2016

BIG BLUE AND KANSAS RIVER FLOODPLAIN MANAGEMENT

For Communities along the Confluence of the Big Blue and Kansas Rivers

Big Blue River Technical Advisory Group

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Big Blue and Kansas Rivers Floodplain Management Plan

For Communities Along the Confluence of the Big Blue and Kansas Rivers

I. Introduction

A floodplain management plan (FMP) serves to communicate many important decisions about the use of a floodplain. The FMP includes important historical details, considerations, and an action plan about the activities and features that help to manage flood risks. The *Big Blue and Kansas Rivers Floodplain Management Plan* is sponsored by the U.S. Army Corps of Engineers (USACE), State of Kansas, City of Manhattan, Riley County, and Pottawatomie County. These pages serve as a living document for the local communities to use to manage flood hazards along the Big Blue and Kansas Rivers. Managing these flood risks is a shared responsibility of the local communities, the state and federal agencies.

Description of the Area

The City of Manhattan, Riley County, and Pottawatomie County are at the downstream end of the Big Blue River watershed. This is the largest tributary in the Kansas River Basin. The counties' boundaries are generally defined as the Big Blue River channel. The City and the rural areas of the counties below Tuttle Creek Dam are at the extreme downstream end of the watershed, where the rainfall runoff is eventually concentrated.

Big Blue Watershed Facts

This is the largest tributary in the Kansas Basin. Tuttle Creek Lake was built in 1962 and the Manhattan Levee was built in 1963.

The watershed presents a unique flood risk to the south and eastern side of the City of Manhattan and residents and business owners in the rural areas of the two (2) counties. This presents a noticeable risk to development from flooding. The Big Blue River Watershed is 9,733 square miles in area and reaches into Central Nebraska. In the middle of the 1900s, the country was in the "Big Dam Era," when large structures, including levees, were constructed to help manage flood risks. Tuttle Creek Lake was built in 1962, and not long after, the Manhattan Levee System was built in 1963. Runoff from the watershed is collected in Tuttle Creek Reservoir, just to the north of the City. Tuttle Creek Reservoir is the only man-made reservoir of its size in the Big Blue River Basin. Tuttle Creek Dam has provided flood protection to the area below since its completion.

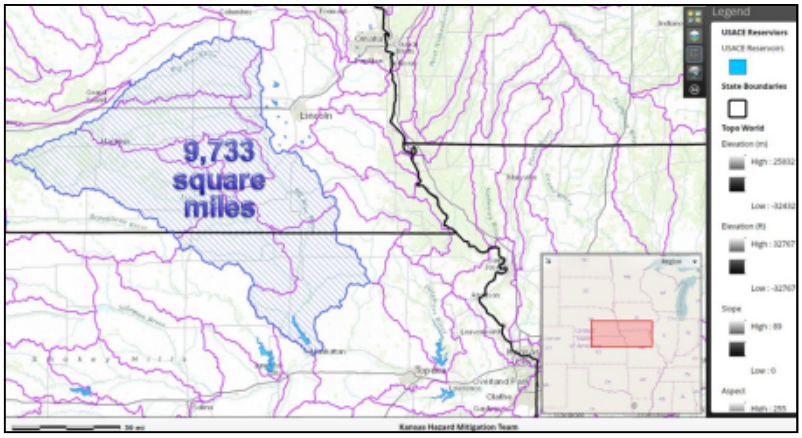


Figure 1: The Big Blue Basin

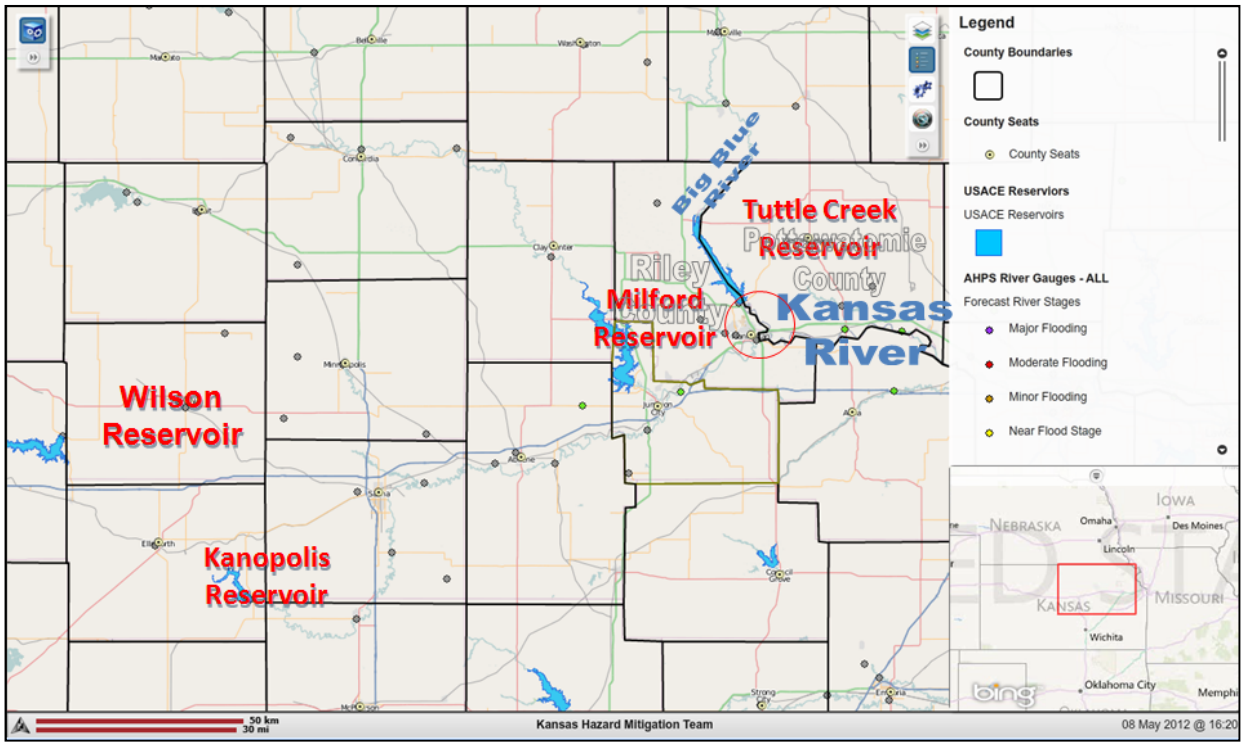


FIGURE 2: REGIONAL MAP, WHICH REFLECTS THE FOCAL POINT OF FLOOD RISK FOR THE STAKEHOLDERS AT THE CONFLUENCE OF THE BIG BLUE RIVER AND KANSAS RIVER

In addition, the flood stage and the associated flood risk on the Kansas River is directly related to the flooding on the Big Blue River. The Big Blue River has its confluence with the Kansas River to the east of Manhattan, near the U.S. Highway 24 Bridge. Upstream of the Big Blue River/Kansas River confluence, additional dams were built on the Kansas River. The next USACE lake upstream of Manhattan on the Kansas River is Milford Lake, which was impounded in 1967. Kanopolis, Wilson, and Harlan County (Nebraska) lakes were impounded in 1948, 1964, and 1952, respectively. Figure 2 shows these USACE reservoirs in the region. The system is operated in coordination with the Bureau of Reclamation dams, such as Cedar Bluff, Glen Elder (Figure 2), Keth Sebelius, Kirwin, Lovewell, Salt, Waconda, and Webster (although some are not visible in the Figure 2). This system of reservoirs can directly impact flooding in the area of concern of this floodplain management plan. Area floodplain managers should be familiar with this reservoir system.

The areas susceptible to flooding discussed under this plan are in the Big Blue River and the Kansas River floodplains. This includes an approximate six mile stretch of the Big Blue between the confluence with the Kansas River and the Tuttle Creek Dam. Specifically, the area studied in the floodplain management plan includes the protected and unprotected areas surrounding the Manhattan Levee; the residential areas along Casement Road and Marlatt Avenue; the commercial corridor along U.S. Highway 24 in Pottawatomie County; and the residential, commercial, industrial and agricultural areas within the rural areas of both counties.

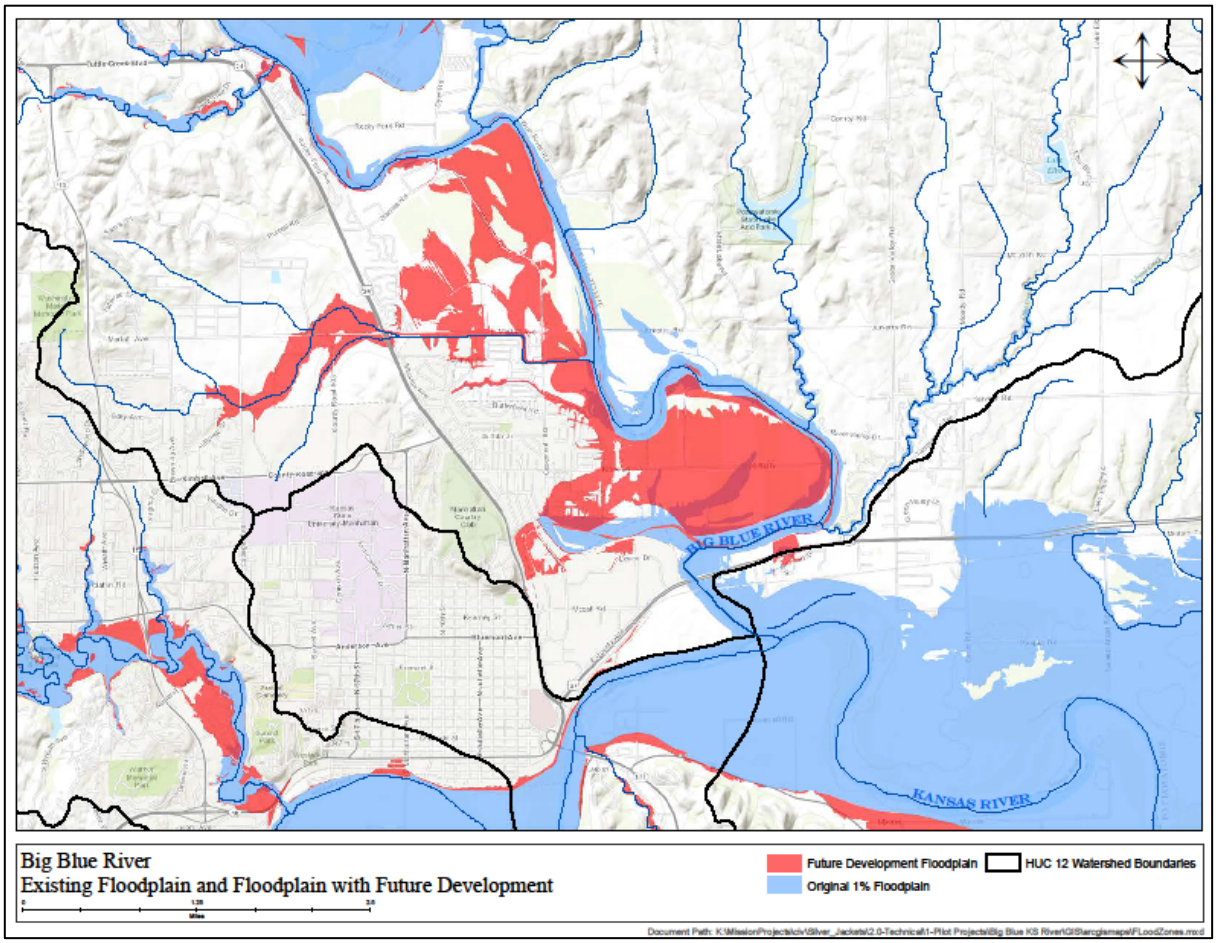


FIGURE 3: FLOODPLAIN MANAGEMENT PLAN AREA OF CONCERN

Purpose of the Floodplain Management Plan

The purpose of a Floodplain Management Plan (FMP) is to make a community or a coalition of communities improve its resiliency to flooding. "Resiliency" refers to addressing the cumulative effects of development within the floodplain and impacts on areas adjacent to the floodplain. Resiliency also means the community, as a whole, can quickly recover from the natural occurrence of floods, because the community is able to lessen or avoid the impacts of flooding to their economy and to the lives of those living there. The FMP attempts to lessen the damaging effects of floods, maintain and enhance natural floodplain values, and assist in making effective use of water and related land resources within the floodplain. An effective FMP should result in continuing consideration of the flood hazard in the use of land and water resources in the floodplain and provide benefits to all government levels and the public, including:

1. Reducing loss of life, injury and hardship due to floods;
2. Reducing flood damages;

3. Reducing public expenditures for construction of additional flood damage reduction measures, emergency response actions, and post-disaster assistance; and,
4. Preserving and enhancing natural floodplain values for fish and wildlife habitat along with their attendant benefits of groundwater recharge, moderation of floods, water quality improvement, and reduced erosion and sedimentation.

A FMP also attempts to balance benefits obtainable from the use of the floodplain with the potential losses arising from such use. The comprehensive nature of such a plan stresses consideration of the full range of large and small measures potentially useful in achieving its objectives. The concepts contained in this FMP were developed to closely follow the 1994 Unified National Program for Floodplain Management and to ensure compatibility with the National Flood Insurance Program's Community Rating System.

Effective Flood Risk Management.

Effective management of both floodplains and floodwaters can break the cycle of damage and rebuild.

Effective management of both floodplains and floodwaters can break the cycle of damage, rebuild and repeat. A dedicated effort allows the government to break this cycle and create a sustainable flood risk management cycle (see Figure 4) and a resilient community.

FIGURE 4: SUSTAINABLE FLOOD RISK MANAGEMENT CYCLE

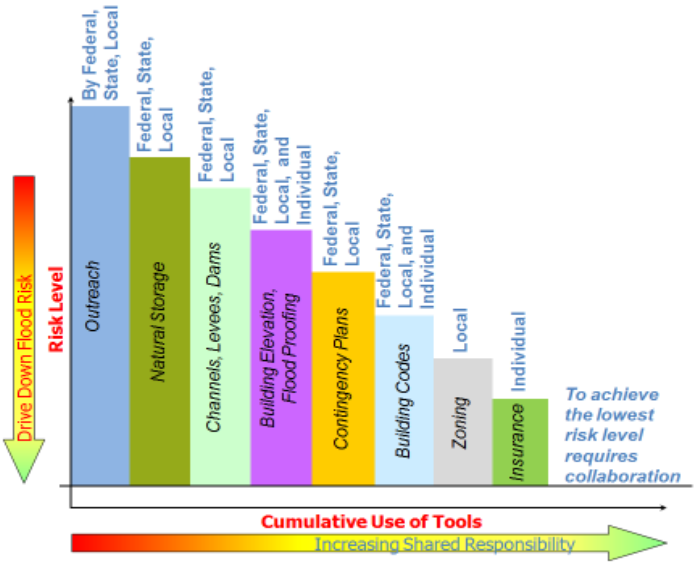


FIGURE 5: VARIOUS TOOLS MUST BE ACCEPTED AT THE STATE, LOCAL, AND THE INDIVIDUAL LEVELS TO DRIVE DOWN FLOOD RISKS

The most difficult challenge is determining which of the strategies and tools for reducing flood risks are most appropriate. Figure 5 illustrates lower levels of risk require increasing involvement from the community. Flood risk management is a shared responsibility, therefore, a variety of stakeholders must be involved in the decision making process.

Flood risk management is a constant effort and requires staff dedicated to the work. The work includes building features that manage floodwaters and also conducting a variety of floodplain

management activities. Floodplain management plans are a shared planning methodology that documents a community's approach to reduce flood risks. This plan serves to show flood management decisions reached over long periods. These long periods often overlap the careers of many different people in the communities, including professional staff. The floodplain management plan serves to operationalize flood risk management for the long term benefit of a community.

Driving Down Flood Risks.

Floodplain management plans are a shared planning methodology that can drive down flood risks.

Local, state, and federal planners have prepared this FMP in accordance with Federal standards originating from Executive Order 11988, which began unified floodplain management in 1977. The standards are consistent with Public Law 104-303 of the Water Resources Development Act (WRDA) of 1996, which amends Section 402 of the WRDA of 1986 (also see 33 U.S.C. 701b-12; 100 Stat. 4133). Below is an excerpt from the Federal requirement.

*SECTION 202(c) OF **WRDA 1996***
FLOODPLAIN MANAGEMENT PLANS
c) Floodplain Management Plans.
(1) In general. --Section 402 of such Act (33 U.S.C. 701b-12; 100 Stat. 4133) is amended to read as follows:
SEC. 402. FLOODPLAIN MANAGEMENT REQUIREMENTS.
a) Compliance With Floodplain Management and Insurance Programs. –Before construction of any project for local flood protection, or any project for hurricane or storm damage reduction, that involves Federal assistance from the Secretary, the non-Federal interest shall agree to participate in and comply with applicable Federal floodplain management and flood insurance programs.
b) Floodplain Management Plans. --Within 1 year after the date of signing a project cooperation agreement for construction of a project to which subsection a) applies, the non- Federal interest shall prepare a floodplain management plan designed to reduce the impacts of future flood events in the project area. Such plan shall be implemented by the non-Federal interest not later than 1 year after completion of construction of the project.
c) Guidelines. --
(1) In general. --Within 6 months after the date of the enactment of this subsection, the Secretary shall develop guidelines for preparation of floodplain management plans by non-Federal interests under subsection b). Such guidelines shall address potential measures, practices, and policies to reduce loss of life, injuries, damages to property and facilities, public expenditures, and other adverse impacts associated with flooding and to preserve and enhance natural floodplain values.
(2) Limitation on statutory construction. --Nothing on this subsection shall be construed to confer any regulatory authority upon the Secretary or the Director of the Federal Emergency Management Agency.
d) Technical Support. --The Secretary may provide technical support to a non-Federal interest for a project to which subsection a) applies for the development and implementation of plans prepared under subsection b).
(2) Applicability. --The amendment made by paragraph (1) shall apply to any project or separable element thereof with respect to which the Secretary and the non-Federal interest have not entered into a project cooperation agreement on or before the date of the enactment of this Act.

Minimum standards of the FMP has components that comply with the U. S. Army Corps of Engineers (USACE) planning guidance for floodplain management plans (USACE 2), as required when a cost share construction project using USACE funding is proposed for flood risk management projects. In this case, the project is the Manhattan Levee project site. A recently completed USACE feasibility study, called the *Manhattan, Kansas Local Protection Project Section 216 Feasibility Study* (2015), documents a federal interest in assisting Manhattan with improving its existing levee system. This FMP also meets the minimum standards for two Federal Emergency Management Agency's (FEMA) programs. The first is Section 510 of the Community Rating System (CRS), as described in the CRS coordinator's manual (FEMA 1), and secondly, the FMP complements the local hazard mitigation plan for Region I of Kansas.

II. Development Process of the Floodplain Management Plan

This section includes the documentation of the process used to develop the floodplain management plan (FMP). The process begins with a thorough assessment of flood hazards, whether for loss of life or property damage. Additional steps include the detailing of records of meetings and public involvement activities, which appears below in this FMP.

Future Conditions Flows

The flood hazard area will be altered over time as changes occur in impervious areas in the basin, in the location and "morphology" of river channels or with stormwater infrastructure and flood protection measures, such as stormwater sewers, detention basins and levee systems. The creation of future condition flood models and stream flow models are designed to account for these changes. The USACE Manhattan Levee feasibility study (*Manhattan, Kansas Local Protection Project Section 216 Feasibility Study*, 2015), has selected final alternatives that could be funded by Federal dollars to improve the flood protection functions of the Manhattan Levee System. These proposed levee improvements can affect flows on the Big Blue and Kansas Rivers for less frequent events or higher flood elevations, which may affect more upstream land owners. During the USACE study, analysis indicated effects were minimal, less than 0.4-foot of a rise of the flood waters, for these less frequent events would possibly occur (2015).

Floodplain Hazard Assessment

Numerous reports and studies exist that describe the problems associated with flooding along the Big Blue and Kansas Rivers. The References section presents a bibliography of these resources. The following sub-sections describe the flood hazards for different reaches along the Big Blue River. The reaches begin at the downstream end and work sequentially toward upstream. The left bank (looking upstream) floodplains are listed first, then the right bank floodplains.

History

AMEC's Levee Certification Report for the Manhattan Levee System (January 4, 2013) states 43 flood events occurred between 1904 and 1951. The most historic flood occurred in 1951, which led to the decision to build the Tuttle Creek Reservoir for flood control of the area and the Kansas River Basin. The Manhattan Levee System was also built to protect the City of Manhattan and surrounding areas. The dam was completed in 1962 and the levee was completed in 1963.

Tuttle Creek Reservoir Flood Control

One of the authorized purposes for Tuttle Creek Reservoir is flood control. The term "flood control" is used to describe the U.S. Army Corps of Engineers (USACE) efforts to reduce flood damages from the more frequent, less intense flood events that occur in the river valley. The reservoir is not designed to prevent all floods. *Larger, infrequent storm events will occur that exceed the capacity of reservoir, requiring water to be released from the reservoir, impacting homes and businesses downstream.*

According to the USACE, since the construction of Tuttle Creek Reservoir in 1962, eighty-five (85) individual storms created runoff that would have exceeded the capacity of the Big Blue River channel near Manhattan. These storm events would most likely have caused flooding in the areas described in the following sections. Several of these storms occurred in a single year. Of the eighty-five (85) storm events described, six (6) storms (1973, 1983, 1984, 1987, 1990, 1992, & 2008) had flows entering into Tuttle Creek Reservoir that were larger than the flood event that caused the 1993 flood and would have likely caused substantial damage in the Manhattan area. The storm event in 1973 was so intense that, if Tuttle Creek Reservoir was not in place, the flood waters would have overtopped the Manhattan Levee System. Fortunately, the reservoir had enough capacity to contain the flood events so the flood waters could be released from the reservoir at a controlled rate. According to USACE economists, Tuttle Creek Reservoir has provided over $6.5 billion in cumulative flood damage protection since it was constructed. As previously mentioned, the dam structure and reservoir is not designed to prevent flooding, but to minimize potential risks.

1993 Flood Event

Conditions were right in 1993, to cause significant flooding on the Big Blue River, Kansas River and other river basins in the Upper Mississippi River Valley. The flood in the summer of 1993 was a historic event that impacted nine (9) states in the Upper Mississippi River Valley, including Kansas. Starting in January, snow and rain storms filled ponds and lakes and saturated the ground in the region. The rain did not stop until the end of July. According to the U.S. Geological Survey (Wahl et al., 1993), the Manhattan area had over five (5) times its normal amount of rain in July alone. From July 22nd to 24th, two (2) to thirteen (13) inches of rain fell in parts of Kansas and Nebraska alone. On July 23rd, USACE officials were forced to open the flood gates to 58,800 cfs to control the capacity of the reservoir based on the amount of water flowing into the already full reservoir. This release from Tuttle Creek Reservoir caused significant flooding to residences and businesses in rural Riley County, the Dix Addition in the City of Manhattan, the Fairmont neighborhood south of the Kansas River and the Blue Township area of Pottawatomie County.

