Flood Protection Study
City of Parkville, Missouri

U.S. Army Corps of Engineers

Contract No: W912DQ-08-D-0048

December 2013

Flood Protection Study

City of Parkville, Missouri

USACE Contract No.: W912DQ-08-D-0048
Task Order: 0020

Prepared for:

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Table of Contents

Appendices

List of Tables

List of Figures

Acronyms

AASHTO	American Association of State Highway and Transportation
BNSF	Burlington Northern Santa Fe
CDM Smith	CDM Federal Programs Corporation
CFR	Code of Federal Regulations
City	City of Parkville
D-FIRM	digital Floodplain Insurance Rate Map
Downtown	historic downtown business district
FEMA	Federal Emergency Management Agency
FEMA Study	Flood Study 290294V000
FIS	Flood Insurance Study
HDR 1999	Continuing Authorities 205 Study Parkville, Missouri Recommendation Report by HDR 1999
HEC-RAS	Hydrologic Engineering Centers River Analysis System
LOMR	Letter of Map Revision
Park	English Landing Riverfront Park
SEMA	Missouri State Emergency Management Agency
SFHA	Special Flood Hazard Area
SFT	secure file transfer
Test Report	Flood Technology Test Report
USACE	U.S. of America Corp of Engineers
USGS	U.S. Geological Survey
WSE	water surface elevation

Report Synopsis

This study is being prepared through the U.S. Army Corps of Engineers (USACE) under the authority of Section 22 of the Water Resources Development Act (WRDA) of 1974. The purpose of this authority is to assist state, local and Tribal governments in the preparation of plans to address water resources and related problems. This Flood Protection Study was conducted by CDM Federal Programs Corporation (CDM Smith) on behalf of the USACE to develop flood protection recommendations that can be incorporated into an integrated, cost efficient, and effective flood protection plan for the City of Parkville (City). This study focused on two separate areas in Parkville for flood planning: the historic downtown business district (Downtown) and English Landing Riverfront Park (Park). The Downtown study area is north of the Burlington Northern Santa Fe (BNSF) railroad tracks and west of the White Aloe Branch. The Park area is south of the BNSF railroad tracks, east of the White Aloe Branch and extends adjacent to the Missouri River.

The height of flood protection for Downtown was determined using the difference between the base flood (commonly referred to as the 100-year flood or 1-Percent Annual Chance Flood) elevation and ground elevation. The height of flood protection for the Park consisting of a berm was analyzed using the difference between the 10-Percent Annual Chance Flood and ground elevations. Trail elevation to 749 feet was also considered. The ground elevation was determined using a combination of contour and survey information provided by the City.

Flood protection systems considered included traditional levee/floodwall systems and innovative flood protection concepts that have been developed and installed over the last decade. Additionally, this study reviewed the regulatory floodway and base flood protection restrictions from the Federal Emergency Management Agency (FEMA) and the effect it could have on the City's Flood Protection Plan.

The evaluation of flood protection technologies used the following considerations (parameters): effectiveness, constructability, cost/affordability, and maintenance and storage requirements. Additional points of considerations included physical constraints along the proposed flood protection alignment; equipment, people, and time requirements for installation; response planning; safety; and servicing the system under potentially prolonged flood conditions.

The Downtown study area is a commercial use area with various businesses. Therefore, vehicular and pedestrian access, location of existing buildings, and location of existing utilities, including an active railroad, restrict the available width for flood protection construction and implementation. In the Park, the location of large mature trees and the banks of the Missouri River and White Aloe Branch affect construction of any flood protection technology.

The City's preferred flood protection alignment for Downtown runs along the west side of White Aloe Creek to the north side of the BNSF tracks, then westerly along the tracks. The required height of flood protection along this alignment ranges from 7 to 10 feet.

The types of flood protection systems evaluated for Downtown included concrete walls, fabric membrane dams, metal panels, water-inflated tubes, and water-inflated baffled bladders. Specific benefits were found related to installation of each technology and in meeting the FEMA freeboard criteria. Since the width of the flood protection is determined by the desired height of the flood protection, the narrower base requirement for both the metal panel and concrete wall technologies is an important factor. Table RS-1 summarizes the results of each technology reviewed.

Table RS-1 Summary of Flood Protection Technologies Evaluated for Downtown Flood Protection

Technology	Parameter	Advantages	Disadvantages
 Concrete Floodwall (Photo Source: CDM Smith)	Maintenance	▪ Reduces long-term maintenance (annual inspection may be required)	▪ Limits dry side drainage ▪ Potential for graffiti
	Installation	▪ Requires minimal base width ▪ Reduces time needed for flood fighting effort versus temporary efforts ▪ Can be built in any configuration ▪ Permanent protection (possibly lead to Letter of Map Revision [LOMR])	▪ Requires adequate space for construction
	Cost	▪ Reduces long-term maintenance cost ▪ No storage costs ▪ No repeated installation costs	▪ Initial installation more expensive
 Fabric Membrane Dam (Photo Source: Portadam)	Maintenance	▪ City personnel familiar with maintenance process from 2011 experience	▪ Can be punctured ▪ Must be continually inspected during operation ▪ Must be thoroughly cleaned prior to storage after each use
	Installation	▪ City personnel familiar with installation process ▪ $1/10^{th}$ the weight of standard sandbags ▪ Does not require permanent foundation ▪ Does not require prepared surface ▪ Can be installed in any configuration	▪ Requires sandbag supplementation ▪ Wind effects (until weight of floodwater stabilizes) ▪ Equipment required to move pallets of material to installation spots
	Cost	N/A	▪ Most expensive of the fabric flood protection technologies (material cost)
 Metal Panel Flood Protection (Photo Source: EKO Flood Systems USA, LLC)	Maintenance	▪ Minimal Maintenance Easily stored (stackable)	▪ Must be cleaned with pressure washer after each use
	Installation	▪ Quick Installation (Example: 1 person can install 1,000 square feet in five hours) ▪ Multiple configuration options (footer, stem wall) ▪ Greater height does not require a greater above surface base width ▪ Can be used with permanent stem wall (reduces time needed for installation of flood protection)	▪ Seepage occurs ▪ Equipment required to move pallets of material to installation spots ▪ Requires permanent footer - Size of footer dependent upon soil structure and wall height - Requires adequate space for initial construction of footer
	Cost	▪ Additional panels can be purchased in future to increase height of flood protection	▪ Most expensive of temporary applications

Table RS-1 Continued

Technology	Parameter	Advantages	Disadvantages
 Water-Inflated Tubes (Photo Source: US Flood Control Corporation)	Maintenance	▪ Can withstand up to 2,680 pounds of lateral pressure (depending on anchor diameter) ▪ Punctures do not necessarily result in loss of flood protection	▪ Must be thoroughly cleaned prior to storage after each use ▪ Can be punctured ▪ Must be continually inspected during operation
	Installation	▪ Quick Installation ▪ Stackable (to achieve greater height) ▪ Can be installed in many configurations ▪ Does not require permanent foundation	▪ Greater height requires a wider base (approximate 1V:1H) ▪ Equipment required to move pallets of material to installation spots ▪ Limited turning radius
	Cost	▪ Least expensive of reviewed flood protection	N/A
	Maintenance	▪ Limited maintenance during installation	▪ Can be punctured ▪ Must be continually inspected during operation ▪ Must be thoroughly cleaned prior to storage after each use
	Installation	▪ Quick Installation ▪ Stable (will not roll) ▪ Does not require permanent foundation	▪ Greater height requires a wider base (1V:2.25H) ▪ Limited height (protects up to 6-foot Water Surface Elevation (WSE) ▪ Limited configuration (Does not bend like Water-Inflated tubes) ▪ Not stackable ▪ Equipment required to move pallets of material to installation spots
	Cost	N/A	N/A

Flood protection technology cost estimates obtained from vendors were used to perform a cost comparison of the technologies on a cost per linear foot basis. The concrete wall unit cost included installation, as this is a one-time expense. Both the concrete wall and the metal panel unit cost include an estimate of a typical footer cost, installed, as required for installation. All other technologies included material cost only, as installation cost will be required for each flood event in use. Fabric membrane, water-inflated tubes, and water-inflated baffled bladders all require more labor and time for installation when compared to the concrete floodwall or metal panel systems. These systems also cannot meet the height requirements through the entire alignment due to the required base width for installation. The costs of the technologies were within $200 per linear foot at a height of 8-feet.

The recommended flood protection plan for the Downtown is a combination of permanent concrete walls and metal panels (with sill plate) at road crossings as shown on Figure RS-1. With this recommendation, the City could achieve protection of the Downtown area for the base flood elevation, while retaining its connection with the Missouri River and providing services to its residents. This recommendation has several benefits:

- **Maintenance.** Maintenance requirements for the concrete wall would be limited to annual inspections and items identified during these inspections. Metal panels can be stacked and stored at existing City facilities.
- **Installation.** With one-time installation for the concrete wall, there would be a decreased need for both City staff time and volunteer time for flood fighting activities in the Downtown study area. Installation would only be required during a flood event for the metal panels at the road crossings. While this will affect vehicular traffic in the area, Downtown would still be accessible from the north. In addition, this installation meets the width constraints present on the alignment.
- **Cost.** The cost incurred with construction of the recommended system would primarily be a one-time construction cost. Annual inspection and maintenance costs would also be required.
- **Regulatory.** Precedence has been set in FEMA Region VII for use of concrete walls and metal panels in updating the flood insurance study. The City could pursue a LOMR to remove the protected areas from the special flood hazard area zone.
- **Aesthetics.** A permanent concrete floodwall can incorporate with current Downtown historical features, as shown on Figure RS-2 (view heading west along Highway 9) and Figure RS-3 (view south on Main Street).

The estimated conceptual cost for this recommendation is $2.4 million. This cost is a feasibility level estimate and could vary significantly based on geotechnical investigations and decisions on final aesthetics of the proposed concrete wall.

The flood protection review for the Park took into consideration both the City's goals and the different physical, design criteria, and regulatory constraints specific to the Park. The City's goals for flood protection of the Park include:

- Building a berm to achieve a level of protection that will protect the Park from frequent floods that damage the park, generally within the 5- to 25-year event range
- Retaining existing large mature trees
- Retaining trail alignment
- Retaining the trail width of twelve feet and
- Retaining the parks connection with the Missouri River (aesthetic views)

Items considered for the Park flood protection included the Missouri River flood elevation estimates, ground elevations in the park and along the trail, opportunities for flood protection tie-in based on natural and manmade high ground (such as the railroad embankment), constraints due to mature tree location along the proposed berm or trail elevation alignment, and the City's goals for flood protection.

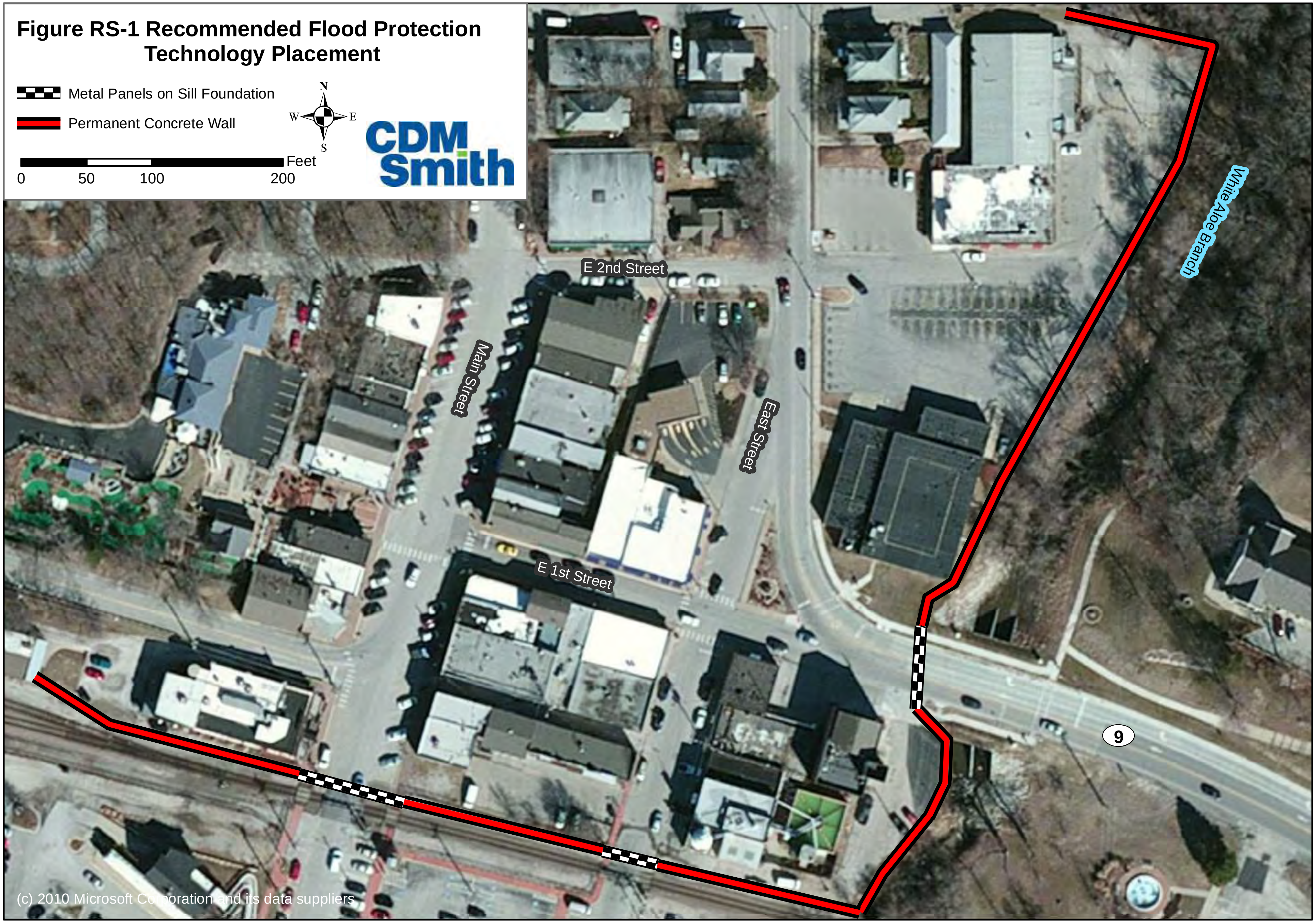

Figure RS-1 Recommended Flood Protection Technology Placement
Metal Panels on Sill Foundation
Permanent Concrete Wall
N
W
E
S
Feet
0
50
100
200
CDM Smith
E 2nd Street
Main Street
East Street
E 1st Street
White Aloe Branch
9
(c) 2010 Microsoft Corporation and its data suppliers

