information sources, relevant studies, existing conditions, preliminary goals and objectives, and additional information needs. Only phase 1 has been completed to date. The next three phases are identified as (2) Upper Turkey Creek Advisory Committee and issue identification, (3) development and prioritization of strategies, and (4) implementation, monitoring, and updating. The following five goals were identified for the Upper Turkey Creek Watershed SAMP in this report:

1. Establish an Upper Turkey Creek Advisory Committee
2. Improve Turkey Creek water quality to support native aquatic communities and enhance and maintain high-quality aquatic and terrestrial habitat in the Turkey Creek watershed.
3. Identify opportunities and mechanisms to educate and involve the public in enhancement of Turkey Creek.
4. Develop detailed comprehensive statements of policies, standards, and criteria to guide public and private uses of lands and waters as well as outline of mechanisms for implementation.
5. Establish a regulatory component addressing USACE 404 permits, stormwater permits, and USEPA regulatory information as well as other relevant regulatory components identified and agreed to through memorandum of understanding with the various agencies and stakeholders giving some sense of continuity and predictability based on a watershed area approach.

Rock Creek Watershed Planning Final Feasibility Report, USACE, August 2007. Rock Creek is an adjacent watershed to Upper Turkey Creek. This report includes a stream assessment methodology and results, recommended stream restoration projects, a presentation of BMP concepts, an implementation strategy for best management practices throughout the Rock Creek watershed and probable costs associated with these projects. A BMP implementation strategy was developed using probable life cycle costs, evaluation of water quality benefit, and a methodology to locate BMPs in appropriate sites.

Rock Creek Alternative Futures Study, USACE, August 2009. Rock Creek is an adjacent watershed to Upper Turkey Creek. The Alternative Futures Study, as an addition to the Rock Creek Watershed Study, compared the life-cycle cost and benefit of low impact development (LID) versus traditional redevelopment, analyzed the return on investment for LID and traditional redevelopment, and informed policy and ordinance recommendations for the City of Mission. The study identified key changes to the

City of Mission's municipal code to increase the use of LID practices in the City of Mission and to realize the water quality benefits outlined in the study.

Manual of Best Management Practices for Stormwater Quality, Mid-America Regional Council and American Public Works Association (APWA), Second Edition, August 2009.

The BMP Manual provides guidance for land development practices within the region, including the study area. Developers, engineers and planners can reference the manual's developing flexible tools to reduce the volume of stormwater discharge while conserving water quality at the same time. Development is on-going and will be refined as test sites produce results for the Metro Area. The manual provides specific guidance for planning and implementing BMPs, and describes how to assess alternative site-design approaches to maximize the benefits for individual sites. It also defines BMPs, provides performance goals for site development and describes methods for determining development impacts. The second section contains design criteria and more detailed design guidance for non-structural and structural BMPs. If local communities decide to provide a particular "level of service," the formulas and methodology outlined in the manual help define the technical parameters needed to meet local water quality goals. The manual can be accessed on the internet at http://www.marc.org/environment/water/bmp_manual.htm.

13.2 LITERATURE CITATIONS

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

City of Overland Park. 2012. Stormwatch. Johnson County Kansas Regional Weather. Accessed online on October 9, 2012 at: http://www.stormwatch.com/.

U.S. Environmental Protection Agency (EPA). 1998, Climate Change and Kansas, EPA 236-F-98-007i, 4 pp.

Kansas Department of Wildlife & Parks (KDWP). 2004. Subjective Evaluation of Aquatic Habitats. Developed By: Kansas Department of Wildlife & Parks, Environmental Services Section, 28 pp.

Larkin Group, Northeast Johnson County Watershed Study, May 2005.

NOAA (2013). National Weather Service Hydrometeorological Design Studies Center Precipitation Frequency Data Server Atlas 14. National Oceanic and Atmospheric Administration website. Available at http://hdsc.nws.noaa.gov/hdsc/pfds/.

Rast, Brian. Proceedings of the American Society of Civil Engineers Watershed Management Conference 2010 Innovations in Watershed Management Under Land Use and Climate Change. Madison. *Multi-Objective Management and Planning for Urban Watersheds*. 27 Aug 2010.

Rast, Brian. Proceedings of the Environmental & Water Resources Institute of the American Society of Civil Engineers World Environmental & Water Resources Congress 2009, Kansas City. *Nexus Projects in Kansas City's Suburban Watersheds*. 17 May 2009.

U.S. Census Bureau; American Community Survey, 2010 American Community Survey 5-Year Estimates, DP02, Selected Social Characteristics in the United States; generated by Thomas Topi. <http://factfinder2.census.gov>; (6 June 2012).

U.S. Census Bureau; American Community Survey, 2010 American Community Survey 5-Year Estimates, DP03, Selected Economic Characteristics; generated by Thomas Topi. <http://factfinder2.census.gov>; (6 June 2012).

U.S. Census Bureau; American Community Survey, 2010 American Community Survey 5-Year Estimates, DP04, Selected Housing Characteristics; generated by Thomas Topi. <http://factfinder2.census.gov>; (6 June 2012).

U.S. Census Bureau; American Community Survey, 2010 American Community Survey 5-Year Estimates, DP05, ACS Demographic and Housing Estimates; generated by Thomas Topi. <http://factfinder2.census.gov>; (6 June 2012).

U.S. Census Bureau; American Community Survey, 2010 American Community Survey 5-Year Estimates, S1701, Poverty Status in the Past 12 Months; generated by Thomas Topi. <http://factfinder2.census.gov>; (6 June 2012).

U.S Census Bureau; Economic Census, CB0700CZ2, 2007 County Business Patterns: Zip Code Business Statistics: Zip Code Business Patterns by Employment Size Class: 2007; generated by Thomas Topi. <http://factfinder2.census.gov>; (7 November 2012).

U.S. Department of Agriculture (USDA). 1998. Stream Visual Assessment Protocol, National Water and Climate Center Technical Note 99-1. 42 pp.

U.S. Fish and Wildlife Service (USFWS). 1980. Habitat Evaluation Procedures (HEP) ESM 102, 130 pp.