City of Dubuque, Iowa

2013 Drainage Basin Master Plan Amendment

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[2] Figure numbers are numbered with an "A" to reflect their relevance to this 2013 Drainage Basin Master Plan Amendment.

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1.0 INTRODUCTION

The City of Dubuque (City) retained HDR Engineering, Inc. to complete an amendment to the 2001 Drainage Basin Master Plan (2001 DBMP). This amendment is called the 2013 Drainage Basin Master Plan Amendment (2013 DBMP). This updated master plan documents the stormwater accomplishments since the implementation of the 2001 DBMP, illustrates the current status of stormwater projects/programs within the City, and identifies stormwater improvements that will address existing and future drainage needs in the City's drainage basins.

Many of the recommended projects outlined in the 2001 DBMP has been implemented or are in the process of being implemented. This amendment documents the changes in the North Fork Catfish Creek and Bee Branch Drainage Basins studied as part of the 2001 DBMP as well as city-wide endeavors related to stormwater management and flood damage mitigation. Figure 1-1A shows the various drainage basins within the City limits.

Although this 2013 DBMP focuses on the Bee Branch Drainage Basin, some projects extend outside the drainage boundaries of the Bee Branch Drainage Basin. The City projects/programs are not limited to the Bee Branch Drainage Basin and can be implemented in the adjacent drainage basins.

1.1 Organization of this Drainage Basin Master Plan Amendment

This 2013 DBMP is intended to update, but not replace, the 2001 DBMP. Therefore, this document is divided into the following five sections, consistent with the 2001 document:

- Section 1.0, Introduction, introduces this 2013 DBMP.
- Section 2.0, Background and Methodology, documents stormwater management changes that have occurred in the drainage basins since 2001 and describes the methodology used to develop this 2013 DBMP.
- Section 3.0, North Fork Catfish Creek Drainage Basin, documents stormwater projects that have been completed since 2001 and changes within the North Fork Catfish Creek Drainage Basin.
- Section 4.0, Bee Branch Drainage Basin, updates the discussions of the problem areas, alternative solutions, and recommendations for improvement for each drainage subarea.
- Section 5.0, Financing Drainage Improvements and Operations, presents capital funding opportunities, including the City's stormwater utility.

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2.0 BACKGROUND AND METHODOLOGY

This section contains new text to document changes that have occurred in the drainage basins and the City since 2001, and to describe the methodology used to develop this 2013 DBMP.

Amend 2001 DBMP Section 2.0 with new Sections 2.7 through 2.9 as follows:

2.7 Drainage Basin Hydrologic and Hydraulic Changes

Since the 2001 DBMP was completed, the hydrology and hydraulic behavior of the City's drainage basins have undergone changes. Frequent, intense storm events had resulted in an increase in flooding, and an increase in the frequency of federally declared disasters. The following sections describe the hydrologic and hydraulic changes in more detail.

2.7.1 Storm Changes

In the 12 years since the 2001 DBMP was released, several intense storm events have occurred in the Dubuque metropolitan area. By analyzing past rainfall events, statistics about rainfall recurrence can be determined for standard return periods or frequencies, such as the amount of rainfall that statistically occurs every 100 years. Table 2.9 outlines the magnitude and frequency of theoretical rainfall amounts reflected in the 1992 *Rainfall Frequency Atlas of the Midwest*, prepared by Floyd A. Huff and James R. Angel[3] (1992 Atlas), for selected storm periods in northeast Iowa, which includes the Dubuque area. As the probability of occurrence decreases, the rainfall amounts increase for a given duration. The probability of a 100-year storm or greater occurring in any given year is 1/100 or 1 percent. According to the 1992 Atlas, there have been three 100-year storm events, two 50-year storm events, one 25-year storm event, and one 10-year storm event since 2001.

Table 2.9
Magnitude and Frequency of Theoretical Rainfall Amounts for Selected Storm Periods in Northeast Iowa From 1992 Atlas

Duration (hours)	Rainfall (inches) for Indicated Recurrence Interval or Frequency (Years)			
	10	25	50	100
1	2.03	2.40	2.69	2.99
2	2.50	2.96	3.32	3.69
3	2.76	3.27	3.67	4.07
6	3.23	3.83	4.30	4.77
12	3.75	4.45	4.99	5.53
18	4.05	4.80	5.39	5.98
24	4.31	5.11	5.73	6.36
48	4.69	5.62	6.34	7.09
72	5.14	6.19	7.00	7.84

Note: Rainfall frequency amounts are from the 1992 *Rainfall Frequency Atlas of the Midwest* (Huff and Angel).

[3] The 1992 Atlas is based on rainfall data for a period of record between 1948 and 1992.

In April 2013, the National Oceanic and Atmospheric Administration (NOAA)[4] published precipitation frequency estimates for the state of Iowa. The precipitation estimates were calculated for a variety of frequencies and durations. The analysis used statistical calculations on annual maximum series generated from over 4,800 stations. The stations in Iowa that were used to generate the precipitation frequency estimates have variable rainfall periods of record that were utilized in the analysis, spanning from 1893 to 2010. NOAA did not use a standard period of record for its analysis, but rather it conducted the analysis using available records. The available records vary for various durations. Table 2.10 compares predicted rainfall amounts for 24-hour duration storm events for the 1992 Atlas and 2013 NOAA data. The 1992 Atlas data are for northeast Iowa, while the NOAA data are based on point-based frequency estimates for a specific point in Dubuque, Iowa (latitude = 42.4968, longitude = -90.6693). The probability of occurrence of a less frequent storm has increased, and the 2013 NOAA 100-year storm depth has increased 20 percent from the 1992 Atlas rainfall amount. With the evaluation of more intense rainfall data, the probability of occurrence of higher rainfall amounts has increased. The rainfall depth that was predicted to occur once every 100 years is now predicted to occur once every 50 years.

Table 2.10
Comparison of Predicted Rainfall Amounts for 24-Hour Duration Storm Events at Selected Recurrence Intervals

Frequency (Years)	Rainfall Amounts (inches)		Rainfall Percentage Increase
	1992 Atlas[1]	2013 NOAA[2]	
10	4.31	4.43	3
25	5.11	5.55	9
50	5.73	6.54	14
100	6.36	7.65	20

Notes:
1. Rainfall amounts are from the 1992 *Rainfall Frequency Atlas of the Midwest* (Huff and Angel).
2. Rainfall amounts are taken from NOAA *Atlas 14, Precipitation-Frequency Atlas of the United States*, Volume 8. NOAA National Weather Service website at http://hdsc.nws.noaa.gov/hdsc/pfds/

Table 2.11 summarizes rainfall amounts in Dubuque between 1999 and 2011, with an estimate of the storm's statistical frequency of occurrence. In May 1999, a rainstorm dropped 3 inches of rain in 90 minutes. The subsequent damage resulted in the first in a series of seven Presidential disaster declarations over a 12-year period. In 2001, the record for rainfall recorded in a 24-hour period was 6.4 inches. This amount was equaled in 2002 and later surpassed in 2011. During the months of May and June 2008, a record total rainfall of 15.7 inches fell in Dubuque. In August 2002, the 35-year-old record for most rain in a 24-hour period was matched, and in July 2011, the 24-hour record was surpassed when 10.6 inches of rain fell, with 10.2 inches falling in a 12-hour period.

[4] 2013 NOAA Atlas 14 data are based on daily rainfall data with an average of 68 years of data used for frequency estimates.

Table 2.11
Summary of Storm Event Rainfall in Dubuque Between 1999 and 2011

Date of Storm Event	Rainfall[1] (inches)	Recording Rainfall Duration (hours)	1992 Atlas Frequency	2013 NOAA Frequency
May 16, 1999	3.0	1.5	> 25-year	~ 50-year
June 3-5, 2002	6.4	48	> 50-year	> 50-year
August 21-22, 2002	8.9	24	> 100-year	> 200-year
May 21-23, 2004	3.9	48	> 5-year	> 2-year
July 18, 2007	5.1	48	> 10-year	~ 10-year
July 22-23, 2010	7.4	48	> 100-year	> 25-year
July 27-28, 2011	10.2	12	> 100-year	> 500-year

Note: Rainfall information was obtained from the National Weather Service, National Climatic Data Center, and U.S. Geological Survey.

2.7.2 Bee Branch Drainage Basin Flooding

Historically, the Mississippi River has flooded the City's low-lying riverfront areas several times over the past 150 years. After the record flood of 1965, a concerted effort by local, state, and federal officials to construct a levee system was initiated. In 1973, a 6.4-mile-long earthen levee and concrete floodwall system, known as the John C. Culver Floodwall, was completed along the Mississippi River. In addition, with more 100-year storm events occurring more frequently, flash flooding has become an even greater public health, safety, and economic issue for the City. Unlike Mississippi River flooding, flash flooding occurs with little or no warning time, with water levels rising and flowing at extremely fast rates.

Floods are the second most common and widespread of all-natural disasters, second only to fire. The National Climatic Data Center lists 65 flood events in Dubuque County from January 1, 1950, through December 31, 2012. Prior to 1973, the flooding experienced by the City was related to the Mississippi River. With construction of the aforementioned floodwall, disasters related to the Mississippi River have largely been avoided. However, there have been six disasters since 1999 unrelated to the Mississippi River. These disasters have been a result of localized, intense rainstorms in the Dubuque area. One of the most destructive flash floods in the City occurred on May 16, 1999, with $16 million in property damage. The 2010 State of Iowa Hazard Mitigation Plan estimates that Dubuque County has an annual loss of $10,566,235 due to flooding.

More recently, in July 2011, the City experienced a significant flash flood event. According to the National Climatic Data Center, during the early evening hours on July 27, 2011, showers and thunderstorms developed and continued to redevelop and move over the City for approximately 18 hours. Record-setting rainfall totals of 7 to 15 inches resulted in flash flooding of much of the area. The City experienced significant street flooding, causing sewer covers to be blown off or washed downstream with the floodwaters. The hardest hit areas of the City included the vicinities of St. Mary's Catholic Church,

Elm Street, and the Historic Millwork District, all of which are located in the Bee Branch Drainage Basin.[5]

2.7.3 Presidential Disaster Declarations

Presidential disaster declarations are issued when emergency conditions are beyond the recovery capabilities of local and state governments. Since the first Presidential disaster declaration in the U.S. was issued in 1953, disasters have been declared for a variety of reasons, including: acts of terrorism, extreme weather events, droughts and flooding. The damage caused by the event is a primary metric that determines if a Presidential disaster declaration is issued.

There are multiple prerequisites to a Presidential disaster declaration. A governor must first consult with local government officials to determine that the recovery appears to be beyond the combined resources of both the local and state governments. The governor must then certify that the severity and magnitude of the disaster does in fact exceed local and state capabilities. A preliminary damage assessment team is then assembled, comprised of personnel from the Federal Emergency Management Agency (FEMA), the state's emergency management agency, county and local officials, and the U.S. Small Business Administration (SBA). The team begins by reviewing the types of damage and emergency costs incurred by local and state governments and the impact on critical facilities such as public utilities, hospitals, schools, and fire and police departments. The damage assessment team also looks at the effect of the event on individuals and businesses, including the number of homes and businesses damaged, the number of people displaced, and the threat to health and safety caused by the storm event. During the assessment, the team collects estimates of the expenses and damages, and reports its finding. FEMA assesses a number of factors to determine the severity, magnitude, and impact of the emergency conditions. FEMA's recommendation to the President for federal disaster assistance considers other factors, such as the following:

- Amount and type of damage (number of homes destroyed or with major damage)
- Impact on infrastructure and critical facilities
- Imminent threats to public health and safety
- Impacts on essential government services
- Concentration of damage[6]

Since 1953, when the first Presidential disaster declaration in the U.S. was issued, until 1998, seven disasters were declared for Dubuque County due to flood damage, the first in 1969 and the last in 1993, as shown in Table 2.12. As discussed in Section 2.7.2, early Dubuque flooding was related to a combination of Mississippi River flooding and/or relatively minor rainfall events. With the completion of the John C. Culver Floodwall in 1973, the City of Dubuque has prevented multiple disasters related to Mississippi River flooding.

[5] Information in this section was provided by the City of Dubuque, Iowa.
[6] Information in this section was obtained from FEMA's website.

Table 2.12
Summary of Presidential Disaster Declarations in Dubuque County
1953 - 1998

Date of Declaration	Disaster Number	Reason for Declaration	Cause of Damage
April 25, 1969	259	Flooding	Mississippi River stage at 21.7
August 14, 1969	269	Flooding and heavy rain	3.2 inches of rain in 48 hours
August 18, 1972	348	Flooding and severe storms	3.0 inches of rain in 24 hours
September 26, 1972	354	Flooding and severe storms	2.2 inches of rain in 5 hours
May 23, 1973	386	Flooding and severe storms	Mississippi River stage at 20.3
June 24, 1974	443	Flooding and severe storms	Mississippi River stage at 15.2, 2.0 inches of rain in 10 hours
July 10, 1993	996	Flooding and severe storms	Mississippi River stage at 22.3, 3.9 inches of rain in 24 hours

Notes:
1. The information provided above was obtained from the FEMA, Iowa Homeland Security and Emergency Management, and the Iowa Emergency Management Association websites.
2. The Mississippi River flood stage is 17.0 feet at River Mile 579.9 located on the right bank at the foot of 4th Street in Dubuque adjacent to the right abutment of the Illinois Central Railroad bridge.
3. The floodwall construction was completed in 1973.

Starting in 1999, statistically rare and intense local storm events have repeatedly caused damage above the threshold required for Presidential disaster declarations. Seven Presidential disaster declarations occurred between 1999 and 2011, as shown in Table 2.13.

Table 2.13
Summary of Presidential Disaster Declarations in Dubuque County
1999 - 2011

Date of Declaration	Disaster Number	Reason for Declaration	Cause of Damage
May 21, 1999	1277	Flooding, severe storms, tornadoes	3 inches of rain in 1.5 hours
May 2, 2001	1367	Flooding, severe storms, tornadoes	Mississippi River stage at 23.7
June 19, 2002	1420	Flooding and storms	4.9 inches of rain in 24 hours
June 2, 2004	1518	Flooding, severe storms, tornadoes	3.9 inches of rain in 48 hours
May 27, 2008	1763	Flooding, severe storms, tornadoes	15.7 inches of rain in 2 months
August 14, 2010	1930	Flooding, severe storms, tornadoes	4.8 inches of rain in 12 hours
August 30, 2011	4018	Flooding, severe storms, tornadoes	10.2 inches of rain in 12 hours

Notes:
1. The information provided above was obtained from the FEMA and Iowa Homeland Security and Emergency Management websites.
2. The Mississippi River flood stage is 17.0 feet at River Mile 579.9 located on the right bank at the foot of 4th Street in Dubuque adjacent to the right abutment of the Illinois Central Railroad bridge.