Figure RS-2 View of Simulated Concrete Floodwall, Facing West along Highway 9

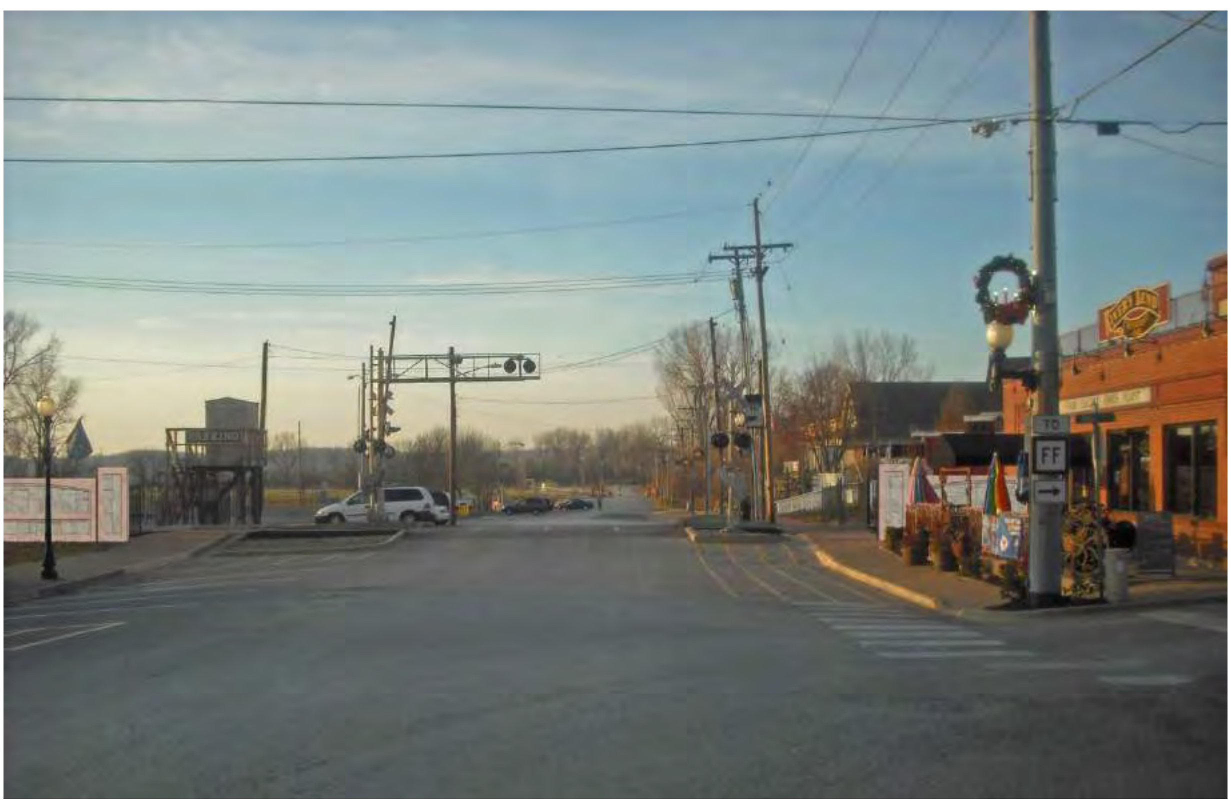

Figure RS-3 View of Simulated Concrete Floodwall, Facing South along Main Street

The current trail is approximately 6 feet lower than the 10-Percent Annual Chance Flood event water surface elevation (WSE). Since the scope of work for this project states that overtopping of the flood protection system is considered acceptable, no freeboard was included in this estimation (44 CFR recommends no less than 2 feet of freeboard). Taking into consideration the proximity and multi-purpose function of the trail to the river in conjunction with the steepness of the slope of the sides of the berm, the American Association of State Highway and Transportation Officials' (AASHTO) design criteria is recommended for any trail modifications. For the purposes of this analysis, a 10- to 12-foot trail width was assumed. For the portions of the trail east of the Park road cul-de-sac, a 2-foot wide shoulder on the dry side of the trail and a 5-foot wide shoulder on the river side of the trail were assumed as part of any modification.

This Park is renowned for its many festivals (Arts, Blues, Jazz, and RiverJam, Parkville Days, Turkey Trot and Christmas on the River). Many people visit the Park to enjoy its "scenic walking trails" which provide a unique connectivity to the Missouri River (City of Parkville English Landing Webpage, 2012). The height of the berm at 6 feet will block the view of the Missouri River from within the Park as shown on Figure RS-4. An additional negative impact would be the loss of over 50 mature trees. The study concluded that the height and width of the Park berm would have a negative impact on the aesthetic nature of the Park. The study identified that the preferred alignment was located within the regulated FEMA floodway for the Missouri River.

A cost analysis was performed to evaluate flood protection options for the Park. The analysis utilized a historical flood analysis of Park, conceptual costs of building and maintaining a berm, and the historical flood repair costs from the City. The cost analysis resulted in four options.

Option #1 No Action: Budget for Park Clean Up

With flooding occurring at the Park less than 2.5-percent of the time based on the historical Missouri River gauge data, one approach to addressing flood repair costs incurred is for the City to proactively budget for these anticipated costs using a pay-as-you-go sinking fund approach. This type of fund accumulates revenues until sufficient money is available for an identified project, or, in this case, a known cost incurred by the City on a regularly occurring basis. This would assist the City in building a fund to specifically address the Park flood recovery effort costs, when they are incurred.

Option #2 Six-Foot Berm Construction: Raise Trail Elevation to 752 feet

The City has expressed a desire to construct a berm to provide flood protection of the Park as described previously. Figure RS-5 shows an approximate alignment of this berm, which would be at a height of 6 feet. The berm is estimated to provide the Park protection from a 10-year flood event. Annual costs are still incurred with routine inspection and maintenance of a berm. Because the berm would only be constructed to provide a 10-year level of protection for the Park, flooding would still occur and, therefore, the City would still incur flood repair and clean-up costs to the Park.

Figure RS-4 Superimposed 6-foot High Berm along West Side of Park

Option #3 Temporary Flood Protection: Water-Filled Tubes

In lieu of a permanent berm, the City could pursue a temporary flood protection option for the Park. The summary of technologies reviewed discussed advantages and disadvantages of three temporary flood protection options: fabric membrane, water-inflated tubes, and baffled bladders. Of these, water-filled tubes would allow the City the flexibility of choosing the best alignment to protect resources within the Park, while also allowing the City to purchase additional material, as funds are available. This would allow the City to adjust flood protection of the Park to a desired level for future flood events. Similar to the permanent berm, annual costs are still incurred with temporary flood protection technologies (storage, etc.).

Option #4 Three-Foot Berm Construction: Raise Trail Elevation to 749 feet

An additional alternative could include the City pursuing incremental flood protection of the Park by elevating the trail approximately 1 to 3 feet, to elevation 749 feet. Appendix C includes conceptual plan and profile views of what this trail elevation could look like. Annual costs are still incurred with routine inspection and maintenance of trail elevation. Flooding would occur less frequently, but the City would still incur flood repair and clean-up costs to the Park.

Evaluation of Options for Flood Protection of English Landing Park

Table RS-2 summarizes the estimated initial (construction and/or material acquisition) costs and estimated annual costs for each option.

Table RS-2 Estimated Costs Summary for Flood Protection of English Landing Park

Option	Description	Estimated Cost (2012) [1]	
		Initial Cost	Annual Cost [2]
Option #1 No Action	Budget for Park Clean Up	$0	$230,000
Option #2 2 Six-Foot Berm Construction	Raise Trail Elevation to 752 feet	$1,820,000	$280,000
Option #3 Temporary Flood Protection [3]	~~3-Foot High Water Filled Tubes~~	~~$270,000~~	~~$250,000~~
	~~6-Foot High Water Filled Tubes~~	~~$520,000~~	~~$260,000~~
Option #4 Three-Foot Berm Construction	Raise Trail Elevation to 749 feet – Contract Construction	$670,000	$260,000
	Raise Trail Elevation to 749 feet – City Self Perform Construction	$510,000 [4]	$230,000 [5]

[1] Estimated costs have been rounded up to the nearest $10,000.

[2] Annual costs do not include intangible costs that cannot be quantified (i.e. loss of use).

[3] Use of water-filled tubes is considered infeasible and is not recommended for further consideration.

[4] Assumes City cost to construct is 75% of contracted cost.

[5] Assumes City would self-perform annual maintenance and flood repair.

Under the "No Action" option, no initial cost would be incurred by the City. Instead, the City would proactively budget for anticipated future flood repairs in the Park.

The annual costs for Options #2 and #4 include building the berm, repairing the berm after minimal flood events, and annual maintenance of the berm. These costs do not included loss of use during flood events, the impact of any berm construction adjacent to established trees, modification to existing light poles and benches, and a reduction of the river view from the Park (particularly from the River Stage Park Shelter). Raising the trail along the southern edge of the Park reduces accessibility to the trail and increased maintenance tasks. Currently the trail is accessible from any point in the Park for physically challenged people. Adding additional areas of accessibility to the trail would increase the financial costs associated with the berm. The additional maintenance tasks include inspecting for damage from burrowing animals, inspecting for scouring from high WSE events, and repairing noted damages.

Any fill placed for a berm or trail elevation should be compacted to meet USACE standards. This fill should be placed in 6 to 10 inch lifts. With the significant number of trees adjacent to the existing trail alignment, an arborist should be consulted to determine fill allowable near trees or design requirements for tree protection. Existing stormwater conveyance paths through the Park to the river are critical to retain. In addition, tie-in of a trail elevation or berm could pose challenges at the railroad tracks. Additional requirements may be required from BNSF to place any fill adjoining the railroad embankment. It should be noted that the entirety of the Park is within the FEMA regulated floodway of the Missouri River and will require a City floodplain permit for any land modifications.

Sandbag closures would be required at certain points where berm construction or trail elevation is not feasible. These locations include the Park road entrance, existing boat ramp, and Park road cul-de-sac, as well as potentially the connection adjacent to the railroad. A one to two day lead time would most likely be required to construct these measures prior to flooding. The Park would be closed leading up to and during any flood event. During the flood event, the berm and/or trail elevation area would require continuous monitoring to assess the structural integrity as well as the dewatering needs within the Park. Following any flood event, a full inspection of any berm and/or trail elevation should be completed with repairs completed as identified.

Due to the current lack of available water at the Park, the use of water-filled tubes (Option #3) as a temporary means of flood protection is considered infeasible. It is also uncertain how well the tubes would hold up under prolonged flooding conditions of the Missouri River as their placement would be in an area of higher flow velocity.

Figure RS-5 Preferred Park Flood Protection Alignment and Extended Alignment Option

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Section 1

Introduction

1.1 Authority

This study is being prepared through the U.S. Army Corps of Engineers (USACE) under the authority of Section 22 of the Water Resources Development Act (WRDA) of 1974. The purpose of this authority is to assist state, local and Tribal governments in the preparation of plans to address water resources and related problems.

1.2 Purpose

This Flood Protection Study was conducted by CDM Federal Programs Corporation (CDM Smith) on behalf of the USACE to develop flood protection recommendations that can be incorporated into an integrated, cost efficient, and effective flood protection plan for the City of Parkville (City).

Flood protection systems considered included traditional levee/floodwall systems and innovative flood protection concepts that have been developed and installed over the last decade. The newer concepts include both new technical approaches to flood protection and selected measures that are classified as semi-permanent/permanent flood protection concepts. Additionally, this study reviewed the regulatory floodway and base flood protection restrictions from the Federal Emergency Management Agency (FEMA) and the effect it could have on the City's Flood Protection Plan.

1.3 City of Parkville Historical Flood Information

In 1999, under the continuing authority of Section 205 Flood Control Act, a preliminary assessment study was conducted for the USACE. The study evaluated non-structural land use zoning, floodplain management and flood-warning emergency response systems, and traditional structural levee/floodwall systems. This study determined that conventional structural alternatives were too costly to protect the downtown area and undesirable in terms of impacts to the aesthetics, historic assets/buildings, environmental habitat, and connectivity to the river.