Month	Year	Name of Water Body	Estimated Probability of Occurrence in Each Year *(limited by uncertainty in period of record, also uncertainty varies depending on year)*
June	1903	Kansas River and Big Blue River	Not Available
June	1935	Kansas River and Big Blue River	Not Available
July	1951	Kansas River and Big Blue River	0.2% *(500-year return frequency)*
	1962	Tuttle Creek Reservoir Construction Completed	
	1963	Manhattan Levee System Construction Completed	
July	1993	Kansas River and Missouri River	*1.4% (about 70-year return frequency)*

Table 1: Big Blue River Flood History *(Source: Pottawatoime County Flood Insurance Study, 2015 and Riley County Flood Insurance Study, 2015)*

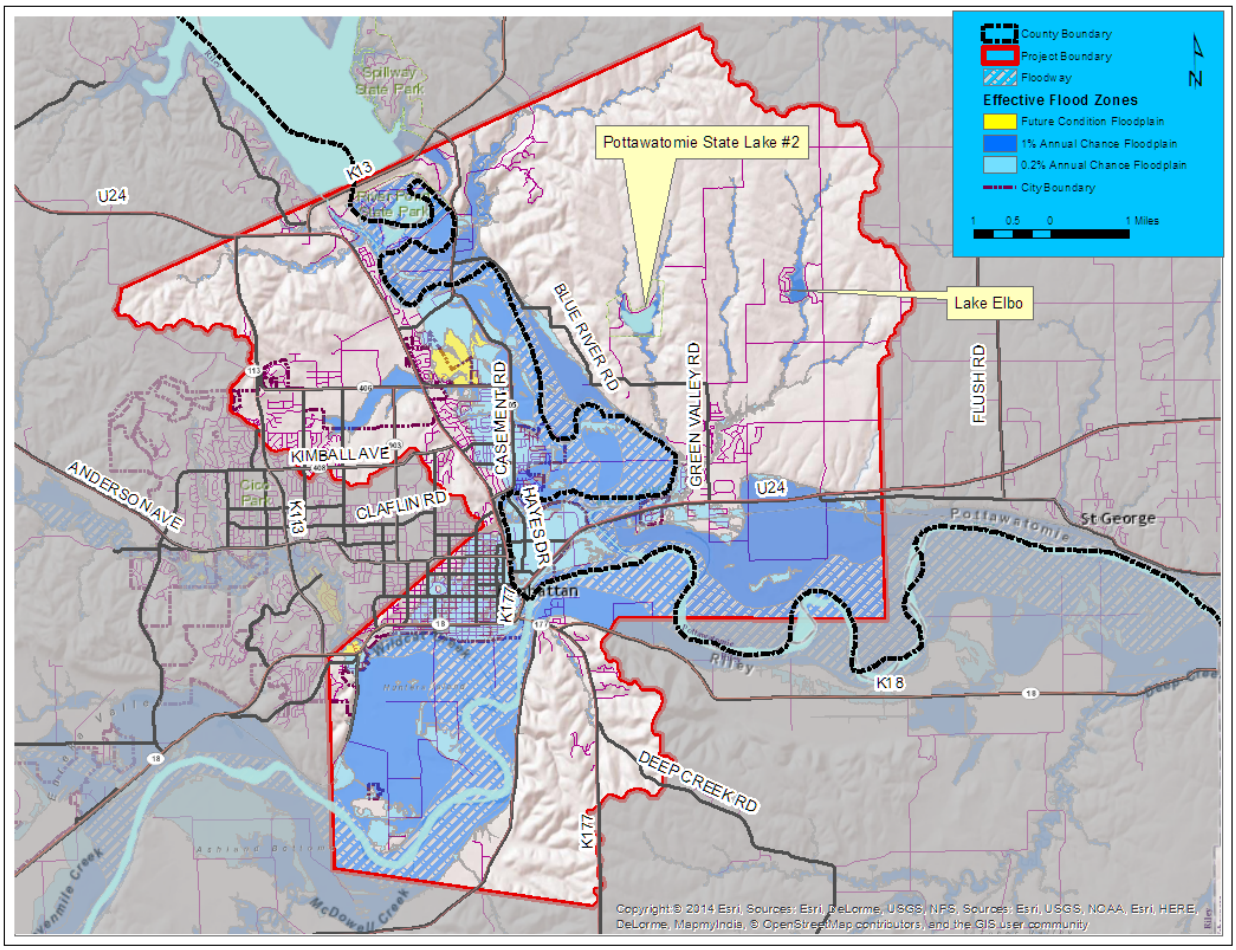


FIGURE 6: THE PROJECT AREA

REACH 1 FLOOD HAZARDS: KANSAS RIVER (UNPROTECTED SIDE OF LEVEE)

1. Identification of the Area. This area is west and south of the Manhattan Levee alignment outside of its protection area. This includes the Kansas River area west and upstream of the confluence with the Big Blue River. Hunter's Island is within this reach. Wildcat Creek is adjacent to the northwest side of this area (see Wildcat Creek Floodplain Management Plan, separate document).

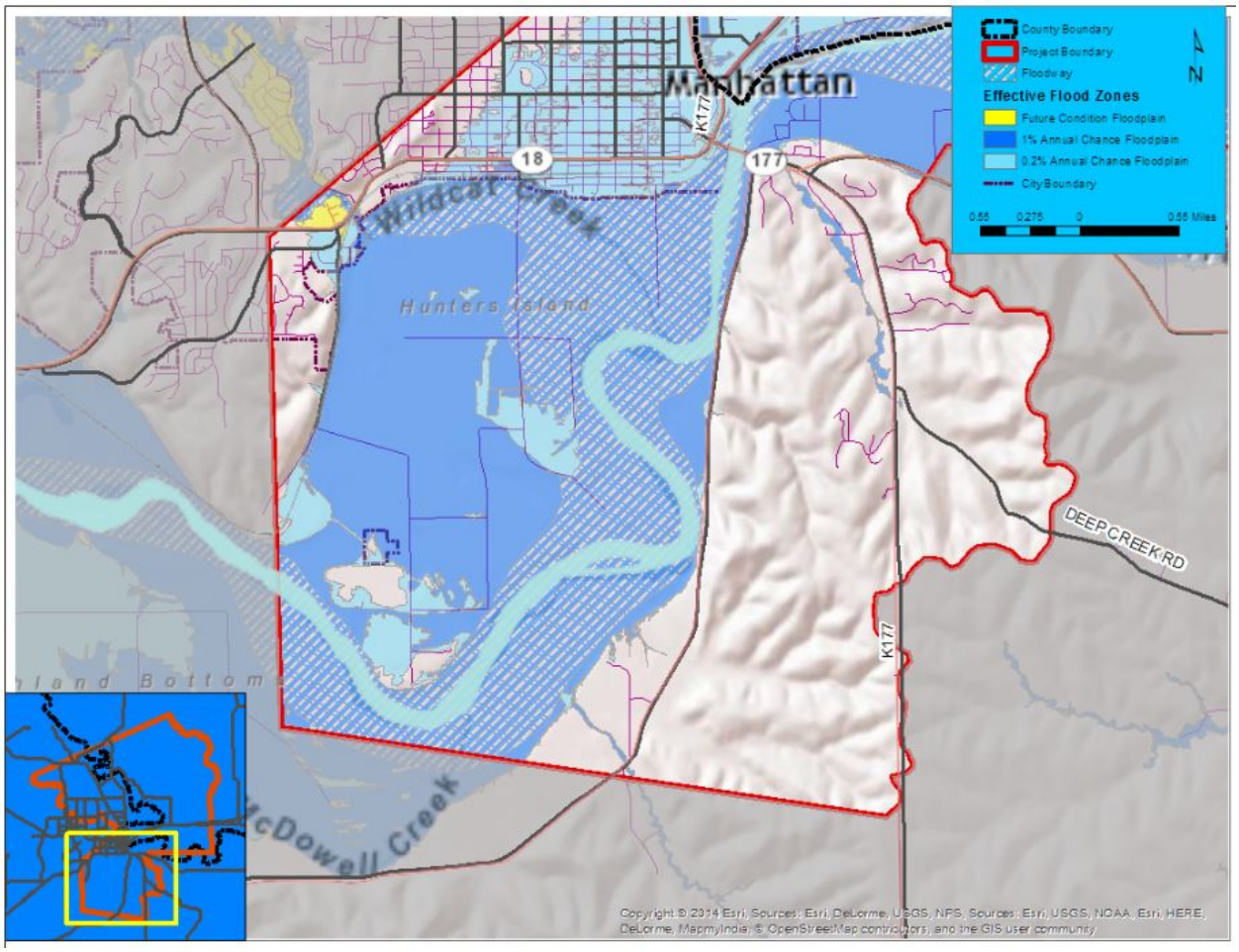


FIGURE 7: KANSAS RIVER (UNPROTECTED SIDE OF LEVEE)

2. Source of the Problem. The main source of the flood risk for this reach is the Kansas River and its interaction with the Big Blue River and Wildcat Creek. As previously mentioned, both the Kansas River and the Big Blue River are controlled waterways, which diminish the potential for flash floods. Wildcat Creek is uncontrolled and creates flash flood conditions in this reach. The extent of Wildcat Creek's flooding can be impacted by the flows in the Kansas River. When the Kansas River's stream flows are high, Wildcat Creek has limited abilities to drain, causing a backwater effect into Hunter's Island and other areas upstream along Wildcat Creek. This same backwater effect occurs on the Big Blue River at the confluence with the Kansas River.

3. Flood Data. The vast majority of this reach is within a mapped floodplain or floodway. The Summary of Discharge table from the 2015 Riley County Flood Insurance Study (FEMA, 2015) lists the peak discharge at the confluence with the Big Blue River during the 1% Annual Chance Flood event (100-year flood) as 177,300 cfs. The 2015 flood model shows the flood elevation of the 1% Annual Chance Flood elevation at the K-177 Bridge to be 1017.1 feet. At the intersection of S. Manhattan Avenue and Collins Lane, the 1% Annual Chance Flood elevation is 1020.8 feet.

4. Recent Flood History. As described above, the Kansas River and the Big Blue River experienced frequent flooding during the early to mid-1900, the worst event being in 1951. Since the construction of Tuttle Creek Reservoir and the Manhattan Levee System, the largest flood of record was in 1993. This flood threatened to overtop and/or breach the levee system, inundating the City of Manhattan. Fortunately, the flood waters receded and the levee system remained intact; protecting the City from catastrophic flooding.

   Although 1993 is the major flood of record since the 1960's, there has been flooding in this reach of the study area in recent years. This has primarily been the result of flash flooding along Wildcat Creek. These flood events have occurred in 2007, 2010 and 2011. During a flood on Wildcat Creek, the floodwater inundates this portion of Riley County and spreads out in the low, flat areas adjacent to the Kansas River. Homes and businesses along S. Manhattan Avenue were significantly impacted by these floods.

5. Land Use & Building Data. The area can be classified as predominately agricultural, with a few farm houses, large lot, single-family residences and a few businesses. The businesses include, but not limited to, a sand and gravel dredging operation, a contractor business and Riley County's solid waste facility. The businesses are approximately 20 to 30 years old.

   Most of the homes within this reach of the study were built from the 1930's through the 1960's. A number of homes were purchased by Riley County, using Federal Disaster Grant funds, following the 1993 flood event. These tracts of land are vacant and held by Riley County as open space, with development controlled by deed restrictions.

6. Development Trends. The Hunter's Island area has remained relatively agricultural and largely undeveloped. Because of the risk of flooding from the floodway and the 1% Annual Chance Floodplain, this area is projected to remain relatively undeveloped.

7. Development Constraints. The majority of this reach is either in the Floodway or in the 1% Annual Chance Floodplain. The risk of flooding is the largest constraint towards development. Essentially no development can occur in the Floodway. Development in 1% Annual Chance Floodplain requires at least one (1)-foot of freeboard above the base flood elevation. This would require fill or floodproofing of approximately 2 - 5 feet throughout much of the area.

8. Critical Facilities. Riley County Rural Fire Department's Hunter's Island fire station and Riley County's solid waste facility are located within this reach. Manhattan Township's maintenance facility is also located within this reach.

Reach 2 Flood Hazards: Blue Township

Identification of the Area. This reach is the suburban and highway commercial area of Pottawatomie County on the east bank (left bank looking downstream). The area includes community commercial, industrial, and agricultural land uses. U.S. 24 Highway, including the properties north and south are part of this reach.

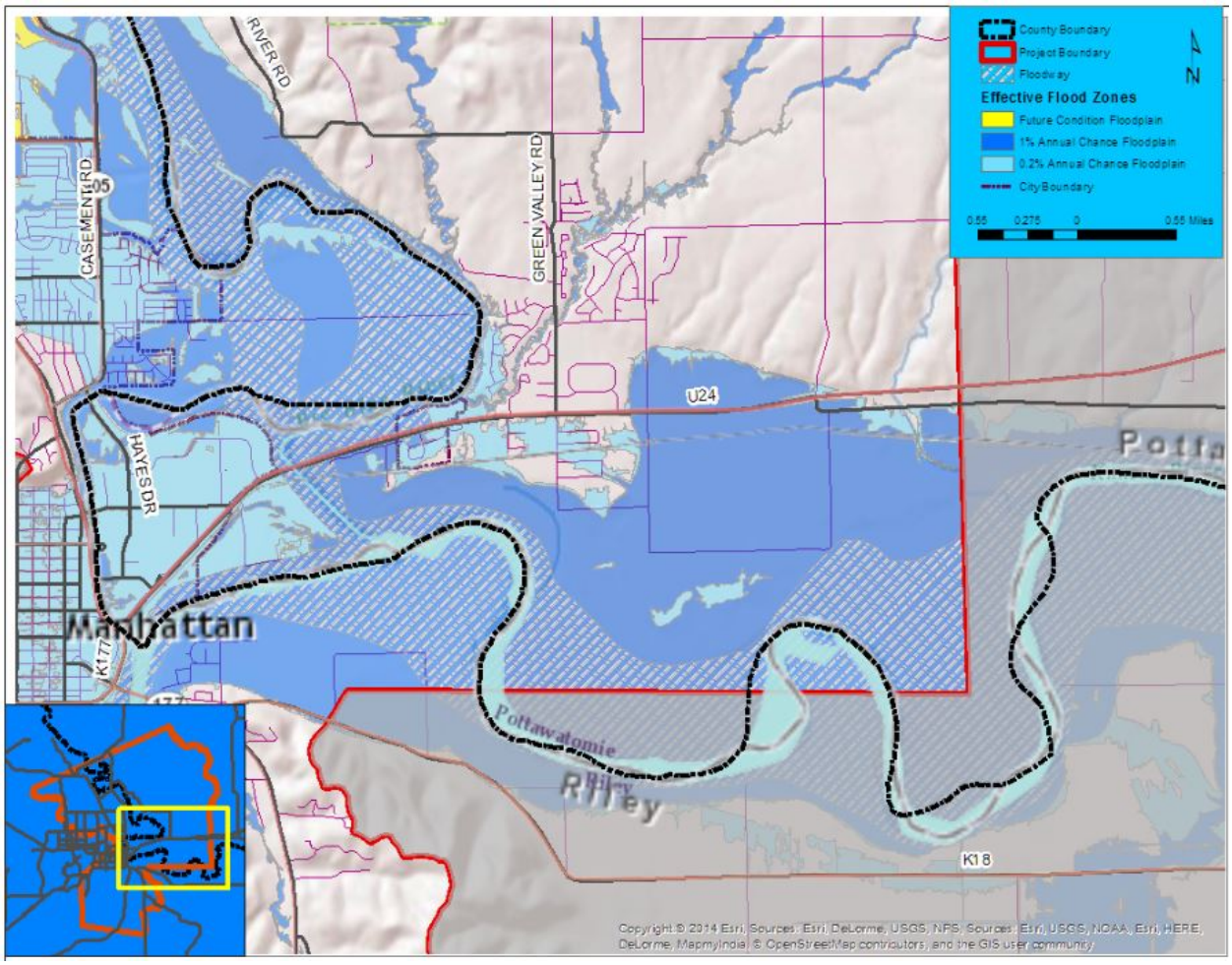


Figure 8: Blue township

1. Source of the Problem. The flood risk associated with this reach is from the Big Blue River and the backwater effect at the confluence of the Big Blue River and Kansas River. The flood risk is also caused by two constrictions: the U.S. Highway 24 Bridges and the Union Pacific railroad bridge. As with other ravine flooding conditions, unmonitored and controlled vegetation in the stream channel can adversely impact flooding.

   Near the confluence with the Kansas River, much of the flood risk is due to property being in the floodway of the Big Blue or backwater effects created by the confluence of the two major rivers. Both of these scenarios significantly impact the commercial and agricultural uses in this reach of the study.

During an event at or larger than a 1% Annual Chance Flood event, floodwaters will overtop U.S. Highway 24, which increases the flood risks in this reach by allowing more floodwaters to flow freely throughout the area.

In addition, of the flood risks associated with the Big Blue River, Elbo Creek flows into the Big Blue River. This small creek is the outflow of Lake Elbo to the north and creates a flood risk for several single-family homes adjacent to the creek. Elbo Creek does have steep banks, so the flood risk is largely contain within those banks. However, the creek is extremely windy; with several, nearly 90 degree turns. Because of the creek form, severe erosion can be a concern for landowners adjacent to Creek.

2. Flood Data. The significant portion of this reach is within a mapped floodplain or floodway. The Summary of Discharge table from the 2015 Riley County Flood Insurance Study (FEMA, 2015) lists the peak discharge at the mouth of the Big Blue River at the during the 1% Annual Chance Flood event (100-year flood) is 71,600 cfs. The 2015 flood model shows the flood elevation of the 1% Annual Chance Flood elevation at the US-24 bridge to be 1013.9 feet.

   At the Green Valley Road Bridge, near Elk Creek Road, the 1% Annual Chance Floodplain is 1026 feet.

3. Recent Flood History. The Kansas River and the Big Blue River saw frequent flooding in the early to mid-1900. The 1908 flood event on the Big Blue River altered the river channel, moving it to the east and generally way from the City of Manhattan. The most damaging event being in 1951. This flood event was caused by significant rains in the region in both the Kansas River and Blue River Valley. The result was massive flooding in Manhattan's older neighborhoods, central business district and industrial areas along the rivers, as well as the rural areas throughout the region. Since the construction of Tuttle Creek Reservoir and the Manhattan Levee System, the largest flood of record was in 1993.

   At the time, the 1993 flood was assumed to be larger than the 1% Annual Chance Flood event, as shown in the Flood Insurance Study (FIS) and the Flood Insurance Rate Maps (FIRMs) at that time. The current FIS and FIRMs have studied the flood situation, in part, using the 1993 flood event, and have concluded the event was more likely a "75-year storm" and not as intense as originally assumed. The 1993 caused significant damage to the homes and businesses in this reach.

4. Land Use & Building Data. This reach has a mix of agricultural uses near the Big Blue River, commercial and industrial uses along U.S. Highway 24 and single-family homes to the north and south of U.S. Highway 24. The commercial and industrial areas along the highway range from 20 – 30 year old developments to new developments. The residential uses in the reach are similar in age. This area has been a major residential growth area for the region over the past several years.

5. Development Trends. Blue Township is a growth corridor for Pottawatomie County and the region. Several new commercial areas have been developed in recent years along the highway corridor. To the north and south the of highway corridor, a large number of single-

family residential neighborhoods have been developed. This trend will continue for the unforeseeable future, as the region continues to grow. Areas along U.S. Highway 24 will continue to develop or re-develop as commercial space.

6. Development Constraints. To the north and west side of the Blue Township is floodway and floodplain of the Big Blue River. The floodway will be a significant constraint to development, as development or re-development is largely prohibited. Development in the floodplain will require new commercial or industrial development be elevated or floodproofed to one (1)-foot above the base flood elevation, which is roughly 1015 feet along the highway.

7. Critical Facilities. A number of critical facilities are located in Blue Township, including a fire station, a sheriff's department sub-station office and a parochial school. However, none of these facilities are located in a high risk flood zone.

   There are a number of businesses in this reach of the Big Blue River that sell, store and/or produce hazardous materials above the Tier II threshold that are considered critical facilities. Because of the need to keep these critical facilities confidential, the exact location has not been provided; however, officials of Pottawatomie County, Riley County, the City of Manhattan and the State of Kansas have the location and information regarding these facilities.

Reach 3a-d Flood Hazards: Urban Manhattan, Various Sub-Watersheds

Reach 3a: City of Manhattan Protected by Levee System

1. Identification of the Area. The Manhattan Levee System protects a large portion of the originally platted land of Manhattan and all of the commercial and industrial areas along Tuttle Creek Boulevard and McCall Road.

   The older portion of the City protected by the levee system includes Manhattan's Central Business District, the commercial and industrial areas along Ft. Riley Boulevard and the original Ward District neighborhoods of Manhattan. Specifically, the area impacted by the 1% Annual Chance Floodplain or 0.2% Annual Chance *Floodplain if the levee was not present* would generally be a diagonal line starting near the intersection of S. 17th Street and Ft. Riley Boulevard and ending near the corner of Bertrand Street and N. 5th Street. Everything to the east of this approximate line is at an elevation, which if the levee was not constructed, would be impacted by a 1% Annual Chance Flood or a larger flood event.

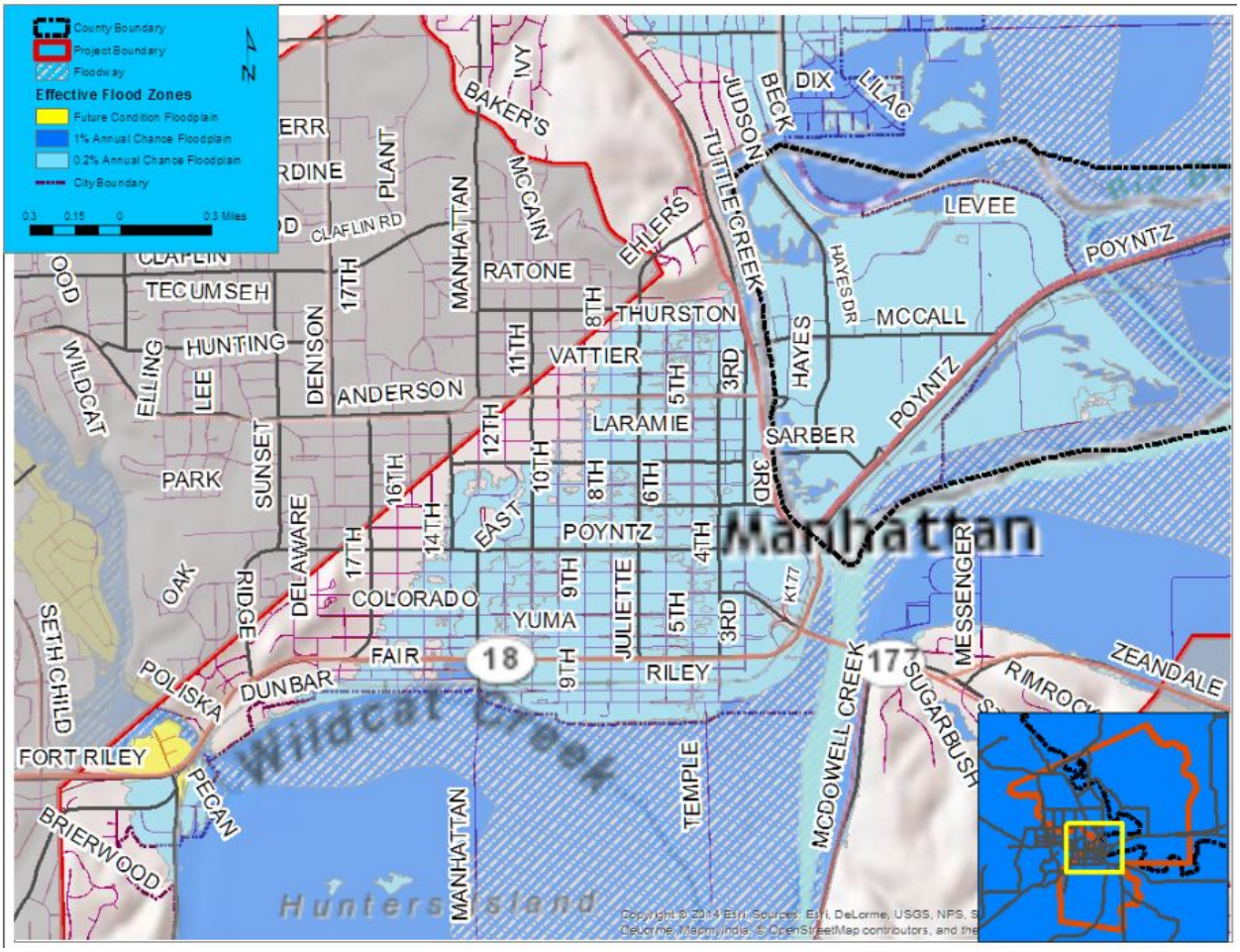


FIGURE 9: CITY OF MANHATTAN PROTECTED BY LEVEE

2. <u>Source of the Problem</u>. The existing Manhattan Levee System protects a large majority of the area described above from the 1% Annual Chance Flood event. The levee system was certified by FEMA on February 3, 2013 to protect against at least the 1% Annual Chance Flood elevation event plus three (3) feet.