As a result of the storms and floods experienced in Dubuque and nine surrounding counties in May 1999, a Presidential disaster declaration was issued. FEMA reported that as a result of the storms and flooding:

- 2,743 victims registered for assistance.

- $3.6 million was set aside for temporary housing, minor housing repairs, and other private disaster related expenses.
- $6.5 million in disaster loans were approved by the SBA.
- $435,000 was obligated under the federal Public Assistance program.

On May 2, 2001, a Presidential disaster declaration was issued for flooding, severe storms, and tornadoes that damaged private property starting on April 8, 2001. As of June 7, 2001, over $2 million had been approved in grants and low interest loans through federal disaster assistance. No other detailed information was available for this disaster declaration.

On June 19, 2002, a Presidential disaster declaration was issued for flooding on June 3 and June 4 in eastern Iowa. Radar indications estimated that as much as 8 to 10 inches of rain fell during that period. Dubuque received a total of 6.4 inches of rain, with 4.9 inches recorded in 24 hours. The National Climatic Data Center reported that "the counties hit hardest were Delaware and Dubuque. This heavy rain resulted in widespread and significant flash flooding" and public property damage of $2.1 million in Dubuque County.[7] According to the National Weather Service, "flash flooding caused significant property damage to homes and businesses. Rainfall rates of over 2 inches per hour were recorded… with $7.2 million of property damage."[8] It was reported in the Telegraph Herald that the Director of Dubuque County Disaster Services, Tom Berger, toured flood damaged areas including "'well over 200' homes in the Dubuque area."[9] Based on the National Flood Insurance Program Bureau and Statistical Agent Iowa loss report, as presented by the U.S. Geological Survey (USGS), the reported damage (building and contents) per Dubuque household was $6,900.[10] Businesses were damaged as well.

On June 2, 2004, a Presidential disaster declaration was issued for severe storms with tornadoes and flooding. As reported by USGS, a series of thunderstorms that crossed north-central and northeast Iowa on May 21−23 caused flash flooding across northeast Iowa. Intense rain occurred in the late evening of May 21 to sunrise on May 22, followed by intense rain on the late evening of May 22 to the early morning of May 23.[11] FEMA officials reported that 4,813 individuals registered for assistance, and that more than $11 million of aid had been approved for individuals, families, and businesses in Iowa.[12]

The Presidential disaster declaration on May 27, 2008, that included Dubuque also included much of Iowa. As reported by USGS, "precipitation from December 2007 through May 2008 was the second wettest on record from 1895 to 2008. Notably, the precipitation in eastern Iowa and southern Wisconsin was characterized by extremely wet conditions that normally occur less than 2.5 percent of the time."[13] In Dubuque, the 15.7 inches of total rain for May and June measured by the NOAA National Climatic Data

7 NOAA National Climatic Data Center, Storm Events Database, NOAA National Climatic Data Center website, http://www.ncdc.noaa.gov/stormevents/ , accessed April 8, 2013.

8 National Weather Service Weather Forecast Office (Quad Cities, IA/IL), "East Central Iowa and Northwest Illinois Flooding – June 4, 2002," National Weather Service website, http://www.crh.noaa.gov/dvn/?n=06042002_cwaflood , accessed April 5, 2013.

9 Erin Coyle. "Storms unleash flooding – Dubuque hit by record rainfall," Telegraph Herald 5 June 2002.

10 USGS, "Flood of June 4-5, 2002 in the Maquoketa River Basin, East-Central Iowa," Open-File Report 2004-1250.

11 USGS, "Flood of May 23, 2004 in the Turkey and Maquoketa River Basins, Northeast Iowa," Open-File Report 2006-1067.

12 FEMA, "Combined Disaster Aid for Iowa Reaches $13 Million," Press release, 27 July 2004.

13 USGS, "Floods of May and June 2008 in Iowa," Open-File Report 2010–1096.

Center was the highest total since recording began in 1951. More than $800.4 million in federal assistance was provided, with more than $133.7 million going to 31,484 households.[14]

A Presidential disaster declaration was issued on August 14, 2010, for Dubuque as a result of a rainfall event on July 22 and 23. Heavy rain, which fell in 12 hours, resulted in flash flooding. About 15 inches of water was flowing in various streets in Dubuque as torrential rains continued.[15] According to Police Lieutenant Scott Baxter, "the fierce water flow . . . created dangerous conditions. He said that at least one person tried walking through deep water and nearly fell into a storm sewer (manhole) left uncovered by a blown manhole (lid)."[16] Numerous homes experienced property damage from the storms, including flooded basements. The City's Fire Department and Public Works Department helped pump out more than 100 basements, the majority of which are in the City's north end.[17] Claims for public property damage in Dubuque totaled more than $891,000.[18]

The Presidential disaster declaration issued on August 30, 2011, was the result of a storm event that stalled over northeast Iowa in July 2011. According to the National Weather Service, "thunderstorms developed repeatedly on the back of the storm and then 'trained' across the same areas. The heaviest rain fell from near Dyersville, IA to Dubuque, IA. Rainfall totals reached record levels in Dubuque and extreme flash flooding resulted."[19] It was reported that up to 15 inches of rain fell . . . within a 12-hour period on July 27 and 28, causing flash flooding that tore up roads and bridges, flooded homes and businesses, and claimed two lives.[20] Public property damage in Dubuque totaled more than $3.1 million.[21] Families who live along Elm Street within the Bee Branch Drainage Basin surveyed the damage as they waited for the fire department to come pump the water from their homes. The City of Dubuque Fire Department pumped out 254 basements in the hours and days following the rainstorm.

Within the past decade, Presidential disaster declarations as a result of severe storms and flooding have occurred in eastern Iowa, Dubuque County, and the City. Although damage amounts are not published for the City, millions of dollars have been spent providing public assistance to flood victims and providing monies to restore public infrastructure. With the occurrence of more intense rainfall events, effective stormwater projects/programs are necessary to avoid, minimize, and mitigate flooding.

2.8 Changes to the Stormwater Management Program

Since the development of the 2001 DBMP, stormwater-related projects/programs have been completed. These accomplishments are summarized in the subsequent sections.

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14 FEMA, "Governor Culver, FEMA officials announce Iowans have received more than $800 million in total assistance," Press release, 12 November 2008.

15 NOAA National Climatic Data Center, Storm Events Database, NOAA National Climatic Data Center website, http://www.ncdc.noaa.gov/stormevents/, accessed April 8, 2013.

16 Courtney Blanchard. "Storm swamps tri-states," Telegraph Herald, 24 July 2010.

17 Kera Mashek. "Dubuque continues flood clean-up," KWWL, 28 July 2010.

18 USGS, "Floods of July 23-26, 2010, in the Little Maquoketa and Maquoketa River Basins, Northeast Iowa," Open-File Report 2006-1067.

19 NOAA National Climatic Data Center, Forecast Office, "Historic Heavy Rain and Flash Flooding in Dubuque and Jo Daviess Counties, 07/27-07/28/2011," NOAA National Climatic Data Center, Forecast Office website, http://www.crh.noaa.gov/dvn/?n=event_072711_dubuqueflashflood, accessed April 9, 2013.

20 Kurt Ullrich. "Depth of damage still sinking in," Telegraph Herald, 2 August 2011.

21 Andy Piper. "Storm's precision adds insult to injury," Telegraph Herald, 12 August 2011.

2.8.1 Stormwater Projects Completed Since 2001

Within the Bee Branch Drainage Basin, conveyance and detention improvements were defined in the 2001 DBMP. Detention was provided along Carter Road, and the existing West 32nd Street Detention Basin was expanded. In the 2001 DBMP, it was proposed that a portion of the existing Bee Branch storm sewer trunk line be replaced with an open channel. This channel would begin at the 16th Street Detention Cell, located near the Mississippi River, and would proceed upstream to near 24th Street. A phased approach separated the Bee Branch storm sewer into "Lower" and "Upper" creek restoration segments. The Lower Bee Branch Creek Restoration extends from the 16th Street Detention Cell to the Canadian Pacific Railway[22] (CP Railway), and construction of the restored creek and floodplain area was substantially complete in 2011. The Upper Bee Branch Creek Restoration will continue north of the CP Railway crossing and terminate at 24th Street. Land acquisition is near completion for the Upper Bee Branch Creek Restoration, with construction scheduled to begin in the spring of 2014.

Table 2.14 summarizes the 2001 DBMP projects that have been completed, and Table 2.15 summarizes other conveyance and storage improvement projects that were not specifically identified in the 2001 DBMP but have been implemented. These other projects are described in more detail within the individual subarea discussions in Section 4.0. Figure 2-1A shows the locations of the implemented projects.

Table 2.14
2001 DBMP Completed Projects

2001 DBMP Project Identifier	Location	Implementation Summary	Approximate Project Cost[1]
W32-DET-2	Carter Road	Construction of Carter Road Detention Basin. Construction was completed in 2004.	$1.4 million
W32-DET-3	West 32nd Street Detention Basin	Expansion of existing detention basin. Construction was completed in 2009.	$4.6 million
BB-1, Lower Bee Branch Creek Restoration	16th Street Detention Cell to 19th Street	Restoration of Bee Branch Creek from 16th Street Detention Cell to CP Railway (19th Street) included property acquisition, demolition, and construction. Construction was substantially completed in fall 2011. Final project acceptance is pending.	$15.9 million[2]

Notes:
1. Project cost includes engineering, property acquisition, construction, and legal fees (as necessary). Project costs escalated to current dollars (June 2013) using the Engineering News Record (ENR) 20-city average Construction Cost Indices.
2. Final project cost has not been established by the City of Dubuque City Council. Cost does not include the additional $1.6 million in planned appurtenances.

[22] Formerly known as Dakota, Minnesota and Eastern Railroad (DM&E) which consolidated with Iowa, Chicago and Eastern Railroad (IC&E) in 2002. DM&E and IC&E were acquired by Canadian Pacific Railroad in 2008.

Table 2.15
Other Completed Conveyance and Storage Improvement Projects

Project Name	Location	Implementation Summary	Approximate Project Cost[1]
Locust Street Improvements	Locust Street between Rosedale Avenue and Kirkwood Street	Reconstruction of Locust Street included replacement of the existing storm sewer system with 48-inch diameter reinforced concrete pipe. Construction was completed in 2003.	$0.4 million
Burden Street Reconstruction	Burden Street	Reconstruction of Burden Street included the installation of a storm sewer system. Construction was completed in 2001.	$0.2 million[2]
Windsor Avenue Relief Storm Sewer	Windsor Avenue from Burden Street to Sutter Street	Construction included the installation of a 42-inch diameter storm sewer system extending from Burden Street to Sutter Street. Construction was completed in 2008.	$0.2 million
Historic Millwork District	Within boundary of White Street, Highways 151/61, and 11th Street	Construction included reconstruction of the street system with pervious pavement and other complete street elements. Construction was completed in 2012.	$8.3 million
Impervious Area Reduction	Various alleys and Washington Street Parking Lot	Construction included replacement of impervious alley and parking surfaces with pervious pavement technologies within the Bee Branch Drainage Basin. Construction started in 2009. To date, eight alleys and one parking lot are complete.	$1.2 million[3]

Notes:
1. Project cost includes engineering, property acquisition, construction, and legal fees (as necessary). Project costs escalated to current dollars (June 2013) using the ENR 20-city average Construction Cost Indices.
2. This cost is for only the storm sewer construction. Total project cost was ~ $1 million.)
3. Represents the costs as of October 2013.

2.8.2 Stormwater Management Utility

The City created a Stormwater Management Utility on February 27, 2003. The Stormwater Management Utility is a unit within the City that manages stormwater through public right-of-way and property owned by the City. The Stormwater Management Utility generates its revenue solely through a user fee, which is used to cover the costs of stormwater management activities, including individual projects, stormwater programs, and compliance with the National Pollutant Discharge Elimination System (NPDES) program within the corporate limits of the City. Operation and maintenance of stormwater systems are funded via the general fund and not the stormwater management utility.

The stormwater utility fee is billed by way of the City utility bill and is based on the measurement of a property's impervious ground coverage. Impervious area means the number of square feet of hard-surfaced areas. Instead of attempting to maintain a current, accurate measurement of the impervious area of the approximately 20,000 residential properties, the City charges the majority of single family homes

for one billing unit, or one Single Family Unit (SFU), per month. As part of the development of the stormwater utility fee, it was determined that the average single family residential (SFR) property in the City has approximately 2,917 square feet of impervious area. Therefore, 2,917 square feet of impervious area are associated with one SFU.

At its inception, the stormwater utility fee was $1.29 per month per SFU as stormwater management activities were funded in part with property tax and sales tax funds. The stormwater utility ordinance was amended in 2008 to become a self-supported utility and the SFU rates were revised accordingly. The charge in 2013 is $5.60 per month per SFU. In order to build upon the equity of the fee structure, a tiered system was established so that SFR parcels with impervious area 1.5 times more than the SFU impervious area are charged 1.5 SFUs. SFR parcels that have impervious area that is less than half of the SFU impervious area pay 0.5 SFUs. The SFU for a non-residential property is based on the actual, measured impervious area of the parcel. The SFUs are determined by dividing the total measured impervious area by the impervious area associated with one SFU, or 2,917 square feet. The monthly fee for non-residential properties is then determined by multiplying the number of SFUs by the rate per SFU.

No properties are exempt from paying the stormwater utility fee. The stormwater utility fee generated between $0.6 and $0.7 million dollars in its inaugural year, and is projected to generate approximately $3.2 million for Fiscal Year (FY) 2013.[23]

2.8.3 National Pollutant Discharge Elimination System (NPDES) Permit

The City's current NPDES permit (Permit No. 31-26-0-04) was issued on November 30, 2009, by the Iowa Department of Natural Resources (IDNR). The City is permitted as a Phase II Municipal Separate Storm Sewer System (MS4). Phase II MS4s are designated as small regulated cities or counties. The City is regulated to prevent and manage stormwater pollution, to the extent practicable, in accordance with the implementation of six best management practices (BMPs) and measurable goals. These six BMPs include:

- Public Education and Outreach on Stormwater Impacts – The City complies with this requirement by distributing a stormwater education brochure, operating a telephone hotline for reporting stormwater-related problems, hosting a website for communicating stormwater-related topics and interaction between residents and the City, labeling storm drains, and conducting a public education program.
- Public Involvement and Participation – The City complies with this requirement by holding meetings with an environmental advisory committee comprised of community stakeholders and by working with various groups to monitor water quality and collect water quality data at stormwater outfalls.
- Illicit Discharge Detection and Elimination – The City complies with this requirement by enforcing an illicit discharge prohibition ordinance, implementing an illicit discharge detection and elimination program, and enforcing a pet waste ordinance requiring pet owners to remove and dispose of their pet's waste immediately upon deposition on public property.