A Flood Insurance Study (FIS) for Parkville completed in August 1977 documented the existence and severity of flood hazards within the study area. Flood hazard boundary maps of the City were re-evaluated and updated in 1978 for the National Flood Insurance Program. Although the Missouri River Basin has been studied extensively, no previous reports or studies specific to the Parkville area have been conducted. FEMA recently performed a flood study along the Missouri River from which preliminary digital Floodplain Insurance Rate Maps (D-FIRMs) and models were created. Currently, this preliminary information has not been adopted by FEMA as effective. One significant change noted on the preliminary maps and models is the reduction in the Missouri River base flood elevation. The base flood elevation for the Missouri River and White Aloe Branch in the study area changes from 762 feet to 760 feet.

1.4 Study Area

This study focuses on two separate flood planning areas in Parkville: the historic downtown business district (Downtown) and English Landing Riverfront Park (Park). As shown on Figure 1-1, the Downtown study area is north of the Burlington Northern Santa Fe (BNSF) railroad tracks and west of the White Aloe Branch. The Park area is south of the BNSF railroad tracks, east of the White Aloe Branch, and extends adjacent to the Missouri River.

The flood water source for both study areas is the Missouri River. Flood events occur in the Park first, due to the Park's low ground surface elevation and proximity to the Missouri River. Currently, most of the Downtown area receives minor flood protection from the railroad track embankment. There is approximately a 20-foot elevation increase between the edge of the Park and the railroad embankment.

Figure 1-1 Study Area

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Section 2
Data Collection

An inventory of available information was completed for the Downtown and Park study areas to identify and characterize a recommended flood protection alignment and technology. The previous study was reviewed for baseline hydrology and hydraulic information. Data was collected from the City, FEMA, Missouri State Emergency Management Agency (SEMA), USACE, the Internet, and field visits. Data collected included historical flood events information, including site-specific flood depths, and volunteer numbers and hours.

2.1 Data from USACE

During the kick-off meeting USACE staff provided contact information for USACE flood fighting staff as a source of information for the flood protection system utilized by the City in 2011. The USACE flood fighting staff were interviewed by phone in August 2012. The USACE flood fighting staff also provided (e-mail) information about the flood protection systems currently being utilized by the USACE. The data provided by the USACE is listed on Table 2-1.

Table 2-1 Data Provided by USACE

Data Description	Format
Continuing Authorities 205 Study Parkville, Missouri Recommendation Report by HDR 1999 (HDR 1999)	PDF
Hydrologic Engineering Centers River Analysis System (HEC-RAS) hydraulic models (KCLeveesPh1 - 2006 and MoR100yrFldwy – 2007)	HEC-RAS files
Temporary Flood Protection System Information	e-mail (September 2012) verbal (August 2012)

2.2 Data from City

The 2011 flood event resource contact information was provided by the City during the kick-off meeting. Contacts included the City Manager, Police Department, and Public Works personnel. Data from the City was provided through meetings, phone and e-mail communication, and via a field visit/computer download. Table 2-2 lists the information provided by the City.

Table 2-2 Data Provided by City

Data	File Type
Geographic Information System files: City Limit Contours Sanitary Sewer System Stormwater System Trees 2011 Flood Protection System Alignment	GIS Shapefiles (Received September 2012, creation date unknown)
2011 High Water Observations	Excel Spreadsheet
2011 Volunteer count and hours	Database Hardcopy
2011 Flood Fighting Costs	Meeting Record
Survey Points (November 2012)	PDF

2.3 Data from SEMA

The SEMA office was contacted to determine if there was digital flood information available for the Missouri River and White Aloe Branch within the study area. The preliminary hydraulic modeling information and the D-FIRM created on behalf of FEMA were downloaded from the SEMA secure file transfer (SFT) website.

In review of this data it was noted that, while the effective Floodplain Insurance Rate Maps (FIRM) and preliminary D-FIRMs currently refer to White Aloe Branch as White Aloe Branch, the hydraulic modeling files and profiles refer to White Aloe Branch as White Branch.

2.4 FEMA Data

Information regarding FEMA floodplain regulations as found in the Code of Federal Regulations (CFR), CFR 44 revised as of October 1, 2010 and the online electronic CFR (e-CFR) was gathered for flood protection design criteria reference.

2.5 Data from Flood Protection Vendors

Utilizing the initial list of flood protection types and manufacturers from the scope of work, the Internet was used to collect data and contact information for multiple flood protection manufacturers. In order to perform a direct comparison of vendor cost estimates, each vendor was provided the following assumptions for this conceptual level estimate by e-mail:

- Estimated length and height of flood protection needed as related to four flood events (Significant Damage, Base Flood, 1993 Event and 500-Year, and HDR 1999)
- Three road crossings in the area for the flood protection system
- Option of recommending use of a mix of flood protection technologies

The following manufacturers provided cost estimate information for this study:

- Architecture Metals Ltd.
- EKO Flood Systems USA, LLC
- Flood Control America
- Hydrological Solutions, Inc.
- Portadam Inc.
- US Flood Control Corp.

The information provided by each manufacturer reflected sole source installation of each flood protection technology and is included in Appendix A.

2.6 Site Visit Material

Site visits occurred in September and November of 2012 to collect photos for visual aids and measurements at minimum width points on potential flood protection alignments. Photos were taken in the vicinity of the BNSF railroad tracks, the Downtown area, and the Park. The minimum width points of the Downtown flood protection alignment occur beside the U.S Post Office Building (approximately 8 feet between the edge of building and the White Aloe Branch bank) and between the railroad and buildings on the west side of Main Street (approximately 14 feet between the edge of railroad fence and building).

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Section 3

Flood Protection Technologies and Technology Evaluation

This evaluation consisted of a brief review of various technologies available for flood protection. The review focused on five flood protection technologies. The goal of this evaluation was to provide a basis for the recommended flood protection system for the City.

3.1 Flood Protection Technologies Considerations

The evaluation of flood protection technologies used the following considerations (parameters): effectiveness, constructability, cost/affordability, preliminary alignment constraints, and maintenance and storage requirements. Additional points of considerations included equipment, people and time requirements for installation, response planning, safety, and servicing the system under potentially prolonged flood conditions.

3.1.1 Aspects Considered

Specific aspects considered for each of the flood protection technologies included:

- Effectiveness
  - Length of time to set up the system (how much warning time is needed)
  - Function of the system during extended flood events (durability)
- Constructability
  - Labor requirements for installation (ease of constructability)
  - Special equipment requirements for installation
- Affordability
  - Cost of system per linear foot of alignment
  - Initial and recurring costs
- Alignment Constraints
  - Foundation requirements
  - Available area for installation (width and height)
  - Existing utility impacts

- Maintenance and storage
  - Inspection and maintenance requirements during extended flood conditions
  - Maintenance requirements during non- and post flood conditions

3.1.2 Aspects Not Considered

The evaluation of flood protection technologies did not consider the following information:

- Potential relocation of existing utilities
- Geotechnical design for any foundations or embankments
- Hydrologic and hydraulic analysis of the drainage area to each study area
- FEMA floodway analysis
- Under seepage protection or permanent pump stations
- Required right-of-way or easement acquisitions
- Temporary technologies supplemental costs, including shipping and labor to install

3.1.3 Flood Protection Technologies

The types of flood protection systems evaluated included permanent, temporary, and combined system solutions. The evaluated flood protection technologies include:

- Concrete walls
- Fabric membrane dams
- Metal panels
- Water-inflated tubes
- Water-inflated baffled bladders

3.2 Evaluation Parameters

The evaluation process consisted of determining preliminary physical constraints found in the study areas. Specific constraints included minimum width availability as relates to proposed flood protection alignment and estimated existing ground surface elevation along proposed flood protection alignment. Additionally, the various technologies were reviewed utilizing standards listed in the scope of work, standards found in the USACE Flood Technology Test Report (Test Report), interviews with USACE flood fighting staff, interviews with flood protection technology vendors, and through Internet research.

3.2.1 Determination of Flood Protection Height and Width

Height Determination

The height of flood protection for the Downtown area was determined using the difference between the base flood elevation and ground elevation. This difference varies along the flood protection alignment. The Missouri River base flood elevation (1-Percent Annual Chance Flood) of 760 feet is from the preliminary D-FIRM as shown on Figure 3-1 and on the preliminary profile as shown by the red dashed line crossing the solid red line on Figure 3-2. The preliminary D-FIRM indicates that the Downtown study area is within an AE Zone. FEMA defines an AE Zone as an area subject to inundation by the 1-Percent Annual Chance Flood event with base flood elevations shown (44 CFR 64.3 (a) (1) AE: area of special flood hazard with water surface elevation (WSE) determined).

The height of flood protection for the Park was determined using the difference between the 10-Percent Annual Chance Flood elevation (as shown at the blue dashed line crossing the solid red line on Figure 3-2), or 752 feet, and the ground elevation, an average of 746 feet. The preliminary D-FIRM indicates that the entire Park is within an AE Zone, as shown on Figure 3-1. Additionally the majority of the Park is located within a defined floodway, also shown on Figure 3-1.

Preliminary D-FIRM data was determined to be the most appropriate for all flood technology evaluation and for recommendations. If the preliminary D-FIRMs do not become effective, the effective based flood elevation for the Missouri River is 762 feet.

A comparison of the elevation contours and the November 2012 City provided survey points found the survey point recorded at the low water bridge in the northwest corner of the park was within 0.07 of a foot of the contour line elevation. The level of accuracy of the elevation contours was determined acceptable for the conceptual level of this study; therefore, the elevation contours provided an estimate of the ground elevation throughout the study area.

Width Determination

Width constraints affect flood protection of both the Downtown and the Park. The Downtown study area is a commercial use area with various businesses. Therefore, vehicular and pedestrian access, location of existing buildings, and location of existing utilities, including an active railroad, restrict the available width for flood protection construction and implementation. In the Park, the location of large, mature trees, and the banks of the Missouri River and White Aloe Branch affect construction of any flood protection technology. Key width constraints include:

- Downtown Study Area:
  - Limited width between White Aloe Branch and the U.S. Post Office Building (approximately 8 feet).
  - Limited width between railroad and buildings (approximately 14 feet).
- Park Study Area:
  - Limited width between the large mature trees and the bank of the Missouri River (average 37 feet).

3.2.2 Review Federal Design Standard

Flood protection installed in each study area must meet local, state, and Federal design criteria, including USACE and FEMA design standards. For the flood protection evaluation, the USACE Test Report provided flood protection evaluation criteria. In the USACE Test Report, the USACE tested three of the available flood protection technologies: Rapid Deployment Flood Wall (plastic grid device and granular material), Portadam (fabric dam) and Hesco Bastion Concertainer (geotextile lined metal mesh container and granular material).


Figure 3-1 Preliminary Floodplain and Floodway (SEMA, March 2012)
Base Flood Elevation Cross Section
Preliminary Zone AE
Preliminary Floodway
Waterway
N
W
E
S
E 3rd Street
East Street
E 2nd Street
Main Street
Mill Street
E 1st Street
White Aloe Branch
760
760
9
English Landing Drive
Rush Creek
760
Missouri River
(c) 2010 Microsoft Corporation and its data suppliers

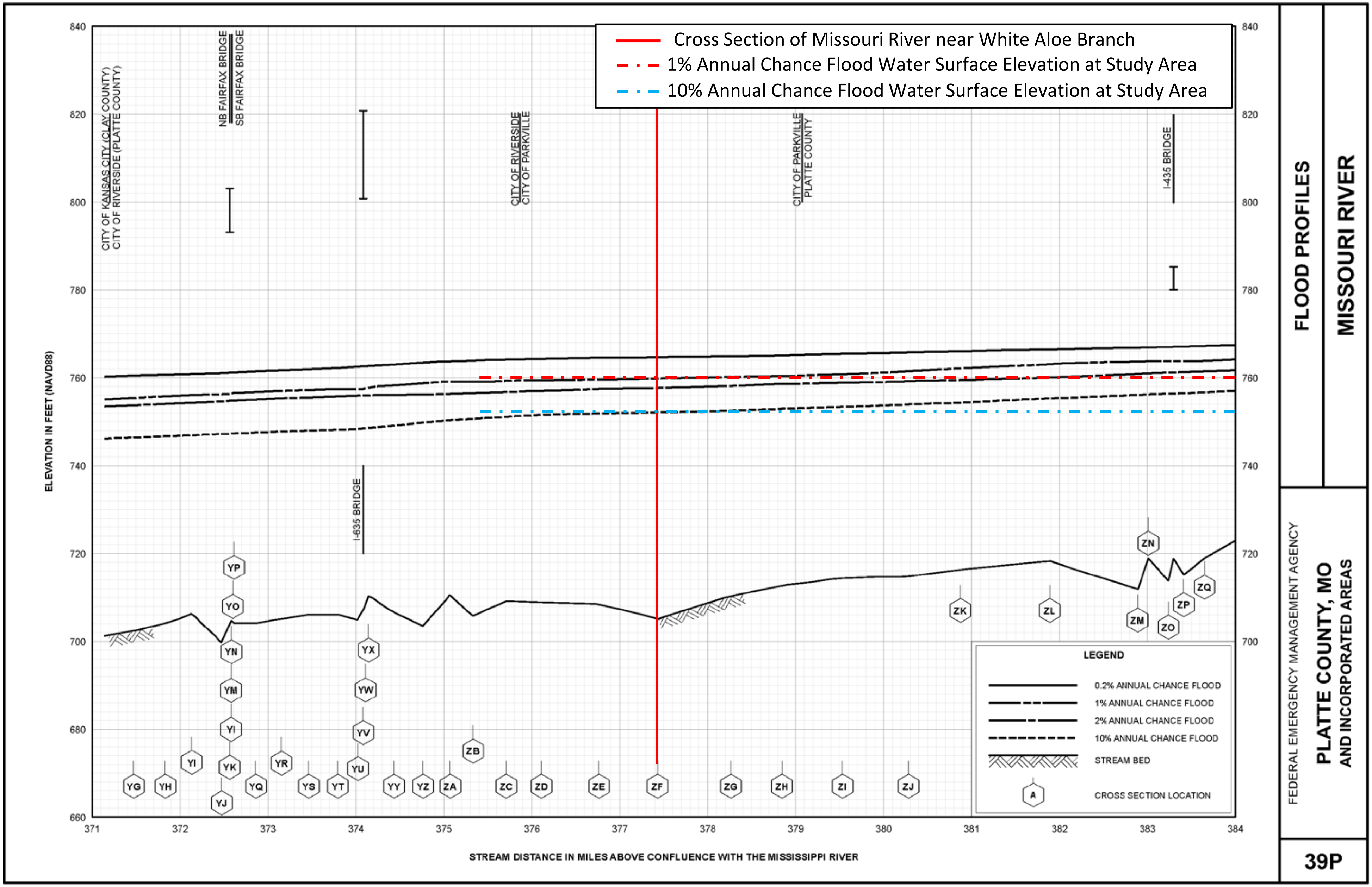

Figure 3-2 Preliminary Flood Profile for Missouri River (SEMA, March 2012)

The review for this study utilized some of the USACE Test Report's evaluation, such as the possibility of puncture and leakage, and constructability.