   The March 16, 2015 Flood Insurance Study and corresponding Flood Insurance Rate Maps shows ponding affects for some of the commercial and industrial properties along Tuttle Creek Boulevard, particularly the large drainage ditch, and low lying areas near the Big Blue River Levee segment. This area along McCall Road and Hayes Drive has experienced rapid redevelopment. The redevelopment activity has added substantial fill in the area to improve site drainage and prevent flood risks from shallow ponding. Generally speaking, the mapped flooding related to ponding is a function of the stormwater runoff being "trapped" behind the levee system when drainage gates are closed due to high water stages on the Big Blue River and the Kansas River. In these situations, pump systems are required to move the water up and over the levee system to reduce the flooding impacts behind the levee.

Localized flooding can also occur due to minor changes to the local terrain, drainage channels or failures of private or public infrastructure, such as plugged rain spouts, street inlets or culverts.

3. Flood Data. As previously described, the Manhattan Levee System protects a vast majority of this reach from at least the 1% Annual Chance Flood event. The portion of the reach that is in a mapped 1% Annual Chance Floodplain is the result of shallow flooding that ponds behind the levee and collects in the roadway, in various roadside ditches and the large drainage structures along Tuttle Creek Boulevard, commonly referred to as the "Pretty Ditch". The Base Flood Elevation for this area is a static 1008 feet.

4. Recent Flood History. As described above, the Kansas River and the Big Blue River experienced frequent flooding in the early to mid-1900. The worst event being in 1951. Since the construction of Tuttle Creek Reservoir and the Manhattan Levee System, the largest flood of record was in 1993. This flood threatened to overtop and/or breach the levee system, inundating this area. Fortunately, the flood waters receded and the levee system remained intact; protecting this area from catastrophic flooding.

   Although 1993 was the only major flood since the 1960's, there has been flooding on the dry side of the levee that has impacted several properties. This localized flood risk has been a result of the relatively flat land in the area, undersized and/or lack of stormwater infrastructure in the residential and commercial areas of the Ward Districts and the limited points for the stormwater to drain towards the river. A number of stormwater infrastructure improvement projects were outlined in the Eastside Drainage Report (BG Consultants, 2006) to improve drainage to the east of Tuttle Creek Boulevard. A number of these projects were completed with the McCall Road improvements in 2013. However, localized flooding still remains an issue in this reach.

5. Land Use & Building Data. The Manhattan Levee System protects over $1 billion dollars of existing development. This includes a mix of residential, commercial, industrial land uses, schools and public infrastructure.

   The residential land uses comprise a mix of single-family and multiple-family development ranging in age from the early Manhattan homes, some of which have been designated as historic properties or districts, to newly renovated, and brand new residential structures, most of which are multiple-family apartment buildings.

   The commercial properties include the historical Central Business District, Manhattan Town Center Mall, and the new redevelopment areas situated to the north and south of the Central Business District. The area to the east of Tuttle Creek Boulevard is a mix of commercial and industrial uses. The properties along McCall Road and the Tuttle Creek Boulevard Frontage Road have experienced a recent trend to redevelopment the properties to big box commercial stores, drive-thru restaurants and similar highway commercial uses.

   Industrial uses, such as manufacturing, warehouses, trades offices; and service commercial uses, like auto mechanics and self-storage are present in the McCall Road area and along Ft. Riley Boulevard.

6. Development Trends. This reach has experienced area of preservation of historic structures and neighborhoods, including the Central Business District, as well as large areas of redevelopment. The areas to the north and south of Poyntz Avenue have had a significant amount of both public and private redevelopment activity. The areas along McCall Road and Tuttle Creek Boulevard have also had a number of redevelopment projects that has shifted the area along the major arterial roadways from industrial uses to highway commercial uses. Additional redevelopment can be expected in this reach for residential, commercial and industrial uses.

7. Development Constraints. With the protection of flooding by the Manhattan Levee System, there are no significant constraints on development or redevelopment.

8. Critical Facilities. A number of critical facilities are located in this reach that service the entire City, suburbanized and rural areas of Pottawatomie County and Riley County (Executive Order 11988).

   The City's Water Treatment Plant, including some of the raw water wells and the Waste Water Treatment Plant are located on the protected side of the Manhattan Levee System. Through inter-local agreements, the City wholesales water and in some situations, sanitary sewer services to the suburbanized and rural areas of the two (2) aforementioned counties.

   Manhattan City Hall, a number of the City's department buildings, the Riley County Courthouse and administrative buildings are located behind the Manhattan Levee System.

   Three (3) USD 383 Manhattan/Ogden elementary schools, the 9th Grade Center and the Manhattan Catholic School are protected by the levee system. There are also a number of businesses and residential uses that cater to the young or elderly (i.e. childcare centers & assisted living centers) in this area that are also behind the Manhattan Levee System.

   There are a number of businesses in this reach of the Big Blue River which sell, store and/or produce hazardous materials above the Tier II threshold and are therefore considered critical facilities. Because of the need to keep these critical facilities confidential, the exact location has not been provided; however, officials of Pottawatomie County, Riley County, the City of Manhattan and the State of Kansas have the location and information regarding these facilities.

Reach 3b: City of Manhattan – Northeast Park Area (Unprotected)

1. Identification of the Area. This area is generally located to the north of the Manhattan Levee System – Big Blue River Segment, east of Casement Road and along Knox Lane. This area historically was the old river channel of the Big Blue River until the flood of 1908, which moved the portion of the Big Blue River to the east, away from the City of Manhattan ("Riley County," n.d.). This area of the City was most impacted by the 1993 flood event.

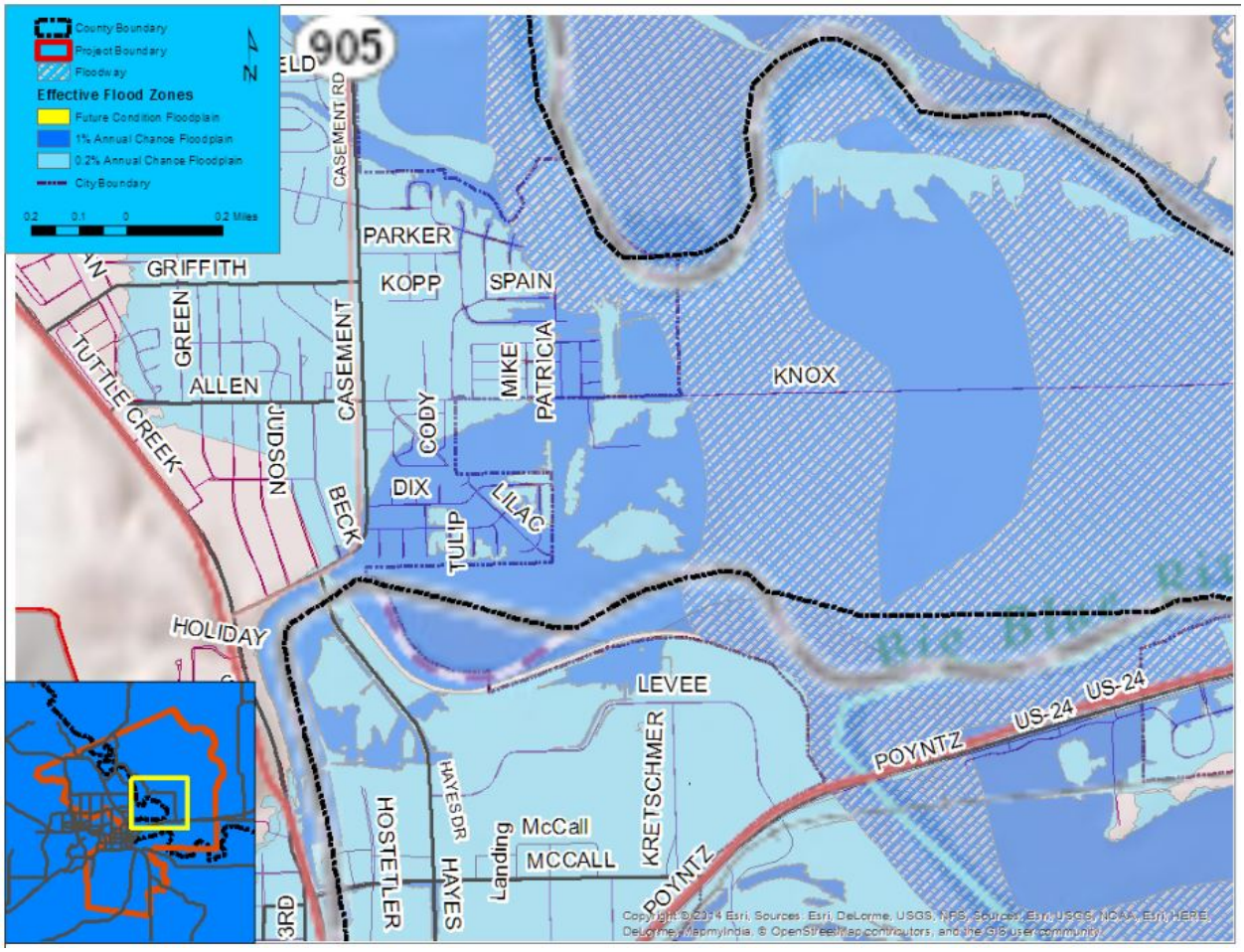


FIGURE 10: CITY OF MANHATTAN – NORTHEAST PARK AREA

2. Source of the Problem. The source of the flooding problem is when the Big Blue River is at or above the flood stage for the 1% Annual Chance Floodplain (100-year floodplain). The Summary of Discharge table from the 2015 Riley County Flood Insurance Study (FEMA, 2015) lists the peak discharge for the Big Blue River at the mouth of the river during the 1% Annual Chance Flood event (100-year flood) is 71,600 cfs. During this size of a storm, the Big Blue River leaves the confines of its banks and impacts the area in a variety of ways. A wide, natural overflow channel is created, causing an oxbow in the river. This overflow channel directs the flood waters immediately to the south towards the confluence with the

Kansas River. Due to the relatively flat ground in the area, the flood waters spread out from this natural overflow channel and impacts the immediate area.

During this size of flood event, the river follows the former river channel that was altered during the 1908 flood (Riley County, n.d.) The old river channel generally runs in a diagonal line from the intersection of Spruce Street and Knox Lane to the intersection of Hayes Drive and Casement Road. The flood water than meets the Manhattan Levee System and is diverted back to the natural overflow channel via a drainage ditch on the west side of the levee.

Localized flooding can also occur due to minor changes to the local terrain, drainage channels or failures of private or public infrastructure, such as plugged rain spots, street inlets or culverts.

3. Flood Data. The Summary of Discharge table from the 2015 Riley County Flood Insurance Study (FEMA, 2015) lists the peak discharge for the Big Blue River at the mouth of the river during the 1% Annual Chance Flood event (100-year flood) is 71,600 cfs. The 2015 flood model shows the flood elevation of the 1% Annual Chance Flood elevation for the Dix Addition, generally south of Knox Lane and east of Casement Road ranged from 1015.7 feet on the northern edge of the residential neighborhood to 1015.2 feet on the southern edge of the area. The 1% Annual Chance Flood elevation in the Countryside Manufactured Home Community to the south of Knox Lane is 1016.0 feet. The Countryside Manufactured Home Community to the north of Knox Lane has a flood elevation ranging from 1016.5 feet on the north to 1016.1 feet to the south.

4. Recent Flood History. The Kansas River and the Big Blue River experienced frequent flooding in the early to mid-1900's. The 1908 flood event on the Big Blue River altered the river channel, moving it to the east and generally way from the City of Manhattan. The most damaging event being in 1951. This flood event was caused by significant rains in the region in both the Kansas River and Blue River Valley. The result was massive flooding in Manhattan's older neighborhoods, central business district and industrial areas along the rivers, as well as the rural areas throughout the region. Since the construction of Tuttle Creek Reservoir and the Manhattan Levee System, the largest flood of record was in 1993.

   At the time, the 1993 flood was assumed to be larger than the 1% Annual Chance Flood event, as shown in the Flood Insurance Study (FIS) and the Flood Insurance Rate Maps (FIRMs) at that time. The current FIS and FIRMs have studied the flood situation, in part, using the 1993 flood event, and have concluded the event was more likely a "75-year storm" and not as intense as originally assumed. The 1993 flood caused significant damage to the homes in this reach.

5. Land Use & Building Data. This reach is predominately single-family homes, some of which are manufactured homes. The Manufactured Home Parks were established in the 1960's. The Dix Addition was built in the 1970's and the Knoxberry Addition began developing in the 1980's.

6. Development Trends. The area is almost completely built out. Single-family homes are built on moderately sized lots (7,500 square feet to 10,000 square feet). The home designs are generally ranch style, some with basements or walkout basements. Other homes are built with slab on grade foundations. The manufactured homes in the area are part of a large manufactured home park, Countryside Estates. The layout of the residential neighborhoods is a function of the subdivision design. No significant terrain elements dictated how the homes were developed.

7. Development Constraints. The reach is almost completely built out. Vacant land located to the east towards the Big Blue River has been designated as Flood Hazard Area on the Future Land Use map of the 2015 Manhattan Urban Area Comprehensive Plan. This designation corresponds to the effective Flood Insurance Rate Maps (March 16, 2015) or the vacant land inundated by the 1993 flood event. Through the Comprehensive Plan process, the community has determined that development should be prohibited in the Flood Hazard Area because of the "potential to endanger life, resources, and property."

8. Critical Facilities. There are no critical facilities due to the small size of the reach.

Reach 3c: City of Manhattan – Prairie Lakes Area (Unprotected)

1. Identification of the Area. The residential area is defined by the manmade lake, Prairie Lakes and its manmade and natural drainage channel that drains into the Big Blue River. The reach includes the residential properties in the Knoxberry and Hackberry Subdivisions to the east of Casement Road, as they are adjacent to the confluence of the Prairie Lakes drainage channel with the Big Blue River.

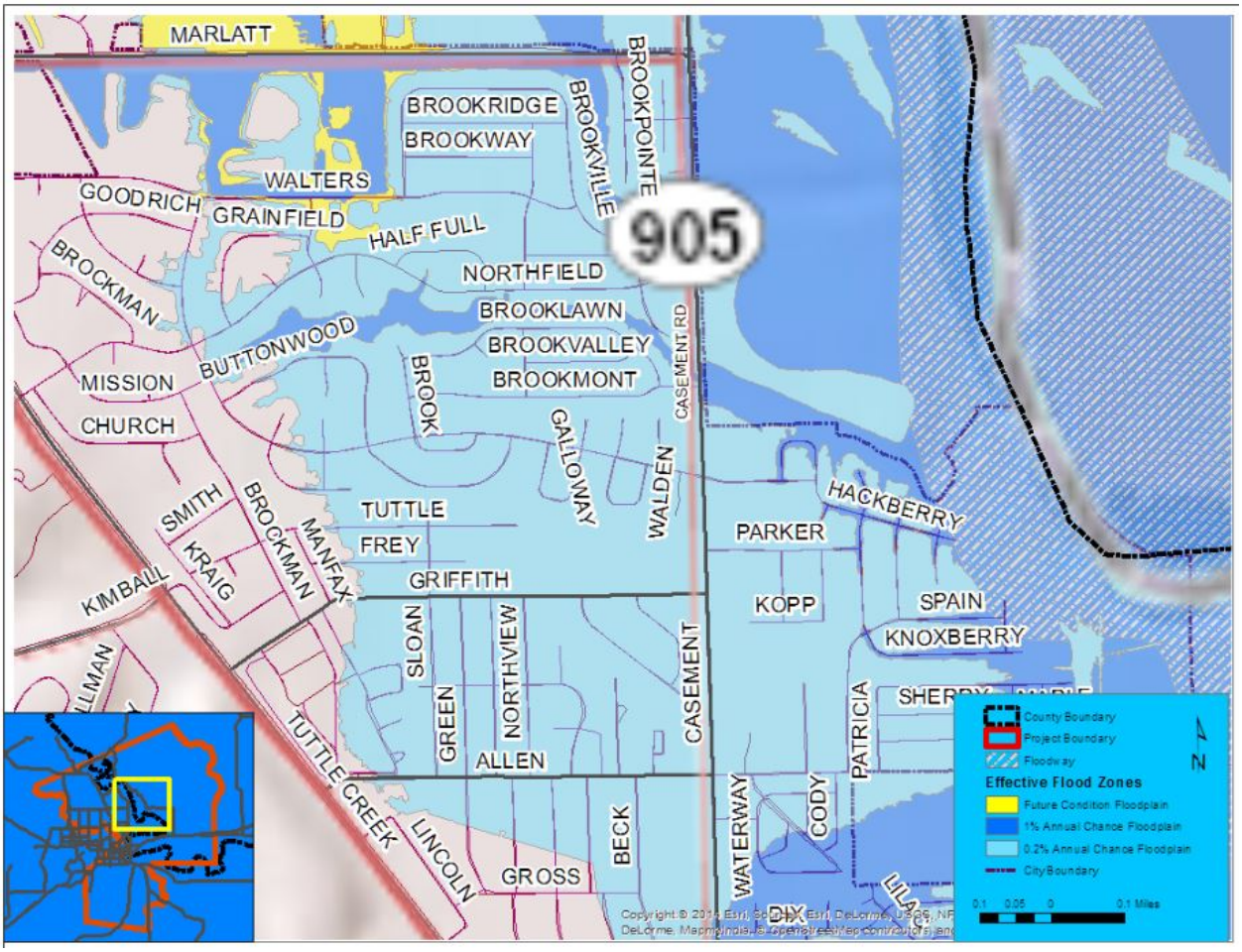


FIGURE 11: CITY OF MANHATTAN – PRAIRIE LAKE AREA

2. Source of the Problem. The source of flooding is both from the drainage of Prairie Lakes, a small lake designed to handle the stormwater runoff from the surrounding residential neighborhoods and from the effects of the Big Blue River.

   Prairie Lakes is an approximately eleven (11) acre body of water that is approximately 10 – 15 feet deep. The wet basin is on a separate tract of land and is owned and maintained by the home owners association. The separate tract is adjacent to the rear yards of several homes in the neighborhood. Near the intersection of Brookhaven Drive and Brooklawn Drive, the basin drains to a concrete lined drainage channel that directs the overflow from the lake to the Big Blue River. The channel is in the rear of many homes. The channel crosses under Casement Road, where the channel becomes unimproved and is in its "natural state". The channel then flows to the southeast, adjacent to the Hackberry & Knoxberry Subdivisions until it reaches the Big Blue River.

   In addition to the flood risks associated with Prairie Lakes, the Big Blue River impacts these areas by inundating low lying areas associated with the old river channel. The low lying areas, including some residential areas in the Knoxberry subdivision are in the mapped

floodway. There is also a risk of flood waters backing up into the drainage channel of Prairie Lakes.

3. Flood Data. The entire area is relatively flat. The mapped 1% Annual Chance Floodplain generally follows the natural and manmade channel and the low lying areas, as described above. The elevation of the 1% Annual Chance Floodplain throughout the reach is approximately 1018 feet.

4. Recent Flood History. As previously described, the last major flood event on the Big Blue River was in 1993. The only developments in this reach that existed at the time of the 1993 flood were in the Knoxberry Addition on the extreme eastern edge of the City, adjacent to the Big Blue River. These homes were impacted by the flooding in 1993.

   All other existing developments in this reach were constructed after 2002. Before these neighborhoods were constructed, it was farmland within the Big Blue River Valley. The developer of these newer homes took additional measures to minimize the risk of flooding by increasing the ground or building elevation above the flood elevations known at that time. However, as previously discussed, the FEMA and USACE mapping products at the time underestimated the base flood elevations, as they are related to the USACE operation of Tuttle Creek Reservoir.

5. Building Data. The reach consists of single-family, single-family attached, and two-family homes built from 1990's to present. The foundations of the homes range from full basements to slab-on-grade.

6. Development Trends. The area is almost completely built out. A small area on the east side of Prairie Lakes is currently under construction. This is the last remaining vacant area of residential land.

   Single-family homes are built on moderately sized lots (7,500 square feet to 10,000 square feet). The home designs are generally ranch style homes with slab on grade foundations. The layout of the residential neighborhoods is a function of the subdivision design. Other than the location of the retention basin, no significant terrain elements dictated how the homes were developed.

7. Development Constraints. The reach is almost completely built out. Vacant land located to the east towards the Big Blue River has been designated as Flood Hazard Area on the Future Land Use map of the 2015 Manhattan Urban Area Comprehensive Plan. This designation corresponds to the effective Flood Insurance Rate Maps (March 16, 2015) or the vacant land inundated by the 1993 flood event. Through the Comprehensive Plan process, the community has determined that development should be prohibited in the Flood Hazard Area because of the "potential to endanger life, resources, and property."

8. Critical Facilities. Due to the small size of the reach there are no critical facilities.

Reach 3d: City of Manhattan – Marlatt Avenue Area (Unprotected)

1. Identification of the Area. This reach of the unprotected areas of the City of Manhattan is along the Marlatt Ditch. The headwaters of the small watershed are generally on the Kansas State University property to the west. This land is currently used for row crop agricultural research. The flood hazard analysis was focused on the area east of Tuttle Creek Boulevard to the Big Blue River.

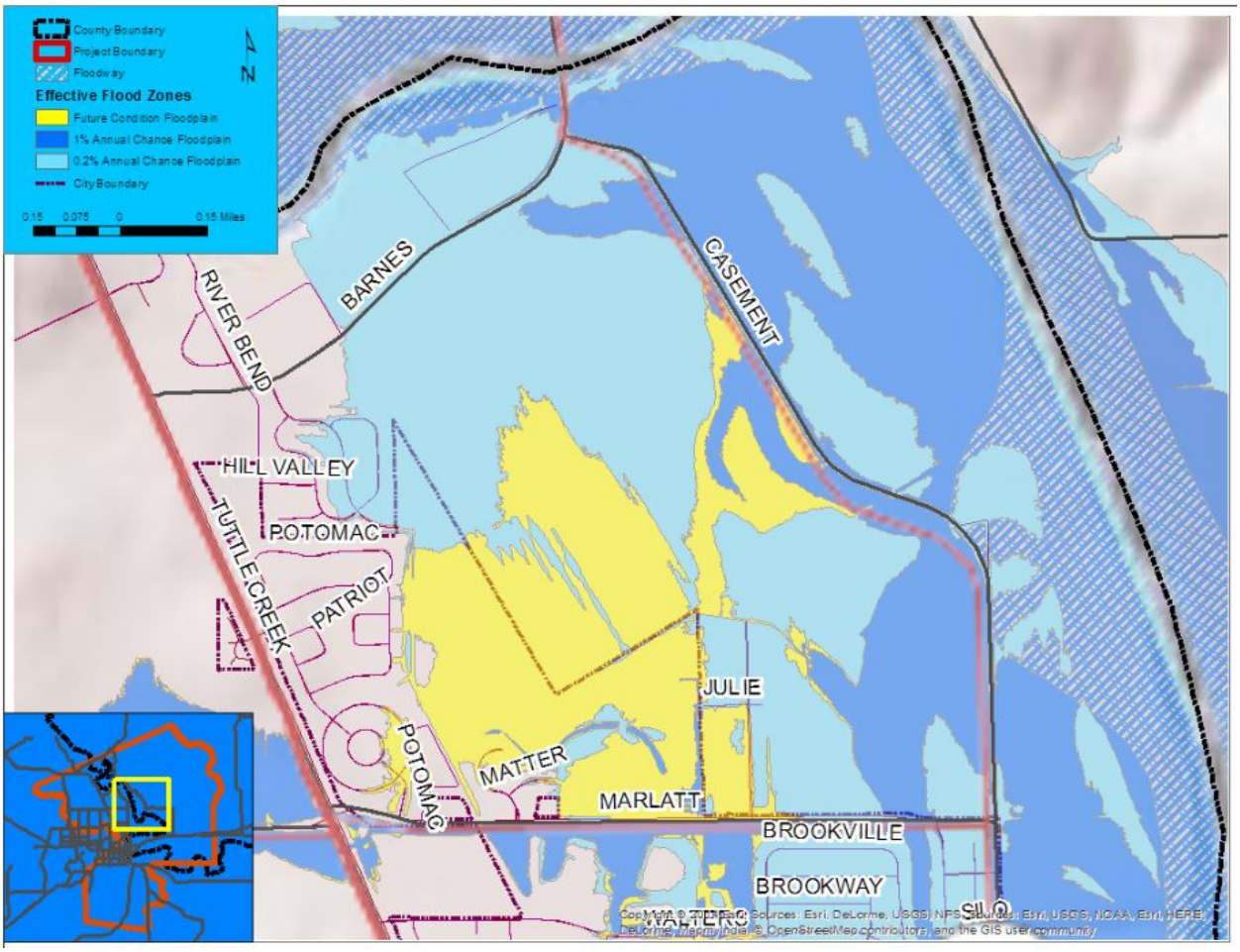


FIGURE 12: CITY OF MANHATTAN – MARLATT AVENUE AREA

2. Source of the Problem. The main source of flooding issues for the reach is due to backwater effects from the Big Blue River during significant storm events. The flood waters on the Big Blue River would travel upstream in the ditch and inundate affected areas. The potential exists for stormwater runoff from developments in the upper reaches of the drainage basin to impact properties downstream. This could be exacerbated during flood stages on the Big Blue River.