[23] Information in this section was obtained from the City of Dubuque Code of Ordinances 13-4, last amended on February 28, 2013, and from the City of Dubuque's website (http://www.cityofdubuque.org/index.aspx?NID=877).

- Construction Site Stormwater Runoff Control – The City complies with this requirement by enforcing a construction site runoff control ordinance, conducting a construction site review and inspection program including plan review and site inspections for specific permit provisions, inspecting runoff control BMPs for proper maintenance, and providing or sponsoring a contractor workshop that educates consultants and contractors on the implementation of erosion and sedimentation control BMPs on site.
- Post-construction Stormwater Management – The City complies with this requirement by enforcing a post-construction site runoff control policy ordinance, requiring review and approval of post-construction runoff control BMP design prior to construction, inspecting runoff control BMPs for proper maintenance, implementing a drainage basin assessment program that includes flood reduction and water quality improvement measures, and providing or sponsoring a low impact development (LID) workshop to educate developers about LID techniques for stormwater runoff quality improvement.
- Pollution Prevention/Good Housekeeping – The City complies with this requirement by operating and maintaining the City's MS4 system (including street sweeping; inspecting storm sewers, catch basins, and detention basins; and maintaining them as appropriate), managing municipal application and storage of pesticides and fertilizers to reduce pollutant discharge, implementing a training program for municipal employees on practices to reduce stormwater pollution, and assessing and implementing BMPs at City facilities to reduce stormwater pollutants.

As part of the permit requirements, the City is required to submit an annual report that documents the City's status on each of the six above-mentioned requirements, monitoring data, the City's expenditures related to the implementation of permit requirements, and a summary of permit enforcement activities.[24]

2.8.4 Impervious Surface Reduction

Urbanization in the City and surrounding areas has resulted in a steady shift from natural landscapes to impervious surfaces such as roads, driveways, parking lots, sidewalks, and rooftops. This increase in impervious cover is directly correlated to an increase in stormwater runoff volumes, an increase in flow rates, and a substantially increased frequency of moderate flooding. It has been estimated that a flood event occurring once in 100 years could occur as frequently as once every 5 years in the same drainage basin if impervious area within the drainage basin is increased to 25 percent. Similarly, a total impervious cover of 65 percent in the same drainage basin could make the flood event occur every year. Increases in the peak flow of runoff can result from even moderate amounts of drainage basin development, such as 5 to 10 percent impervious area.[25] As outlined in the Iowa Stormwater Management Manual (ISMM), impervious pavements can produce two-thirds of the excess runoff in an urban area as the runoff volume is increased and the time of concentration is decreased, resulting in increased peak rates of runoff. In short, impervious area directly correlates to flooding.

[24] Information on the NPDES system was obtained from NPDES Permit No. 31-26-0-04 issued by IDNR on November 30, 2009, governing the City of Dubuque and the following receiving water courses: Little Maquoketa, Cloie Branch, Granger Creek, South Fork Catfish Creek, Middle Fork Catfish Creek, North Fork Catfish Creek, Catfish Creek, Bee Branch and the Mississippi River. This current permit expires on November 20, 2014.

[25] R.D. Klein, "Urbanization and Stream Quality Impairment," Water Resources Bulletin, 15(4): p.953 (1979).

Conventional approaches to stormwater management can attempt to address increased runoff and prevent flooding and flood damage; however, in many cases, conventional approaches may exacerbate flooding downstream. The National Research Council (NRC) has explored the limitations of traditional approaches to stormwater management, such as large, centralized detention basins that reduce peak runoff flows but do not reduce overall runoff volumes. The NRC advocates for stormwater management approaches that restore hydrologic functions through techniques such as pervious pavement, which conveys runoff into the ground closer to where it originates rather than conveying it quickly downstream. Compared to conventional pavements, pervious pavement conveys stormwater into the ground instead of sheet flowing off the surface.[26]

Pervious pavement can reduce localized flooding and significantly reduce negative downstream impacts in a way that conventional approaches are less able to do.[27] This would decrease the volume of runoff and the runoff rate, both of which contribute to the flash flooding experienced within the Bee Branch Drainage Basin. Some findings have shown that pervious pavement can convey 80 percent of rain into the ground.[28] Increasing infiltration can substantially reduce the overall amount of stormwater and can reduce flooding and flooding-related impacts such as decreased property values and tax revenue associated with flooding, damages to public infrastructure and associated repair costs, and damages to private and public property.[29]

To reduce runoff volumes and flow rates within the Bee Branch Drainage Basin, and to convey runoff into the ground versus conveying it quickly downstream, the City has started reducing the percentage of impervious areas on public right-of-way and on City property by increasing the conveyance of stormwater into the ground by reconstructing impervious alleys and streets within the drainage basin with pervious pavement systems.

There are three main types of pervious pavement designs: pervious asphalt, pervious concrete, and permeable interlocking concrete pavement systems. These three systems have high initial surface infiltration rates and can immediately infiltrate and store rainfall and runoff from high intensity rainstorms. According to ISMM, the typical surface infiltration rates for these pavements exceed 200 to 250 inches per hour. This is several orders of magnitude higher than all of the rainfall intensities encountered in the upper Midwest. These high infiltration rates are also 2 to 3 orders of magnitude higher than most of the soils found in the Bee Branch Drainage Basin which have soil permeability rates ranging from 0.06 to 20.0 inches per hour.[30] As shown in Figure 2-2A, all alleys and the vast majority of streets within the drainage basin are over soils with permeability rates greater than 0.5 inch per hour, the minimum permeability of subsoils required for a pervious pavement system to be able to convey stormwater into the ground.[31] In addition to the permeability of the subsoils, the slope of the pavement system can preclude a pervious pavement system as an effective stormwater management system.

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26 Iowa Department of Natural Resources. "Iowa Stormwater Management Manual" (Version 3; October 28, 2009).
27 National Research Council. "Urban Stormwater Management in the United States" (2008).
28 From Booth, Leavitt, and Peterson (1996). "The University of Washington Permeable Pavement Demonstration Project: Background and First-Year Field Results." The Water Center at the University of Washington, Seattle, WA.
29 Joint report by American Rivers, the Water Environment Federation, the American Society of Landscape Architects and ECONorthwest. "Banking on Green", April 2012.
30 USDA-Soil Conservation Service. "Soil Survey of Dubuque County Iowa" (1985).
31 Stephen Jones, PE. "Site Evaluation for Porous Pavements." Presentation given at ASCE Geotechnical Conference (2009).

Prior to drainage basin-wide implementation, a pilot project was undertaken to identify the viability of pervious pavement systems as well as to determine construction materials and design preferences. The Green Alley Pilot Project involved the reconstruction of two asphalt alleys between White and Jackson Streets running from 11th to 12th Streets and from 12th to 13th Streets. The two alleys allowed for evaluating two systems: brick pavers and pervious asphalt. The alley running from 11th to 12th Streets was paved with brick pavers using a high-strength, permeable interlocking concrete pavement, and the alley running from 12th to 13th Streets was paved with pervious asphalt. As a part of another pilot project to evaluate pervious concrete, a City-owned parking lot was paved using pervious concrete.

Based on the experiences and knowledge gained from the Green Alley Pilot Project, completed in 2010, the City determined that pervious alleys are viable within the Bee Branch Drainage Basin as a stormwater management system. In addition, permeable interlocking concrete pavement is the best value in terms of its life-cycle costs (including construction cost, maintenance costs, durability, and design life). As of June 2013, the City has rehabilitated 8 alleys with 40,720 square feet of pervious pavement systems.

In addition to the elimination of impervious alleys, the City has also completed a pilot pervious street pavement system as part of the Historic Millwork District Complete Streets Project. This project included the reconstruction of underground utilities, roadway sub-base, concrete streets, concrete sidewalks, pervious pavers in some of the parking areas, and re-use of existing brick pavers in streetscape areas. The project was completed in 2012 with financial assistance from a U.S. Department of Transportation (USDOT) Transportation Investment Generating Economic Recovery (TIGER) grant and from a private contribution.[32] To date, the pervious street system has proven to be a viable pavement choice for streets. When streets are scheduled for reconstruction, the viability of replacing the impervious street pavement with a pervious pavement system will be investigated as part of the design process. In general, however, streets are less viable as pervious pavement systems due to limitations related to traffic volumes, traffic loads, turning movements, and environmental issues.

2.8.5 Lot Source Reduction

Another way to mitigate flooding is to reduce the concentration and volume of runoff from individual properties. To that end, the City has implemented a cost share program to promote the installation of rain gardens and the stabilization of stream banks. This program helps defray costs for individual property owners to implement rain gardens or stabilize stream banks located on their property. The assistance is limited to providing materials for the projects and it cannot exceed more than half of the total cost of the project. Applications for assistance are evaluated by City staff on a case-by-case basis, and awards are contingent on available funding.[33]

2.8.6 City Requirements for Stormwater Treatment and Detention

The City has implemented the Unified Development Code (UDC), which is a combination of the City's

[32] Information on the Millworks District project was obtained from the January 24, 2012 Historic Millwork District Complete Street Project Final Project Acceptance Memo.

[33] Information on lot source reduction programs were obtained from the City of Dubuque public education pamphlet on Stormwater Quality improvement.

zoning ordinance, subdivision regulations, historic preservation ordinance, and portions of the building code. The UDC includes requirements for sustainable subdivision development tools in Section 11-10. The UDC also includes a sustainable site development requirement to use two or more Low Impact development (LID) or other Best Management Practice (BMP) tools approved by the City engineer, as specified in Section 13-3.3 of the UDC. The allowable tools for use on a site development include the following:

- Reduced lot grading
- Check dams
- French drains or soak away pits
- Green roofs
- Microbasins
- Permeable pavement
- Rainwater harvesting systems
- Sidewalks and drives sloped toward open space
- Bioswales
- Native plantings
- Open water features
- Rain gardens
- Swales
- Trees and other plantings
- Tree filters
- Vegetative buffers

The primary purpose of these features is to encourage more infiltration and/or filtration of stormwater runoff, thereby reducing the amount of stormwater exiting the site. Reducing stormwater runoff at the source helps to better manage downstream flooding. These features also can improve the quality of the stormwater runoff.

In addition to the UDC LID requirements, City policy codified by an ordinance requires detention requirements for new development greater than 1 acre in size. The post-development peak runoff rate for the 2-, 10-, and 100-year storm event cannot exceed the pre-development peak runoff rate. The operation and maintenance of the detention facilities located on non-residential land is the responsibility of the property owner. On residential development, the developer is responsible for the construction of the detention facility, and the City may, by ordinance, assume operation and maintenance responsibility and then assess costs to the subdivision residents.

2.8.7 FEMA Floodplain Revisions

At the time of the 2001 DBMP, the effective Flood Insurance Rate Maps (FIRMs) for the City (dated September 6, 1989) showed shaded and unshaded Zone X zones within the area of the Central Business District – North Subarea and the Central Business District Subarea. Shaded Zone X zones indicate the 500-year floodplain. There was no floodplain designation along the Bee Branch. In 2009, FEMA updated its analysis for these subareas and published draft maps for the City's review. See Figure 2-3A for a graphical depiction of FEMA's draft floodplain maps from 2009. These maps showed the Central Business District – North, Central Business District, and portions of the Kaufmann Avenue and West 32nd Street Subareas within the 1-percent annual chance (100-year) floodplain.

Following the publication of FEMA's draft floodplain maps in 2009, the City investigated the buildings present within the revised floodplain boundary as well as potential impacts of flood insurance requirements within the revised floodplain boundary. Figures 2-4A and 2-5A reflect the buildings and the

historic nature of those buildings that were included in the 2009 proposed floodplain boundary. Based on information from the City Assessor's Office, 85 percent of the impacted properties include potentially eligible buildings for listing on the National Register of Historic Places, the official list of the Nation's historic places worthy of preservation. In fact, 57 percent of the 1,373 buildings are more than 100 years old.

But this boundary did not incorporate the flood attenuation benefits associated with the construction of the Carter Road Detention Basin and the expansion of the West 32nd Street Detention Basin. The City initiated an appeal process to adjust the proposed floodplain boundary. The City appealed these maps and showed revised inundation boundaries by incorporating the effects of the Carter Road and West 32nd Street detention projects. This resulted in a smaller floodplain boundary, as shown in Figure 2-6A, than FEMA showed in its proposed boundary. FEMA accepted the revised information, further revised the floodplain boundary, and published revised maps that became effective on October 18, 2011, as shown in Figure 2-7A.

2.9 Methodology

The proposed project identification and recommendations presented in this 2013 DBMP were completed using the following methodology:

- Limited hydrologic and hydraulic (H&H) modeling was completed, either as part of separate efforts by City staff or under separate task work orders, to analyze projects presented herein.
- Project evaluation was conducted on a qualitative basis.
- Cost opinions presented herein are based on 2013 dollars. Costs have been adjusted from the time of implementation or estimation.
- City staff provided input in the descriptions of completed projects and in the identification of proposed projects.
- The 2013 DBMP was prepared as part of a collaborative effort on the part of HDR and the City.

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3.0 NORTH FORK CATFISH CREEK DRAINAGE BASIN

This section contains new text to document stormwater projects that have been completed since 2001 and changes within the North Fork Catfish Creek Drainage Basin.

Amend 2001 DBMP Section 3.0 with new Sections 3.8 and 3.9 as follows:

3.8 Stormwater Projects Completed Since 2001

Within the North Fork Catfish Creek Drainage Basin, conveyance and detention improvements were defined in the 2001 DBMP. Detention was expanded and improved at Northwest Arterial and upstream of Pennsylvania Avenue. In addition, conveyance improvements were implemented along the North Fork Catfish Creek between Northwest Arterial and Pennsylvania Avenue. **Table 3.11** summarizes the 2001 DBMP projects within the North Fork Catfish Creek Drainage Basin that have been completed.