The FEMA design standards include a freeboard requirement for base flood protection. The height of FEMA flood design flood protection is based on the base flood elevation and the permanent flood levee protection regulations as found in 44 CFR 65.10 (b) (1) *Freeboard* (Table 3-1).

Table 3-1 FEMA Freeboard Requirements [1]

Type	Description
Minimum freeboard [2]	Three feet above base flood elevation
Freeboard either side of structure (such as bridge)	An additional one foot for a distance of 100 feet on either side of structure
Upstream end of levee	An additional one-half foot starting at upstream end of levee system tapering to minimum at the downstream end

[1] Source 44 CFR 65.10 (b) (1)
[2] Exceptions may be approved after appropriate and approved engineering analysis, however freeboard less than 2 feet is unacceptable per 44 CFR 65.10 (b) (1) (ii).

3.2.3 Interview Comments

USACE flood fighters and flood protection vendors provided their comments on the practical use of each technology. These comments provide a real-world perspective on the use of these flood protection technologies. Some of their comments included:

- Stop logs (metal panel flood protection) have some seepage.
- Most fabric membrane (including dams and water-inflated options) does not last as long as advertised due to weakened spots from exposure to elements and along fold lines from storage.
- Storing of the temporary fabric technology is more labor intensive. It requires thorough cleaning and proper folding to prevent rot and weakening of fabric.
- Wind effects fabric technology during set-up and prior to flood waters holding the fabric in place.
- It is important to practice installing temporary technologies. The installation process can be difficult to implement during an emergency due to panic, stress, etc. that can affect human reactions.
- Technologies with multiple pieces can suffer from loss/misplace of system pieces.

3.2.4 Internet Research Results

Material retrieved from the Internet included vendor contact information, product specifications, photos, and installation locations. This information is provided in Appendix A.

3.3 Evaluation of Technologies

This section evaluates each flood protection technology using the parameters defined in Sub-Section 3.2. The following tables present advantages and disadvantages related to these parameters, more specifically to the installation, maintenance, and cost for each respective flood protection technology.

3.3.1 Concrete Walls

The use of concrete walls is a permanent flood protection technology as shown on Figure 3-3. Table 3-2 lists the advantages and disadvantages of using a concrete wall for flood protection.

Figure 3-3 Concrete Floodwall (Photo Source: CDM Smith)

Table 3-2 Concrete Floodwalls Advantages and Disadvantages

Parameter	Advantages	Disadvantages
Maintenance	▪ Reduces long-term maintenance (annual inspection may be required)	▪ Limits dry side drainage ▪ Potential for graffiti
Installation	▪ Requires minimal base width ▪ Reduces time needed for flood fighting effort versus temporary efforts ▪ Can be built in any configuration ▪ Permanent protection (possibly lead to LOMR)[1]	▪ Requires adequate space for construction
Cost	▪ Reduces long-term maintenance cost ▪ No storage costs ▪ No repeated installation costs	▪ Initial installation more expensive

[1] For a fee, a Letter of Map Revision (LOMR) is a procedure offered by FEMA that changes the Special Flood Hazard Area (SFHA) based on revised hydrology and hydraulics.

3.3.2 Fabric Membrane Dams

The use of fabric membrane dams is a temporary flood protection technology as shown on Figure 3-4. Table 3-3 lists the advantages and disadvantages of using fabric membrane dams for flood protection. The City utilized this temporary flood protection technology for the Downtown study area in 2011.

Figure 3-4 Fabric Membrane Dam Flood Protection (Photo Source: Portadam)

Table 3-3 Fabric Membrane Dam Advantages and Disadvantages

Parameter	Advantages	Disadvantages
Maintenance	▪ City personnel familiar with maintenance process from 2011 experience	▪ Can be punctured ▪ Must be continually inspected during operation ▪ Must be thoroughly cleaned prior to storage after each use
Installation	▪ City personnel familiar with installation process ▪ 1/10th the weight of standard sandbags ▪ Does not require permanent foundation ▪ Does not require prepared surface ▪ Can be installed in any configuration	▪ Requires sandbag supplementation ▪ Wind effects (until weight of floodwater stabilizes) ▪ Equipment required to move pallets of material to installation spots
Cost	N/A	▪ Most expensive of the fabric flood protection technologies (material cost)

3.3.3 Metal Panels

The use of metal panels is a temporary flood protection technology with a permanent footer as shown on Figure 3-5. Metal panels are also usable as a mixed technology with the use of a permanent stem-wall. Table 3-4 lists the advantages and disadvantages of using metal panels for flood protection.

Figure 3-5 Metal Panel Flood Protection (Photo Source: EKO Flood Systems USA, LLC)

Table 3-4 Metal Panel Advantages and Disadvantages

Parameter	Advantages	Disadvantages
Maintenance	▪ Minimal maintenance – Easily stored (stackable)	▪ Must be cleaned with pressure washer after each use
Installation	▪ Quick Installation (Example: 1 person can install 1,000 square feet in 5 hours) ▪ Multiple configuration options (footer and stemwall) ▪ Greater height does not require a greater above surface base width ▪ Can be used with permanent stem wall (reduces time needed for installation of flood protection)	▪ Seepage occurs ▪ Equipment required to move pallets of material to installation spots ▪ Requires permanent footer – Size of footer dependent upon soil structure and wall height – Requires adequate space for initial construction of footer
Cost	▪ Additional panels can be purchased in future to increase height of flood protection	▪ Most expensive of temporary applications

3.3.4 Water-Inflated Tubes

The use of water-inflated tubes is a temporary flood protection technology as shown on Figure 3-6. Table 3-5 lists the advantages and disadvantages of using water-inflated tubes for flood protection.

Figure 3-6 Water-Inflated Tubes at Testing Grounds (Photo Source: US Flood Control Corporation)

Table 3-5 Water-Inflated Tubes Advantages and Disadvantages

Parameter	Advantages	Disadvantages
Maintenance	▪ Can withstand up to 2,680 pounds of lateral pressure (depending on anchor diameter)[1] ▪ Punctures do not necessarily result in loss of flood protection	▪ Must be thoroughly cleaned prior to storage after each use ▪ Can be punctured ▪ Must be continually inspected during operation
Installation	▪ Quick installation ▪ Stackable (to achieve greater height) ▪ Can be installed in many configurations ▪ Does not require permanent foundation	▪ Greater height requires a wider base (approximate 1V:1H due to interlocking of tubes as shown in Figure 3-7) ▪ Equipment required to move pallets of material to installation spots ▪ Limited turning radius
Cost	▪ Least expensive of reviewed flood protection	N/A

[1] Wenck Associates, Inc. Review of the Tiger Dam System Technical Memorandum dated March 22, 2010.

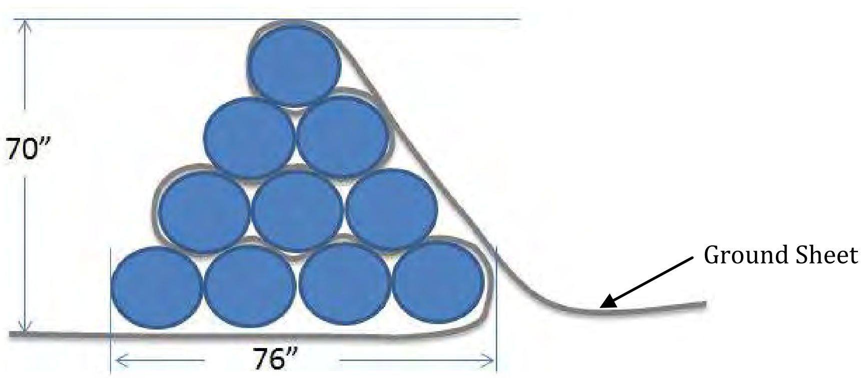

Figure 3-7 Water-Inflated Tubes Dimension Cross Section

3.3.5 Water-Inflated Baffled Bladders

The use of water-inflated baffled bladders is a temporary flood protection technology as shown on Figure 3-8. Table 3-6 lists the advantages and disadvantages of using water-inflated baffled bladders for flood protection.

Figure 3-8 Water-Inflated Baffled Bladder (Photo Source: Hydrological Solutions, Inc.)

Table 3-6 Water-Inflated Baffled Bladders Advantages and Disadvantages

Parameter	Advantages	Disadvantages
Maintenance	▪ Limited maintenance during installation	▪ Can be punctured ▪ Must be continually inspected during operation ▪ Must be thoroughly cleaned prior to storage after each use
Installation	▪ Quick installation ▪ Stable (will not roll) ▪ Does not require permanent foundation	▪ Greater height requires a wider base (1V:2.25H) ▪ Limited height (protects up to 6-foot WSE) ▪ Limited configuration (Does not bend like water-inflated tubes) ▪ Not stackable ▪ Equipment required to move pallets of material to installation spots
Cost	N/A	N/A

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Section 4

Flood Protection Plan and Cost Estimate for Downtown Parkville

The level of flood protection for Downtown Parkville is the maximum achievable within the constraints of the desirable and maximum allowable height of barrier (aesthetics and flood protection technology constraints), available project base width for installation, desired alignment, affordability by the City, compliance with FEMA floodplain regulations, interior stormwater drainage, and other utilities considerations. As such, the level of protection evaluated for Downtown was the base flood elevation (commonly referred to as the 100-Year flood or 1-Percent Annual Chance Flood).

4.1 Downtown Parkville Flood Protection Alignment

During the October 5, 2012 project progress meeting, the City stated that they have evaluated flood protection access to the businesses located south of the BNSF tracks. Therefore, this area was not considered in the recommendation for the Downtown study area. Figure 4-1 shows the City's preferred flood protection alignment for the Downtown. The flood protection alignment runs along the west side of White Aloe Creek to the north side of the BNSF tracks, then westerly along the tracks. This alignment was used to determine physical parameters for flood protection, such as ground surface elevation and available space for installation.

According to the elevation contours and the November 2012 survey provided by the City the ground surface elevation varies between 754 feet and 756 feet along the preferred flood protection alignment.

Data provided by the City indicates that the proposed flood protection alignment for the Downtown has at least three areas that cross over sanitary sewer lines and at least three areas that cross over stormwater lines as shown in Figure 4-1.

4.2 Determination of Recommended Downtown Flood Protection Technology

The recommended flood protection technology for the Downtown area was based on an evaluation of three parameters: maintenance, installation, and cost.

4.2.1 Flood Protection Technology Maintenance

In order to determine the recommended flood protection technology, the types of maintenance requirements associated with the different flood protection technologies was researched and compared. The concrete floodwall had the least long-term maintenance concerns, as cleaning requirements are related to aesthetics, versus specific cleaning requirement that are required post-flood for all of the temporary technologies. The fabric membrane technologies and the metal panel system require frequent inspection to identify possible puncturing of the fabric or seepage in a metal panel system. To reduce chances of rotting and cracking fabric membranes, water-inflated tubes, and water-inflated baffled bladders require more thorough cleaning of the flood protection material and specific folding requirements for long-term storages.