   The City of Manhattan hired AMEC Foster Wheeler to conduct a study to determine if placing flap gates or other structures on existing culverts along Marlatt Ditch would lessen the backwater effects on properties to the north of Marlatt Avenue, while not increasing the

flooding impacts on the properties to the south of the roadway. The study determined that placing a flap gate on two (2) culverts along Marlatt Avenue could reduce the flood elevation of a 1% Annual Chance Storm by as much as 0.4 feet (AMEC, 2013). These two (2) culverts are adjacent to a rural Riley County residential neighborhood.

3. Flood Data. The entire area is relatively flat. The mapped 1% Annual Chance Floodplain generally follows the natural and manmade channel and the low lying areas, as described above. The elevation of the 1% Annual Chance Floodplain throughout the reach is approximately 1019 feet to the south of the Marlatt Ditch and 1020 feet to the north of Marlatt Ditch.

   This area is considered a growth corridor of Manhattan, primarily to the north of Marlatt Avenue. Because of this, the City had the Future Conditions Flood Study done for this area. The Future Conditions Flood Study was done by Foster Wheeler, using the base FEMA Flood Model used for the 2015 Riley County Flood Insurance Study Update (FEMA, 2015) and used the runoff values based on a complete build out of the watershed, as shown on Future Land Use Map of the 2003 Manhattan Urban Area Comprehensive Plan (City of Manhattan, 2005). The Future Conditions Flood Study predicts the 1% Annual Chance Flood area and elevations for future floods without stormwater management measures taken into account. The flood model predicts the most conservative future floodplain. The Future Conditions Flood Study is shown on the Flood Insurance Rate Maps (FIRM) as "Zone X Future Base Flood." The base flood elevation for the Future Conditions Floodplain is approximately 1022 feet.

4. Recent Flood History. As previously described, the last major flood event on the Big Blue River was in 1993. The majority of the new homes in this area were built after 2005. The residential developments outside of Manhattan City limits were built around 1980's. Older farmstead homes in the area were built in the early 1900's.

   The Brookfield Neighborhood began developing in 2005. Before these neighborhoods were constructed, the land use was farmland. The developer of these newer homes took additional measures to minimize the risk of flooding by increasing the ground or building elevation above the flood elevations known at that time. However, as previously discussed, the FEMA and USACE mapping products at the time underestimated the base flood elevations, as they are related to the USACE operation of Tuttle Creek Reservoir.

5. Building Data. The reach consists of single-family, single-family attached, two-family homes and a few apartment buildings constructed from the 1990's to present. The foundation construction of the homes consists of mostly slab-on-grade designs.
6. Development Trends. The area to the south of Marlatt Avenue is generally built out with single-family, single-family attached, two-family dwellings and a few apartments. The area to the north of Marlatt Avenue is a growth area of the City. This area is also where a number of existing single-family homes in rural Riley County are located. Recent developments include the Northwing Neighborhood, a single-family development and The Links at Manhattan apartment complex. The 2015 Manhattan Urban Area Comprehensive Plan shows this as

Low to Medium Residential, which generally equates to a residential density of less than 1 – 11 dwelling units per net acre.

7. Development Constraints. The largest development constraint to the undeveloped areas and future redevelopment areas is adequately managing stormwater runoff and protecting against floodwaters. Because of relatively flat grades, creating adequate slopes to drain stormwater runoff from a site to Marlatt Ditch and/or Casement Road is challenging. Unique stormwater management designs and construction has been developed for the Northwing Neighborhood and The Links at Manhattan apartment complex. These unique stormwater management designs also incorporated measures to protect again flood damages.

8. Critical Facilities. The only critical facility in the reach study area is a USD 383 Middle School site.

Reach 4 Flood Hazards: Rural Riley County, Big Blue River

1. Identification of the Area. This reach of the study is the unincorporated, rural areas of Riley County north of the City of Manhattan, within the immediate Blue River Valley. This reach includes private property bordered by the Big Blue River to the east, U.S. Highway 24 to the west, the city limits of Manhattan to the south and the State of Kansas and Army Corps of Engineers land associated with Tuttle Creek Reservoir to the north.

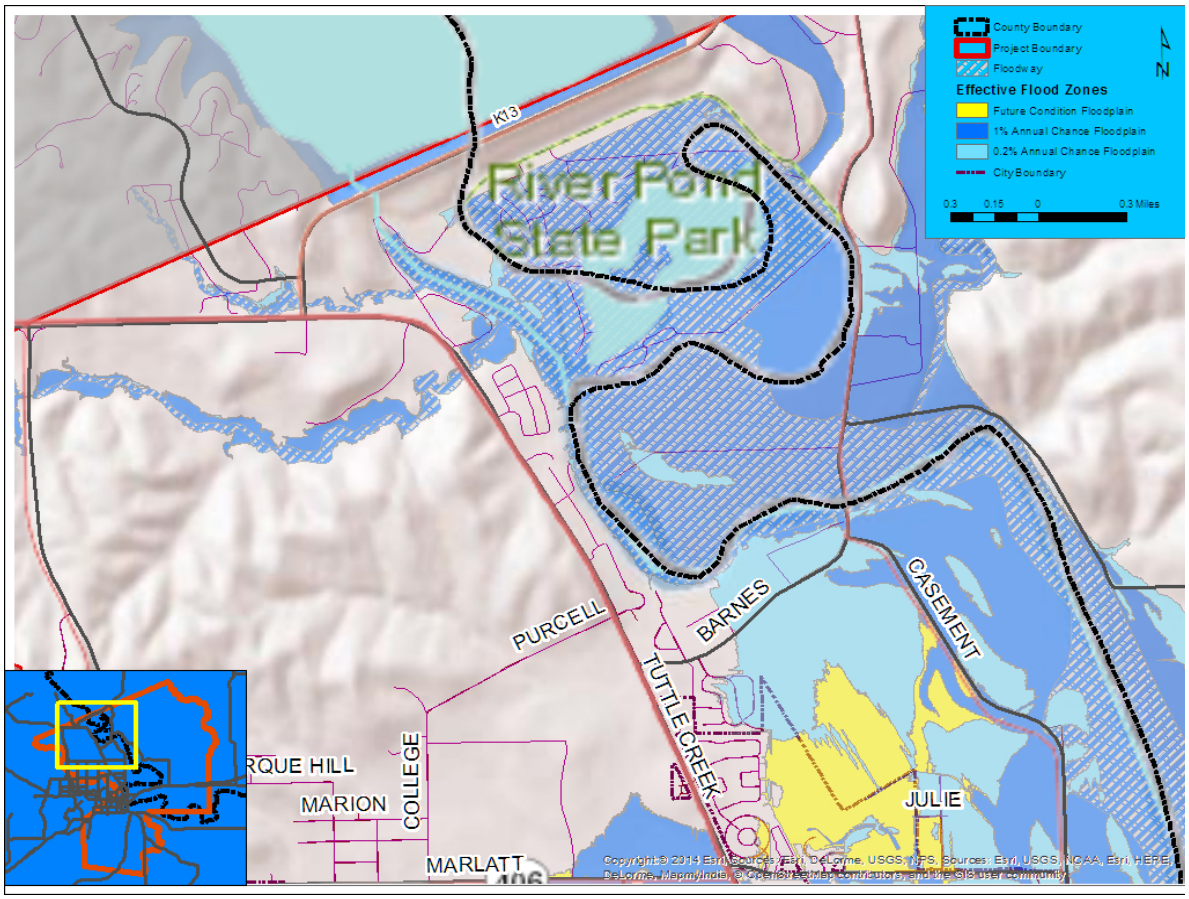


Figure 13: Rural Riley County – Big Blue River

2. Source of the Problem. The main source of flooding for this reach of the study is the Big Blue River. However, localized flooding in low-lying areas can occur due to the relatively flat grade of the reach and possible poor drainage throughout the area. The areas of concern for flooding are primarily along Casement Road and from Casement Road to the east towards the Big Blue River. Areas along road ditches and drainage channels are also susceptible to flooding due to backflow of floodwaters from the Big Blue River.

3. Flood Data. The entire area is relatively flat. The mapped 1% Annual Chance Floodplain generally follows the natural and manmade channel and the low lying areas, as described above. The elevation of the 1% Annual Chance Floodplain throughout the reach is approximately 1020 feet to the north of Marlatt Ditch and 1023 feet at the northern edge of the reach.

4. Recent Flood History. As described above, the Kansas River and the Big Blue River experienced frequent flooding in the early to mid-1900's. The worst event being in 1951. Since the construction of Tuttle Creek Reservoir and the Manhattan Levee System, the largest flood of record was in 1993. This flood event adversely impacted several of the farm houses, buildings, equipment, agricultural lands and livestock throughout the area.

5. Building Data. The area is mostly agricultural, with row crops and small livestock operations. There are a few single-family homes associated with the farms and "outbuildings" for equipment and livestock. The single-family subdivision on Nelson's Landing is located in this reach. This subdivision was developed in the mid- to late-1980's with slab-on grade homes and manufactured homes.

6. Development Trends. This area is considered a growth area for Manhattan and the region. The Manhattan Urban Area Comprehensive Plan, adopted in March 2015, shows this area low to medium residential density on the Future Land Use Map. A large apartment complex was approved by the City in 2015 on the southern edge of this reach. Development in this reach can be expected in the future if Manhattan and the region continue to grow.

7. Development Constraints. The largest development constraint to the undeveloped areas and future redevelopment areas is adequately managing stormwater runoff and protecting against floodwaters. Because of relatively flat grades, creating adequate slopes to drain stormwater runoff from a site to Barnes Road, the Marlatt Ditch and/or Casement Road is challenging. Unique stormwater management designs and construction have been developed for the recent developments in the City. These unique stormwater management designs also incorporated measures to protect again flood damages.

8. Critical Facilities. There are no critical facilities in this reach of the study area.

Reach 5 Flood Hazards: Rural Pottawatomie County, Big Blue River

1. Identification of the Area. This is the unincorporated, rural areas of Pottawatomie County outside of the commercial and suburban residential areas of Blue Township. This reach would be the east bank of the Blue River, bordered by Blue River Road to the east.

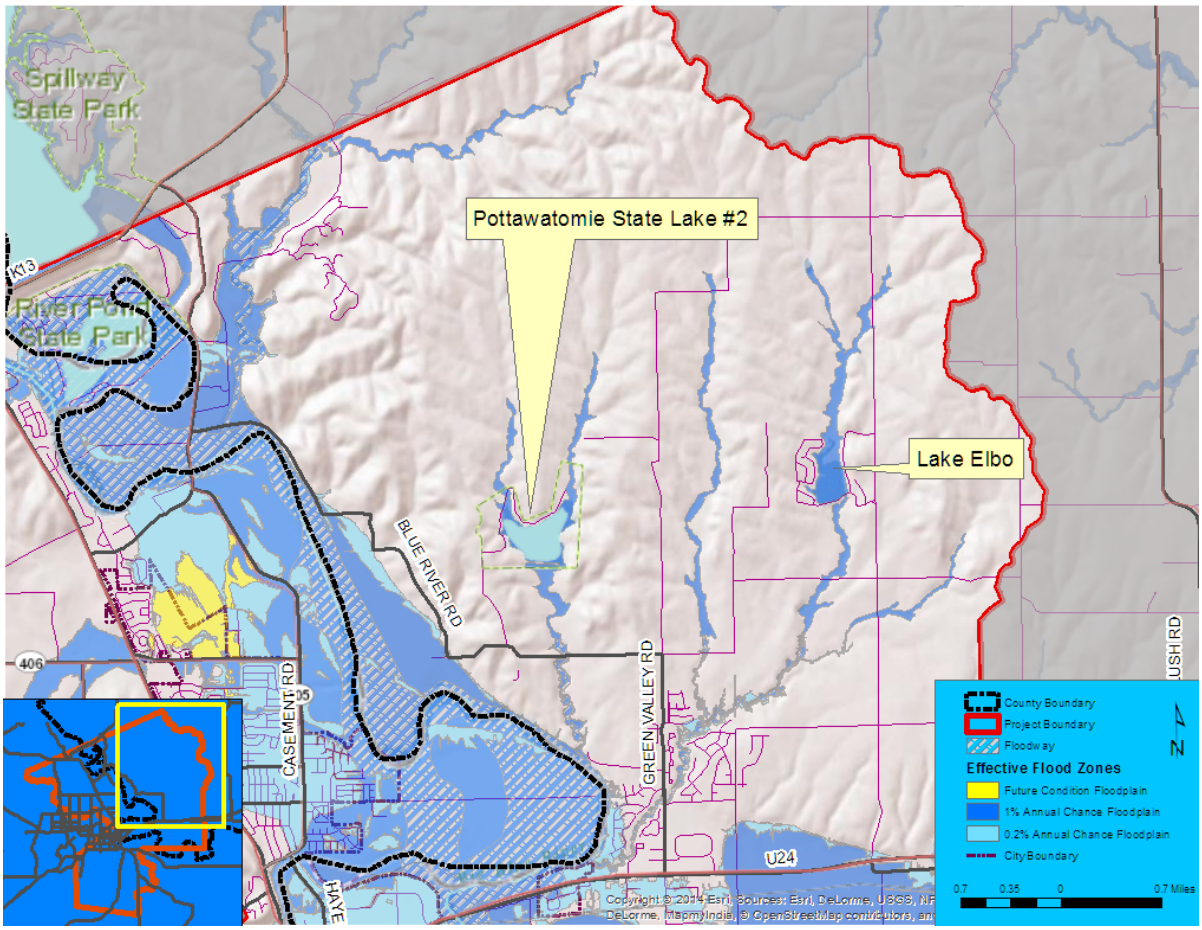


Figure 14: Big Blue River – Rural Pottawatomie County

2. Source of the Problem. The main source of flooding for this reach of the study is the Big Blue River. The risk of flooding also occurs on the smaller, unnamed streams and dry water courses found draining from the Flint Hills to the east in Pottawatomie County.

3. Flood Data. The landforms found in this reach of the study include relatively flat lands adjacent to the Big Blue River and steep ravines to the east, which are typically found in the Flint Hills. The mapped 1% Annual Chance Floodplain generally follows the natural and manmade channels and the low lying areas along the river, as described above.

   The elevation of the 1% Annual Chance Floodplain throughout the reach is approximately 1017 feet to the north of Marlatt Ditch and 1023 feet at the northern edge of the reach.

Lake Elbo is a man-made lake with a surface area of approximately 30 acres. The Big Blue River Tributary that flows out of Lake Elbo has a steep grade and the elevations of the 1% Annual Chance Floodplain range from 1058 feet near the lake to 1016 feet near its confluence with the Big Blue River. Because of the size of the lake, this would generally be considered a high-risk dam.

Many of the unnamed streams and ravines found in the Flint Hills do not meet FEMA's mapping standards because of the low density of development within these minor watersheds, thus there is not a mapped floodplain for these areas.

4. Recent Flood History. As described in other parts of the section, flooding of the Kansas and Big Blue Rivers impacted the region through the early and mid-1990's. Since the construction of Tuttle Creek Reservoir, the largest flood of record was in 1993. This flood event adversely impacted several farm houses, buildings, equipment, agricultural lands and livestock throughout the area.

5. Building Data. Outside of the residential and commercial properties that were previously described in the Blue Township Reach, few residential and commercial developments exist in the reach. There are several large lot, single-family homes found in the upper sections of the Flint Hills. The lower areas of the reach adjacent to the Big Blue River consist of primarily row crop agricultural.

6. Development Trends. Currently, it is envisioned that development patterns for this reach would remain similar to what has been developed, open rangeland associated with the Flint Hills or large lot, single-family residential homes.

   There is discussion and research being conducted by officials with Pottawatomie County and Riley County on the viability of a major road improvement in this reach to connect northern Manhattan and adjacent rural Riley County to Blue Township and U.S. Highway 24. This major transportation project is a long range planning project, so the development impacts in this reach are currently unknown.

7. Development Constraints. As with other reaches, the floodway and floodplain along the Big Blue River is the major constraint to developing near the river. Development either is prohibited in the floodway by local regulations or is cost prohibitive due to required fill or floodproofing to protect against the flood risks. No significant constraints on development are known for the land in the Flint Hills portion of this reach.

8. Critical Facilities. There are no critical facilities in this reach of the study area.

Public Involvement Process

Three public meetings have been held regarding how to manage flood risks along the rivers.

Meeting Name	Location	Date
Technical Advisory Group	City Hall	November 13, 2013
Technical Advisory Group	City Hall	November 21, 2013
Technical Advisory Group	City Hall	December 12, 2013
Technical Advisory Group	City Hall	January 30, 2014
Technical Advisory Group	City Hall	February 20, 2014
Technical Advisory Group	City Hall	February 27, 2014
Public Open House	County Commission Room	March 11, 2014
Technical Advisory Group	City Hall	March 27, 2014
Public Open House	Denison Fire Station	April 16, 2014
Public Action Working-group	County Commission Room	June 10, 2014
Public Action Working-group	County Commission Room	September 23, 2014
Public Action Working-group	County Commission Room	October 28, 2014
Public Open House	Denison Fire Station	November 5, 2014

TABLE 2: RECORD OF PUBLIC MEETINGS

The public meeting in November 2014 discussed the following issues:

1. Causes and extent of flooding
2. What is being done about flooding
3. What to do during a flood
4. How people can protect their homes
5. Flood insurance
6. Maintaining drainage ways
7. Status of implementing this FMP and the development of the FMP goals

Public outreach is a continual process by all parties involved. This includes implementing annual awareness campaigns that should be done by the City and the counties. The local authorities can use these public outreach efforts for credits in the CRS program as defined in Strategies and Tools section.

Through the public meetings in 2014, a documented interest from stakeholders was identified for taking steps to reduce flood damages on an individual basis. Individual businesses and residents

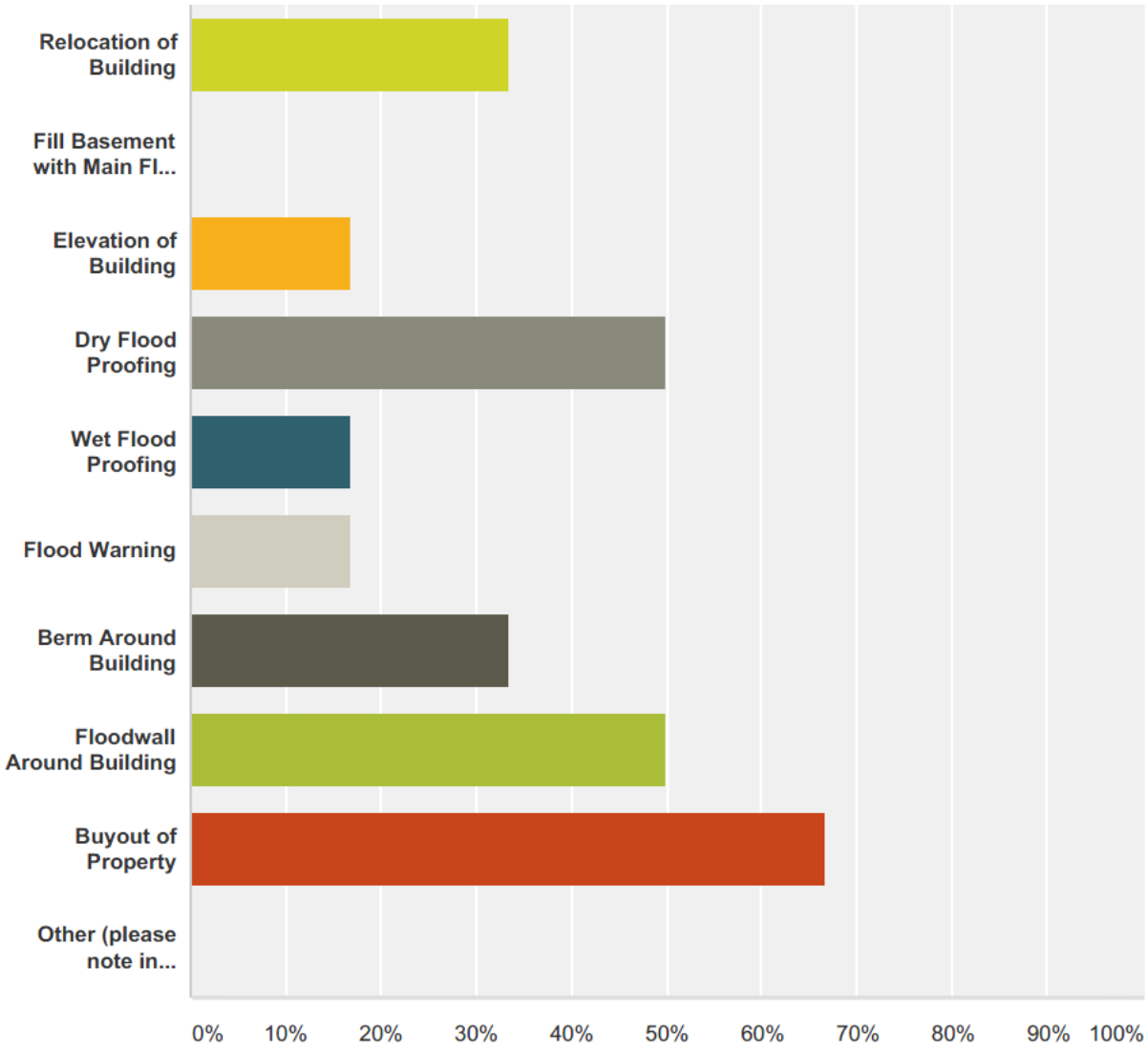


FIGURE 15: SURVEY RESPONSES SHOW INTEREST IN TOOLS INDIVIDUALS CAN PURSUE FOR THEIR HOME OR BUSINESS

can take various steps to reduce flood damages, which are outlined in this plan. A survey from November 5, 2014 indicated several tools for addressing flood damage are of interest (Figure 16).

The tools from Figure 15 are discussed in detail in the Strategies and Tools section of this document.

Public Involvement Plan

A separate plan developed to engage the public better was created. It includes findings by the Technical Advisory Group (TAG) and the temporary Public Advisory Working-group (PAW).

Big Blue River Technical Advisory Group

The Technical Advisory Group (TAG) is a planning group established by the City and counties. This group includes planners, Certified Floodplain Managers (CFMs), engineers and emergency managers dedicated to this project. The TAG helped guide the development of the floodplain management plan and was responsible for the completion of the FMP.

Big Blue River Public Action Working group

The Public Advisory Working-group (PAW) was envisioned to consist of various people living, working or otherwise related to the Big Blue River Valley, which could provide guidance to the TAG in developing the project elements and informing the public. It was envisioned the PAW would be active for a shorter amount of time than the TAG. The PAW would provide more targeted outreach than a public meeting, where only a select few might attend. The PAW was expected to meet 3 - 4 times throughout the year and help to advance the community's interest in public meetings.

III. Goals and Objectives

This section presents the goals and objectives that are based on the outcomes of the TAG and PAW meetings (see public involvement section on TAG and PAW) and the public outreach efforts, documenting the consensus from stakeholders. Below are the resulting goals for how to manage the shared flood risks along the Big Blue River. It is important to re-affirm these goals as annual revisions are made due to changing needs and desires.

General Goals

These goals were developed to guide planning and decision-making regarding the strategies and tools discussed in later sections of this FMP:

Goal 1. Develop a collaborative, multi-jurisdictional approach to manage the floodplains and address flood risks and concerns along the Big Blue and Kansas Rivers. The multi-jurisdictional approach should encompass public stakeholders, local, state and federal agencies.

1.1 Objective: Establish an organizational framework to facilitate ongoing collaboration, coordination and discussion of floodplain management issues and activities.