Table 3.11
2001 DBMP Completed Projects

2001 DBMP Project Identifier	Location	Implementation Summary	Approximate Project Cost[1]
NF-ST-7	Northwest Arterial	Excavated upstream detention and built two-stage outlet structure.	$0.2 million
NF-ST-4	Pennsylvania Avenue	Built concrete structural wall.	$0.08 million
North Fork Catfish Creek Stormwater and Sanitary Improvements – Phase I	University to Kensington[2]	Excavated the channel to a trapezoidal channel with a bottom width of 25 feet and side slopes to 3H:1V.	$1.0 million
North Fork Catfish Creek Stormwater and Sanitary Improvements – Phase II	Pennsylvania Avenue and JFK to Keystone[3]	Excavated the channel to a trapezoidal channel with a bottom width of either 10 feet or 25 feet and side slopes of 3H:1V.	$1.3 million
North Fork Catfish Creek Stormwater and Sanitary Improvements – Phase III	Keystone to Northwest Arterial[4]	Excavated the channel to a trapezoidal channel with a bottom width of 10 feet and side slopes of 3H:1V. This project also included the removal of the existing storm sewer and replacement with a triple 10-foot-wide by 8-foot-high reinforced concrete box (RCB).	$2.0 million
		Total Estimated Capital Cost:	**$4.58 million**

Notes:
1. Project cost includes engineering, property acquisition, construction, and legal fees (as necessary). Project costs escalated to current dollars (June 2013) using the Engineering News Record (ENR) 20-city average Construction Cost Indices.
2. This project is downstream of the North Fork Catfish Creek reaches identified in the 2001 DBMP.
3. This project covers a portion of the North Fork Catfish Creek reaches identified in the 2001 DBMP as the Keyway to Pennsylvania Avenue reach and the Rosemont to Keyway reach.
4. This project covers a portion of the North Fork Catfish Creek reaches identified in the 2001 DBMP as the Northwest Arterial to Keyway reach.

3.9 Changes Within the North Fork Catfish Creek Drainage Basin

No other project improvements have been completed or identified in the North Fork Catfish Creek Drainage Basin. Since the acceptance of the 2001 DBMP, the Catfish Creek Watershed Management Authority (CCWMA) has been developed. The CCWMA was formed during the summer of 2012 and is comprised of the City of Dubuque, Dubuque County, the City of Asbury, the City of Peosta, the City of Centralia, and the Dubuque Soil and Water Conservation District. The purpose of the CCWMA is to work together to solve water quality and flooding problems within the watershed. Through the completion of a Watershed Management Plan and other initiatives, it is expected that proposed projects within the watershed will be proposed and administered through the CCWMA.

4.0 BEE BRANCH DRAINAGE BASIN

The discussion of the Bee Branch Drainage Basin in the 2001 DBMP is hereby updated in this 2013 DBMP. Text is being added to update discussions on the problem areas, alternative solutions, recommendations for improvement, and project phasing for the following drainage subareas that comprise the Bee Branch Drainage Basin:

- West 32nd Street
- Kaufmann Avenue
- Locust Street
- Central Business District – North
- Central Business District
- Bee Branch Storm Sewer Trunk Line

Figure 4-1A shows the extent of the Bee Branch Drainage Basin, and Figure 4-2A shows a graphical depiction of the individual subareas within the Bee Branch Drainage Basin.

Each drainage basin subsection below includes an identification of problem areas, conceptual improvement plans to mitigate flooding in the problem areas, and capital cost estimates for each improvement project.

4.1 General Drainage Basin Description

No change from 2001 DBMP.

4.2 West 32nd Street Drainage Subarea

The West 32nd Street Drainage Subarea is located in the upper portion of the Bee Branch Drainage Basin, is approximately 1.9 square miles in size, and drains into the West 32nd Street Detention Basin. See Section 4.2.1 of the 2001 DBMP for more detail on the description of the West 32nd Street Drainage Subarea.

Amend 2001 DBMP Section 4.2 by adding the following text to the end of each designated subsection as follows:

4.2.4 Problem Areas

City staff has identified the open channel drainageway from the outlet of the Carter Road Detention Basin to the upstream end of the West 32nd Street Detention Basin as being in need of monitoring for potential instability and need for potential stabilization. In some locations, sediment was eroded from the side slopes of the channel, creating steep and near vertical banks. As a sediment management strategy, a baseline condition of the stream banks was completed in 2008 by surveying typical cross-sections between the two detention basins. Stream channels that have degraded to a point where the banks are no longer stable, resulting in incision or bank deterioration, hamper the stream's flood control capacity.

4.2.5 Development of Alternative Solutions

One alternative considered for stabilizing the stream banks between the Carter Road Detention Basin and the West 32nd Street Detention Basin was the enclosure of the stream into a culvert system. Similar to what was originally done with the Bee Branch storm sewer trunk line, the open channel would be replaced with a storm sewer system. This option would result in the potential for adverse wetland impacts and would require lateral storm sewers along the alignment.

Another alternative considered was to restore the channel with the construction of grade stabilization structures to reduce the channel grade and prevent erosion, and to modify the channel cross-section to restore capacity and provide stable slopes.

4.2.6 Recommendations for Improvement Alternatives

It is recommended that the existing stream channel alignment between the Carter Road Detention Basin and the West 32nd Street Detention Basin be monitored and, if necessary, restored. On a regular time interval, such as every 3 years, the baseline cross-sections defined in 2008 should be surveyed and evaluated for any change in slope and shape. With the construction of the Carter Road Detention Basin, the average flow rates have been reduced and the impact on the degrading stream minimized. See Figure 4-3A for the location of the proposed stream monitoring project.

4.2.7 Project Phasing

The recommendation for the West 32nd Street Drainage Subarea is stream monitoring along the Bee Branch between the Carter Road Detention Basin and the West 32nd Street Detention Basin. The recommended improvement is summarized in Table 4.9A.

Table 4.9A
West 32nd Street Drainage Subarea
Recommended Improvements Summary

Drainage Basin Priority	Location	Recommended Improvements	Estimated Cost[1]
1	Bee Branch – Along Carter Road and West 32nd Street	Monitor stream banks.	$5,000
Total Estimated Capital Cost:			**$5,000**

Note:
1. Estimated annual cost includes time associated with performing field inspections and gathering data necessary to detect changes year to year.

Amend 2001 DBMP Section 4.2 with new subsection 4.2.8 as follows:

4.2.8 Completed Project Implementation

Since the completion of the 2001 DBMP, the existing West 32nd Street Detention Basin was expanded and the Carter Road Detention Basin was constructed. The stormwater facilities are described below.

The West 32nd Street Detention Basin project included the expansion of an existing detention facility, acquisition of property, the construction of two wet ponds, incorporation of aquatic vegetation in the upstream wet pond, and planting of wild flowers and prairie grasses. The two-cell detention basin was sized to control the 100-year, 24-hour rain event; however, the design includes the ability to reduce discharge rates from more frequent storm events as well. Additional necessary improvements that were constructed as part of the project include the replacement of the bridge under West 32nd Street just east of Wildwood with a twin 9-foot-wide by 8-foot-high box culvert, and construction of 328 feet of 24-inch diameter ductile iron sanitary sewer; 66-, 96- and 108-inch large diameter storm sewer; 2,200 feet of 6-foot-wide sidewalk along West 32nd Street; a stone shoulder along West 32nd Street where no curb and gutter existed; a parking lane for four vehicles along West 32nd Street; and a gate structure for maintenance purposes of the wet pond. See Appendix B for an update to the total project cost.[34]

The Carter Road Detention Basin project included the construction of an earthen dam approximately 350 feet long and 40 feet high, with a principal outlet consisting of a 15-inch diameter drawdown pipe and a 24-inch diameter gated drainage structure. The secondary, or auxiliary, outlet is a 48-inch diameter riser pipe that is approximately 37 feet high. A 350-foot long asphalt road provides access to the outlet structure for operation and maintenance purposes. The existing sanitary sewer was rebuilt as part of this project due to the additional embankment depth associated with the dam. See Appendix B for an update to the total project cost.[35]

See Figure 4-3A for the location of West 32nd Street and Carter Road Detention Basins projects.

4.3 Kaufmann Avenue Drainage Subarea

The Kaufmann Avenue Drainage Subarea is in the west-central portion of the Bee Branch Drainage Basin and is approximately 1.3 square miles in size. Drainage is predominantly in an easterly direction, discharging into the Bee Branch storm sewer trunk line. See Section 4.3.1 of the 2001 DBMP for more detail on the description of the Kaufmann Avenue Drainage Subarea.

Amend 2001 DBMP Section 4.3 by adding the following text to the end of each designated subsection as follows:

4.3.4 Problem Areas

The 2001 DBMP identified locations where the existing storm sewer hydraulic capacity was not in

[34] Information on the West 32nd Street Detention project was obtained from the February 12, 2008, City of Dubuque memo requesting authorization of the public bidding procedure and from the December 1, 2009, City of Dubuque project acceptance memo.

[35] Information on the Carter Road Detention Basin project was obtained from the August 29, 2003, City of Dubuque memo requesting bid award and from the November 29, 2004, City of Dubuque project acceptance memo.

compliance with the City's drainage standards/criteria in Table 4.14. The expansion of the capacity of storm sewer inlets and pipes would significantly reduce flooding of streets and adjacent properties within the Kaufmann Avenue Drainage Subarea. While streets and overland flow routes are an integral part of the storm drainage system, they should convey runoff without flooding buildings. Two locations within the Kaufmann Avenue Drainage Subarea were identified by City staff for priority replacement: Valeria Street and 22nd Street.

Valeria Street

The residents located along the 400 block of Kaufmann Avenue and Valeria Street has experienced persistent flooding over the last two decades. Storm events with rainfall of 3 inches or greater have resulted in surcharge of the storm sewer system, caused overtopping of the curb, and resulted in runoff flowing between the homes causing water to pond behind 15 single family units. The City discussed this issue with the residents in the area and determined that flooding in this area has occurred three to four times since 2001. Removal of accumulated runoff due to flooding of this area must either evaporate or be pumped out by residents.[36]

22nd Street Storm Sewer

From the 2001 DBMP, a hydraulic capacity analysis of the Kaufmann Avenue (22nd Street) storm sewer revealed that the existing storm sewer is insufficient to convey a 2-year rain event. The hydraulic model indicated that a 108-inch diameter storm sewer would be required to safely convey the 10-year storm with minimal street flow, as shown in the 2001 DBMP, Table 4.14.

The shortcoming of the existing 22nd Street storm sewer/street drainage system is that 22nd Street becomes "like a river" across Central Avenue (US Highway 52), White, Jackson, and Washington Streets. Motorists have become stranded in their cars at 22nd and Elm Streets, while other motorists have been forced to abandon their stalled cars in the street. Stormwater flows have repeatedly overloaded the storm sewer system and blown the covers off manholes, creating geysers several feet high. Photo 1 shows a surcharged storm sewer, and Photo 2 shows residents wading in floodwaters.

Photo 1: Surcharging Storm Sewer Manhole on 22nd Street

Photo 2: Residents Wading Through Rushing Floodwaters

[36] Information presented on the Valeria Street project was obtained from an August 20, 2012, City of Dubuque memo titled *Kaufmann-Valeria Flood Reduction Analysis* from Todd Shoemaker, PE, CFM to Deron Muehring and Gus Psihoyos, City of Dubuque Engineering Department.

4.3.5 Development of Alternative Solutions

Alternative solutions to the Valeria Street and 22nd Street problem areas were developed, as discussed in the following sections.

Valeria Street

Alternative solutions that were considered for the mitigation of the backyard ponding along Valeria Street included the installation of a pump station for floodwater conveyance and/or a storm sewer alternative for connecting this low area with the adjacent existing storm sewer system. The pump station was not considered feasible due to the installation cost, ownership questions due to placement of the station, and the long-term operation and maintenance cost. Storm sewer alternatives were analyzed with three different sizes of pipes: 12-inch diameter, 18-inch diameter, and 24-inch diameter RCP. Two inlet structures would be used to capture the runoff, and the storm sewer pipe would then convey the stormwater to the existing storm sewer system located along Kaufmann Avenue.

22nd Street Storm Sewer

Alternatives to relieve the 22nd Street storm sewer system included expanding the Bee Branch open channel to accommodate the Kaufman Avenue Drainage Subarea stormwater runoff. This alternative would require additional property acquisition and would sever traffic connectivity access through the City by eliminating 22nd Street, which serves as a critical east-west corridor across the City.

4.3.6 Recommendations for Improvement Alternatives

Valeria Street

It is recommended that the storm sewer project at Kaufmann Avenue and Valeria Street be constructed. The proposed project would add two catch basins, approximately 170 feet of 24-inch diameter RCP, a backflow preventer, and a connection to the existing storm sewer system along Kaufmann Avenue. The backflow preventer would be used to prevent additional ponding behind these single family homes when the downstream storm sewer system is surcharged. It is further recommended that this project not be constructed until the Upper Bee Branch project has been completed to allow sufficient capacity downstream. See **Appendix C** for the breakdown in project elements and proposed cost for this alternative.

22nd Street Storm Sewer

Since 2001, the H&H modeling for the Kaufmann Avenue Drainage Subarea has been refined as part of the 2004 Bee Branch Creek Alignment Study[37] and further refined during development of the final design of the Bee Branch Creek Restoration Project. The H&H analysis[38] showed that a 10-foot-wide by 6-foot-high reinforced concrete box (RCB) storm sewer along 22nd Street from Central Avenue (US Highway 52) to Elm Street will prevent flooding conditions repeatedly experienced along 22nd Street. As a part of the Bee Branch Creek Restoration Project, a portion of the existing Bee Branch storm sewer system will be removed between 22nd and 24th Streets, and it will be replaced by the restoration of the Bee Branch

[37] Engineering work was performed by CDM Smith (Milwaukee, WI).
[38] H&H analysis was performed by Strand & Associates (Madison, WI) as part of the Bee Branch Creek Restoration Project design.

Creek and associated floodplain. The Bee Branch storm sewer will remain in place and viable as a relief storm sewer south from 22nd Street. The proposed 10-foot-wide by 6-foot-high RCB storm sewer will connect to the portion of the Bee Branch sewer to remain and restrict flow from entering the proposed Bee Branch Creek Restoration Project. Due to the size of the proposed storm sewer, complete reconstruction of 22nd Street and the relocation of traffic, sanitary sewer, and water supply infrastructure would need to be completed. See Appendix C for the breakdown in project elements and proposed cost for this alternative.

See Figure 4-4A for the location of the Valeria Street and 22nd Street Storm Sewer projects.

4.3.7 Project Phasing

The recommendation for the Kaufmann Avenue Drainage Subarea is the proposed 24-inch storm sewer system along the backyards of Valeria Street and the 22nd Street Storm Sewer. The recommended improvement is summarized in Table 4.15A.