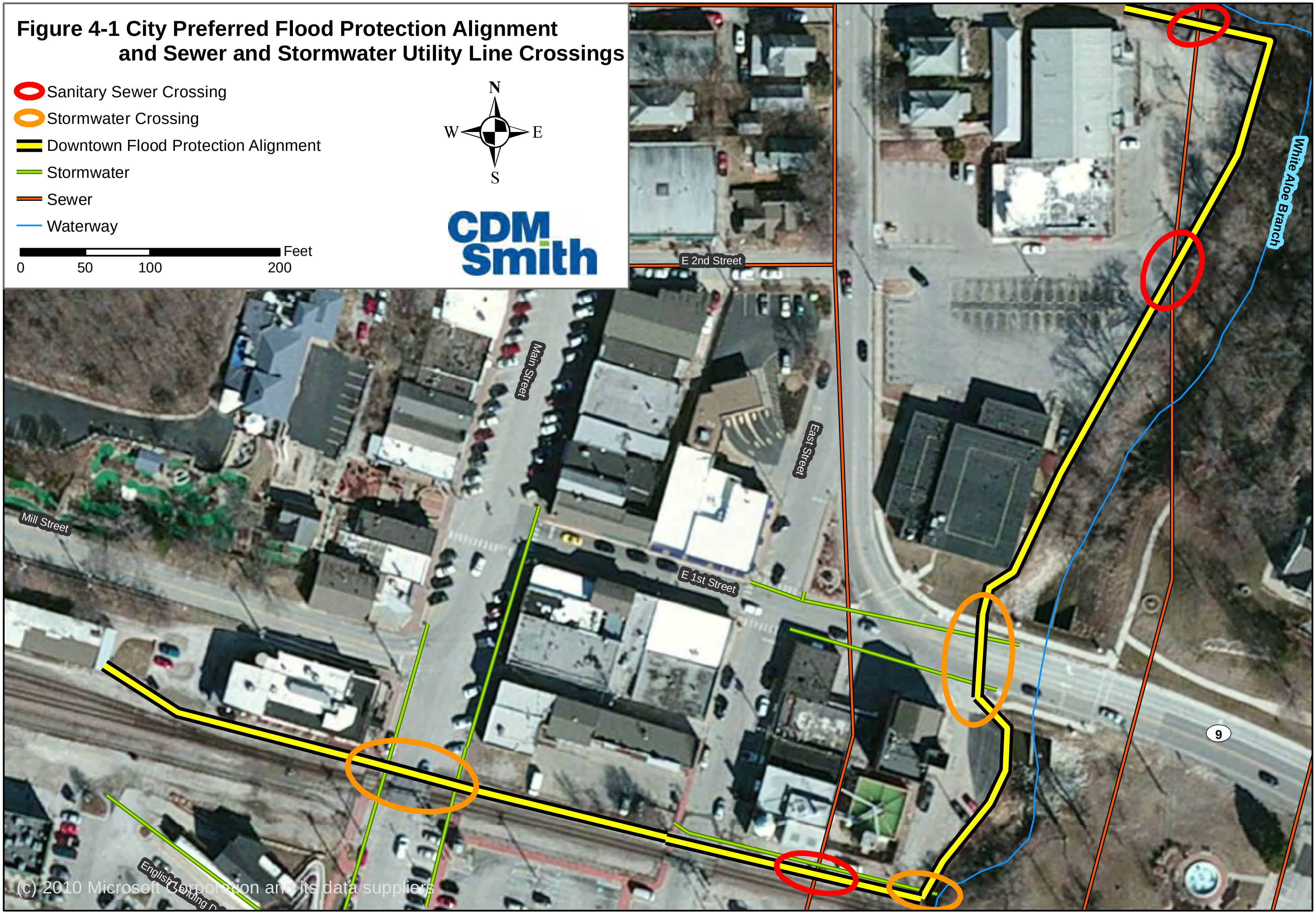

Figure 4-1 City Preferred Flood Protection Alignment and Sewer and Stormwater Utility Line Crossings

4.2.2 Flood Protection Technology Installation

Installation criteria were based on both the flood protection height and associated required width for installation along the preferred flood protection alignment. In order to establish the flood protection height needed to provide protection from the base flood elevation, the height of flood protection was estimated. The estimated flood protection height was based on the preliminary base flood elevation, the current ground surface elevation of the proposed flood protection alignment, and the permanent flood levee protection regulations as found in 44 CFR 65.10 (b) (1) *Freeboard* and described in Table 3-1.

The height of the flood protection vary along the preferred alignment due to the varying ground surface elevation and FEMA freeboard regulations (Table 3-1). Figure 4-2 shows sections of the alignment based on this varying ground surface. Table 4-1 relates the approximate required height of the flood protection in each of these sections.

Table 4-1 Downtown Flood Protection Heights including Freeboard Requirements

Flood Protection	Approximate Height (ft) [1]	Approximate Length (ft)	FEMA Freeboard Requirements [2]
Section 1	7.5	218	Upstream end of levee, minimum freeboard
Section 2	7	157	Minimum freeboard
Section 3	7	238	Minimum freeboard
Section 4	8	106	Freeboard either side of structure (such as bridge), minimum freeboard
Section 5	10	100	Freeboard either side of structure (such as bridge), minimum freeboard
Section 6	9	516	Minimum freeboard
Road Crossing 1	7	83	Minimum freeboard
Road Crossing 2	7	43	Minimum freeboard
Road Crossing 3	10	64	Freeboard either side of structure (such as bridge), Minimum freeboard

[1] Approximate height based on estimated ground elevation along preferred flood protection alignment and the preliminary base flood elevation of 760 feet

[2] As described in Table 3-1

Specific benefits were found related to installation of each technology and also in meeting the FEMA freeboard criteria. Since the width of the flood protection is determined by the desired height of the flood protection, the narrower base requirement for both the metal panel and concrete wall technologies is an important factor. A benefit of the height of the flood protection meeting the FEMA design criteria is that this estimated height varies between one-half and one and a half feet below the 1993 flood WSE of 764.5 (based on HDR 1999 report), and therefore could provide increased protection.

Fabric membrane, water-inflated tubes, and water-inflated baffled bladders all require more labor and time for installation when compared to the concrete floodwall or metal panel systems. These systems also cannot meet the height requirements through the entire alignment due to the required base width for installation.

4.2.3 Flood Protection Technology Cost

Flood protection technology cost estimates obtained from vendors were used to perform a cost comparison of the technologies on a cost per linear foot basis. This is shown graphically in Figure 4-3. The green line representing the baffled bladder indicates the maximum flood protection height of 6 feet specific to this technology. The purple line representing the fabric dam represents the maximum flood protection height of 10 feet specific to this technology.

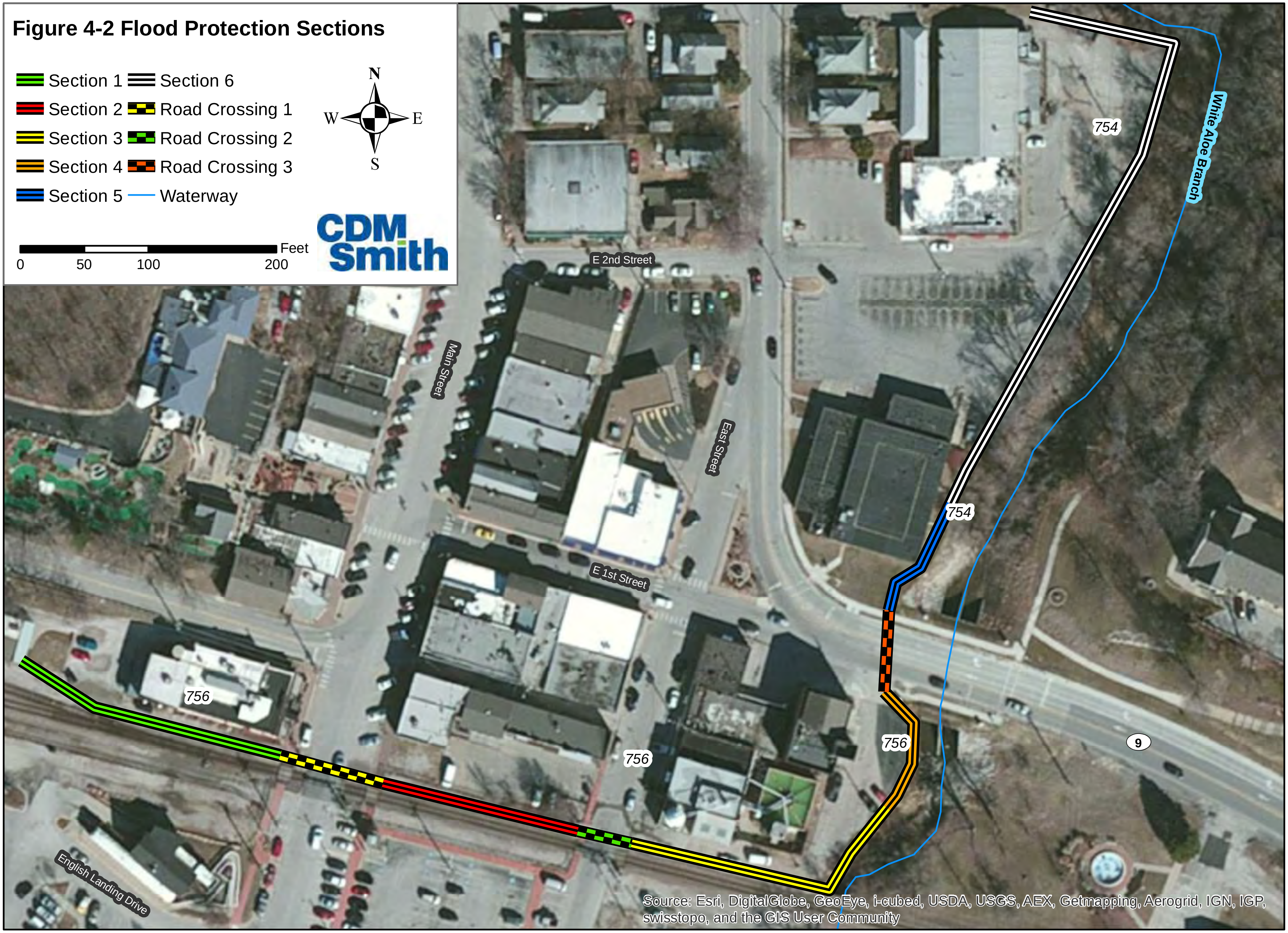

Figure 4-2 Flood Protection Sections

The blue box on Figure 4-3 highlights the approximate flood protection heights from Table 4-1 along with their corresponding costs per linear foot. Of note, four of the technologies are within $200 per linear foot when installed at the flood protection height of 8 feet. It is important to note that the unit cost for the temporary technologies only include material costs and do not include the costs associated with installation, maintenance, and storage.

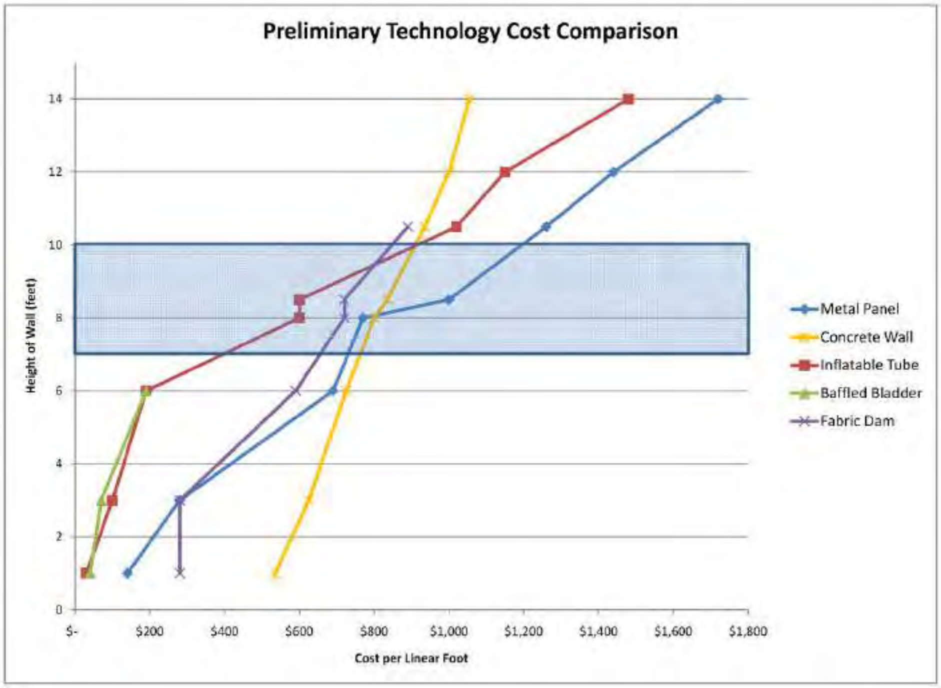

Figure 4-3 Flood Protection Material Cost Curve

Table 4-2 uses interpolated unit costs from Figure 4-3 in conjunction with the heights and lengths listed on Table 4-1 to estimate a total material cost for the installation of a single flood protection technology on the preferred alignment. The water-inflated baffled bladder flood protection technology is not included in Table 4-2 due to its installation height not meeting the requirements for the Downtown study area.

Table 4-2 Flood Protection Technology Cost Comparison

Description	Concrete Floodwall with Footer [2]	Fabric Dam[1]	Water-Inflated Tubes[1]	Metal Panels with Footer [1,3]
Subtotal	$1,091,100	$1,065,900	$1,059,700	$1,463,300
Gate/Road Crossings	n/a [4]	$147,700	$140,900	$196,700
Single Technology Total	**$1,091,100**	**$1,213,600**	**$1,200,600**	**$1,660,000**

[1] Technology costs were determined using cost estimates (as of September 2012) based on sole source use of flood protection technology based on a linear foot calculation.

[2] Concrete floodwall unit cost for estimate provided by USACE.

[3] Metal panels includes the cost of a typically footer construction. Foundation and footer costs may vary significantly depending on geotechnical analysis.

[4] Concrete floodwall technology does not include cost for gate/road crossing. Any temporary flood protection technology can be utilized at these locations.

For comparison purposes, it is important to note that only the concrete wall unit cost includes installation, as this is a one-time expense. Both the concrete wall and the metal panel unit costs include an estimate of a typical footer cost, installed, as required for installation. All other technologies are represented by material cost only, as installation cost will be required for each flood event in use. Additionally, there are costs associated with the temporary flood control technologies that are not in Table 4-2 costs. These include storage, annual training costs, material replacement cost, and flood event installation costs (set-up and breakdown).