1.2 Objective: Adopt and implement a Big Blue and Kansas Rivers Floodplain Management Plan by Riley County, Pottawatomie County and the City of Manhattan.

Goal 2. Actively manage and reduce the flood risks along the Big Blue and Kansas Rivers to protect life and property.

2.1 Objective: Reduce risk to life, property and the economy to acceptable levels identified by the community and policy makers.

2.2 Objective: Identify and mitigate damage in repetitive loss areas.

2.3 Objective: Revise floodplain and subdivision policies and regulations to better prepare for and protect against flooding issues.

2.4 Objective: Identify and understand the unique flood risks associated with the Big Blue River Watershed below the Tuttle Creek Reservoir Dam related to flood risk.

Goal 3. Improve the public's understanding of flooding risks along the Big Blue and Kansas Rivers and the impacts of those risks on residents, property owners and businesses.

3.1 Objective: Develop a range of educational tools to inform the general public, elected officials and interested parties (i.e. realtors, property owners, tenants and developers) of the flood risks and the unique characteristics of the Big Blue and Kansas River Valleys to promote floodplain stewardship and connect citizens to the riparian environments.

3.2 Objective: Develop a range of educational and informational tools between the Federal Government (i.e. US ACE), the local jurisdiction and local media outlets to better communicate before, during and after a flood event.

3.3 Objective: Continue the existing early warning siren and voice modulated system in the Big Blue River Watershed and expand it to include the National Weather Service Big Blue River Prediction Model, Northeast Kansas Emergency Notification system, as well as other internet based systems and area media outlets (i.e. radio and television).

3.4 Objective: Coordinate the emergency preparedness and evacuation plan with federal, state and public officials and business partners (i.e. radio and television stations) for residents and property owners within the floodplain.

Goal 4. Create a balance between the development needs in the Big Blue River Watershed and the proper functions of the natural floodplains along the river.

4.1 Objective: Implement appropriate policies and regulations that incorporate the Community Base Floodplain and address needs of existing properties.

4.2 Objective: Implement appropriate Best Management Practices (BMP's) for water quality for new and redevelopment public and private projects. Encourage green infrastructure through incentives and development standards for redevelopment areas and with new development.

4.3 Objective: Encourage BMP's for water quality related to agriculture and range land through appropriate incentives.

4.4 Objective: Identify and preserve undeveloped land critical to the integrity and maintenance of the various flood controls and protection of infrastructure in the Big Blue River Watershed and the confluence with the Kansas River.

Goal 5. Project and preserve the natural environment of the riparian corridor to enhance habitat connectivity, water quality, erosion and sediment management, bank and channel stabilization, and provide compatible recreation opportunities.

5.1 Objective: Implement appropriate Best Management Practices regulations and guidelines to stabilize channel and stream banks, protect wildlife and habitat, conserve open space and re-establish riparian corridors.

5.2 Objective: Research, plan for and implement ways to restore the natural functions of floodplains including the storage capacity, when appropriate.

5.3 Objective: Identify compatible recreation opportunities in the floodplain along the Big Blue River.

IV. Strategies and Tools

The Technical Advisory Group considered a long list of strategies and tools that could address the flood risk on the Big Blue River. This section serves to describe the reasons for inclusion or rejection of those tools. The Big Blue and Kansas Rivers Floodplain Management Plan categorize the list of strategies and tools as follows:

- Modifying Human Susceptibility to Flood Hazards
  - Flood Risk Adaptive Measure
- Modifying the Impact of Flooding
- Preserving and Restoring the Environmental Quality of Floodplains
- Modifying Floodwaters

The Actions, the Tools, the Measures.

The tools are in fact the "measures" the planning community refers to with very deliberate terminology, because these will lead to the eventual action items in the floodplain management plan.

These four categories of strategies and tools were created by the Federal Interagency Floodplain Management Task Force (FIFM-TF) during the formation of a Unified National Program for Floodplain Management. The four categories and corresponding tools are the "measures" the flood risk management professional refers to with very deliberate terminology, as they lead to the eventual action items in the floodplain management plan. This terminology serves to clarify the measures fall under the category of either

- an "activity" or
- a "feature."

An activity is an effort done by the city, counties or partnering state and federal agencies to study, inform or react to a flood risk. Examples of an activity could be an informational outreach program, an updated study of a flood-prone area or an emergency action plan.

Features are actual construction projects on a property or properties that an individual, the city, counties or partnering agencies can perform. Features can include major civic works projects such as levees, or smaller "flood risk adaptive measure," such as elevating an existing home or business. USACE typically calls these smaller features "nonstructural measures," which originates from FEMA policy. This plan will refer to these types of features as "flood risk adaptive measures."

Stakeholders will view each tool differently and a consensus will be established over time. The city and counties evaluated and designated each of the possible tools using one of the following terms after involving the stakeholders through public involvement in the decision process:

- **Not Advisable**
- **Further Evaluation Needed**
- **Advisable**

These specific terms will appear with each tool prior to the discussion section, and also in the body text in bold format, because these represent important supporting information to the action items later in the floodplain management plan. These terms help stakeholders to

Decision History

This decision history is an important part of the floodplain management plan because a community's unique story is made up of a risk assessment followed by years of decisions about how to manage floodwaters and the floodplain.

better understand the decision history for flood risk management along the rivers and their tributaries. This decision history is an important part of the floodplain management plan, as a region's unique story is made up of a risk assessment followed by years of decisions about how to manage floodwaters and the floodplain. The specific terms also help improve public involvement and can be applied to specific reaches of a river or a tributary. Since the public needs to be involved with defining their individual acceptable level of risk, these terms facilitate buy-in and get the community focused on the actual action items identified later in this plan. These action items eventually lead to more effective hazard mitigation by the City, the Counties and State and Federal agencies, whom are all partners sharing the responsibility of reducing the risks from flooding and other natural disasters.

This input based approach allows an FMP to be established and work to begin on realizing the goals of the plan. Communities can work on annual revisions to the FMP and update evaluations on the tools' effectiveness.

Over a period of several years, consensus will be established and a collaborative approach to building projects can be done, effectively leveraging the invested infrastructure dollars in the City and Counties. This can assist with implementing various tools in the Action Plan.

Strategy 1: Modifying Human Susceptibility to Flood Hazards

This strategy and set of tools relates to measures directed toward managing the floodplain. These measures include specific activities and features. Activities include land use regulations, public redevelopment policies, flood warning systems and flood emergency preparedness plans (including emergency action plans and flood fighting plans). Features include flood-proofing buildings in the floodplain, berms and floodwalls for buildings, elevation of buildings, filling basements, acquisition of buildings (for demolition), and relocation of buildings. This deliberate terminology distinguishing between activities and features, will help the reader understand that floodplain management plans, emergency action plans, flood fighting plans and hazard mitigation plans are not the same.

Tool: Development Policies and Land Use Regulations

Advisable

In several meetings of the TAG and PAW, land use policies and regulations were at the top of the list of objectives. Topics that are more specific included:

- Prohibit development in the:
  - Floodway
  - Historical flood areas
  - 1% Annual Chance Floodplain
  - Future Conditions Floodplain
- Establish higher standard floodplain regulations
- Limit repair/improvements of existing structures in the floodplain
- Establish Comprehensive Plan policies identifying appropriate development/redevelopment areas outside of floodplain.
- Compensatory Storage

This tool covers both development policies and land use regulations. Development policies can be found in the Comprehensive Plans for the City and the two counties. These policies help guide the

community's decisions of where new development or redevelopment should occur. An example of this tool put into practice, is the Manhattan Urban Area Comprehensive Plan documenting the area inundated by the 1993 flood, designating this area as environmentally sensitive, and implementing policies to adequately protect this area.

Land use regulations can be used to implement a wide variety of site and building requirements, restrictions, and prohibitions to protect new and existing developments. The National Flood Insurance Program (NFIP) and the State of Kansas have established a minimum standard of floodplain regulations. Some of these minimum standards may not be appropriate for a growing community like Manhattan and the surrounding areas in Pottawatomie and Riley counties, or for places located directly below a major dam and reservoir.

This tool is readily acceptable as an effective measure to protect existing homes, businesses and new developments from flooding. This tool is **advisable** to be included in the Action Plan of the FMP to invoke changes to development practices to better protect existing and future development from flood damages.

TOOL: FLOOD WARNING SYSTEMS

Advisable

Flood warning systems are a flood risk adaptive measure and are categorized as both an activity and a feature. Flood warning systems include several components and are usually part of a process written into an emergency response plan (not to be confused with this floodplain management plan). The first component is a flood threat recognition system. The next component is a warning dissemination system for risk communication. Emergency response follows and should be integrated through use of an emergency response plan. This means collaborative involvement across several professional groups, including emergency responders, public works, and staff charged with operation and maintenance of flood features like levees or dams. Because a flood warning system is inter-related with an emergency action plan, the tool is not simply a feature. Maintaining the system and integrating it with the emergency action plan make this an on-going activity.

Flood Forecast Inundation Map

Advisable

Through an interagency project, a tool has been developed for the Big Blue River known as a Flood Forecast Inundation Map (FFIM). The FFIM is tied to the USACE flow releases from Tuttle Creek Reservoir. This tool was of high importance during the TAG and the PAW meetings to visually communicate special impacts of flooding. The FFIM is similar to the Wildcat Creek FFIM located near Scenic Drive. Agencies involved in creating the FFIM are the Kansas Hazard Mitigation Team, the KDA Division of Water Resources, the USACE, KDEM, the NOAA National Weather Service (NWS), and USGS. The system is hosted on the NWS Advanced Hydrologic Prediction Service (AHPS) and is operated by NWS in perpetuity. The system includes a set of static map books tied to the USGS gage (#06887000) near Rocky Ford on Barnes Road. This system provides valuable information to the public and to emergency responders. As an example of the effectiveness of this tool, during a series of rain events in June, 2014, the Wildcat Creek AHPS site received over 600 unique visits. This website activity during storm events shows the public and those responsible to

act in an emergency are using the FFIM to make decisions in response to the elevation of Wildcat Creek, before the creek reaches flood stages. It is further **advisable** the FFIM be tied to emergency action plans, since the action stages developed with the NWS are thresholds for specific response tasks.

Warning Dissemination, Flood Warning Lights & Sirens

Advisable

A flood risk communication tool, such as flood warning lights on roadways, can notify travelers of high water on roadways and can help motorists from being trapped in moving water or worse, drowning, by warning of the dangers and the need to turn around. During the Manhattan Levee study, the hydraulic engineers noted the U.S. Hwy 24 Bridge and the associated roadway will overtop for the 0.5% annual exceedance probability (a 200-year storm). This highway corridor is the most direct evacuation route for some people living and working in the area. A set of flood warning lights tied to the Flood Forecast Inundation Map and the associated NWS forecast point and USGS gage is recommended to be located near the U.S. Hwy 24 Bridge that crosses the Big Blue River. Other areas along the Big Blue River may benefit from a flood warning light system for motorists. Similar warning lights that are tied to action stages have been established by a joint City/Counties emergency preparedness plan for Wildcat Creek (includes emergency action plan and flood fighting emergency operation plan). It is **advisable** that this general system be provided along the Big Blue and Kansas Rivers.

Warning Dissemination, Multi-Media

Advisable

As a flood risk communication tool, multi-media approaches, such as Instant Messaging and Short Message Services (SMS), have advanced considerably, although other traditional means, such as radio and television, are also still relevant. An objective noted during public involvement work with the TAG and the PAW was to use public warning systems via multi-media outlets. One **advisable** step is to further promote the region's use of the Northeast Kansas Notification system and website announcements. During major flooding events similar to 1993, daily status updates could be channeled through the local television and radio stations, and social-media outlets, such as Twitter and Facebook. Pre-identified roles could be established to present daily updates during the flood to local "traditional" media outlets, as well as through the newer outlets. Another **advisable** step is to formalize public media engagement through a section in a new emergency action plan. This may include predefined messages that correspond to action stages identified with the NOAA NWS for the FFIM for the Big Blue Kansas Rivers, based on existing river gauges in the area.

TOOL: EMERGENCY OPERATIONS PLANS

Advisable

Corresponding with the previously mentioned flood warning system is an emergency operations plan (EOP) for flooding. Generally speaking, emergency operations plans include several topics related to preparing for, responding to, and mitigating against the risk:

- Flood risk management;
- Emergency communications;
- Emergency response; and
- After event actions.

Each of these is relevant, but all have a unique focus and audience.

Flood Risk Management: Flood risk management is an element of every EOP. The plan is designed to provide necessary actions based on water levels released from Tuttle Creek Reservoir or the water elevations on the Big Blue River. Using the FFIM described above, Emergency Managers for Manhattan, Riley County and Pottawatomie County can outline when certain actions should be initiated. These action stages could be the activation of the Emergency Operation Center, the activation of outdoor warning sirens, mobilization of emergency personnel, closure of roads at risk of flooding and the evacuation of impacted areas.

Pottawatomie County and Riley County are part of the Regional I Hazard Mitigation Plan. Each county has an EOP, which is based on all-hazards planning. These emergency plans support functions rather than individual hazards for planning and guidance during an event.

Emergency Communication: As with any emergency situation, communicating to the public is key to describe the event, discuss the risks, and explain appropriate actions to be taken. An emergency situation is often chaotic and sometimes communicating the risk and other necessary information is not always done adequately. An emergency communication guide can create a framework of roles and responsibilities, templates, and suggested media outlets. This would then cause the release of effective information, timely flow of information, and reduce the duplication of messages and/or conflicting messages from different sources.

Pottawatomie County and Riley County participate in and promote the Northeast Kansas Notification system. This is a subscription based service that provides emergency notifications such as storm warnings, road closures, and other emergency information via text message, telephone call, or email. This system can be promoted more effectively to reach a broader audience and provide more timely emergency notification.

Emergency Response: Riley County and Pottawatomie County have Emergency Operations Plans (EOP). Riley County has several documents attached to their EOP which pertain to evacuation procedures for known flood-prone locations in the county, as well as action stages for several rivers/creeks in the area.

After Event Action Plans: After an event, items such as damage assessment, material disposal, clean up, recovery communications, and economic recovery need to be addressed. These are completed using the Emergency Support Functions in the EOP or referring to the Debris Management Plan.

This is an **advisable** activity to create a prepared and resilient community in the face of the flood risk along the Big Blue River. These plans should be periodically practiced and vetted via table top exercises and small scale simulated drills to ensure the variety of plans are up to date and accurate.

Flood Risk Adaptive Measure

Flood risk adaptive measures are construction projects and/or operational actions that can be taken to lessen the likelihood of damages from flooding. Careful consideration needs to be made before selecting the appropriate flood risk adaptive measure. Items to consider are:

- The probability/frequency of flooding
- The depth of flood waters
- The velocity of flood waters
- The duration of the flood event
- The cost of the construction project or actions
- The financial benefits from the measures taken, including
  - Reduction in flood insurance costs
  - Reduction in structural and content damage costs

These tools can be applied to several of the reaches defined in the study area. Figure 17 helps illustrate some of the subdivisions that should consider nonstructural measures.

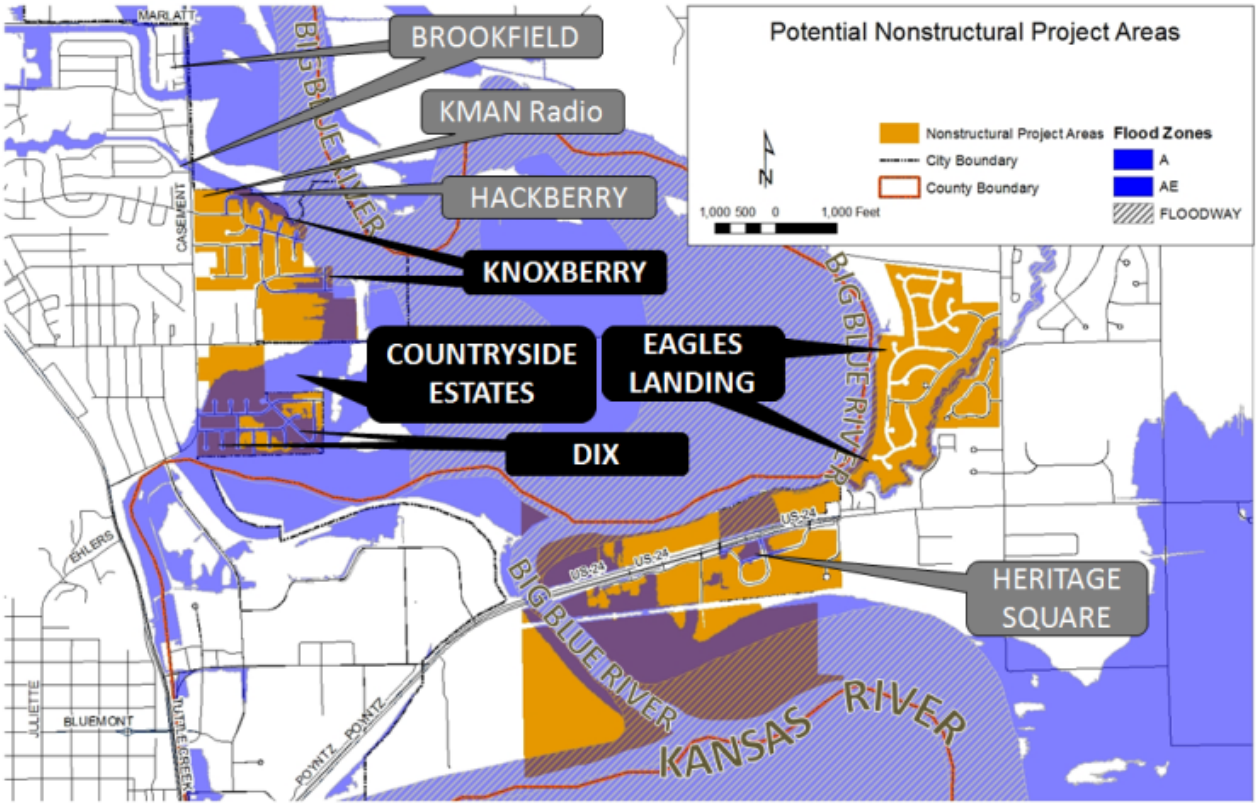


FIGURE 16: SUBDIVISIONS IDENTIFIED FOR CONSIDERING NONSTRUCTUAL MEASURES

Tool: Elevation of Buildings

Advisable

This flood risk adaptive measure lifts an existing building to an elevation that is greater than the elevation of the 1% annual chance flood. The elevation of buildings is a tool that can be used with several approaches. The most common approach in this region is to elevate a building on earthen fill material. For structures with poured concrete foundation walls, extending the stem walls is possible. Elevation of slab-on-grade foundations can be elevated in a similar fashion. In some cases, the structure may be elevated on piles. In others cases, pillars or columns could be used. These last two cases are not frequently used in the region, but are accepted methods to meet the objective of protecting a home from the flood risk.

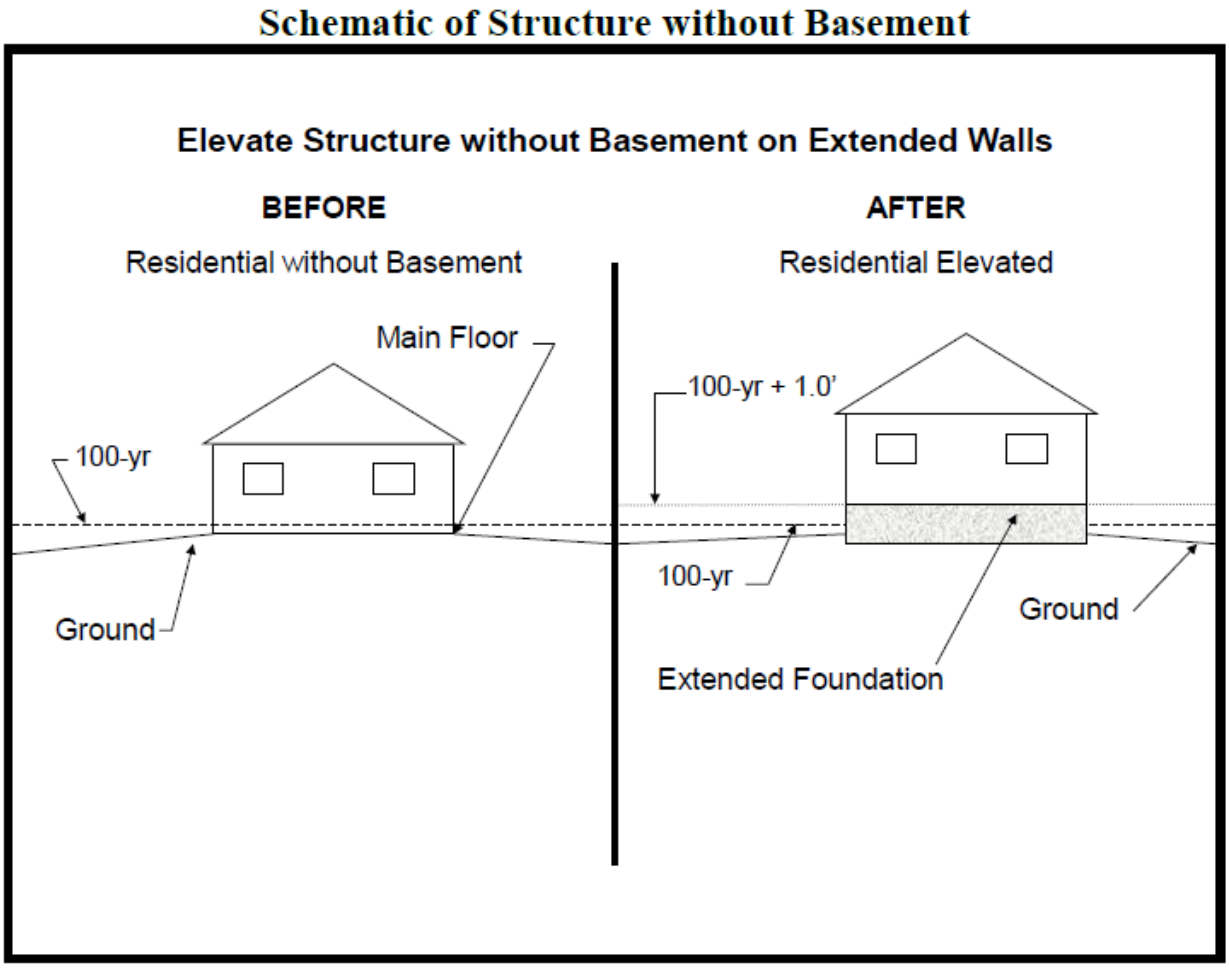


Figure 17: Elevation buildings to minimize flood risk

Individuals need to remember the challenge of accessing an elevated home or business when a flood occurs. The effect of an elevated building could be the creation of an island within the floodplain. Considering the type of flood risk for the Big Blue and Kansas Rivers, the island effect could last for an extended period. The challenge could be evacuating from the elevated structure or

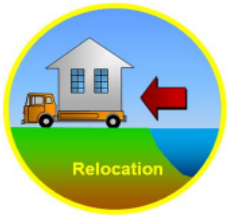
the ability of emergency service personnel to reach the building during a flood event. The elderly or disabled should take this challenge into consideration.

This tool is generally accepted as a mitigation option for new and existing structures at risk of flooding. Through the public involvement process and surveys gathered in 2014, 16% of respondents indicated interest in elevating their home. This tool is **advisable** for its effectiveness and the interest expressed.

Further research and evaluations are required to understand better cost-engineering aspects of the tool for the variety of structures in the Big Blue and Kansas River floodplains. Several federal programs are available to assist in mitigating the flood risk in the area. Because of the federal funds available, a comprehensive flood hazard mitigation study should be considered. This study could be created across the Big Blue and Kansas River floodplains, and even throughout the two (2) counties. For each mitigation area, off-the-shelf projects should include groupings of structures which may be tied to subdivisions, types of flood risk (considering flood depth, velocity, rate-of-rise and duration of inundation), and population at risk. Groupings may also be tied to the type of structure and common elements, as this may lead to a more effective future construction contract. This approach could assist in developing a prioritization list and increase the benefit-to-cost ratio to meet federal grant program requirements. By evaluating this tool for specific properties and developing a prioritized list of projects, these projects can be mobilized when the next round of hazard mitigation funds become available.