Table 4.15A
Kaufmann Avenue Drainage Subarea
Recommended Improvements Summary

Drainage Basin Priority	Location	Recommended Improvements	Estimated Capital Cost[1]
1	Valeria Street/Kaufmann Storm Sewer	Install 24-inch diameter storm sewer with two catch basins.	$0.05 million
2	22nd Street Storm Sewer	Install 920 linear feet of 10-foot-wide by 6-foot-high storm sewer with catch basins between Central Avenue (US Highway 52) to the existing Bee Branch storm sewer system at Elm Street.	$3.2 million
		Total Estimated Capital Cost:	**$3.25 million**

Note:
1. Estimated capital costs are in current (June 2013) dollars.

Amend 2001 DBMP Section 4.3 with new subsection 4.3.8 as follows:

4.3.8 Completed Project Implementation

In the 2001 DBMP, the only recommendation for the Kaufmann Avenue Drainage Subarea was the construction of the Grandview/Kaufmann Detention Basin. This detention basin was determined to be infeasible due to the potential roadway closure, traffic impacts in the area, public safety impacts associated with the proposed project, and anticipated public opinion. This proposed detention basin would adversely affect the transportation system in the area. The Grandview/Kaufmann Detention Basin is not likely to be implemented; therefore, it was eliminated from further consideration.

4.4 Locust Street Drainage Subarea

The Locust Street Drainage Subarea is in the upper portion of the Bee Branch Drainage Basin, is approximately 0.9 square mile in size, and drains into the Bee Branch storm sewer which connects to the Lower Bee Branch Creek Restoration Project. See Section 4.4.1 of the 2001 DBMP for more detail on the description of the Locust Street Drainage Subarea.

Amend 2001 DBMP Section 4.4 by adding the following text to the end of each designated subsection as follows:

4.4.4 Problem Areas

The 2001 DBMP identified locations where the existing storm sewer hydraulic capacity was not in compliance with the City's drainage standards/criteria in Table 4.17. The increased capacity of storm sewer inlets and pipes would significantly reduce flooding of streets and adjacent properties within the Locust Street Drainage Subarea.

Photo 3: Stalled Cars on 17th Street during Flash Flooding in 2011

A problem area has been identified at the base of Locust and 17th Streets. The grade flattens along the street and storm sewer at this intersection, creating flooding in this area. In addition, stormwater flows rapidly down 17th Street. The flow must cross Central Avenue (US Highway 52), and White, Jackson, and Washington Streets. Photo 3 shows the depth of stormwater against stalled cars on 17th Street west of Central Avenue. There is too much water flowing in the streets as evidenced in Photo 3, as there is a lack of sufficient conveyance capacity draining to the Lower Bee Branch Creek Restoration Project.

4.4.5 Development of Alternative Solutions

Alternatives considered for the problem area at Locust and 17th Streets included: 1) a relief storm sewer system, 2) an open channel system, and 3) an upsized storm sewer system in the downstream reach.

From the 2001 DBMP, a hydraulic capacity analysis of the 16th Street and Cedar Street storm sewer revealed that the existing storm sewer is insufficient to convey a 2-year rain event. The hydraulic model indicated that a 72-inch diameter relief storm sewer was required to safely convey the 10-year storm with minimal street flow, as shown in the 2001 DBMP, Table 4.17.

An open channel would have significant impact at this intersection and areas further south and east. The road right-of-way is limited in this area and would require acquisition of a significant number of commercial and residential properties to accommodate the channel.

An upsized storm sewer system could be limited by the low grade change in the area of the Locust and 17th Streets intersection.

4.4.6 Recommendations for Improvement Alternatives

It is recommended that a replacement storm sewer be constructed in the area of Locust and 17th Streets to provide additional conveyance capacity for the downstream portion of the Locust Street Drainage Subarea. The storm sewer would be constructed from Dorgan Place to approximately Elm Street, discharging into the Bee Branch Creek Restoration Project. The existing 72-inch diameter stone sewer would be replaced or augmented with a proposed 84-inch diameter storm sewer. See Figure 4-5A for the Locust and 17th Streets Replacement Storm Sewer projects.

4.4.7 Project Phasing

The recommendation for the Locust Street Drainage Subarea is to provide for a replacement 84-inch diameter storm sewer system along 17th Street. The recommended improvement is summarized in Table 4.30.

Table 4.30
Locust Street Drainage Subarea
Recommended Improvements Summary

Drainage Basin Priority	Location	Recommended Improvements	Estimated Capital Cost[1]
1	17th Street Replacement Storm Sewer Project	Install 2,750 LF of 84-inch diameter storm sewer with area inlets from Ellis Street to east of Elm Street.	$6.8 million
		Total Estimated Capital Cost:	$6.8 million

Note:
1. Estimated capital costs include contingencies (25%) to account for estimated quantities, unit price adjustments, and miscellaneous work-related items. An additional 15% was included for administrative, legal, and engineering costs. Right-of-way, operation and maintenance, and mitigation costs were not included.

Amend 2001 DBMP Section 4.4 with new subsection 4.4.8 as follows:

4.4.8 Completed Project Implementation

Locust Street was improved from Rosedale Avenue to Kirkwood Street as part of a street improvement project. This Rosedale/Kirkwood project involved improving storm sewer capacity to a 48-inch diameter storm sewer and extending the existing 36-inch diameter storm sewer along Rosedale Avenue. See Appendix B for more detailed project costs.

4.5 Central Business District – North Subareas

The Central Business District – North Subareas are in the center portion of the Bee Branch Drainage Basin and total approximately 1.9 square miles in size. These subareas encompass the previously defined Washington Street, Windsor Avenue, Hamilton Street, Dock Street, and Upper Kerper Subareas. The Washington Street and Windsor Avenue Drainage Subareas drain into the Bee Branch storm sewer trunk line. Storm flows in the Hamilton and Dock Subareas are diverted to the Mississippi River under gravity

conditions and into the 16th Street Detention Cell when high water levels on the Mississippi River restrict gravity flow. The Upper Kerper Subarea drains directly into the 16th Street Detention Cell. Additional improvements to the Bee Branch storm sewer trunk line and creek restoration are discussed in Section 4.7, below. See Section 4.5.1 of the 2001 DBMP for more detail on the description of the Central Business District – North Subareas.

Amend 2001 DBMP Section 4.5 with new subsection 4.5.8 as follows:

4.5.8 Completed Project Implementation

Two relief storm sewer projects have been constructed in the Central Business District – North Subareas, as discussed below.

Burden Street Reconstruction Project

To help improve stormwater runoff conveyance efficiency and reduce localized flooding, storm sewer improvements associated with the Burden Street reconstruction project were completed. Storm sewer ranging in size from 15-inch diameter to 36-inch diameter RCP was installed along Burden Street from Hogrefe Avenue to Windsor Avenue. See Appendix B for more detailed project costs.

Windsor Avenue Storm Sewer Extension Project

A 42-inch diameter storm sewer was constructed along Windsor Avenue from Burden Street to Sutter Street. This storm sewer extension connects the storm sewer installed along Burden Street with the existing 48-inch diameter storm sewer along Sutter Street. These improvements were constructed to facilitate storm drainage along Windsor Avenue and the intersection of 22nd, Elm Street, and Kniest Streets. See Appendix B for more detailed project costs.

See Figure 4-6A for the Burden Street Reconstruction and Windsor Avenue Storm Sewer Extension projects.

4.6 Central Business District Subareas

The Central Business District Subareas are in the lower portion of the Bee Branch Drainage Basin and are approximately 0.9 square mile in size. These subareas encompass the previously defined 8th, 11th, and 14th Streets, and Lower Kerper Drainage Subareas. Stormwater drains from these subareas into the 16th Street Detention Cell. The 8th Street Subarea discharges to the Mississippi River under gravity conditions and into the 16th Street Detention Cell when gravity flow is prohibited. See Section 4.6.1 of the 2001 DBMP for more detail on the description of the Central Business District Subareas.

Amend 2001 DBMP Section 4.6 with new subsection 4.6.8 as follows:

4.6.8 Completed Project Implementation

With federal funding in the form of a TIGER grant, the City was able to redevelop a portion of this area, known as the Historic Millwork District, including the first pervious street system designed and built within the City. The project resulted in a decrease in directly connected impervious surface and a decrease

in impervious surface, allowing for infiltration and decreased runoff. Conveying stormwater into the ground through the pervious pavement system aids in reducing the threat of flooding and mitigates flood damage in the area.

In addition to the directly connected impervious surface and impervious surface reductions associated with the Historic Millwork District project, additional reduction benefits were realized with the re-construction of alleys in the area using pervious pavement systems. Additional information on the pervious pavement elements can be found in Sections 2.8.4 and 4.8. See Figure 4-7A for the Historic Millwork District project.

Amend the title of Section 4.7 to match the following:

4.7 Bee Branch Storm Sewer Trunk Line and Open Channel (Bee Branch Creek Restoration)

The 2001 DBMP recommended a combination of storage and conveyance to mitigate the impacts of the 100-year storm event. This included constructing the Carter Road Detention Basin, expanding the West 32nd Street Detention Basin, increasing the capacity of the 16th Street Detention Cell, and restoring the Bee Branch trunk line to a large open channel floodway from the 16th Street Detention Cell upstream to 24th Street. The flood control channel is described in the 2001 DBMP as Phase I and Phase II. These phases later became the Lower and Upper Bee Branch Creek Restoration Projects.

In addition to implementing drainage improvements reflected in the 2001 DBMP, advancing engineering designs, and further investigating problem areas; drainage deficiencies have been documented and studied and solutions/improvements identified.

Amend 2001 DBMP Section 4.7 with new subsection 4.7.1 as follows, and renumber existing subsections 4.7.1 through 4.7.3 as subsections 4.7.2 through 4.7.4:

4.7.1 Problem Areas

Upper Bee Branch Creek Restoration (Open Waterway)

With the substantial completion of the Lower Bee Branch Restoration Project in 2011, which extends upstream from the 16th Street Detention Cell to the eastern edge of the CP Railway property, the construction of the Upper Bee Branch Creek Restoration Project can begin. As identified in the 2001 DBMP, the existing Bee Branch storm sewer trunk line has insufficient drainage capacity to handle the 100-year storm event. As evaluated in the 2001 DBMP and the 2004 *Bee Branch Creek Restoration Alignment Study*, and as refined in the 2009 design of the Lower Bee Branch Creek Restoration, the Upper Bee Branch Creek Restoration Project is an open channel and flood plain area that would extend from downstream of the CP Railway property to 24th Street.

Existing 16th Street Detention Cell Gates

The flood control gates and pump station located at the 16th Street Detention Cell are in need of rehabilitation. The 16th Street Detention Cell discharges into a cutoff channel of the Mississippi River

through twin 12-foot-wide by 12-foot-high concrete box culverts under normal river stages. The flood gates were installed in the 1950s and modified by the U.S. Army Corps of Engineers (USACE) in the late 1960s as part of the construction of the John C. Culver Floodwall, the floodwall/levee system that protects the City from the Mississippi River. . During gravity flow, the twin 12-foot-wide by 12-foot-high flood gates are open; conversely, during flood events, the flood gates are closed to prevent the Mississippi River from flooding the landward side of the levee. During the rainstorm in July 2011, the Mississippi River was above flood stage, and the flood gates were closed. What resulted was interior flood depths higher than the level of the Mississippi River. The flood gates were manually opened long enough to allow the respective water elevations to equalize.

The functionality of the existing flood gates at the 16th Street Detention Cell has been investigated by the City. The engineering investigation and associated data collection effort also revealed that the existing 12-foot-wide by 12-foot-high flood gate system has sustained damage over the past 30 years. Corrosion of the gates and damage to the concrete wing walls on the upstream and downstream sides of the gates have been documented.[39]

North End Storm Sewer

Repetitive flooding occurs in the "North End" of the Washington Street Subarea between White and Elm Streets on 25th to 30th Streets during heavy rains due to inadequate drainage capacity. With the completion of the Lower Bee Branch Creek Restoration Project, the need for additional storm sewer and catch basins in the vicinity of the existing Bee Branch storm sewer trunk line can be further refined.

Amend 2001 DBMP Section 4.7 by adding the following text to the end of each designated subsection as follows:

4.7.2 Development of Alternative Solutions

Upper Bee Branch Creek Restoration (Open Waterway)

Since the idea of the Bee Branch Creek Restoration Project was first presented in 2001, the City has actively engaged the public, sharing information and asking for public input.

In May 2003, the City kicked off the Bee Branch Creek Alignment Study. The main objective was to work with impacted residents, in the form of a citizen advisory committee, to ensure that the recommended alignment location and waterway design were based on input from the neighborhoods impacted by the proposed open waterway. The Bee Branch Citizen Advisory Committee (BBCAC) provided input with regard to the social and economic concerns and the needs of the impacted neighborhoods. It helped establish the criteria that would be used to evaluate alternative alignments/preliminary designs for the open waterway, and ultimately the BBCAC made an alignment/preliminary design recommendation to the City Council. Collectively, the 16-member committee was made up of impacted Bee Branch Drainage Basin residents, impacted property owners, senior citizens, a developer, a State representative, and a Dubuque Board of Realtors member. In addition to the 16 citizens who participated in the BBCAC meetings, hundreds of citizens living in the flood-prone

[39] Information on flood gates obtained from the Engineering Capital Improvements Plan (CIP) project write-up for Bee Branch Flood Control Pumping Station Gates Replacement Project.

neighborhoods were informed about the project through a series of Bee Branch Alignment Study Newsletters that were mailed to them.

On March 30, 2004, the BBCAC co-hosted a public meeting at a neighborhood elementary school. The meeting included an open house, project background presentation, question-and-answer period, and public input session. Approximately 70 citizens attended the meeting. The meeting provided citizens with the information they sought and provided the BBCAC, engineers, and City staff a better understanding of citizens' concerns with the proposed Bee Branch Creek Restoration Project.

In addition to the afore-mentioned public meeting, several other presentations were given by City staff. The project elements were presented multiple times to the following organizations:

- North End Neighborhood Association
- Point Neighborhood Association
- Washington Street Neighborhood Council
- North End Neighborhood Resource Fair
- City Expo
- Lion's Club
- Masons
- Morning Optimist Club

The BBCAC's preferred alignment for the open channel was presented in a letter from the BBCAC Chairperson to the City Council dated June 30, 2004. The City selected BBCAC's preferred alignment because it best met the top three criteria established by the BBCAC: 1) preserve commercial and non-commercial services, 2) minimize residential property acquisitions, and 3) minimize the project cost. The preferred alignment impacted 65 residential homes and 15 non-residential buildings. More information regarding the alternatives analysis that was conducted, resulting in this preferred alignment, is presented below.