4.3 Recommended Flood Protection for Downtown Parkville

A blend of flood protection technologies is recommended based on the City's preferred flood protection alignment for the Downtown study area and the review parameters of maintenance, installation and cost. Use of permanent concrete walls and metal panels (with sill plate) road crossings is recommended as shown on Figure 4-4. An estimated conceptual cost for this recommendation is shown in Table 4-3. Please note that this cost could vary significantly based on geotechnical investigations and decisions on final aesthetics of proposed concrete wall.

Table 4-3 Downtown Recommended Flood Protection Technology Conceptual Costs

Description	Estimated Cost
Permanent Flood Protection (Concrete Floodwall)	$1,091,000
Gate/Road Crossings (Metal Panels w/footer)	$197,000
Subtotal	***$1,288,000***
Easement and Acquisition (5% of Construction Cost)	$65,000
Utility Coordination/Relocation (16% of Construction Cost) [1]	$206,000
Local/State/Federal Permitting (5% of Construction Cost)	$65,000
Engineering Design, Borings, Surveys (25% of Construction Cost) [1]	$321,000
Contingency (35% of Construction Cost) [1]	$460,000
Subtotal	***$1,117,000***
Total	**$2,405,000**

[1] Percent per USACE

Figure 4-4 Recommended Flood Protection Technology Placement

With this recommendation, the City could achieve protection of the Downtown area for the preliminary base flood elevation, while retaining its connection with the Missouri River and providing services to its residents. This recommendation has several benefits:

- **Maintenance.** Maintenance requirements for the concrete wall would be limited to annual inspections and items identified during these inspections. Metal panels can be stacked and stored at existing City facilities.
- **Installation.** With one-time installation for the concrete wall, there would be a decreased need for both City staff time and volunteer time for flood fighting activities in the Downtown study area. Installation would only be required during a flood event for the metal panels at the road crossings. While this will affect vehicular traffic in the area, Downtown would still be accessible from the north. In addition, this installation meets the width constraints present on the alignment.
- **Cost.** The cost incurred with construction of the recommended system would primarily be a one-time construction cost. Annual inspection and maintenance costs would also be required.
- **Regulatory.** Precedence has been set in FEMA Region VII for use of concrete walls and metal panels in updating the FIS. The City could pursue a LOMR to remove the protected areas from the SFHA zone.
- **Aesthetics.** A permanent concrete floodwall can incorporate with current Downtown historical features, as shown on Figure 4-5 (view heading west along Highway 9) and Figure 4-6 (view south on Main Street).

Figure 4-5 View of Simulated Concrete Floodwall, Facing West along Highway 9

Figure 4-6 View of Simulated Concrete Floodwall, Facing South along Main Street

The following assumptions were made as part of this recommendation:

- All recommendations are conceptual in nature. Prior to construction, recommendations should go through a formal design process and be sealed and signed by a registered professional engineer in the State of Missouri.
- All cost estimates are conceptual in nature. Prior to construction, design drawings should undergo a detailed cost review based on final design.
- Coordination and permits with the USACE and FEMA may be required due to the preferred flood protection alignment and construction location along the White Aloe Branch.
- Coordination with BNSF is required due to the preferred flood protection alignment and construction location in the proximity of the railroad tracks.
- Attainment of right-of-way and/or easements may be required along portions of the preferred protection alignment.
- Utility locates were not performed or surveyed as part of this study. Sanitary and storm sewer-line crossing were identified via City provided shapefiles; however, the actual location of lines was not verified.
- Stormwater drainage on the dry side of the proposed flood protection alignment was not evaluated as part of this study.

- Geotechnical investigation is necessary to adequately design the proposed concrete floodwall. Information obtained during a geotechnical investigation impacts the structural design of the wall, including depth, width, and reinforcing requirements.
- A topographic survey of flood protection alignment area was not performed as part of this study.
- The effect of flood protection on the WSE of the Missouri River was not evaluated as part of this study.

  The effect of flood protection on White Aloe Branch was evaluated using HEC-RAS. Utilizing the preliminary modeling information from FEMA for White Aloe Branch, no significant rise in WSE on White Aloe Branch occurs with the building of flood protection of this alignment. A memorandum with details of this analysis is included in Appendix B.

Section 5

Flood Protection Plan and Cost Estimate for English Landing Park

Flood protection consisting of a low levee/embankment (berm) system to protect the Park was reviewed. The study area is from the east bank of White Aloe Branch extending downstream along the Missouri River to the point where the Riverfront Trail has its first loop back toward the Railroad embankment and the Park's interior, as shown on Figure 5-1. An alignment further downstream past where the Riverfront Trails merge, as shown in Figure 5-1, was also initially considered.

5.1 Park Flood Protection Planning Considerations

Items considered for the Park flood protection included the previous Missouri River flood elevation estimates, ground elevations in the Park and along the trail, opportunities for flood protection tie-in based on natural and manmade high ground (such as the railroad embankment), constraints due to mature tree location along the proposed levee alignment, and the City's goals for flood protection. The City's goals for flood protection of the Park include:

- Building a berm to achieve a level of protection that protects the Park from frequent floods that damage the Park, generally within the 5- to 25-year event range
- Retaining existing large mature trees
- Retaining trail alignment
- Retaining the trail width of 12 feet
- Retaining the Park's connection with the Missouri River (aesthetic views)

Building on the City's goals, CDM Smith evaluated the project area from a regulatory and constructability perspective. This included the following parameters:

- All proposed fill would be outside of the FEMA floodway. A levee designed and certifiable to FEMA or USACE design standards was not required. Another consideration and constraint for this plan is the FEMA floodplain impacts upstream, downstream and across the river.
- Keeping the flood protection level between 5- to 25-year level should cause no significant impacts on the base (100-year) flood; however, the Missouri River was not hydraulically modeled as part of this study.
- Since the proposed berm is intended to protect a low risk area, under seepage protection was not evaluated nor was a permanent pump stations considered to dewater the dry side of the berm.
- Overtopping of the proposed berm for events beyond the level of protection was considered acceptable.
- Physical constraints of berm caused by the trail height and width, trees, and tie-in points.

Figure 5-1 Preferred Park Flood Protection Alignment and Extended Alignment Option

5.2 Park Flood Protection Evaluation

The Park flood protection evaluation was based on regulatory considerations, desired level of protection, berm structure analysis, and pre-and post- flood protection activity related cost analysis.

5.2.1 Regulatory Considerations

According to the effective FEMA Flood Study 290294V000 (FEMA Study) and FIRM 2902940001B both dated May 15, 1978, the entire English Landing Park is located within the regulated floodway as shown on Figure 5-2. This conclusion was reached as the 100-year floodplain boundary is located north of the entire Park and the FIRM for this area does not delineate the floodway. Per the FEMA Study, Pages 7 through 10, whenever the floodway edge and the 100-year floodplain boundary coincide only the floodway boundary is shown. The preliminary D-FIRM and profile does not remove the Park from the floodway (refer to Figure 3-2).

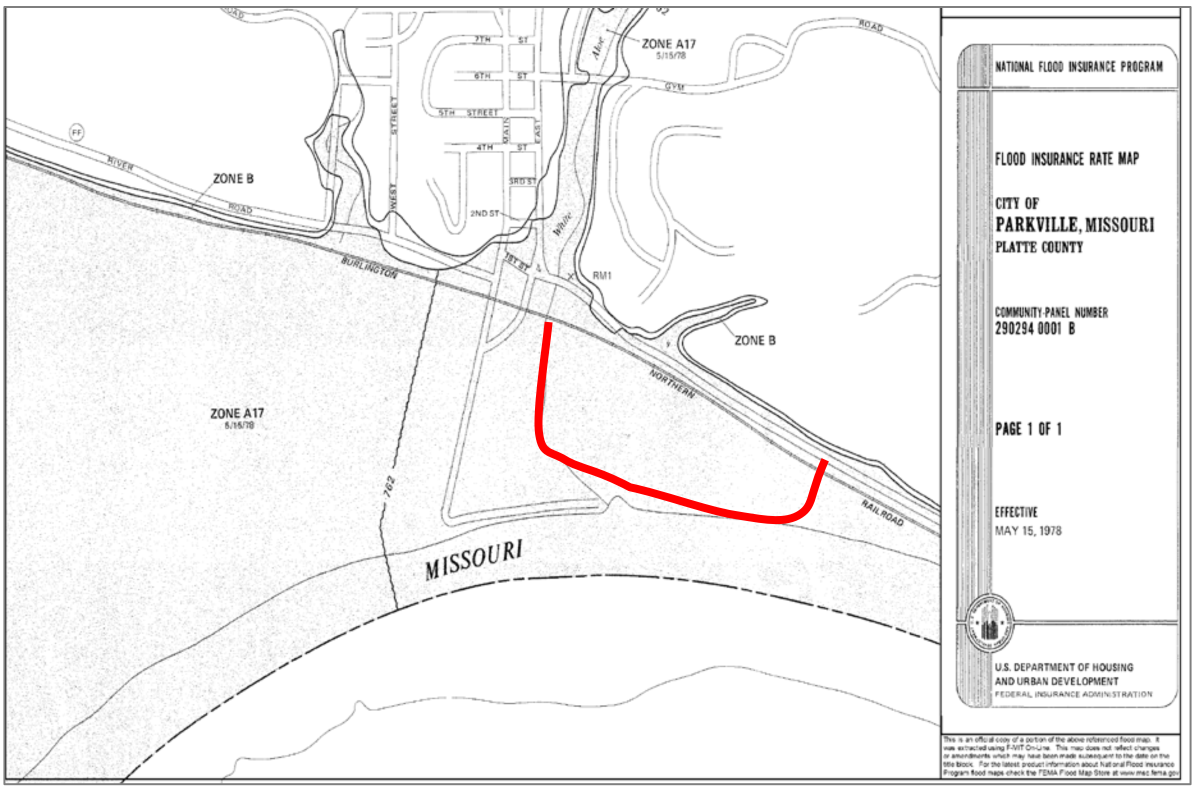

Figure 5-2 English Landing Park Study Area and FEMA Floodway

Per 44 CFR 60.3 (d) (3) communities should prohibit encroachment (including fill) in floodways unless a hydrologic and hydraulic analysis, performed in accordance with standard engineering practice, demonstrates that the proposed encroachment will not result in any increase in the flood levels within the community during the occurrence of the base flood discharge.

5.2.2 Level of Protection

Flood protection for the 10-Percent Annual Chance Flood (commonly referred to as the 10-year) event was chosen in order to meet the goal of a providing between a 5-year to 25-year level of flood protection for the Park. The reason for utilizing this flood event is that this is the only event within the 5-year to 25-year event range in the effective and preliminary FEMA model and profile. Per the preliminary profiles for the Missouri River as shown on Figure 3-2 in Section 3, the 10-Percent Annual

Chance Flood event WSE (dashed blue line) for the Missouri River at the Park is 752 feet. Per the City provided 2-foot contours and the survey performed in November 2012, the average ground surface elevation of the Park along the Missouri River is 746 feet.

It should be noted that the HDR 1999 report stated the elevation of the toe of the berm as 750 feet versus the average of 746 feet along the trail demonstrated by the November 2012 survey. The berm height needed to achieve a 10-Percent Annual Flood Chance protection was determined to be 6 feet. This was calculated based on the difference between the average ground elevation of 746 feet and the 10-Percent Annual Chance Flood WSE of 752 feet.

5.2.3 Berm Structure Analysis

The 2012 American Association of State Highway and Transportation Officials' (AASHTO) Guide for the Development of Bicycle Facilities provides design criteria for a shared use path, such as the Riverfront Trail. Should the Riverfront Trail be reconstructed as part of the flood protection, it is recommended to follow these design criteria. The design criteria are defined in Table 5-1.

Table 5-1 Shared Use Path Design Criteria per AASHTO

Description	Design Criteria
Two-directional shared path	10-foot minimum 11-foot minimum to allow for passing with steep side slopes
Berm Slope	1V:3H
Shoulder width	2-foot minimum 5-foot recommended when path is adjacent to bodies of water or downward slopes of 1V:3H or steeper*
Obstacle clearance	2-foot minimum from edge of path to edge of obstacle

* If the width is less than 5-foot AASHTO recommends that a physical barrier be placed if slopes of 1V:3H or greater are used next to a parallel body of water. The physical barrier can consist of dense shrubbery, railing, or fencing.

The current trail is approximately 6 feet lower than the 10-Percent Annual Chance Flood event WSE. Since the scope of work for this project states that overtopping of the flood protection system is considered acceptable, no freeboard was included in this estimation (44 CFR recommends no less than 2 feet of freeboard). Taking into consideration the proximity and multi-purpose function of the trail to the river in conjunction with the steepness of the slope of the sides of the berm it is recommended that the top of the berm be no narrower than 21 feet using AASHTO design criteria. The dimensions of the berm to provide flood protection for a 10-Percent Annual Chance Flood event are shown on Figure 5-3 and listed in Table 5-2.