Tool: Relocation of Buildings

Advisable



This flood risk adaptive measure requires physically moving the at-risk structure away from the floodplain area. In some cases, relocation of a structure can occur on the same property where it is currently located, but is safely away from the high-risk flood area. In other situations, the structure is moved entirely away from the property on which it is currently located because there is no viable location where the structure would be safe from flooding. When the structure is moved away from the property, the land is typically purchased and future development is prohibited.

This tool is generally accepted as a flood risk adaptive measure for existing structures at risk of flooding. The public involvement process and the 2014 survey indicated 33% of the respondents were interested is this tool. This tool is an **advisable** feature. Once again, further research and evaluations are required to better understand cost-engineering aspects of the tool for the variety of structures in the Big Blue and Kansas River floodplains. As discussed above in the Building Elevation tool, opportunities exist to study this tool in a comprehensive manner to create a list of -projects that would be prioritized and ready to submit for federal grant funding.

Figure 18: Example post-project aerial view of a site where residences were relocated

Tool: Floodproofing Buildings in the Floodplain

Floodproofing is a possible approach to defending against rising floodwaters outside a residential home or commercial building. Two approaches are wet or dry floodproofing measures (explained below). *It should be noted these tools may not reduce the cost of flood insurance for residential structures.* Only commercial, industrial and accessory structures are allowed to be floodproofed according to the National Flood Insurance Program (NFIP). Residential structures could benefit from floodproofing measures in certain situations; however, the effort will not reduce the cost of the flood insurance premium for the residential structure.

Tool: Wet Flood Proofing

Further evaluation needed

Dependent on its application, this tool was found to be acceptable. The evaluation is supported by public involvement and surveys gathered in 2014, where 16% of respondents indicated interest in wet floodproofing.

Wet floodproofing is defined as permanent or temporary/contingent measures applied to a structure and/or its contents to prevent or provide resistance to damage by allowing floodwaters to enter the structure. This flood adaptive measure is applicable either as a stand-alone measure or as a measure combined with other measures, such as elevation.

As a stand-alone measure, all construction materials and finishing materials need to be water resistant and all utilities must be elevated above the design flood elevation. Wet floodproofing is quite applicable and generally **advisable** for commercial and industrial structures when combined with a flood warning and flood preparedness plan. This measure is generally not applicable to deep flood waters and/or high velocity flows.

Due to the structural and health risks associated with allowing flood waters to inundate a dwelling, wet floodproofing is generally **not advisable** as a mitigation option for residential applications. The one exception is the use of engineered openings in an elevated or "crawl space" foundation of a

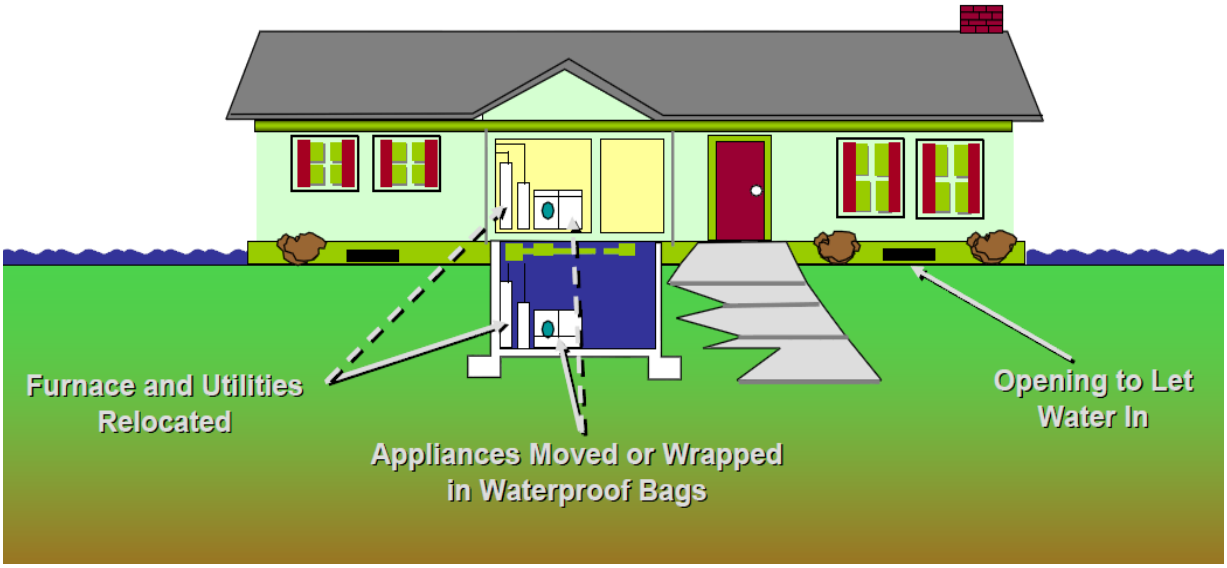


Figure 19: Wet Flood Proofing

home. In this application, openings or vents of a specific size are installed in a new or existing foundation to allow flood waters to enter the elevated foundation and equalize the hydrostatic pressure of the flood waters. Without these vents, the force of the flood waters could be enough to damage or destroy the foundation. The specific requirements of FEMA (FEMA, August 2008) and local floodplain regulations require permits and oversight by local officials. The installation of this type of wet floodproofing could reduce the cost of flood insurance premiums for a home if installed appropriately. Property owners wishing to utilize this method should contact their local Floodplain Administrator.

Dry Flood Proofing

Further evaluation needed

Dependent on its application, this tool was found to be **Acceptable**. The evaluation is supported by public involvement and surveys gathered in 2014, where 50% of respondents indicated interest in dry floodproofing.

Dry floodproofing is defined as a measure involving sealing the walls of a structure with water-proofing compounds, impermeable sheeting or other materials and using closures for covering and sealing openings from floodwaters.

This tool is **Acceptable** for commercial and industrial structures and can be used in residential homes in specific circumstances, such as when flood waters are not anticipated to be deep or move at fast speeds. This tool achieves flood risk reduction, but is not recognized by the NFIP for any flood insurance premium rate reduction if applied to a residential structure. Commercial and industrial structures can use this tool and realize an improved flood insurance premium. Based on laboratory tests, a “conventional” built structure can generally only be dry floodproofed up to 3-feet in elevation. A structural analysis of the wall strength would be required for higher protection. Openings into the structure, such as doors and windows below the base flood elevation, would need watertight closures to achieve the desired results. Sump pumps and French drain systems should be installed as part of the measure. For buildings with basements and/or crawlspaces, the only way dry floodproofing could be effective is for the first floor to be made impermeable from inundation of floodwaters.

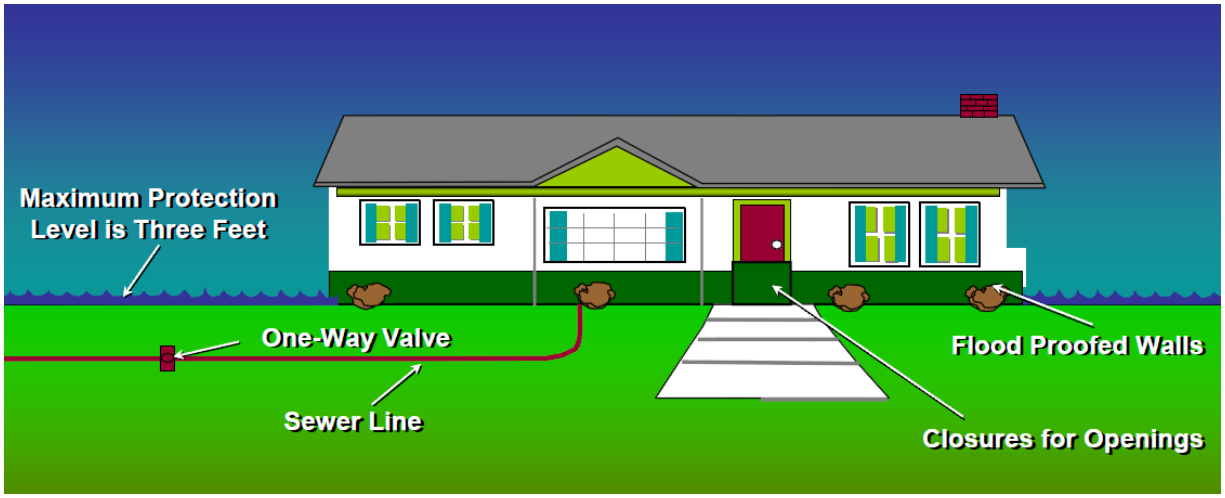


FIGURE 20: DRY FLOOD PROOFING

As discussed, dry flood proofing for residential structures may be applicable in limited situations, but is not an eligible measure to reduce the cost of flood insurance premiums. This tool would be an acceptable application for homes on the outer fringe of the area of the base flood, and/or within the 0.2% annual chance floodplain (500-year floodplain). These areas are generally impacted by shallow, low velocity floodwaters that cause damage to flooring, HVAC and other utility equipment low to the floor. In these situations, temporary water-proof barriers to building openings, such as doors, could be installed and foundations could be sealed to prevent infiltration into the home. This would not be an acceptable solution for deep or fast moving floodwaters. This tool would also not be acceptable to a homeowner seeking to lower their flood insurance premiums, as these flood damage reduction measures do not qualify under the NFIP.

TOOL: BERMS AND FLOODWALLS FOR BUILDINGS

Further evaluation needed

This tool could be **advisable** if certain measures are undertaken to limit or prevent adverse impacts on adjacent properties. The evaluation was supported by public involvement and surveys gathered in 2014, where 33% of respondents indicated interest in installing a berm or a floodwall around their building.

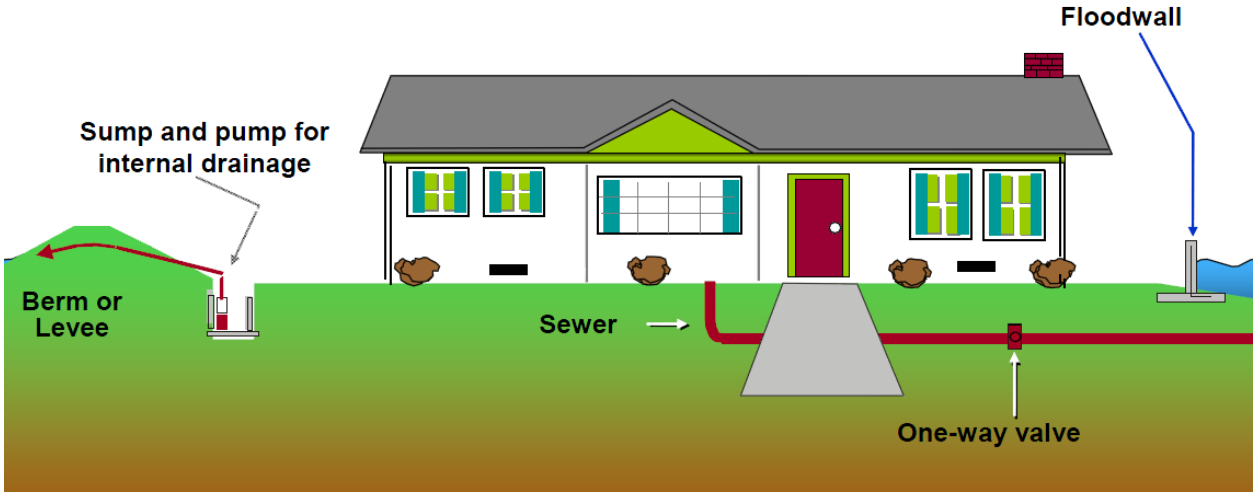


FIGURE 21: BERMS AND FLOODWALLS

This flood adaptive measure is applicable on a small-scale basis. It is intended to reduce the frequency of flooding, but currently would not eliminate floodplain regulation and flood insurance requirements. These measures can be placed around a single structure or a small group of structures. As a flood-adaptive measure, berms and floodwalls should be constructed to no higher than six (6) feet above grade and generally cannot raise the elevation of the floodwaters. The "No Rise" requirement is to ensure the berm or floodwall will not displace the floodwaters onto an adjacent property and increase their risk and cost of flooding.

In order to eliminate the need for flood insurance and floodplain regulations, the berm or floodwall would need to be substantially built to the level of a major civic works project, such as a levee, which would generally not be financially feasible for most property owners and neighborhoods.

Berms and floodwalls for buildings would be a tool for a smaller number of the homeowners in the Big Blue and Kansas River floodplains. This tool requires a larger effort and engineering cost to ensure it will not adversely impact adjacent properties and is designed to withstand the forces of floodwaters. Also, space constraints between structures can be a significant issue, requiring floodwalls instead of berms to be installed, which may be more expensive. Businesses may find this the best approach for their property. Further evaluation is needed to study applicability of this measure and outreach to stakeholders is needed to identify local interest. This could be organized through a workshop with homeowners associations or neighborhood groups. Cost engineering is needed to help individuals understand what the estimated cost and benefits would be to implement berms or floodwalls. For the most part, individual property owners need to pursue implementation of this tool.

Tool: Fill or Conversion of a Basement with Main Floor Addition for Buildings

Further Evaluation Needed

This nonstructural technique consists of filling in the existing basement or converting the basement space to an uninhabitable crawl space, without elevating the remainder of the structure. The measure is applicable only if the 1st floor of the structure that is above grade is higher than the base flood elevation. In addition to filling in an existing basement, homeowners may also consider placing an addition onto the side of the structure or add an additional floor above to compensate for the lost living space. In rare cases, the former basement area could become space for storage; however, this is generally discouraged because of the possibility of the space being converted back to living space. New owners may wish to "re-purpose" the storage area as a basement again and since inspections for compliance would be difficult, use of this area for storage is not recommended.

As this measure results in the reduction of living space and the loss of the primary area for protection against tornadoes, the survey participants did not openly accept this measure. There were zero respondents that indicated interest in this tool. However, it still is an acceptable tool to minimize the risk of flooding and can substantially decrease the cost of flood insurance. This tool is listed as **further evaluation needed** to better understand the cost of this tool and determine whether or not some property owners may be interested.

Schematic of Structure with Basement Filled in and Addition on Main Floor

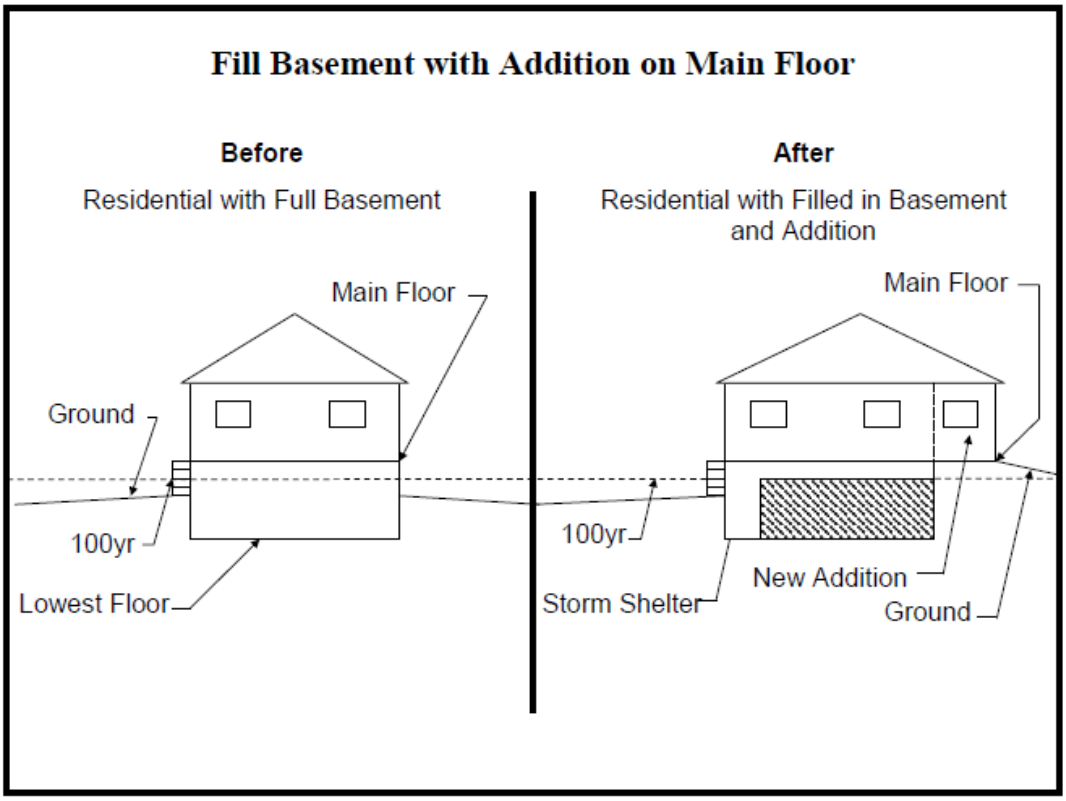


Figure 22: Filled Basement

Tool: Acquisition of Buildings

Advisable

This tool was found to be acceptable. The evaluation was supported by public involvement and surveys gathered in 2014, where 66% of respondents indicated interest in being bought out or selected the tool Acquisition of Buildings on the survey.

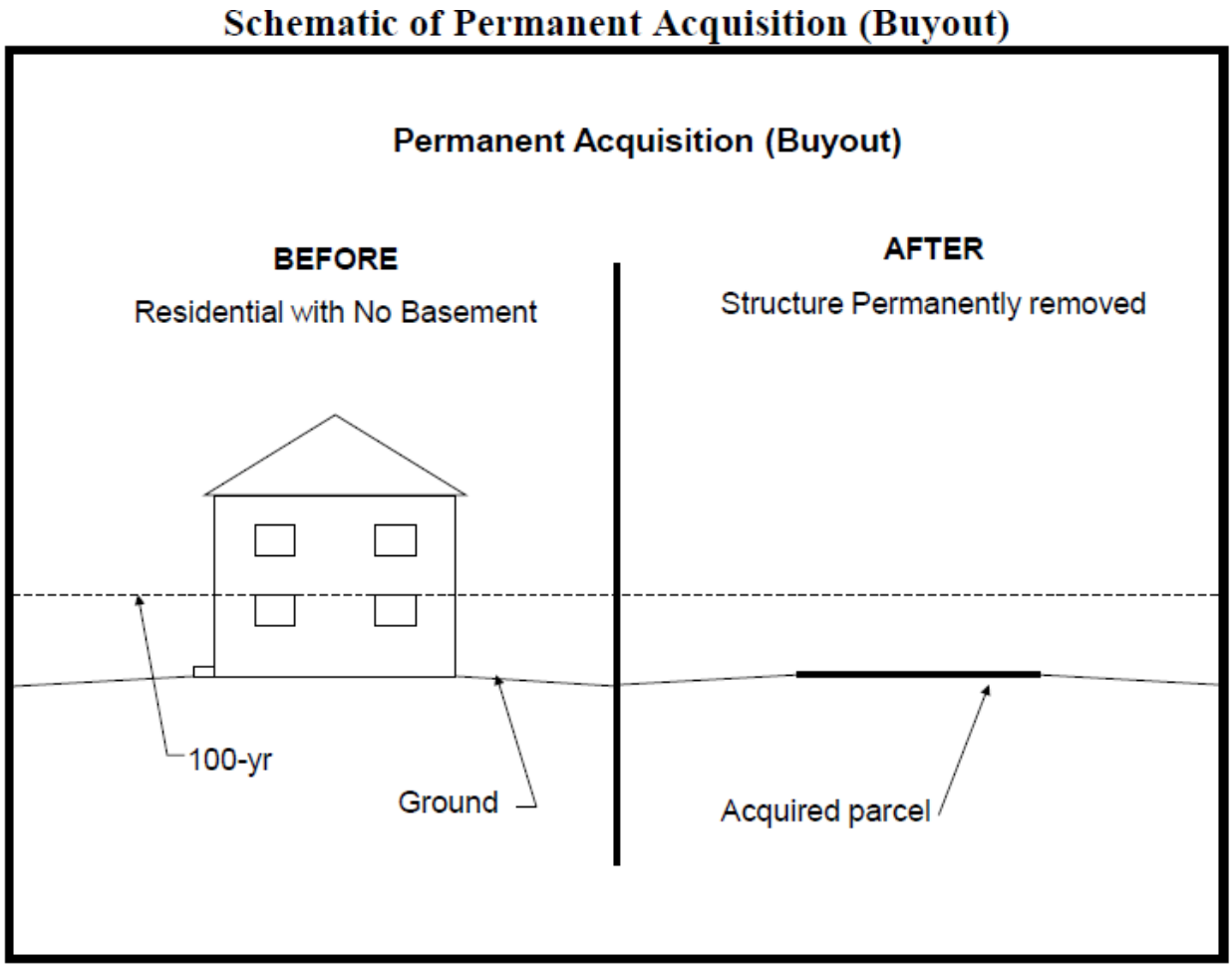


Figure 23: Permanent Acquisition

This flood adaptive measure consists of buying the structure and the parcel of land. The structure is either demolished or is sold and relocated to a site outside of the high risk floodplain. The purchased land is then converted to passive open space, used for recreational purposes or allowed to be reclaimed by the river. Part of a proposed project could be the development of adequate and comparable home sites outside of the floodplain in order to provide locations where displaced persons may build new homes within an established community.

This tool's feasibility will depend heavily on a funding mechanism. Federal, state and local resources exist. The most likely funding source is federal grants from Housing and Urban Development, FEMA, or USACE. In all of these cases, the new use of the land would be required to

be undeveloped in perpetuity or could be used for recreation, such as a playing field, environmental enhancement, ecosystem restoration, or a combination of these. Concept projects should be studied and developed and leverage as many opportunities as possible. The creation of open space, public involvement processes and other similar activities could provide eligible credit for the communities in the FEMA Community Rating System.

Groupings of structures in each impacted area may be conceptualized to create a list of potential projects should funding become available. Groupings may be tied to subdivisions or neighborhoods, types of flood risk (considering flood depth, velocity, rate-of-rise, duration of inundation and population at risk). Groupings may also be tied to the type of structure and common elements, which may lead to a more effective future construction contract.

Strategy 2: Modifying the Impact of Flooding

This strategy and set of tools has to do with managing the floodplain with the following specific activities: information and education, flood insurance, tax adjustments, emergency relief, and post-flood recovery processes.

Tool: Information and Education

Advisable

A primary purpose of the FMP is communicating flood risks and increasing the public understanding of flood hazards. City and County officials should, through a variety of methods and media, further inform residents, business owners and the general public of the flood risks present on the Big Blue and Kansas Rivers

Flood Risk Mapping: Both the City and the two Counties have a wealth of flood risk information available for the public in the form of FEMA flood studies, local flood studies, as well as "non-regulatory" flood maps provided with these studies, and other flood risk efforts. Providing this information, or at least advertising that this information is available to the public, is highly effective.

The standard way for a community to express the risk of flooding is through the FEMA Flood Insurance Rate Maps (FIRMs). These floodplain maps were recently updated using the most up to date information for both Counties and the City. In addition to the traditional paper floodplain maps, this information is made available digitally for web maps through FEMA. The City of Manhattan, Pottawatomie County and Riley County have all incorporated this digital information into their existing web maps on their respective websites.

In addition to the FEMA floodplain maps, other information on flooding in the area, such as historic floodplain maps, localized flood studies and "non-regulatory" flood maps, should be provided to the residents, businesses and property owners in an easy to acquire manner. An example of a "non-regulatory" flood map is depth grid maps representing not only the location of the floodplain for a particular storm event, but also the depth of the floodwater. The City of Manhattan facilitated the creation of depth grid maps for the floodplains in the City and the rural areas surrounding the City. These maps provide valuable information to the impacted resident or business owner, as well as to City and County officials for flood preparedness. Other non-regulatory maps, such as flood risk probability maps and floodwater velocity maps, could also be created to further explain the risk of flooding for an area. The City and Counties should look to expand these map products and share them with the residents and business owners, where available.

As a part of the USACE Silver Jacket Project Big Blue and Kansas River Flood Planning Project, NOAA and the National Weather Service (NWS) has created Advanced Hydrologic Prediction Service (AHPS) web pages for the Big Blue River, from the face of the Tuttle Creek Dam to the confluence with the Kansas River. The core of the AHPS web pages is the flood forecast inundation maps (FFIMs). The FFIM on the Big Blue River helps to correlate flow releases from Tuttle Creek Dam and visualize the extent of flooding. It should be noted that because of the multitudes of variables and complexities associated with the different water elevations on the two rivers, the Big Blue FFIM ties to one specific water elevation on the Kansas River. The water elevations of the Big Blue River are adjustable to represent the releases from Tuttle Creek Reservoir. Because of these variables and limitations of the AHPS webpage, the flood information is for planning and

preparedness efforts and should not be relied upon as exact locations of floodwaters on the Big Blue or Kansas River.