As part of the alternatives analysis performed in the October 2004 *Bee Branch Creek Restoration Alignment Study*, two main alternatives were considered for the Bee Branch. Both alternatives included an open waterway from the 16th Street Detention Cell to the CP Railway tracks just south of Garfield Avenue. One alternative included a culvert from the CP Railway tracks to 24th Street while the other extended the open waterway from the CP Railway tracks to 24th Street. These two alternatives are described in further detail below.

Culvert Analysis

Based on analysis of the culvert alternative, in order for a culvert to convey the necessary flow, dual concrete arch pipes between 36- and 42-feet in width would be required. This would result in a 150-foot-wide project corridor. The construction of the twin concrete pipe arch concept would require the reconstruction of road intersections over the pipe alignment.

Open Channel Analysis

For analysis of the open channel alternative, the open channel was assumed to consist of a 25-foot-wide low flow channel, a 120- to 130-foot-wide flood control channel, and an approximately 30-foot-wide overbank area. This results in a total corridor of 180 feet. The construction of this open channel would require the construction of bridges to maintain traffic connectivity and road reconstruction to accommodate the open channel.

As stated above, the open channel alignment alternative was selected as the preferred alternative. In August 2008, the City hired an engineering consulting firm to prepare the final design of the Bee Branch Creek Restoration Project. As part of the design process, a landscape committee was formed that consists of City staff as well as citizens from the North End and Washington Street Neighborhood Associations. The purpose of the Bee Branch Landscape Design Advisory Committee was to facilitate the development of a landscaping plan based on the input and direction of citizens and local businesses. Committee meetings were conducted to discuss the previous and upcoming citizen workshops, discuss landscape design issues as they impact or relate to individual committee members and the neighborhood or department they represent, and advise the design consultant team.

As part of the design process, the City hosted a series of workshops to gather citizen input. A press release was issued before each workshop, and over 2,000 postcards were sent to households in targeted neighborhoods. At the first workshop, held in October 2008, citizens were asked to identify their hopes and fears for the project. In addition, citizens were asked to provide input on the various potential landscape features, bridges, and secondary uses (for example, pathways, and locations for park benches, and playground equipment). At the second workshop held in November 2008 and continued in January 2009, the design team presented conceptual drawings that began to address the citizens' hopes and fears for the project as well as their landscape preferences. At the third workshop, in February 2009, the design concept, developed based on citizen direction, was presented to the public for comment.

Several modifications to the 2004 Bee Branch Creek Restoration Project design were incorporated the final design. A partial list of these design modifications is provided below:

- The Bee Branch Creek Channel was extended approximately 1,500 feet from US Highways 151/61 to Kerper Boulevard through the existing 16th Street Detention Cell; thereby, increasing the Phase I channel length from approximately 2,000 feet to approximately 3,500 feet.
- Excavated soil generated by the Project would be placed within the footprint of the existing 16th Street Detention Cell, resulting in the creation of an approximate 8-acre parcel along 16th Street that can be developed at a later date.
- The 16th Street Detention Cell shoreline adjacent to East 12th Street was realigned to provide a less linear and more natural appearance.
- The structural design of the proposed roadway bridges at Sycamore Street and 16th Street was changed from precast concrete CON/SPAN®-type structures to cast-in-place concrete structures.
- The Sycamore Street structure was modified from a 48-foot-wide by 11-foot-high precast arch culvert to a cast-in-place, 109-foot long, three-span flat-slab bridge with an arch facing. Similarly, the 16th Street structure was modified from an 11-foot-high by 48-foot-wide precast arch culvert to a cast-in-place, 110-foot long, three-span flat-slab bridge with an arch facing.
- The structural design of the roadway bridges at Rhomberg Avenue and 22nd Street changed from precast concrete CON/SPAN®-type structures to cast-in-place concrete structures.
- The Rhomberg Avenue and 22nd Street structures were modified from 11-foot-high by 48-foot-wide precast arch culverts to cast-in-place, 90-foot long, three-span flat-slab bridges with arch facing.

- The typical channel cross-section has changed from using a vegetated floodway channel with a 25-foot-wide low-flow channel to a permanent wet pool for the full width of the floodway channel. The width of the floodway channel varies from 65 to 145 feet.
- A level control structure was added upstream of the proposed CP Railway crossing.[40]

One of the more significant changes is related to conveying the stormwater through the railroad property. Originally, this was proposed as a pre-cast bridge, but other alternatives were investigated due to the complications of building a conveyance structure through an active railroad yard with two main line tracks and a half-dozen yard tracks. The alignment established in the 2004 Bee Branch Creek Alignment Study determined that the yard office building would be acquired by the City and removed. A proposed alternative alignment was evaluated.

The original alignment required the acquisition of CP Railway property from Garfield Avenue to the CP Railway right-of-way, removal and replacement of the CP Railway yard office, and crossing of as many as 10 tracks with multiple switches. By comparison, the proposed alternative alignment requires the acquisition of all or a portion of the Dubuque Furniture & Flooring (430 Garfield Avenue) property, and permanent and temporary construction easements from CP Railway and A-1 Crane.

Track operations, including the mainline and yard tracks, must be maintained during construction based on criteria established by CP Railway. The extent of track modifications depends on whether the structure type requires phasing to maintain track operations. Track phasing for open-cut and trenchless construction options were evaluated. Track phasing for open-cut construction of the bridge structure on the original alignment requires upgrading the tracks and switches in excess of $5 million to meet CP Railway requirements. Track phasing for trenchless construction of the culverts on the proposed alternate alignment is anticipated to be limited to periodic adjustment if active monitoring reveals unacceptable movement.

Several alternatives were analyzed, as follows:

> Alternative 1: 141-foot long Three-Span Steel Bridge. Alternative 1 includes the construction of a bridge that would pass the flow from the Upper Bee Branch to the Lower Bee Branch under the CP Railway tracks. The existing twin 10-foot-high by 12-foot-wide box culverts would remain in place, conveying only stormwater from the existing Bee Branch storm sewer under the CP Railway tracks. The initial plans for the proposed bridge crossing included a 141-foot-long bridge with a width of 87 feet 2 inches. The 141-foot long three-span steel bridge option provided 6.01 and 5.16 feet of freeboard below the bridge low chord elevation for the 50- and 100-year storm event, respectively. The hydraulic performance of the bridge exceeds the CP Railway hydraulic design criteria for bridges (that is, 2.0 feet and 0.0 feet for a 50- and 100-year storm event, respectively). This alternative also would improve hydraulic performance of the existing twin 10-foot-high by 12-foot-wide box culvert by providing 5.52 and 3.36 feet of freeboard below the crown of the existing twin culverts at the upstream and downstream end, respectively, for a 50-year storm event. For a 100-year storm event, 4.67 and 2.53 feet of freeboard would be

[40] Strand & Associates, Technical Memo 2, Status Update of Bee Branch Hydraulic Design.

provided below the crown of the existing twin culverts at the upstream and downstream end, respectively.

Alternative 2: Four 9.5-foot diameter Steel Culverts. Alternative 2 involves constructing new culverts under the CP Railway tracks and combining them with the existing twin 10-foot-high by 12-foot-wide box culverts under the CP Railway tracks to convey both the Bee Branch storm sewer and the flow from the Upper Bee Branch to the Lower Bee Branch.

Alternative 2 e involved boring and jacking four 9.5-foot diameter steel culverts under the CP Railway tracks. Unlike Alternative 1, the existing Bee Branch box culverts would discharge into an open channel that conveys upstream flows from the storm sewer and channel flows.

The upstream and downstream invert elevations of the new culverts would be 590.0 and 589.39, respectively. This alternative included the construction of a concrete junction chamber at the upstream end of the railroad culverts. Four 10-foot high by 10-foot wide box culverts would extend upstream (north) from the junction chamber to the north side of Garfield Avenue. The existing Bee Branch culvert would connect into a proposed junction chamber.

Hydraulic modeling results indicated that the proposed culverts would meet the CP Railway hydraulic design criteria for culverts (that is, 50-year hydraulic grade line (HGL) at or below the culvert crown and 100-year HGL no more than 1.0 foot above the culvert crown). Comparing hydraulic modeling results to Alternative 1, similar improvement to the hydraulic performance of the existing twin box culverts would be realized.

Alternative 3: Six 6.5-foot diameter Steel Culverts. This crossing alternative involved boring and jacking six 6.5-foot diameter steel culverts under the CP Railway tracks. The upstream and downstream invert elevations of the culverts would be 589.9 and 589.4, respectively. Alternative 3 also incorporated a concrete junction chamber at the upstream end of the railroad culverts and involves four 10-foot high by 10-foot wide box culverts under Garfield Avenue.

Hydraulic modeling results indicated that the proposed culverts would not meet the CP Railway hydraulic design criteria for culverts (that is, 50-year HGL at or below the culvert crown and 100-year HGL no more than 1 foot above the culvert crown). The hydraulic performance improvement realized by the existing twin box culverts would be similar to the crossing improvements under Alternatives 1 and 2.

Alternative 4: Seven 6.5-foot diameter Steel Culverts. A sensitivity analysis was performed to estimate the change in hydraulic performance of adding another 6.5-foot diameter steel culvert to the Alternative 3 crossing. Similar to Alternatives 2 and 3, Alternative 4 incorporated a concrete junction chamber at the upstream end of the railroad culverts and involves four 10-foot high by 10-foot wide box culverts under Garfield Avenue.

Based on the results of this analysis, the 50- and 100-year storm event HGL elevation in the existing Bee Branch near Rhomberg Avenue was lowered by 0.23 and 0.27 feet, respectively. The 50- and 100-year storm event HGL elevation in the existing Bee Branch near 22nd Street would be lowered by 0.1 and 0.2 feet, respectively.

Alternative 5: Five 9.5-foot diameter Steel Culverts. Alternative 5 was developed in an effort to achieve Upper Bee Branch hydraulic performance at the Rhomberg Avenue and 22nd Street bridges that is at least equivalent to that of Alternative 1 (that is, a 141-foot long three-span steel railroad bridge). Alternative 5 would be similar to Alternative 2, but it included an additional 9.5-foot diameter culvert under the CP and involves construction of five 10-foot high by 12-foot wide box culverts under Garfield Avenue.

Hydraulic modeling results indicated that Upper Bee Branch 100-year storm event HGL elevations at the Rhomberg Avenue and 22nd Street bridges are both 0.1 feet lower when compared to the Alternative 1 hydraulic modeling results.[41]

Existing 16th Street Detention Cell Gates

Potential solutions to repair or replace the damaged existing flood gates at the 16th Street Detention Cell outfall include the replacement or rehabilitation of the flood gates, and replacement or rehabilitation of the pump station. An alternative design was developed that would allow interior floodwaters to automatically pass into the Mississippi River when a positive hydraulic gradient occurs.

The design alternative would provide increased protection for a 100-year storm event occurring in the Bee Branch Drainage Basin during a "Gates Closed" operating condition. To attain this higher level of flood damage reduction, six 96-inch diameter rubber duckbill style check valves would be implemented immediately downstream of the existing twin 12-foot-high by 12-foot-wide box culverts at Kerper Boulevard. The six rubber duckbill style check valves would be mounted on the downstream side of a new flared concrete structure constructed onto the ends of the existing twin 12-foot-high by 12-foot-wide box culverts.

North End Storm Sewer

Potential solutions to the flooding of the streets and properties along the buried Bee Branch storm sewer trunk line from 24th Street to 32nd Street are limited to those providing increased conveyance. One option would be to extend the open waterway (restoration of the buried Bee Branch Creek) north from 24th Street to 32nd Street. This would entail a significant increase in residential and commercial property acquisition and come at a considerable cost to the City. Another potential option would be to construct underground vault storage systems, which might provide relief but would also entail significant property acquisition and disturb a significant portion of the area that is highly urbanized and developed with historic buildings. A third option would be to construct relief or replacement storm sewers with additional storm sewer intakes to ensure that the area remains well drained during severe weather and heavy rains.

[41] Strand & Associates, Technical Memo 5, Alternatives Analysis of Canadian Pacific Railway Crossing Options.

The extent of acquisition and construction cost for the channel expansion and underground vault systems are incredibly cost prohibitive (that is, $30 million to $60 million), and would likely result in unfavorable public opinion. The construction of a relief storm sewer system is limited to a utility corridor that is more easily managed in an urban setting than either previously identified option. It would provide the same flood damage reduction as the other options but at a small fraction of the cost ($1 million).

The design of the North End Storm Sewer system is based on ensuring that the maximum amount of stormwater can be conveyed from the area through the existing Bee Branch Storm Sewer Trunk Line (Bee Branch Sewer). The H&H model created as part of the 2001 DBMP and further refined as part of the 2004 Bee Branch Creek Alignment Study indicates that the conveyance capacity of the Bee Branch Sewer varies, it is limited to 320 cubic feet per second (cfs) north of 24th Street. To prevent the stormwater from collecting and flooding any particular area, and recognizing the uniformity of the entire area to be drained, the optimum design involves additional storm sewer conveyance capacity and additional storm sewer intakes along 25th, 26th, 27th, 28th, 29th, and 30th Streets running generally between White and Elm Streets. Each street system would intercept and convey approximately 55 cfs to the Bee Branch Sewer, requiring a network of 15-, 18-, 24-, and 30-inch diameter storm sewer conduits with 106 storm sewer intakes.

4.7.3 Recommendations for Improvement Alternatives

Upper Bee Branch Creek Restoration (Open Waterway)

The construction of the Bee Branch Creek Restoration Project is intended to re-create historic flood control conveyance through the City while reducing flood damages. The existing Bee Branch storm sewer trunk line will remain in service between 22nd Street and the Lower Bee Branch Creek to supplement the channel's capacity.[42]

As of October 2013, the Lower Bee Branch Creek Restoration Project is substantially complete, and the Upper Bee Branch Creek Restoration Project is under design. The construction of the Upper Bee Branch Creek Restoration Project will be bounded by 24th Street, the southern edge of the CP Railway property just south of Garfield Avenue, and Kniest, Prince, and Elm Streets. This project will entail the construction of large diameter culverts under the CP Railway yard and an open channel upstream of the railroad tracks. The portion of the alignment under the railroad, located just south of Garfield Avenue, will consist of five 9.5-foot diameter culverts. It is anticipated that construction will occur using a trenchless installation method to reduce the impact on railroad operations. Construction is anticipated to begin in the spring of 2014. The western edge of the open channel between the railroad and 22nd Street will be along Kniest Street. The open channel will generally be centered along Elm Street between 22nd and 24th Streets. The project will include property acquisition (both partial and full), roadway reconfigurations, construction of bridge crossings at Rhomberg Avenue and 22nd Street, and a headwall at 24th Street at the connection to the existing Bee Branch storm sewer.