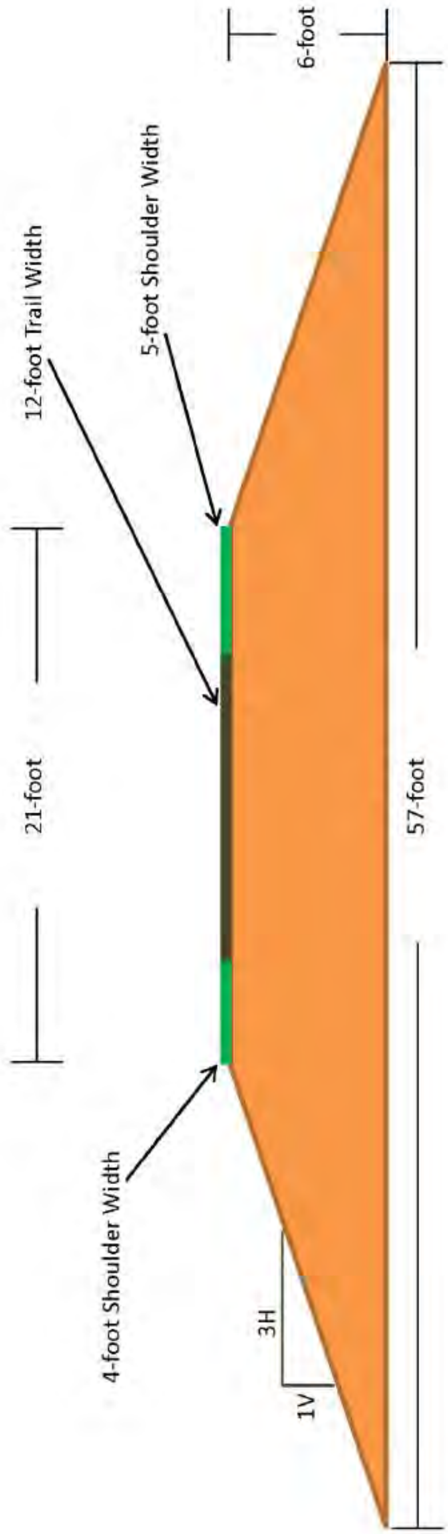

Figure 5-3 Berm and Shared Use Path Design Criteria Dimensions (based on AASHTO design criteria)

Table 5-2 Park Berm Dimensions

Description	Dimension
Berm Height	6 feet
Berm Top Width	21 feet
Shoulder width	4 feet on land side (to allow for benches and lights along trail) 5 feet adjacent to the Missouri River
Trail Width	12 feet
Total Berm Width	57 feet (accounts for both sides maintaining a 1V:3H slope)
Berm Length	2,700 feet

This Park is renowned for its many festivals (Arts, Blues, Jazz, and RiverJam, Parkville Days, Turkey Trot, and Christmas on the River) and is frequented by many people who currently enjoy its "scenic walking trails" which provide a unique connectivity to the Missouri River (City of Parkville English Landing Webpage, 2012). The height of the berm at 6 feet obstructs the view of the Missouri River from within the Park as shown on Figure 5-4. An additional negative impact would be the loss of over 50 mature trees, as shown on Figure 5-5, which currently run along the length of the Riverfront Trail.

Figure 5-4 Superimposed 6-foot High Berm along West Side of Park

Figure 5-5 Tree Removal along Preferred Park Flood Protection Alignment

CDM Smith

5.2.4 Cost Analysis of Flood Protection Options

The cost analysis of the flood protection options for the Park was performed utilizing a historical flood analysis of the Park, conceptual costs of building and maintaining a berm, and the historical flood repair costs from the City.

5.2.4.1 Background to Recommendation Analysis Approach: Historical Flood Analysis at Park

Using historical U.S. Geological Survey (USGS) gauge data, the number of days that the WSE has exceeded the average ground elevation in the Park was estimated (Table 5-3). Two USGS gauges were used, one upstream of the Park (Gauge 06820475) and one downstream of the Park (Gauge 06893000), to interpolate the daily WSE at the Park. This WSE was then compared to the average ground elevation in the Park. Figure 5-6 provides a visual representation of this analysis.

Table 5-3 Gauge Analysis of Historical Record of Flooding at English Landing Park

Period of Record	Days of Record/Year	Number of Days WSE Greater than 746 feet	Percentage of Year
Days in 1990	91	0	0.00%
Days in 1991	364	0	0.00%
Days in 1992	365	4	1.10%
Days in 1993	364	57	15.66%
Days in 1994	364	0	0.00%
Days in 1995	364	37	10.16%
Days in 1996	365	11	3.01%
Days in 1997	364	2	0.55%
Days in 1998	364	7	1.92%
Days in 1999	364	12	3.30%
Days in 2000	365	0	0.00%
Days in 2001	364	2	0.55%
Days in 2002	364	0	0.00%
Days in 2003	364	0	0.00%
Days in 2004	365	0	0.00%
Days in 2005	364	0	0.00%
Days in 2006	364	0	0.00%
Days in 2007	364	7	1.92%
Days in 2008	365	9	2.47%
Days in 2009	364	0	0.00%
Days in 2010	333	15	4.50%
Days in 2011	364	76	20.88%
Days in 2012	226	0	0.00%
Total Historical Gauge	7935	239	3.01%
	Number of days where Missouri River WSE calculated to exceed 746 feet.		

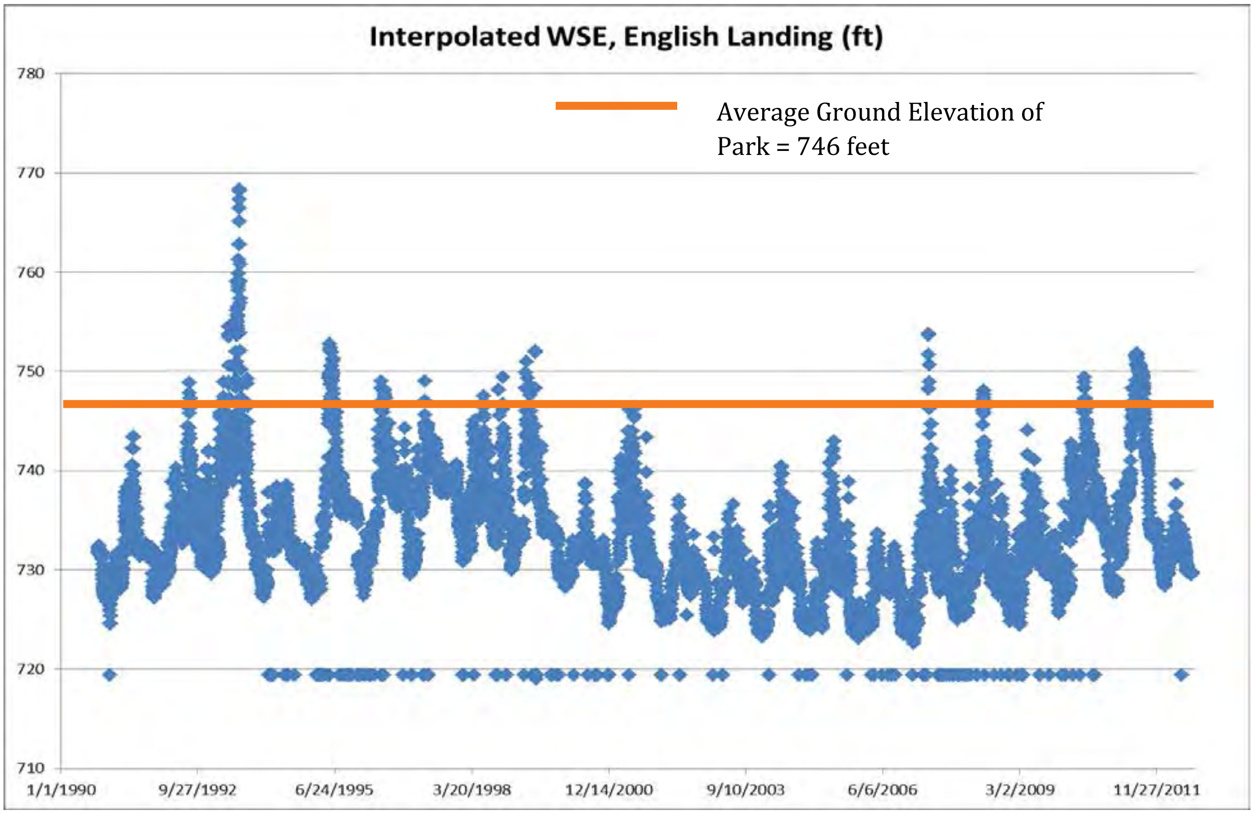

Figure 5-6 Visual Representation of Gauge Analysis of Historical Record of Flooding at English Landing Park

For the historical gauge record, it is estimated that the Park experiences Missouri River flooding approximately 3-percent of the time. This flooding has happened during 12 years of the total 22 year record of data.

An analysis was also completed comparing the historical gauge data to an approximate berm height of 6 feet for the Park. The goal of this analysis was to approximate the frequency at which the Park would still experience flooding from the Missouri River, even with the installation of a berm. With the installation of a berm, it is estimated that the number of days that the Park would have experienced flooding during the historical record would have been reduced by 198 days to 41 days of flooding. With the installation of a berm 6 feet in height, flooding would still occur in the Park approximately 1-percent of the time.

At the time of this study, flood repair costs incurred specifically for the Park were not available for the entire historical record or gauge data. However, City staff verbally quoted an average flood repair expense of the Park from 2007 through 2012 at $416,667 per event. These expenses included general clean-up efforts, sediment removal, seeding, and landscaping.

Option #1 No Action: Budget for Park Clean Up

With flooding occurring at the Park less than 3-percent of the time based on the historical gauge data, one approach to addressing flood repair costs incurred is for the City to proactively budget for these anticipated costs using a pay-as-you-go sinking fund approach. This type of fund accumulates revenues until sufficient money is available for an identified project, or, in this case, a known cost incurred by the City on a regularly occurring basis. This would assist the City in building a fund to specifically address the flood recovery efforts in the Park when they are incurred.

To estimate the needed annual contribution to this type of fund in order to build an adequate safety-net, the average annual flood repair expense at the Park was extrapolated over the number of years in the historical record that the Park has experienced flooding based on the USGS gauge interpolation (Table 5-3).

$$(Total\ Historical\ Estimated\ Cost\ for\ Flood\ Repairs\ to\ Park) = (Average\ Annual\ Flood\ Repair\ Expense, 2007 - 2012)\ mulitplied\ by\ (Number\ of\ Years\ of\ Park\ Flooding)$$

$$\$5{,}000{,}004 = \$416{,}667\ x\ 12\ years$$

This total estimated historical cost incurred for flood repairs at the Park was then divided by the total number of years in the historical record to obtain an annual cost incurred for flood repairs.

$$(Historical\ Annual\ Cost\ of\ Flood\ Repairs\ to\ Park) = \frac{(Total\ Historical\ Estimated\ Cost\ for\ Flood\ Repairs\ to\ Park)}{(Number\ of\ Years\ in\ Historical\ Record)}$$

$$\$228{,}000 = \$5{,}000{,}004 \div 22$$

Therefore, it is estimated that the City could contribute approximately $230,000 annually to a sinking fund dedicated to Park flood repairs in order to anticipate the costs incurred from a flood event. Table 5-4 summarizes the estimated cost for this option.

Table 5-4 Option #1 No Action, Budget for Park Clean Up, Estimated Annual Cost

Total Annual Flood Repair Estimate Based on Historical Gauge Record	
Average Flood Repair Cost	$416,667
Total Historical Estimated Flood Repair Cost	$5,000,004
Average Annual Flood Repair Cost	*$228,000*
Recommended Annual Sinking Fund Budget, Park	*$230,000*
Total City Annual Costs	**$230,000**

Option #2 Six-Foot Berm Construction: Raise Trail Elevation to 752 feet

The City has expressed a desire to construct a berm to provide flood protection of the Park as described previously. Table 5-5 provides a conceptual level estimated one-time construction cost of a berm 6 feet in height and Figure 5-1 shows an approximate alignment of this berm. This berm is estimated to provide the Park protection from a 10-year flood event.

Table 5-5 Option #2 Six-Foot Berm Construction, Estimated Conceptual Construction Cost to Raise the Trail Elevation to 752 feet

Estimated Conceptual Construction Cost of Berm		
Initial Construction Cost Description	**Cost**	**Assumptions**
Berm (6 feet) Estimated Construction Cost	$1,184,349	Initial Cost, (27,543 Cubic Yards * $43[1]/CY)
Utility Coordination/Relocation (8% of Construction Cost)	$94,748	Benches and Electrical Relocation; Tree Removal
Local/State/Federal Permitting (5% of Construction Cost)	$59,217	CLOMR/LOMR/MDNR Permitting
Engineering Design Fee (15% of Construction Cost)	$177,652	Geotechnical Design Required
Contingency (25% of Construction Cost)	$296,087	
Total Conceptual Construction Costs	**$1,812,054**	

[1] Cost per cubic yard based on the HDR 1999 report converted to 2013 dollars using Engineering News Record multiplier.

Along the trail alignment, berm construction elevation should adhere to the "Shared Use Path Design Criteria" per AASHTO for trail design (Figure 5-3). For the purposes of this analysis, a 10- to 12-foot trail width was assumed. For the portions of the berm east of the Park road cul-de-sac, a 2-foot wide shoulder on the dry side of the berm and a 5-foot wide shoulder on the river side of the berm were assumed for fill calculations.