The true benefit of the AHPS service is to provide individuals a mapping tool that can be used during flood events as well as information to prepare for future floods. Property owners can reference the AHPS services to plan for future development. Residents, business owners and community emergency planners can develop accurate contingency plans ahead of flood events.

During major flood events, the NWS will also provide a forecast of stages, which is valuable information to those needing to know the anticipated peak flood stage. Projecting the various stages of the river will provide several hours of advanced warning for emergency management personnel and impacted residents and business owners.

Information to Prepare and Recover: A number of local, state and federal agencies, such as the Kansas Division of Water Resources, American Red Cross, FEMA and the National Flood Insurance Program, have prepared detailed pamphlets, books and other informational pieces on how to prevent, prepare for and recover from a flood event. Officials from the City and Counties should continue to collect, review and maintain a sufficient library of information to assist residents with these topics. This information should be readily available to residents and business owners via the internet and also local libraries in the two counties.

Information on other topics related to flooding, such as water quality and water conservation, should be collected and made public in similar fashion as the flood hazard and prevention information. This information can be provided at the City and County offices and/or the public libraries in the two counties. A variety of media types can be used to inform residents and other interested parties about these flood related topics. The City of Manhattan, Pottawatomie County and Riley County maintain informative websites where this information can be displayed. Newsletters, newspaper advertisements, press releases, notices on utility bills and other government notices, social media and direct mailings, could be used. The entities should be creative as to how these messages are relayed to the public, both broadly and specifically, in an effort to have a well-informed community regarding the hazards of flooding.

During the distribution of these preventative, preparedness and recovery messages, it is recommended to more actively address vulnerable population groups. During the 2014 public involvement process, including the Public Action Working Group (PAW) meetings and the open houses, two vulnerable populations were identified and discussed. Students and soldiers, who are transient and may only be in the community for a short time, may unknowingly rent structures in the floodplain. Being new to the community, these individuals often do not know of the risks associated with flooding or how to prevent, prepare for and recover from a flood event. Specialized information techniques are **advisable** to inform these vulnerable populations. Points of contact for living arrangements at Kansas State University and at the Army garrison at Fort Riley should be utilized to inform these new residents of the flooding risks in the area. Additionally, providing the information in multiple languages is also **advisable**.

FIGURE 24: EXAMPLE STEPS, INCLUDING OUTREACH, FOR REDUCING FLOOD RISK TO ACCEPTABLE LEVELS

TOOL: FLOOD INSURANCE

Advisable

Pottawatomie County, Riley County and the City of Manhattan are participating communities in the National Flood Insurance Program (NFIP) by the Federal Emergency Management Agency (FEMA). The NFIP is similar to most other types of insurance; however, it is controlled by the Federal Government and managed by FEMA. As the City and Counties participate in the NFIP, flood insurance is available to home and business owners and tenants of the properties. If an insurable structure is located in a high risk floodplain and a federally backed loan is involved, flood insurance is mandatory. For properties not in a high risk floodplain or when federally backed loans are not involved, flood insurance is optional.

Flood Insurance is one means of establishing a resilient community. Similarly to other types of insurance, flood insurance transfers the financial risk of being impacted by a flood to a broader population, even during a catastrophic event. This tool is considered to be highly effective. Depending on the disaster and the situations, funds become available in the form insurance claims or through low-interest loans and grants to recover from a flood event and to mitigate against future flood risks. It is the individual property owners as well as the community who share the responsibility of managing flood risks by having flood insurance that will cover damages. Therefore, this evaluation lists this tool as **advisable** for the property owner to get flood insurance.

Tool: Community Rating System

Advisable

The Community Rating System (CRS) is a national program through FEMA and the NFIP that evaluates a community's floodplain management efforts and rewards those efforts with reductions on National Flood Insurance premiums based on the community's floodplain management performance. Riley County and the City of Manhattan are participants of CRS. To get the reduced premiums, a variety of proactive steps can be done. This floodplain management plan (FMP) is an element that can improve the community's performance in the program and increase the premium discounts. Other activities, such as higher floodplain regulations, dedication of open space in the floodplain and the outreach of information related to flood risk, can qualify for premium discounts. Several manuals on this topic are listed in the Reference section of this FMP.

Tool: Tax Adjustments and Rebates

Further Evaluation Needed

The use of tax adjustments and tax rebates are potential tools to incentivize the establishment of more open space and/or encourage the construction and renovations of homes and businesses that are better protected from the risk of flooding.

Open space along a stream provides for an area free and clear of man-made structures to allow stormwater runoff and flood waters to flow unobstructed, as nature intended. A tax incentive program could provide a reduction of the property tax in exchange for the dedication of the open space area on a parcel through conservation and drainage easements.

With the exception of US Army Corps of Engineers and State of Kansas land near Tuttle Creek Reservoir, the majority of the property along the Big Blue River is privately owned. As a result, the tax adjustment strategy may be effective.

Tax rebates could be made available to home and business owners for a portion of the cost of materials and labor to build a new structure to a higher degree of flood protection or renovate an existing structure to mitigate the flood risk. As an example, the tax credits could be used to offset the cost to elevate the new home above what would typically be required. During the renovations to an existing home, tax credits could be used to cover the cost of engineered openings in the foundation, relocation & elevation of utility equipment or the use of flood resistant materials instead of traditional materials.

More research is needed to determine if this tool would be a substantial benefit to both the property owners and the community and what mechanisms would be needed to make these tax adjustment and tax rebate programs successful.

Tool: Emergency Relief

Advisable

Thanks to the efforts of the Big Blue River Silver Jacket project, the FEMA Flood Insurance Study update for Riley County and Pottawatomie County, efforts by the State of Kansas, USACE and the local communities, a wealth of information is available to local emergency planners, responders, and impacted residents and business owners, to provide accurate and timely information and to devise specific planning efforts for flood events on the Big Blue and Kansas Rivers.

This information can be included in the region's Multi-jurisdictional Hazard Mitigation Plan. Having this vital information included in the region's hazard mitigation plan creates the opportunity to use emergency relief funds and hazard mitigation grants when they become available through a Presidential Disaster Declaration, or other avenues from the State of Kansas and other federal agencies. These funds can address property owners' needs after an event and reduce or remove the impacts of the flood hazards.

Tool: Post-Flood Recovery Processes

Advisable

The City of Manhattan, Riley County and Pottawatomie County have significant training and real-life experience in post-flood events in their jurisdictions. Both the Manhattan Building Codes and the Floodplain Regulations for the City and the two Counties require homes and businesses impacted by flood waters be inspected to ensure they are habitable and meet all regulations and standards.

It is **advisable** that the entities along the Big Blue and Kansas Rivers will continue to inspect damaged homes and businesses after flood events to ensure they comply with all regulations. In addition, the local entities should become a repository of post-flood disaster information on flood safety, clean up and mitigation options for impacted property owners and their tenants.

Manhattan, Riley County and Pottawatomie County officials should also focus their post-flood recovery efforts on long-term needs for a neighborhood and/or the region. These efforts could include economic recovery and infrastructure recovery plans. A significant portion of the region's commercial and industrial uses is located along the Kansas and Big Blue Rivers. Likewise, a substantial portion of the City and the rural areas source of potable water and sanitary sewer service are located along these rivers. Fortunately, the Manhattan Levee System protects many of these regionally vital amenities. However, the levee system does not eliminate the risk of flooding for these areas, and contingency plans should be in place if the worst case scenario occurs. More research is needed on this topic to develop this information.

Strategy 3: Preserving and Restoring the Environmental Quality of Floodplains

This strategy and set of tools refers to managing the floodplain with the following specific activities and environmental features: wetlands protection and restoration, erosion and sediment control, water quality enhancement, enhancement of recreation and educational opportunities, and preservation of cultural resources.

Tool: Wetlands Protection and Restoration

Advisable

Wetlands play an important role in reducing sediment and other pollutants from entering a stream channel and can reduce flood waters in small intensity storms. The City has a number of known and mapped wetlands within the city limits and there are several within the Big Blue and Kansas River Watersheds. Federal and State regulations dictate the protection, restoration and creation of wetlands. The continued protection of established wetlands in the City, Pottawatomie County and Riley County is a priority of all entities.

Where feasible, the restoration of wetlands should be considered in mitigation measures along the Big Blue and Kansas Rivers and their tributaries.

Tool: Erosion and Sediment Control

Advisable

The City of Manhattan is required to follow the Environmental Protection Agency's National Pollutant Discharge Elimination System (NPDES), Phase II program to prevent polluted storm water runoff from entering U.S. water bodies. As part of NPDES, Phase II, the City requires Notice of Intent Permits for construction projects that will disturb an acre or more of ground. The City also has adopted best management practices (BMPs) for construction sites to prevent sediment from reaching the stormwater system and staffs a full-time employee to enforce the BMP construction requirements (City of Manhattan, 2012).

Riley County has adopted riparian buffer regulations requiring specific buffer zones based on the order of the stream (Riley County, 2012).

These policies should be continued within the City and Riley County. A similar policy is encouraged to be adopted in rural Pottawatomie County to reduce erosion of stream banks and improve water quality of stormwater runoff entering tributaries of the Big Blue and Kansas Rivers.

Other agencies, such as the Riley County and Pottawatomie County Conservation Districts, provide educational and technical support and possible funding sources to preserve natural resources in the two counties.

The City has also adopted policies and procedures for post-construction BMPs, which through structural and non-structural measures, are intended to provide for long-term water quality improvement for individual lots and/or entire subdivisions (City of Manhattan, Kansas, 2012).

The City and Counties should continue to participate in these types of programs and projects to protect existing homes and businesses.

Tool: Water Quality Enhancement

Advisable

As described above in Tool: Erosion and Sediment Control, the City, Counties and other agencies have plans, policies, and regulations in place to begin addressing water quality issues. These items include pre- and post-construction BMPs and riparian buffer regulations. However, more can and should be done, where feasible. A variety of local groups and organizations can partner to address both water quality issues and other environmental concerns along the Big Blue and Kansas Rivers and in other parts of the City and the two counties. These groups include classes and organizations at Kansas State University. Collaboration and cooperation projects, such as rain barrel giveaways which have been done in the past at Sunset Zoo, can be accomplished. A number of classes at Kansas State University can assist government entities in developing educational programs and assist private property owners with technical assistance to address water quality concerns. More collaboration and cooperative endeavors should be explored to tackle these needs.

Tool: Enhancement of Recreation and Educational Opportunities

Advisable

A variety of recreation amenities exist along the Big Blue and Kansas Rivers, including the Linear Trail, Rocky Ford Recreational Area and the trails and recreational amenities in the Tuttle Creek River Pond Area (*see map below)*. Currently, there is no direct connection via a recreation trail between all of these amenities. To date, no specific master plan has been created to study and expand on this concept, however an opportunity exists. A trail network is established from the Tuttle Creek River Pond area, to the Rocky Ford Recreation Area and Dyer Road. This trail network could be extended to the city limits to connect to the Linear Trail network and area parks, making this a regional park and trail network along the rivers. An update to the Manhattan Urban Area Comprehensive Plan, jointly developed and adopted by the City, Pottawatomie County and Riley County in 2012, includes applicable policies in Chapter 5 – Natural Resources and Environment that promote the creation of trails and connected open space areas along riparian stream corridors, including the Big Blue and Kansas Rivers.

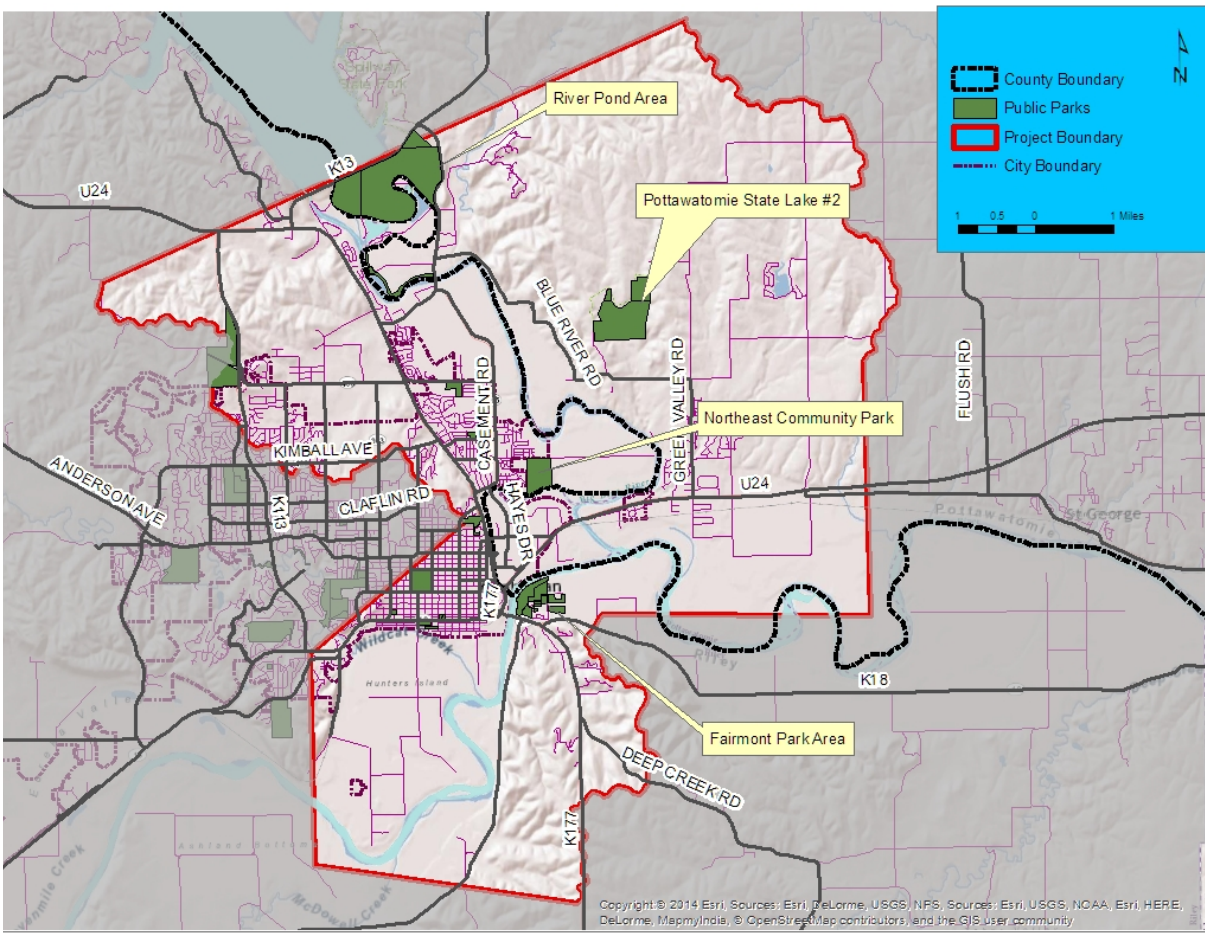


Figure 25: Permanent Acquisition

In addition to the expansion of recreation along the Big Blue and Kansas Rivers, a regional trail and park network, if done correctly, could also be used to preserve more open space in the floodplains, which will assist in improving erosion and water quality and potentially reduce flooding in their tributaries. This concept could also include an educational component to describe a variety of functions and topics related to natural and cultural resources found in the watersheds. A joint venture between the City and the two counties will most likely be needed to study the preferred route, purchase easements and property, and work with the USACE and the State of Kansas Department of Wildlife, Parks and Tourism. A funding source will need to be established to make this trail network a reality.

Tool: Preservation of Cultural Resources

Advisable

The Big Blue and Kansas River watersheds hold a plethora of cultural resources. Artifacts of pre-historic nomadic tribes, American Indian tribes, the Oregon Trail and early settlers can be found in these watersheds. These watersheds also contain an excellent example of today's agrarian lifestyle, characteristic of the Flint Hills.

The City of Manhattan and Manhattan Historic Resources Board, in conjunction with the State Historic Preservation Office, Riley County Historical Society and the History Department at Kansas State University have done both a Phase I and Phase II Archeological Resource Study for the area within the boundaries of the Manhattan Area Urban Area Comprehensive Plan, including some of the Big Blue River Watershed. As structural projects are proposed that are related to this Floodplain Management Plan, these cultural resources must be considered and protected when discovered.

Strategy 4: Modifying Floodwaters

This strategy and set of tools focuses on managing the floodwaters with the following specific features: the dam, stormwater detention basins, levees and floodwalls, landforms, channel alterations, diversions, and pump stations.

Since the late 1950s, communities have considered structural features to bring acceptable solutions for the flood hazards. Several of these structures are currently in place along the Big Blue and Kansas Rivers, including Tuttle Creek Dam and the Manhattan Levee System.

Tool: A Dam and Reservoir

Advisable and Further Evaluation Needed

The Tuttle Creek Dam and Reservoir was built in 1962 and is managed by the USACE. The dam is six miles north of Manhattan. The reservoir is a multipurpose project with the following authorized purposes: Flood Control, Low Flow Supplementation (Big Blue and Kansas Rivers), Navigation Supplementation (Missouri River), Water Quality, Water Supply, Recreation, and Fish and Wildlife. The structure has been a highly effective tool for managing floodwaters on a regional basis, as supported by the estimated $6.5 billion in flood damages prevented as of 2012. On a local basis, the dam is effective at managing floods for the community, working in tandem with other measures such as the Manhattan Levee and floodplain management measures required under the FEMA National Flood Insurance Program. The dam is designed to prevent flooding, but the reservoir operation can be very limited in water release flexibility in times of extreme drought and extreme

flood. Therefore, public understanding of this is important and was the subject of public involvement efforts in 2014 and 2015 as the Flood Insurance Rate Maps were updated.

Sedimentation. The USACE anticipated that Tuttle Creek Reservoir would gradually silt in as soil washed out of the land upstream. Despite land use practices encouraged by the Natural Resource Conservation Service (NRCS), sedimentation has occurred slightly faster than originally projected. However, the Flood Control Capacity does not face as much risk of being adversely affected as the Multipurpose Pool. At some point, perhaps 10 to 20 years from now, **Further Evaluation Is Needed** for studying the effectiveness of managing the sediment accumulated in the reservoir. A future action item could be pursued with USACE, although a local sponsor for the study would have to step forward.

As described, the Tuttle Creek Dam has been successful protecting property downstream from significant, repetitive flooding in most situations and the support of the structure is **advisable.** Additional structures of similar size and scale in the immediate area is unfeasible and is **not advisable.**

Tool: Stormwater Detention Basins

Advisable

In 2009, the City of Manhattan updated its Design and Construction Standard Specifications and Policies to require new subdivisions and infill projects that are 0.5 acres or larger to have stormwater release rates equal to or less than the pre-developed condition for the 2-year, 10-year, and 100-year storms. When the pre- vs. post-development stormwater releases are not achievable, stormwater detention measures are required on the site, in an appropriate location. This stormwater requirement has been implemented in new developments and redevelopment areas in the City. A detention structure would typically be inappropriate near a stream and/or in the floodplain, because the release of the stormwater from the detention basin could coincide with stormwater flowing into the area from upstream, which would compound the amount of stormwater in the area; possibly worsening the flood risks. The most appropriate location for stormwater detention structures in the middle and upper reaches of watershed.

Few examples exist in the Big Blue and Kansas River Watershed, but examples of detention basins in the Wildcat Creek Watershed on the west side of Manhattan have proven to be beneficial in decreasing the risk of flooding as well as improving sedimentation control. These new basins have significantly reduced the rate of runoff from these developments and the surrounding areas to the point they have lessened the base flood elevation and shrunk the mapped floodplain boundaries below these basins, when comparing the 2010 and 2015 flood studies for Riley County.

In addition to requiring detention basins where appropriate, the City of Manhattan has also implemented the practice of requiring restrictive covenants, running with the property, to identify who will own and maintain the basins and what measures will be taken by the City in the event a detention basin is not maintained. These measures may include the City doing the required maintenance of the detention basin and assessing the property for the cost of the work.

Because of the dynamics of the Big Blue Watershed below Tuttle Creek Reservoir, detention basins will not make any meaningful difference to the flood risks along the main stem of the river. However, these basins can decrease localized flooding along tributaries of the Big Blue River to lessen the flood risk and improve sediment and erosion control.

This policy should be continued within the City. A similar policy is encouraged to be adopted in rural Pottawatomie County and Riley County to reduce the rate of runoff from new developments that could go into tributaries of the Big Blue River and effect properties downstream.

Tool: Levees and Floodwalls

Advisable (current structure) and Not Advisable (new structure)

The Manhattan Levee System on the Big Blue and Kansas Rivers was constructed in 1964 by the USACE. Since the completion of the levee system, the City of Manhattan has maintained the structure and its accessory systems. The levee system protects a number of the region's commercial centers, including Manhattan's Central Business District, industrial areas, the City's wastewater treatment plant and fresh water supply, as well as a number of homes in the older part of Manhattan, totaling over $1 billion dollars of public and private investment.

The USACE Manhattan Levee Feasibility Report (2015) documented the opportunities for reducing the flood risk behind the levee in the vicinity of the confluence of the Big Blue and Kansas Rivers. The Big Blue River is the largest tributary of the Kansas River. The feasibility report clarified that a federal interest exists in increasing the level of protection currently offered.

With the completion of the USACE feasibility report, federal funding is pending authorization for a design and construction project. Federal funding appropriations for construction of improvements will eventually follow. A recommended step is for the City to begin budgeting dollars towards the City's portion of property acquisition and construction.

Through the USACE feasibility report, analysis was made to determine if extending the levee system to the north from the intersection of Casement Road and Hayes Road to Barnes /Dyer Road was feasible. Although a new levee system would protect a number of homes and public infrastructure in the northeast part of Manhattan, the initial cost-to-benefit analysis of such a levee did not meet the parameters set forth by the USACE to justify it as a recommended civil works project. The rough estimated price of the new levee was over $65 million, making it unfeasible for the local jurisdictions to fund such a major structure. Because of the cost, a new levee is **not advisable** at this time.

Tool: Landforms

Further Evaluation Needed

The City of Manhattan and Riley County recognize that some areas of the Big Blue and Kansas River floodplains may benefit from structural measures that are less substantial than a levee, but could direct floodwaters away from structures. A landform or training dikes have been used in situations around the country to better manage flows and reduce the adverse effect upon land owners. Analysis of a training dike that may help the land owners around the Dix Subdivision and other subdivisions nearby could be done at a later date. During the development and plan formulation for the USACE Manhattan Levee Feasibility Report (2015), this analysis was initially examined for possible inclusion in the federal project. Although a federal interest was not justified through the report, enough research was done to show some merits in a training dike or other similar landforms to divert floodwaters away from existing structures. The feasibility report also pointed to the need for flood risk adaptive measures, as described in the Modifying Human Susceptibility to Flood Hazards and also Modifying the Impact of Flooding. **Further Evaluation is Needed** to determine if a training dike or other kind of landforms are possible to reduce the risk of flooding in the watershed.

Tool: Channel Alterations, Diversions, and Bypasses

Further Evaluation Needed

The USACE Manhattan Levee Feasibility Report (2015) documented the levee system is an integral component for achieving successful flood risk management for the communities. Two key elements were discussed during the plan formulation work in regards to the channel adjacent to the levee and the diversion nearby in the commercial area on U.S. 24 Highway. The first element relates to constriction points at the U.S. 24 Highway Bridge and the Union Pacific Railroad Bridge, which creates a series of bottle necks to the flow of floodwater in this area. This bottleneck does not allow the floodwaters to flow freely and causes the water to back up further into the Big Blue River floodplain. The second element is the protection against encroaching into the floodway to the north of these two bridges. These issues relate to managing the flow of the floodwaters and the feasibility of a channel alteration that may help by widening the river channel, as opposed to deepening. Another measure would be managing the roughness of the channel, or more specifically how unmanaged vegetation may adversely affect the performance of other vital structural features, namely the Manhattan Levee.