[42] Information in this section was obtained from the October 2004 Final Bee Branch Creek Restoration Alignment Study; the August 11, 2010, memo from City Staff to City Council recommending bid award for the Lower Bee Branch Creek; and the February 8, 2013, Upper Bee Branch Creek Restoration Project Technical Memorandum No. 5 – Alternatives Analysis for Canadian Pacific Railway (CPR) crossing options.

Existing 16th Street Detention Cell Gates

It is recommended that the flood gates be replaced and a few other improvements associated with the outfall structure be made in accordance with the observations during a 2012 inspection. Due to the age of the structure, it is recommended that the flood gates, closure structure, concrete wing walls, and lifting mechanisms be replaced as part of the larger project. It is recommended that the pump station discharge pipes be equipped with automatic air release valves and check valves. Finally, it is recommended that six 96-inch diameter rubber duckbill style check valves be installed immediately downstream of the existing twin 12-foot-high by 12-foot-wide box culverts at Kerper Boulevard. The six rubber duckbill style check valves would be mounted on the downstream side of a new flared concrete structure constructed onto the ends of the existing twin 12-foot-high by 12-foot-wide box culverts. While the existing slide gates would not be routinely used during "Gates Closed" operating conditions, they could be used for emergency backup situations if one of the rubber duckbill style check valves becomes obstructed with debris. Implementation of the rubber duckbill style check valves would automatically provide significant additional gravity flow capacity through the existing twin 12-foot-high by 12-foot-wide box culverts when positive head is available during a "Gates Closed" operating condition. By incorporating these elements into this project, the condition of the pump station would be upgraded to current USACE standards and provide increased flood damage reduction within the Bee Branch Drainage Basin. Any modifications to the operation of or work affecting the pump station requires the review, input, and approval of USACE.

North End Storm Sewer

With the construction of the Bee Branch Creek Restoration Project, improvements to the North End storm sewer would provide increased capacity and reduce flooding of streets and adjacent properties. These improvements include replacing and upsizing the lateral storm sewers along the Bee Branch trunk line. The North End Storm Sewer improvements would be along 25th, 26th, 27th, 28th, 29th, and 30th Streets between White and Elm Streets. The storm sewer along each street would intercept and convey approximately 55 cfs to the Bee Branch Sewer, requiring a network of 15-, 18-, 24-, and 30-inch diameter storm sewer conduits with 106 storm sewer inlets.[43]

See Figure 4-8A for the location of the Upper Bee Branch Channel Restoration, 16th Street Detention Cell Flood Gate Replacement, and North End Storm Sewer projects.

4.7.4 Project Phasing

Table 4.31 updates the project priority list, including storm sewer trunk line area improvements with respect to the creek restoration, flood gate, and North End storm sewer. These improvements are prioritized on the basis of flood damage reduction.

[43] Information in this section was obtained from the City CIP project write-up for the North End Storm Sewer Improvements.

Table 4.31
Bee Branch Drainage Subarea
Recommended Improvements Summary

Drainage Basin Priority	Location	Recommended Improvements	Estimated Capital Cost[1]
1	Upper Bee Branch Creek Restoration	Construct five trenchless 9.5-foot diameter culverts under the railroad and open channel from the railroad just south of Garfield Avenue to 24th Street with two bridge structures, a headwall structure, and street reconfigurations.	$58.9 million
2	16th Street Detention Cell Flood Gate Replacement	Replace damaged flood gates with concrete wing walls and lifting mechanisms, construct automatic air release and check valves on pump station discharge piping, and add six rubber duckbill style check valves mounted on the downstream side of a new flared concrete structure.	$2.2 million
3	North End Storm Sewer Improvements	Upgrade the lateral storm sewer system to connect to the Bee Branch storm sewer trunk line between 25th Street and 30th Street.	$1.0 million
		Total Estimated Capital Cost:	**$62.1 million**

Note:
1. Estimated capital costs are based on current (June 2013) dollars.

Amend 2001 DBMP Section 4.7 with new subsection 4.7.5 as follows:

4.7.5 Completed Project Implementation

The Bee Branch Creek Restoration Project is a drainage basin-wide project involving the daylighting and restoration of a creek through the City from 24th Street to the 16th Street Detention Cell, and selective removal of existing portions of the Bee Branch storm sewer that would be exposed as a result of the open channel project.

The Lower Bee Branch Creek Restoration Project is the first of three phases of this project. The 2,100-foot long channel project extending from the 16th Street Detention Cell to the west across Sycamore, Cedar, and Maple Streets before extending north across 16th Street and along the western portion of the former Dubuque Packing Company site to the railroad tracks just south of Garfield Avenue. The channel was constructed with a 76-foot bottom width, and a maintenance access/hiking/biking path was included along the channel with lighting and security features. The construction of the channel included a 100-foot long bridge at Sycamore Street, a 110-foot long bridge at 16th Street, and a headwall where the existing storm sewer outfalls into the open channel. The project also included reconstruction of sanitary sewer, construction of new storm sewer, and dredging of the 16th Street Detention Cell. Construction was substantially completed in the fall of 2011. Final project acceptance is pending.

The City implemented a public involvement strategy as part of this project to accommodate public input and consider social and economic concerns of those residents being impacted. As discussed in Section 4.7.2, the BBCAC was established as part of the public involvement strategy. A public meeting was held, and several neighborhood meetings were held to discuss the project need, the project alternatives, and address citizen concerns. The BBCAC was comprised of 16 citizens and represented a cross-section of residents that would be affected by the project. The BBCAC met six times at meetings open to the public between September 2003 and June 2004. The committee generated a letter in June 2004 summarizing its recommendations. These recommendations include the following:

- A piped alternative was preferable to the open channel alignment. However, the BBCAC conceded that if the piped alternative was deemed too expensive, the open channel (daylighting) alignment was preferable to doing nothing.
- The committee recommended that a moratorium be established over both alignments until the alignment analysis was completed in more detail. Following analysis and selection of the preferred alternative, it was recommended that construction commence as soon as possible.
- The committee recommended that an erosion control ordinance be enacted, that stormwater runoff reduction BMPs be encouraged for development within the City, and that the City pursue drainage basin-level management practices with other applicable jurisdictions.

Once the open channel design was selected as the alternative of choice, the design team was selected by the City to proceed with the design of the Lower Bee Branch open channel from the 16th Street Detention Cell to the CP Railway property just south of Garfield Avenue. As part of the design process for this project, public input was solicited for project features such as the recreational trail and landscaping plan originally envisioned in the alignment study. As a result of this public participation process, a series of amenities to enhance the project were identified, including the recreational trail, lighting, benches, an amphitheater, and special facades for the bridge crossings over the channel. These amenities were considered essential to the public's acceptance and overall success of the project. To help fund the project, the City successfully pursued multiple grant funds to supplement the established stormwater utility fund. Awarded grants include the I-Jobs II grant and the Vision Iowa River Enhancement Community Attraction and Tourism (RECAT) grant, generating approximately $6.2 million in additional funding. See Figure 4-8A for the location of the Lower Bee Branch Channel Restoration project.

Amend 2001 DBMP with new Sections 4.8 and 4.9 as follows:

4.8 Impervious Area Reduction

As illustrated in Table 2.10, predicted rainfall totals for the City have increased by as much as 20 percent. Impervious area reduction is critical to address the predicted and increasingly intense rainstorms witnessed in the City since 2001. All alleys are located over soils with properties allowing for the infiltration of stormwater. These soils have permeability rates above the 0.5 inch per hour (minimum value criterion in ISMM), and nearly a third of the alleys are constructed over soils with permeability rates between 2.0 and 6.0 inches per hour. The subsections below describe two pervious pavement projects the City has implemented.

4.8.1 Pervious Street Pavement Systems

In 2012, the City completed a TIGER-grant-funded project that included the replacement of an impervious street system with a pervious street pavement system within the Historic Millwork District. Photo 4 shows the nature of the streets prior to the project. Photo 5 shows the pervious pavement system that will convey stormwater into the underlying soil.

Photo 4: Impervious, Flood-prone Historic Millwork District Street Prior to Federal TIGER Grant Complete Streets Improvement Project

Photo 5: Historic Millwork District Pervious Pavement System that Conveys Stormwater into the Underlying Soil

The project was constructed over a 2-year period and included the reconstruction of 10th Street from Jackson to Elm Streets, Washington Street from 9th to 11th Streets, Jackson Street from 7th to 11th Streets, utility upgrades on 11th Street from Jackson to Elm Streets, streetscaping on 9th Street from Washington to Main Streets, streetscaping on 10th Street from Jackson to Main Streets, and the construction of a hike and bike trail from 5th to 7th Streets along the Jackson Street corridor. Other project improvements included the following[44]:

- Reconstruction/replacement of approximately 1,200 feet of 12-inch diameter mainline sewer
- Reconstruction of 11 deteriorated brick sanitary sewer manholes
- Replacement of private sanitary sewer laterals
- Reconstruction of approximately 5,100 linear feet of water main, mainline valves, 19 fire hydrants, and replacement of lead water services
- Construction of approximately 3,400 linear feet of new storm sewer, 16 manholes, and 63 catch basins to improve the stormwater conveyance in the area
- Installation of fiber optics and telecommunications conduit infrastructure
- Replacement of existing sidewalks
- Removal of two underground fuel oil tanks
- Installation of pervious pavers in parking areas
- Re-use of existing brick pavers in streetscape areas

As streets near the end of their life, the possibility of transforming into a pervious pavement system will be evaluated. Considerations will include traffic volumes, street grade, and the nature of the underlying soil. Several good candidates are East 14th, East 15th, East 16th, Sycamore, Cedar, and Maple Streets in the

[44] Information for this section was obtained from the Dubuque Warehouse District Recommendations for Revitalization (undated) and the January 24, 2012, memorandum from City Staff to City Council recommending project acceptance.

vicinity of the completed Lower Bee Branch Creek Restoration Project. Based on NRCS soil information, the underlying soils in this area have permeability rates of over 6.0 inches per hour.

4.8.2 Pervious Alley Pavement System

There are 245 alleys within the Bee Branch Drainage Basin. Computer models WinSLAMM and P8 were used to simulate the benefit of converting alleys into pervious pavement systems. P8 was used to determine the runoff volume and WinSLAMM was used to determine the volume abstraction percentages. WinSLAMM was chosen because it includes a specific calculation routine for pervious pavement, and it is based on actual field observations, with minimal reliance on theoretical processes that have not been adequately documented or confirmed in the field. The models predict reconstruction of the alleys with pervious pavement systems would reduce the runoff volume to the Mississippi River by approximately 50 percent[45]. When fully constructed, approximately 2.5 million gallons of stormwater will be conveyed into the ground and be diverted from the Bee Branch Creek and Mississippi River on an annual basis. The City has completed the reconstruction of eight (8) alleys. Using federal financial assistance, design is underway to reconstruct 73 alleys over a 3-year period so that a third of the alleys in the Bee Branch Drainage Basin will have been converted to systems that convey stormwater into the ground.[46] The remaining alleys are to be converted into similar conveyance systems over a 20-year period as funding is available. Figure 2-2A shows the location of the Bee Branch Drainage Basin alleys.

Tables D-1 through D-4 in Appendix D list the alleys that are proposed to be reconstructed by year, with the anticipated square footage of pervious pavement.

4.8.3 Project Phasing

There is a direct correlation between impervious area and the runoff generated as a result of a rainstorm. The decreased runoff realized by replacing impervious alleys within the Bee Branch Drainage Basin with pervious alleys will help offset the increased rainfall predicted by the 2013 NOAA rainfall analysis. Table 4.32 identifies the recommended impervious alleys within the Bee Branch Drainage Basin.

Table 4.32
Bee Branch Drainage Basin
Recommended Improvements Summary

Drainage Basin Priority	Location	Recommended Improvements	Estimated Capital Cost[1]
1	Bee Branch Drainage Basin	Reconstruct the 237 impervious alleys within the Bee Branch Drainage Basin as pervious alleys to convey stormwater into the ground.	$43.3 million
Total Estimated Capital Cost:			**$43.3 million**

Note:
1. Estimated capital costs based on current (June 2013) dollars.

[45] Models do not use a design storm. WimSLAMM and P8 models simulate actual, continuous, annual rainfall. Total infiltration is based on the total annual runoff volume.

[46] Information on the impervious surface reduction projects was obtained from February 2013 correspondence with the Iowa Department of Natural Resources SRF Coordinator regarding the Dubuque CWSRF Project No. GNS13-1.

4.9 New Stormwater Management Projects

The 2001 DBMP identified stormwater management projects within the North Fork Catfish Creek and Bee Branch Drainage Basins. In addition to the projects identified in the 2001 DBMP, the City has identified other projects for flood damage reduction located outside of the Bee Branch Drainage Basin. One such project is floodproofing at the City's water plant located along the Mississippi River.

4.9.1 Water Treatment Plant Floodproofing

4.9.1.1 Development of Alternative Solutions

The City's water treatment plant is located at the northeast corner of Rhomberg Avenue and Hawthorne Street between the CP Railway property and the John C. Culver Floodwall[47]. The plant supplies potable water to Bee Branch Drainage Basin residents and businesses. It also provides a sufficient quantity and necessary pressure for fire protection and suppression. There are concerns of losing fire fighting capabilities potable drinking water as the result of a flood either as a result of interior drainage flooding or a breach in the John C. Culver Floodwall.

In response to these concerns, an evaluation of a conceptual structural floodproofing strategy was conducted as a part of this drainage master plan amendment. The City is interested in a structural solution that incorporates a combination of permanent and temporary floodproofing measures. The evaluation used available Light Detection and Ranging (LiDAR) topographic data, aerial images of the area, and information on typical earthen berm and floodwall requirements. The City desires to have 6 feet of additional protection around the water treatment plant which can be achieved by either an earthen berm or floodwall. A 6-foot high earthen berm would consist of side slopes of 4H:1V, a 10-foot top width, and a 58-foot bottom width. The floodwall would be a minimum of 1 foot thick, with an approximate 12-foot wide foundation slab. The width of the floodwall foundation slab can be reduced by adding sheet pile reinforcing. A floodwall would occupy a smaller footprint and have less of an impact on adjacent properties than an earthen levee.