While the berm may initially seem a more permanent solution with less recurring costs, annual costs are still incurred with routine inspection and maintenance of a berm. Because a berm would only be constructed to provide a 10-year level of protection for the Park, flooding would still occur and, therefore, the City would still incur flood repair and clean-up costs to the Park. These costs are typically not reimbursable by Federal flood recovery assistance programs, and therefore should be addressed through budgeting endeavors. The estimation of Option #2 annual costs used the same approach for estimating costs as presented in Option #1. The average cost incurred for flood repair expenses at the Park between 2007 and 2012 was extrapolated over the number of years in the historical record that the Park has experienced flooding greater than the estimated 6-foot height of the berm (752 feet) based on the USGS gauge interpolation (Table 5-3).

$$\begin{gathered}(Total\ Historical\ Estimated\ Cost\ for\ Flood\ Repairs\ to\ Park)\\ = (Average\ Annual\ Flood\ Repair\ Expense, 2007-2012)\\ multiplied\ by\\ (Number\ of\ Years\ of\ Park\ Flooding\ With\ Berm)\end{gathered}$$

$$\$1{,}666{,}668 = \$416{,}667\ x\ 4\ years$$

This total estimated historical cost incurred for flood repairs at the Park was then divided by the total number of years in the historical record to obtain a conceptual annual cost that the City would still incur for flood repairs.

$$(Historical\ Annual\ Cost\ of\ Flood\ Repairs\ to\ Park) = \frac{(Total\ Historical\ Estimated\ Cost\ for\ Flood\ Repairs\ to\ Park)}{(Number\ of\ Years\ in\ Historical\ Record)}$$

$$\$75{,}758 = \$1{,}666{,}668 \div 22$$

Therefore, it is estimated that the City could contribute approximately $76,000 annually to a sinking fund dedicated to Park flood repairs in order to anticipate the costs incurred from a flood event, with the berm installation.

It should be noted that with the construction of a berm in a defined floodway, significant damage could be incurred to a berm subjected to a prolonged flooding event that could entail complete reconstruction of the berm. Therefore, an annual sinking fund should also be considered to address these significant repairs. In the available historical record of 22 years, WSE exceeding the estimated berm height of 752 feet for a prolonged period of time has occurred once: 1993 (35 days). The estimated total construction cost of the berm (Table 5-5) was extrapolated over the historical record to estimate an additional annual sinking fund budget specifically for reconstruction of a berm. As part of this estimate, it was assumed that 50-percent of the original construction would be salvageable following a flood event.

$$(Estimated\ Annual\ Cost\ of\ Berm\ Construction)$$

$$= \frac{\begin{pmatrix} Total\ Estimated\ Cost\ for\ Berm\ Construction \\ multiplied\ by \\ Number\ of\ Historical\ WSE\ Exceedance\ Events \end{pmatrix} \times\ 50\%}{(Number\ of\ Years\ in\ Historical\ Record)}$$

$$\$164{,}732 = \$(1{,}812{,}054 \times 4 \times 0.5\ ) \div 22$$

In addition, an estimated annual maintenance cost of the berm was included at 3-percent of the estimated construction cost. Table 5-6 summarizes the estimated annual costs for this option.

Table 5-6 Option #2 Six-Foot Berm Construction, Estimated Conceptual Annual Costs Incurred to Raise the Trail Elevation to 752 feet

Total Annual Maintenance and Flood Repair Estimate for Berm Construction	
Average Flood Repair Cost	$416,667
Total Historical Estimated Flood Repair Cost for Park	$1,666,668
Average Annual Flood Repair Cost	*$75,758*
Total Historical Estimated Berm Reconstruction Cost	$3,624,108
Average Annual Budget for Berm Reconstruction	*$164,732*
Recommended Annual Sinking Fund Budget, Berm Reconstruction	*$165,000*
Recommended Annual Sinking Fund Budget, Park Repairs	*$76,000*
Estimated Annual Maintenance of a Berm (3% of Construction Cost)	*$35,500*
Total City Annual Costs	**$276,500**

The total annual costs associated with berm construction are estimated to be similar in cost of proactively planning for flood repairs (Option #1).

Option #3 Temporary Flood Protection: Water-Filled Tubes

In lieu of a permanent berm, the City could pursue a temporary flood protection option for the Park. Section 3 discussed advantages and disadvantages of three temporary flood protection options: fabric membrane, water-inflated tubes, and baffled bladders. Of these, water-filled tubes would allow the City the flexibility of choosing the best alignment to protect resources within the Park, while also allowing the City to purchase additional material as funds are available. This would allow the City to adjust flood protection of the Park to a desired level for future flood events. However, this method of flood protection is dependent on a readily available source of water to fill the tubes at the point of installation.

Table 5-7 provides an estimated cost for temporary flood protection using water-filled tubes for a wall 3 feet in elevation and a wall 6 feet in height for the alignment shown in Figure 5-1.

Table 5-7 Option #3 Temporary Flood Protection, Estimated Material Cost for Water-Filled Tubes

Estimated Material Cost of Temporary Flood Protection, Water-Filled Tubes		
	Height of Temporary Flood Protection	
Estimated Material Cost	3-foot	6-foot
Estimated Material Cost per linear foot, (Dollars)	$100	$190
Alignment Length, (linear foot)	2700	2700
Total Estimated Material Costs	**$270,000**	**$513,000**

Similar to the permanent berm, annual costs are still incurred with temporary flood protection technologies (storage, etc.). Because the temporary flood protection would only provide flood protection to a defined level for the Park, flooding would still occur. Therefore, the City would still incur flood repair and clean-up costs to the Park. The estimated cost methodology to define this annual cost is the same as presented for Option #2. In addition, labor and inspection costs associated with installation can be estimated. An estimated labor cost per installation was extrapolated over the number of years in the historical record that the Park has experienced flooding greater than the average ground elevation of the Park (746 feet). Similarly, an estimated inspection cost per installation was extrapolated over the number of days in the historical record that the Park has experienced flooding greater than the average ground elevation of the Park (746 feet). All of these estimated costs could be anticipated through annual contributions to a sinking fund. Table 5-8 summarizes the estimated annual costs for this option.

Table 5-8 Option #3 Temporary Flood Protection, Estimated Annual Costs Incurred with Water-Filled Tubes

Total Annual Estimated Costs for Temporary Flood Protection		
Cost Description	Height of Temporary Flood Protection	
	3-foot	6-foot
Average Flood Repair Cost	$416,667	$416,667
Total Historical Estimated Flood Repair Cost for Park	$5,000,004	$5,000,004
Average Annual Flood Repair Cost	*$227,273*	*$227,273*
Total Labor Incurred over the Historical Record [1]	$162,000	$307,800
Total Annual Labor Budget	*$7,364*	*$13,991*
Total Inspection Incurred over the Historical Record [2]	$143,400	$143,400
Total Annual Inspection Budget	*$6,519*	*$6,519*
Estimated Annual Maintenance of Temporary Flood Protection (1% of Material Cost)	*$3,000*	*$6,000*
8Recommended Annual Sinking Fund Budget, Park Repairs	*$228,000*	*$228,000*
Recommended Annual Sinking Fund Budget, Temporary Flood Protection (labor/inspection)	*$14,000*	*$21,000*
Total City Annual Costs	**$245,000**	**$255,000**

[1] Five-percent of material cost times 12 times in historical record.

[2] 239 days x 4 hours/day x 2-people x $75/hour

Option #4 Three-Foot Berm Construction: Raise Trail Elevation to 749 feet

An additional alternative could include the City pursuing incremental flood protection of the Park by elevating the trail approximately 1 to 3 feet to an elevation of 749 feet. Appendix C includes conceptual plan and profile views of what this trail elevation could look like. Table 5-9 summarizes the estimated construction cost for this option.

Table 5-9 Option #4 Three-Foot Berm Construction, Estimated Construction Cost Incurred to Raise the Trail Elevation to 749 feet

Estimated Conceptual Construction Cost of Trail Elevation		
Initial Construction Cost Description	**Cost**	**Assumptions**
Trail Elevation Estimated Construction Cost	$434,816	Initial Cost, (10,112 Cubic Yards * $43[1]/CY)
Utility Coordination/Relocation (8% of Construction Cost)	$34,785	Benches and Electrical Relocation; Tree Removal
Local/State/Federal Permitting (5% of Construction Cost)	$21,741	CLOMR/LOMR/MDNR Permitting
Engineering Design Fee (15% of Construction Cost)	$65,222	Geotechnical Design Required
Contingency (25% of Construction Cost)	$108,704	
Total Conceptual Construction Costs	**$665,268**	

[1] *Cost per cubic yard based on the HDR 1999 report converted to 2013 dollars using Engineering News Record multiplier.*

The City could potentially incur an estimated cost savings of up to 25-percent by using City resources or volunteer labor for trail elevation construction.

Along the trail alignment, trail elevation construction should adhere to the "Shared Use Path Design Criteria" per AASHTO for trail design (Figure 5-3). For the purposes of this analysis, a 10- to 12-foot trail width was assumed. For the portions of the trail east of the Park road cul-de-sac, a 2-feet wide shoulder on the dry side of the trail and a 5-feet wide shoulder on the river side of the trail was assumed for fill calculations.

Annual costs would still be incurred with routine inspection and maintenance of elevating the trail. Flooding of the Park would still occur at elevations greater than 749-feet, and therefore, the City would still incur flood repair and clean-up costs to the Park. These costs are typically not reimbursable by Federal flood recovery assistance programs, and therefore should be addressed through budgeting endeavors. The estimated annual costs for this option was derived similarly to Option #2, with the main difference being in the number of times in the historical record that the WSE has exceeded 749-feet (7 times). Table 5-10 summarizes the estimated annual costs for this option.

Table 5-10 Option #4 Three-Foot Berm Construction, Estimated Annual Costs Incurred to Raise the Trail Elevation to 749 feet

Total Annual Maintenance and Flood Repair Estimate for Trail Elevation	
Average Flood Repair Cost	$416,667
Total Historical Estimated Flood Repair Cost for Park	$2,916,669
Average Annual Flood Repair Cost	*$132,576*
Total Historical Estimated Trail Elevation Reconstruction Cost	$2,328,440
Average Annual Budget for Trail Elevation Reconstruction	*$105,838*
Recommended Annual Sinking Fund Budget, Trail Elevation Reconstruction	*$106,000*
Recommended Annual Sinking Fund Budget, Park Repairs	*$133,000*
Estimated Annual Maintenance of a Berm (3% of Construction Cost)	*$13,100*
Total City Annual Costs	**$252,100**

5.3 Considerations for Flood Protection of English Landing Park

Table 5-11 summarizes the estimated initial (construction and/or material acquisition) costs and estimated annual costs for the options presented in Section 5.2.

Table 5-11 Estimated Costs Summary for Flood Protection of English Landing Park

Option	Description	Estimated Cost (2012) [1]	
		Initial Cost	Annual Cost [2]
Option #1 No Action	Budget for Park Clean Up	$0	$230,000
Option #2 Six-Foot Berm Construction	Raise Trail Elevation to 752 feet	$1,820,000	$280,000
Option #3 Temporary Flood Protection [3]	~~3-Foot High Water Filled Tubes~~	~~$270,000~~	~~$250,000~~
	~~6-Foot High Water Filled Tubes~~	~~$520,000~~	~~$260,000~~
Option #4 Three-Foot Berm Construction	Raise Trail Elevation to 749 feet	$670,000	$260,000
	Raise Trail Elevation to 749 feet – City Self Perform Construction	$510,000 [4]	$230,000 [5]

[1] Estimated costs have been rounded up to the nearest $10,000.

[2] Annual costs do not include intangible costs that cannot be quantified (i.e. loss of use)

[3] Use of water-filled tubes is considered infeasible and is not recommended for further consideration.

[4] Assumes City cost to construct is 75% of contracted cost.

[5] Assumes City would self-perform annual maintenance and flood repair.

Under the "No Action" option, no initial cost would be incurred by the City. Instead, the City would proactively budget for anticipated future flood repairs in the Park.

The annual costs for Options #2 and #4 include building the berm, repairing the berm after minimal flood events, and annual maintenance of the berm. These costs do not included loss of use during flood events, the impact of any berm construction adjacent to established trees, modification to existing light poles and benches, and a reduction of the river view from the Park (particularly from the River

Stage Park Shelter). Raising the trail along the southern edge of the Park reduces accessibility to the trail and increased maintenance tasks. Currently the trail is accessible from any point in the Park for physically challenged people. Adding additional areas of accessibility to the trail would increase the financial costs associated with the berm. The additional maintenance tasks include inspecting for damage from burrowing animals, inspecting for scouring from high WSE events, and repairing noted damages.

Any fill placed for a berm or trail elevation should be compacted to meet USACE standards. This fill should be placed in 6 to 10 inch lifts. With the significant number of trees adjacent to the existing trail alignment, an arborist should be consulted to determine fill allowable near trees or design requirements for tree protection. Existing stormwater conveyance paths through the Park to the river are critical to retain. In addition, tie-in of a trail elevation or berm could pose challenges at the railroad tracks. Additional requirements may be required from BNSF to place any fill adjoining the railroad embankment. It should be noted that the entirety of the Park is within the FEMA regulated floodway of the Missouri River and will require a City floodplain permit for any land modifications.

Sandbag closures would be required at certain points where berm construction or trail elevation is not feasible. These locations include the Park road entrance, existing boat ramp, and Park road cul-de-sac, as well as potentially the connection adjacent to the railroad. A one to two day lead time would most likely be required to construct these measures prior to flooding. The Park would be closed leading up to and during any flood event. During the flood event, the berm and/or trail elevation area would require continuous monitoring to assess the structural integrity as well as the dewatering needs within the Park. Following any flood event, a full inspection of any berm and/or trail elevation should be completed with repairs completed as identified.

Due to the current lack of available water at the Park, the use of water-filled tubes (Option #3) as a temporary means of flood protection is considered infeasible. It is also uncertain how well the tubes would hold up under prolonged flooding conditions of the Missouri River as their placement would be in an area of higher flow velocity.

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