Further Evaluation is Needed by KDOT and Union Pacific Railroad (UPRR) regarding the replacement or major rehabilitation on the two bridges. City-county-county initiatives should collaborate to engage both KDOT and UPRR to address the bridge improvement simultaneously. An upstream conveyance improvement may put the downstream structure at risk for some higher flood events, which is the reason to make future studies coincide.

During significant flood events, the floodway expands beyond the river channel and impacts a number of private property owners and their structures. Because of the impact of these flood waters on private property, as well as the potential impacts on adjacent property if the floodway is encroached upon or obstructed, special floodplain management oversight should be implemented. Although developing in the floodway is strictly discouraged, all three entities allow for development in this high risk flood area, if it can be proven the development will not raise the elevation of the base flood. To mitigate this potential issue, changes to the floodplain regulations for the City and two Counties should be made to prohibit development in the floodway, or the communities should attempt to purchase the properties to control the area and maintain the land in a condition suitable for the conveyance of floodwaters. An alternative approach to purchasing the land could be to purchase the development rights to building structures, etc. on the property.

An important recommendation is to keep a well maintained channel that limits the potential for obstructions caused by debris. Trees represent the highest vegetative restriction to the flood flows. The bridge's structural members will also be a place for flood borne debris to catch, causing an increase in flooding as well as damages to the bridge. The action of debris management could be a collaborative effort by the City of Manhattan, Riley County and Pottawatomie County and could be described in detail as part of a future emergency action plan.

Tool: Pump Stations

Advisable

The USACE Manhattan Levee Feasibility Report (2015) documented how pump stations for managing floodwaters are important to the function of the levee along both the Big Blue and Kansas Rivers. These facilities are aging and, in order to address flood risks, were evaluated as to whether or not there was a federal interest in future improvements.

This tool is an important piece of the Floodplain Management Plan, and several aspects of the tool are effective and have sub-elements or associated elements that are recommended. These pumps stations are **advisable** to be addressed as the USACE feasibility report describes. In addition, the City will need to continue the operation and maintenance in the manner required in the Operation and Maintenance Plan for the Manhattan Levee System. It is **advisable** the City periodically review the requirements of the Public Law 84-99 and ensure the Floodplain Management Plan, the Emergency Action Plan, and any flood fighting plan are in harmony with the requirements for USACE assistance.

V. Action Plan

Through recommendations developed and collected throughout the public input process, as presented previously in the document; the action plan was developed to implement the FMP. Possible strategies and tools of the action plan were evaluated for their relationship to the goals and objectives of the FMP (Section III) and the feasibility to complete the action.

Pottawatomie County, Riley County and the City of Manhattan professional staff developed the following detailed action plan for the implementation of the community's selected strategy and/or tools, and the schedule for implementation. A top priority for the FMP and the action plan is to establish a reliable funding source that will allow the communities to pay for the level of effort necessary to manage the floodplains along the Big Blue and Kansas Rivers, as outlined in this document. Following the development of the action plan, discussions of how to fund these items through existing utility funds or through capital improvement must be conducted. Municipal funds could match state and federal grant funds to further the progress of the action plan. Without a sustainable and dedicated funding source, the FMP will fail to achieve the identified goals and reduce the impacts of flooding along the Big Blue and Kansas Rivers.

Action Items

Action Item	Goal: Collaborative Approach	Goal: Manage & Reduce Flood Risks	Goal: Improve public understanding of flood risk	Goal: Balance needs of development and environment	Goal: Protect the riparian corridor	City	Pottawatomie County	Riley County	Timeline
Adopt the Blue River Floodplain Management Plan (FMP)	X					X	X	X	3 months
Create a Development Coordination Process between the 3 Entities	X	X		X	X	X	X	X	3 months
Amend the Multi-Jurisdictional Hazard Mitigation Plan to include the FMP	X	X		X		X	X	X	6 - 12 months
Develop Future Conditions model and Flood Insurance Rate Maps		X	X	X	X	X	X	X	2+ years
Research and adopt higher standard floodplain regulations		X		X	X		X	X	2+ years
Develop Erosion Control and Water Quality Requirements		X		X	X		X	X	1 year
Develop Stormwater Detention Requirements		X		X	X		X	X	1 year
Maintain and Expand Existing Flood Warning Systems		X	X			X	X	X	Ongoing
Develop a Comprehensive Public Outreach Plan		X	X			X	X	X	1 year
Develop a Post Disaster Recovery Plan	X	X	X						1 year
Develop a Blue River Recreation Plan	X	X	X		X	X	X	X	2+ years
Join the Community Rating System		X	X	X	X		X		12 - 18 months
Maintain and Expand the Existing Flood Protection Facilities		X			X	X	X	X	On-going

Table 3: Summary of action items

Description of Action Items

This section provides the detailed explanation of the FMP action items.

Adoption of the Big Blue and Kansas Rivers Floodplain Management Plan

The Big Blue and Kansas Rivers Floodplain Management Plan is the culmination of over a year of participation and work by the Technical Advisory Group, the Public Action Working Group, concerned citizens and City and the Counties professional staff. The FMP documents these efforts and creates an action plan to implement strategies and tools to promote mitigation of flooding along the Big Blue and Kansas Rivers. To strengthen the resolve of this plan, a public approval process shall be conducted. The public participation process will ultimately conclude with the governing bodies of Pottawatomie County, Riley County and the City of Manhattan amending the Manhattan Urban Area Comprehensive Plan, the Pottawatomie County Comprehensive Plan and the Riley County Vision 2025 Comprehensive Plan to reference the document. This process should begin immediately and is anticipated to be completed within three (3) months.

Establish a City and County Development Coordination Process

The Big Blue River runs along the border of Pottawatomie County and Riley County. The City of Manhattan lies within these two counties. Development within the watershed can affect City and rural County residents and business owners alike in all three jurisdictions. Professional staff members from the entities, and when applicable, from the U.S. Army Corps of Engineers, should form an informal technical working group to discuss development plans occurring within the watershed and how the development may impact the dynamics of the floodplain. This group is informal in nature and is in no way intended to replace the work of the respective planning boards or governing bodies, but rather have planning and engineering employees who can comment on issues and work in a coordinated effort to address them. Staff members who would be included in these informal discussions would be planners, floodplain managers, emergency managers, city and county engineers, and stormwater engineers. The process to create a system for coordinated review of development within the watershed should begin immediately. This system is anticipated to be completed within three (3) months; however, once created, it should remain as a permanent method for promoting communication and coordination.

Include the Big Blue and Kansas Rivers Floodplain Management Plan in the Regional Multi-Jurisdictional Hazard Mitigation Plan

The region, including Pottawatomie County and Riley County, has an approved Hazard Mitigation Plan. This Floodplain Management Plan and its accompanying details should be referenced in the Hazard Mitigation Plan. Some elements that should be considered for inclusion to enhance the understanding of flood risks are the flood hazard profiles associated with the 2015 Flood Insurance Study update. Having a Hazard Mitigation Plan that specifically addresses flood risks on the Big Blue, Kansas and other rivers, creeks and flood prone areas, will be creditable actions in the FEMA Community Rating System and/or contribute to eligibility for FEMA's Hazard Mitigation Grant Program funding. Because of the timing of updates to the regional plan, this action item is anticipated to be completed in five (5) years.

Develop a Comprehensive Flood Hazard Mitigation Plan

Wide varieties of flood risk adaptive measures are available to Pottawatomie County, Riley County and the City of Manhattan to reduce the risk of flooding along the Big Blue and Kansas Rivers. As discussed in the Strategies and Tools Section, the Floodplain Management Plan process included a public engagement component specifically revolving around this topic for property owners. The Strategies and Tools section provides greater details of this topic.

This action item recommends a comprehensive approach to mitigating the risk of flooding on the Big Blue and Kansas Rivers be created. The comprehensive Flood Hazard Mitigation Plan is envisioned to consist of three (3) parts:

1. Structural solutions. This portion of the Comprehensive Flood Hazard Mitigation Plan would be a collection of the City and the two County's list of stormwater infrastructure projects and should be periodically reviewed and potentially combined into shared projects that resolve flood issues. Such projects could be:

    - Detention basins located in the upper reaches of tributaries to the Big Blue and Kansas Rivers.
    - New or enlarged stormwater infrastructure, such as stormwater sewers, culverts, and swales to divert stormwater runoff.
    - Stream bank improvements to minimize or prevent significant erosion.
    - Stream channel restoration projects to improve stream function of tributaries into the Big Blue and Kansas Rivers.
    - Maintenance of existing stormwater infrastructure.

2. Major Flood Adaptive Measures. This section would be the heart of the plan to outline which private properties would benefit from being elevated or moved away from the floodplain to lessen the flood risk or bought out to eliminate the flood risks. As detailed in the Strategies and Tools Section, all applicable flood adaptive measures will be considered. This section should include a prioritized list of properties that would benefit from a flood adaptive measure, based on risk factors of the structure and characteristics of the flood risk. These factors could be:

    - Probability of being flooded
    - Repetitive flooding
    - Depth of floodwaters
    - Velocity of floodwater

    Using a systematic approach to prioritize these properties, a benefit to cost analysis can be created, which would determine not only the most at-risk properties and the ones needing to be mitigated, but also properties that would be the best candidates for state or federal grant dollars that require a benefit-to-cost ratio of 1.0 or greater.

    An added benefit of developing such a prioritized list of properties needing flood adaptive measures is the potential exists that clusters of properties, such as sections of streets or entire neighborhoods, could apply for state or federal grants, which would address the risk collectively, instead of having a "Swiss cheese" effect in an area.

3. Personal Flood Adaptive Measures. Floods can occur in grand scales where homes are destroyed by violent or prolonged flood events. Floods can also cause minor damage to homes or businesses, such as wet carpets. These minor types of floods can be more of a nuisance and would not generally necessitate spending tens of thousands of dollars to elevate or move the house. The third component of the Comprehensive Flood Mitigation Plan would be to develop a list of best practices or a user guide of tools that would create simple barriers to prevent such minor flooding. These tools could be simple waterproof barriers placed in a doorway or applying waterproofing materials on the foundation walls. These strategies and tools generally would not reduce the premium costs of flood insurance, but it could reduce the need for making small claims to the National Flood Insurance Program

Because of the complexity of the Comprehensive Flood Hazard Mitigation Plan, this action item could take two (2) or more years to complete.

Develop Future Conditions model and Flood Insurance Rate Maps

As explained in Section II, the City of Manhattan contracted with AMEC Environment & Infrastructure (AMEC) to develop a flood model based on the Wildcat Creek watershed and the Marlatt Ditch Drainage Area being completely built out, in conformance with the Manhattan Urban Area Comprehensive Plan's Future Land Use Map. This information has been valuable to residents, developers, lenders, and public officials by more accurately depicting what flooding could occur in the future (10 – 15 years) and how new development and redeveloped areas should be designed to protect against flood dangers and to reduce future risks.

The "Future Conditions Model" has been incorporated into the City's floodplain regulations, which uses the future 1% annual chance flood as the basis for regulating new and redeveloped properties. Regulating properties located in the future conditions floodplain and to future 1% annual flood elevation will decrease the level of risk of flooding the property owners will face. The description of adopting higher standard floodplain regulations is further discussed in the sub-section of Strategy 1, under Development Policies and Land Use Regulations.

Limited funds at the time resulted in the future conditions flood model being limited to the two (2) watersheds: the Wildcat Creek Watershed and the Marlatt Ditch Drainage Area. Both areas were growth areas in the City and the Wildcat Creek Watershed had experienced significant and repetitive flooding in the past. The flood model would provide the needed information to determine where residential and business growth should safely occur and to address the flood risks in the areas.

The future conditions model should be expanded to the rest of the Big Blue River Watershed from the face of the reservoir to at least the confluence with the Kansas River and its major tributaries. This will provide the City and the two Counties additional information that can guide future developments, redevelopments and how to mitigate existing properties to a safer extent. Due to funding and the time it takes to develop this complete flood model, this action item will take over two (2) years to complete.

Research and adopt higher standard floodplain regulations

The sub-section Stategy1: Modifying Human Susceptibility to Flood Hazards lists a number of broad, higher standard floodplain regulation concepts that can be considered and adopted. This would allow development within floodplains under certain conditions, while providing for lower risk of

flooding and reduction or elimination of impacts on adjacent properties up or downstream of the development.

The City of Manhattan has developed and adopted a set of higher standard regulations that uses the boundary of the future conditions flood model and the elevation associated with that model. The City's higher standard of floodplain regulations also has compensatory storage requirements for fill in the floodplain and has adjusted substantial damage and improvement requirements. The higher standard regulations are designed to protect new developments, as well as existing homes and businesses.

Pottawatomie County and Riley County should consider creating and adopting similar regulations to establish a uniform development pattern with seamless regulations in the floodplains. This would reduce confusion for property owners and developers and would avoid nonconforming issues for any structures on property being annexed into the City of Manhattan. The City's new regulations were adopted along with the new Flood Insurance Rate Maps (FIRMs) in March, 2015. Developing the new future conditions maps and/or new FIRMs will take several years. However, other regulations such as compensatory storage and lowering the substantial improvement/damage thresholds may be completed in less time. This action item should be considered within the next two (2) years.

Develop Erosion Control and Water Quality Requirements

Erosion control is an ongoing problem along the banks of the Big Blue and Kansas Rivers. Erosion control efforts by the City, Counties and property owners should work to prevent or repair eroded stream banks to restore and stabilize the bank. Assistance can be in the form of sponsoring state and federal grants and projects.

There are many plans, policies and regulations available to ensure water quality. These include pre- and post-construction BMPs and riparian buffer regulations. However, more can and should be done where feasible. A variety of local groups and organizations can be partnered with to address both water quality issues and other environmental concerns. These groups include classes and organizations at Kansas State University and local environmental groups.

Develop Stormwater Detention Requirements

On March 1, 2009, an update to the City of Manhattan's Design and Construction Standard Specifications and Policies was adopted that made changes to the Stormwater Detention Requirements. The updated requirements are summarized as follows:

> The stormwater detention requirement has changed for the post development condition for new subdivision and infill projects that are 0.5 acres or larger. Previously the Stormwater Management Master Plan (SWMMP) established maximum allowable release rates on Page 19 for the 2-year, 10-year and 100-year storm events on a per acreage basis. The new criteria for both new subdivisions and infill developments shall provide stormwater detention on site and the post-development condition shall have stormwater release rates equal to or less than the pre-developed condition. Developers should continue to have licensed professional engineers prepare drainage studies on all new developments and infill projects to determine the impact and mitigating methods to keep post developed conditions for the 2-year, 10-year, and 100-year storm events equal to or less than the pre-developed condition.

The requirement has been implemented in new developments and redevelopment areas where it is appropriate, such as the upper reaches of a watershed. A detention structure would typically be inappropriate near a stream and/or in the floodplain. In addition to requiring detention basins where they are appropriate, the City of Manhattan has also implemented the practice of requiring restrictive covenants on the property identifying who will own and maintain the basins and what measures will be taken by the City in the event a detention basin is not maintained. These measures can include the City doing the required maintenance of the detention basin and assessing the property for the cost of the work. A similar policy is encouraged to be adopted in Pottawatomie County and Riley County to reduce the rate of runoff from new developments.

Detention basins are best used in the middle to upper reaches of a watershed where they can slow the rate of runoff from an area before it reaches a stream. If designed properly, these basins should lessen the impacts of a flood by reducing the amount of peak flows in a flood. A detention basin located in a floodplain or close to the receiving body in the watershed is typically not appropriate because it can hold back floodwaters and release the water at a time when floodwaters from upstream reach the area. This can worsen a flood event by "stacking" the water released from a detention basin onto the peak floodwaters, making the flood event deeper, longer lasting and more significant.

Maintain and Expand Existing Flood Warning Systems

The U.S. Army Corps of Engineers (USACE), Pottawatomie County, Riley County and the City of Manhattan established an extensive system of tone and voice modulated sirens throughout the Big Blue River Valley while the Tuttle Creek Reservoir Dam was being reinforced and retrofitted. This siren system was originally developed in the rare case of a structural failure of the dam before the retrofit and reinforcement project could be completed.

The project was completed by the USACE, in 2010 and the need for this siren system for a structure failure is minimal. However, the equipment still is present and is operated by Riley County, Pottawatomie County and the City of Manhattan to provide notifications to the public, including flooding for the area. This existing system should be maintained and its use continued to warn residents of flood threats and other disasters.

Pottawatomie County, Riley County and the City of Manhattan are using the Northeast Kansas Notification system, a mass notification system that allows the emergency management officials to alert residents of emergency and non-emergency situations. The system is an "opt-in" system, where residents sign up to the service to get email, text or phone call notices of emergencies and other public awareness announcements. Wireless Emergency Alerts (WEA) and Integrated Public Alert and Warning System (IPAWS) may also be used to notify all cellular telephones during a disaster.

The region's emergency notice system should also be expanded to include areas where it currently does not reach to provide complete coverage of the Big Blue Valley and Kansas River Valley. The system should also be expanded to include new technologies that do not currently exist in the mainstream of warning systems.

Develop a Comprehensive Public Outreach Plan

There is an extensive amount of information property owners and tenants in or near a floodplain should know before, during and after a flood event. The City and Counties can be a valuable clearinghouse for this information. Through traditional public information channels and newer channels, such as social media and mobile applications, the following information should be disseminated:

- National Floodplain Insurance Program (NFIP) information and requirements
- Local Floodplain Regulations
- Information and guidelines for developing in the floodplain
- General flood risks for the community
- Specific flood risks for areas of the City
- Emergency preparedness information
- Emergency evacuation information
- Post-flood disaster recovery information

Through a comprehensive public outreach plan, these topics can be better disseminated to the public. A comprehensive public outreach plan can also earn Community Rating System credits, which may decrease NFIP premiums for property owners. The action item should be created within twelve (12) months, then continually maintained, reviewed and refined to provide residents and property owners with information about flood risks.

Develop a Post Disaster Recovery Plan

Due to the dynamics of the flood risk along the Big Blue and Kansas Rivers and the public utility services present in the river valleys, a post disaster recovery plan should be considered. The flood protection offered by Tuttle Creek Reservoir significantly reduces the potential for flash flooding along the Big Blue and Kansas Rivers. Because of the integrated flood protection structures in the Kansas River Watershed, the most likely type of flood event would be a prolonged inundation of floodwaters, spanning over several days or weeks. This type of flooding can devastate the physical and social infrastructure of neighborhoods and communities.

In addition to the prolonged flood risk from the Big Blue and Kansas Rivers, the region's potable water and sanitary sewer systems are located in these river valleys. A significant number of the region's business centers, including Manhattan's Central Business District and several major industrial parks are located in the Big Blue and Kansas River Valley. Restricted access to these areas because of floodwaters, or complete inundation of these regionally important utilities and economic centers, would risk the health and well-being of the region.

Examples of how this type of flooding impacts a city or region are numerous. The examples include the 1993 flood events in the Midwest, flooding on the Red River in North and South Dakota and Minnesota in 1997 and the effects of Hurricane Katrina in 2005. Lessons should be garnered from these past events to develop plans on how the City would recover from such a devastating flood event and other disasters. This plan should include repairing of the impacted utility systems, what steps should be taken while these systems are being repaired and a housing and economic recovery plan.

The complexity of such a plan requires this action item to take two (2) years or more to complete.

Develop a Big Blue River Recreation Plan

As described in *Tool: Enhancement of Recreation and Educational Opportunities,* by expanding upon existing facilities, opportunities are available to develop a recreation corridor along the Big Blue River that could protect the riparian corridor, help maintain the floodway and floodplain as open space, improve quality of life in the City, Pottawatomie County and Riley County and possibly create educational programs and products.

The three (3) entities should jointly develop a recreation plan to create such a corridor. With the complexity of such a master plan, the anticipated time line is at least two (2) or more years.

Join the Community Rating System

The Community Rating System (CRS) is outlined in Strategy 2**:** Modifying the Impact of Flooding. The City of Manhattan was accepted into CRS in May 2013, with a Class 8, a 10% reduction in flood insurance premiums for property owners located in the floodplain. The City should continue its participation in the program and work to earn more activity credits through higher regulatory standards, more public outreach and expanding the flood warning system.

Riley County has also been accepted into the CRS program as a Class 9 Community, which means policy holders are receiving a 5% discount on their flood insurance premiums. Riley County should also continue its participation in the program and work to expand the activity credits to achieve a higher community rating and provide a larger insurance premium discount to NFIP policy holders.

Pottawatomie County should consider joining the CRS Program. Pottawatomie County should earn enough credit points to enter the program and provide at least a 5% reduction in flood insurance premiums to policy holders. The typical application process takes twelve (12) – eighteen (18) months.

Maintain and Expand the Existing Flood Protection Facilities

The City of Manhattan maintains the levee system along the Big Blue and Kansas Rivers. All three entities maintain an extensive system of stormwater infrastructure in their jurisdiction. The adequate maintenance of these existing systems is important to residents, businesses and the environment to reduce widespread flood issues and address erosion concerns.

Where feasible, the City and the two counties should look to expand these flood protection facilities to further protect those in harm's way. For any large civic projects, such as constructing a new levee or dam structure, partnerships with state and federal agencies will most likely be required. For instance, the City has partnered with the USACE to study the feasibility of raising the levee system for added flood protection and to rehabilitate existing pumps and gates associated with the structure.

The continued maintenance of these structures should be ongoing. The study, design and construction of any new stormwater infrastructure improvements can be complicated and may require two (2) or more years to complete. This action item will be ongoing.

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Many thanks to those that have contributed, in the sources shown below, to the communities' shared mission of managing the creek's flood risks.

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DEFINITIONS

The following words help to unify the communities and provide consistency in conducting the work associated with this living document.

Best Management Practices (BMPs) - measures intended to provide an on–the-ground, practical solution to diffuse pollution problems from all sources and sectors. They are technology and education based requirements in federal stormwater regulations that call for the implementation of controls to reduce the discharge of pollutants to the maximum extent practicable in municipal stormwater systems.

Community Based Floodplain – A floodplain modeled based on hydrological and hydraulic data, information and knowledge to predict current and/or future flood risks for an area.

Comprehensive Plan- a plan including recommendations for new and operating projects, primarily for Corps implementation, but in coordination with other agency efforts, and focusing on one or more Corps mission areas in Civil Works.

Geographic Information Systems (GIS) - a database of points, lines, shapes, and a set of attributes that are geospatially referenced and enable quality communication of the interrelationships of the data via visual aids, such as maps.

Ecosystem Restoration- the practice of restoring degraded significant ecosystem structure function and dynamic processes to a less degraded more natural condition; to improve or re-establish structural components and functions of natural areas; to mimic as closely as possible conditions which would occur in the area in the absence of human changes to landscape and hydrology. Considered one of several mission areas of Civil Works planning.

Feasibility Study- for the Corps of Engineers, this is a study lasting less than three years, when adequately funded, that uses a specific six step planning process to form projects composed of alternatives that are acceptable to the locals and the federal government to solve a problem. Also synonymous with Feasibility Planning Study.

Flood Risk Management- the shared practice among local communities, state and federal agencies of flood damage reduction that includes and extends beyond structural measures to include the proper management of all parts of watersheds to address flooding, to address opportunities for wider, shared, programmatic approaches and multi-purpose flood damage reduction projects, and to better clarify the level of risk associated with flood damage reduction measures.

Non-Structural Measures- measures that do not include physical or constructed components but rely sole on policies, maintenance practices, or management activities.

Risk Communication- integrating effective communication of risk and reliability concepts, alternatives levels of risk, and the associated consequences to the public and other stakeholders.

Stakeholders- those that have a stake in the outcome of a project; those that can provide vital input on issues that affect data, possible alternatives, and efforts of the project delivery team (PDT); stakeholders includes sponsors, constituents, residents, businesses, groups, agencies, cities, not-for-profit organizations, etc. and will all be respected even though external to the PDT; may become part of the PDT when the PDT agrees to accept them to be involved with a level of effort identified in a project's project management plan.

Structural Measures- measures that include physical alterations or constructed components as part of an alternative or plan.

Water Quality- a measure of the suitability of water for specific uses based on chemical, biological and physical characteristics. These characteristics are compared to standards and guidelines to determine if the water meets designated uses. Water quality is affected by both natural process as well as human activities, and a healthy environment supports a diverse community of organisms and protects public health.

Watershed- the area that collects and conveys rainfall to a common point along a stream or river. Synonymous with basin.