A potential alignment for the floodwall is along an apparent property line as defined by a fence, as shown in Figure 4-9A. Using this alignment, the floodwall would parallel the railroad tracks to the southeast and follow the existing fence. The alignment intersects three access points to the water treatment plant facility: two access points directly off of Hawthorne Street and one from the parking lot for the Sutton Pool. When the floodwall is constructed, openings will be left for the three access points to the water treatment plant. Instead of flood gates, temporary closure measures will be used in the access locations during flooding. Temporary measures may include collapsible reusable wire mesh, fabric-lined baskets that can be installed and filled with sand, then emptied, removed, and stored when no longer needed. The City's existing baskets are 4 feet high and 3 feet high. In order to achieve 6 feet of protection at the access points, two rows of baskets would be stacked, one on top of the other, across the width of the access

[47] John C. Culver System was federally constructed, but locally operated by the City and protects the City of Dubuque from Mississippi River flooding. The System consists of over 20,000 feet of earthen levees and 7,100 feet of floodwalls along the entire Dubuque riverfront. The system also includes a navigable opening into Dubuque Harbor, three pump stations and three primary ponding facilities.

points. For stability, the bottom row would be double wide, with two baskets set side-by-side, and a row of single baskets placed on top of the bottom row.

4.9.1.2 Recommendations for Improvement Alternatives

It is recommended that the water treatment plant be equipped with a permanent concrete floodwall along the existing alignment of the property fence, with the ability to deploy temporary measures at the access point openings. The floodwall crest will be 6 feet aboveground and is recommended to have a T-wall footing. Due to the floodwall construction, stormwater modifications will need to be designed and constructed. Gravity stormwater pipes will be equipped with backflow prevention devices to prevent ponding water from collecting within the floodproofed area. Stormwater conveyance systems otherwise impacted would need to be replaced with pumping capacity to pump directly to the Mississippi River. For the purposes of this analysis, a detailed interior drainage analysis was not completed to determine the exact pump station capacity. Based upon experience with levee systems, an approximate cost was utilized to approximate the cost.

4.9.1.3 Project Summary

Table 4.33 provides a project summary and conceptual level cost opinion for construction of the permanent floodwall system for the City's only potable water treatment plant. The conceptual cost opinion does not include the cost of temporary measures to be deployed during a flood event.

Table 4.33
Other Stormwater Management Projects
Recommended Improvements Summary

Drainage Basin Priority	Location	Recommended Improvements	Estimated Capital Cost[1]
1	Potable Water Treatment Plant Floodproofing	Construct 2,600-foot long± floodwall with footing, trench drain, site restoration, and stormwater improvements.	$3.4 million
		Total Estimated Capital Cost:	**$3.4 million**

Note:
1. Estimated capital costs include contingencies (25%) to account for estimated quantities, unit price adjustments, and miscellaneous work-related items. An additional 25% was included for administrative, legal, and engineering costs. Right-of-way, operation and maintenance, and mitigation costs were not included. Costs are based on Iowa Department of Transportation 2013 unit prices.

4.10 Summary of Completed Projects in the Bee Branch Drainage Basin

Within the Bee Branch Drainage Basin, conveyance and detention improvements were defined in the 2001 DBMP. Detention was provided along Carter Road, and the existing West 32nd Street Detention Basin was expanded. The open channel alternative that would replace a portion of the Bee Branch storm sewer trunk line as first prepared in the 2001 DBMP was selected for implementation. This channel begins at the 16th Street Detention Cell, located near the Mississippi River, and proceeds upstream to near 24th Street. A phased approach separates the Bee Branch storm sewer into "Lower" and "Upper"

segments. The Lower Bee Branch Creek Restoration extends from the 16th Street Detention Cell to the CP Railway property, and construction of the creek and flood plain area was substantially completed in 2011. The Upper Bee Branch Creek Restoration will continue north of the CP Railway crossing and terminate at 24th Street. Land acquisition is near completion for the Upper Bee Branch Creek Restoration, with construction scheduled to begin in the spring of 2014.

Table 4.34 summarizes the 2001 DBMP projects and other conveyance projects that that have been completed since the 2001 DBMP was issued.

Table 4.34
Completed Project Cost Summary

Project Name	Project Completion Year	Project Summary[1]	Total Cost[2]
Burden Street Storm Sewer Improvements	2001	Installed storm sewer along Burden Street from Hogrefe to Windsor Avenues, ranging in size from 15 to 36 inches in diameter.	$0.2 million
Locust Street Improvements	2003	Reconstructed Locust Street between Rosedale Avenue and Kirkwood Street, and upsized the storm sewer.	$0.4 million
Carter Road Detention Basin	2004	Constructed earthen dam with two principal outlets, one auxiliary outlet, and other associated infrastructure improvements.	$1.4 million
Windsor Avenue Relief Storm Sewer Project	2008	Installed 42-inch diameter storm sewer along Windsor Avenue between Burden and Sutter Streets.	$0.2 million
West 32nd Street Detention Basin	2009	Expanded detention to include wet ponds, outfall structure modifications, and other related infrastructure improvements.	$4.6 million
Lower Bee Branch Creek Restoration	2011	Included 2,100 feet of open channel, selective demolition of existing storm sewer, and other associated infrastructure improvements.	$15.9 million[3]
Historic Millwork District Project	2012	Replaced parking areas with pervious pavement, reused brick pavers in streetscaping areas, and included other infrastructure improvements.	$8.3 million
		Total Capital Cost:	**$31.0 million**

Notes:
1. Information provided above was obtained from sources that include the Project Acceptance Memo, input from City staff, project grant applications and correspondence, and other project-related documentation.
2. Project costs were escalated to current dollars (June 2013) using the ENR 20-city average Construction Cost Indices.
3. Final project cost has not been established by the City of Dubuque City Council. Cost does not include the additional $1.6 million in planned appurtenances.

4.11 Other Dubuque Flood Risk Reduction Projects

In addition to the projects identified within the Bee Branch Drainage Basin, additional improvements associated with the federally constructed, City operated and maintained John C. Culver Floodwall may be appropriate. The levee/floodwall system reduces the risk of Mississippi River flooding in portions of the City. Two projects have been identified for the John C. Culver Floodwall include a levee breach analysis and a levee functional assessment. These projects are described in more detail in the following sections.

4.11.1 Levee Breach Analysis

As acknowledged by the USACE Levee Safety Program and within the recommendations generated from the National Committee on Levee Safety, identification of levee risk is a critical issue. Knowing the affects of a levee breach or failure is a component of understanding a levee system's risk. An evaluation of the affects of a possible Mississippi River levee breach along the City's levee system is necessary to understand the likelihood and the consequences of a levee failure. Mitigation strategies can then be developed to avoid or minimize the impacts of a potential levee failure. The results of a levee breach analysis can be used to supplement a flood risk management plan in order to promote public safety.

4.11.2 Levee Functional Assessment

The John C. Culver Floodwall was constructed by the USACE between 1968 and 1973. Since the construction of this levee/floodwall system, numerous physical modifications and technical advances have occurred. Some of these changes include:

- levee and floodwall criteria and design
- additional emphasis placed on federal levee safety program and local awareness to better understand, manage, and reduce flood risks with levees
- national impacts associated with Hurricane Katrina
- variable flood frequency water surface elevations for the Mississippi River
- increase operation and maintenance responsibilities of the local levee Sponsors
- urbanization impact on the interior drainage system

It is recommended that an assessment be conducted to recognize the current levee's level of flood risk reduction and compliance with current criteria and conditions. This information will help the City to determine what, if any, design and operational modifications need to be incorporated to the John C. Culver Floodwall.

5.0 FINANCING DRAINAGE IMPROVEMENTS AND OPERATIONS

5.3 Capital Funding

5.3.4 Grants

Amend 2001 DBMP Section 5.3.4 with new subsections 5.3.4.1 and 5.3.4.2 as follows:

5.3.4.1 State of Iowa I-JOBS II Funding

In 2010, the Iowa Legislature appropriated $30 million from FY 2011 revenue bonds to the I-JOBS Board of Directors for a Disaster Prevention Grant Program to assist or to provide additional funds to cities and counties. The money was intended to assist cities and counties in the development and completion of public construction projects relating to disaster prevention, including construction, replacement, or reconstruction of local public buildings in a manner that would mitigate damages from future disasters, including flooding. Because the Bee Branch Creek Restoration Project is a disaster prevention project, it was a natural candidate for the grant program.

On July 1, 2010, the City submitted a Notice of Intent to Apply for $7.3 million in I-JOBS II Disaster Prevention Grant Program funds for the Lower Bee Branch Creek Restoration Project, the first phase of the Bee Branch Creek Restoration Project. The Lower Bee Branch Creek Restoration Project is the section from the 16th Street Detention Cell to the CP Railway property just south of Garfield Avenue.

On July 15, 2010, the Iowa Finance Authority notified the City that it was eligible to apply for funds from the program for the Lower Bee Branch Creek Restoration Project and invited the City to complete an online application.

On September 15, 2010, the I-JOBS Board of Directors awarded a total of $30 million to 23 projects in 21 Iowa counties. Of those awardees, the City of Dubuque received $3,965,500 for the Lower Bee Branch Creek Restoration Project, one of the largest awards.

5.3.4.2 Green Project Reserve Capitalization Grants

The federal FY 2010 Appropriation Law (P.L. 111-88) included the requirement that "for fiscal year 2010, to the extent there are sufficient eligible project applications, not less than 20 percent of the funds made available under this title to each State for Clean Water State Revolving Fund capitalization grants and not less than 20 percent of the funds made available under this title to each State for Drinking Water State Revolving Fund capitalization grants shall be used by the State for projects to address green infrastructure, water or energy efficiency improvements, or other environmentally innovative activities." These four categories of projects are the components of the Green Project Reserve (GPR). U.S. Environmental Protection Agency (EPA) used an inclusive approach to determine what is and is not a "green" water project and established that creek daylighting is a Categorical (Green Infrastructure) Project.

Because the Bee Branch Creek Restoration Project is consistent with EPA's definition of a "green" project, in July 2010 the City submitted an application for $14.8 million in State Revolving Fund

(SRF)/GPR funding. The City's application for the Upper Bee Branch Creek Restoration Project was approved and is included on the Iowa State Revolving Fund Program Intended Use Plans (IUP) with 30 percent loan forgiveness, or $4.43 million.

Amend 2001 DBMP Section 5.3 with new subsection 5.3.6 as follows:

5.3.6 State Revolving Fund (SRF) Loan Program

Established by the federal Clean Water Act amendments of 1987, the Clean Water State Revolving Fund (CWSRF) Program provided a new approach to providing funding assistance for water pollution abatement projects. The primary benefit of SRF loans is that the interest rate is predictable, if not already known, and many times is below the market rate. It also allows for a longer repayment schedule.

Congress designed the CWSRF Program to allow states to structure their programs creatively to best serve their needs. States are given the flexibility to offer a variety of assistance options, including low interest loans, refinancing, purchasing or guaranteeing local debt, and purchasing bond insurance. States also set loan terms, including interest rates (from zero percent to market rate), repayment periods, and many other loan features. The CWSRF Program has been used to fund both the construction of wastewater treatment facilities and nonpoint source water quality improvement/protection projects. In 1990, only 1 percent of loan agreements made were for nonpoint source projects. Since then, however, the number of loans made for nonpoint source projects has increased substantially.

The City was able to secure CWSRF loan funds for both the West 32nd Street Detention Basin and the Lower Bee Branch Creek Restoration Project. CWSRF loan funds also has been approved for use on the Upper Bee Branch Creek Restoration Project.

5.5 Municipal Drainage Utilities

Amend 2001 DBMP Section 5.5 by adding text to the end of the section as follows:

In April 2002, the Dubuque City Council authorized City staff to investigate the formation and implementation of a stormwater management utility. The objective was to determine how the City can or should fund the construction, operation, and maintenance of the public stormwater drainage system and the improvements outlined in the 2001 DBMP.

A 30-member Citizen Advisory Council (CAC) was appointed by the City Council. The CAC's responsibilities included representing various areas of constituent interest, acting as advisor, assisting in informing the community, and developing a recommendation for the City Council. The following organizations were represented on the CAC:

- Archdiocese of Dubuque
- Bluff Street Neighborhood
- Clarke College
- Community Development Block Grant Advisory Commission
- Finley Hospital
- Flexsteel Industries
- Greater Dubuque Development Corporation
- Historic Bluffs Neighborhood Association
- Holy Family Schools

- Developer's Roundtable
- Downtown Neighborhood Council
- Dubuque Area Chamber of Commerce
- Dubuque Area Congregations United
- 1st Congregational Church of Christ
- Dubuque Board of Realtors
- Dubuque Community Schools
- Dubuque Homebuilders Association
- Dubuque Main Street Ltd.
- Electrical Workers Local 704
- Environmental Stewardship Advisory Commission
- Impacted Citizen
- Landlord Association
- Long Range Planning Advisory Commission
- Loras College
- Medical Associates Clinic
- Mercy Hospital
- North End Neighborhood Association
- United Auto Workers
- University of Dubuque
- Washington Neighborhood Council
- West Side Business Association

Between June 2002 and January 2003, the CAC held eight meetings to address the basic elements of stormwater management, discuss future stormwater requirements, evaluate funding options, and develop its recommendation. In addressing future stormwater requirements, the CAC considered the impact of new federal regulations, existing maintenance requirements, and increased future maintenance needs due to growth and aging of the City's stormwater system.

Numerous financing options were discussed, including a stormwater management utility, the general fund, local sales tax, Dubuque Racing Association (DRA) funds, reallocation of existing budget authority, and various combinations of those options. The CAC ultimately recommended a combination of a stormwater management utility, existing general fund and local sale tax contributions, and additional DRA funds.

On December 2, 2002, a set of consensus recommendations developed by the CAC were presented to the City Council. The CAC recommended that:

1. The City should implement a major capital improvement program (CIP) to address identified drainage problems as soon as possible. The magnitude of the CIP should start with a target of $24.5 million and be reviewed annually.

2. The City should fund its stormwater management program from a number of sources (all existing funding sources), including a new stormwater utility fee.

3. The City should contribute to the stormwater management program at current funding levels and should identify additional funds, such as federal grants, to keep the stormwater utility fee as low as possible.

The City created a stormwater management utility on February 27, 2003. When created, the stormwater utility fee was $1.29 per month per SFU as stormwater management activities were funded in part with property tax and sales tax funds. The stormwater utility ordinance was amended in 2008 to become a self-supported utility and the SFU rates were revised accordingly. The charge in 2013 is $5.60 per month per SFU, which ranks the second highest of the more than 30 stormwater utilities in the state.

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