Iowa Homeland Security & Emergency Management
7900 Hickman Rd, Ste 500
Windsor Heights, IA 50324

Iowa Flood Mitigation Program (FMP)
Flood Recovery Project Application

What is the Flood Recovery Fund?

A Flood Recovery Fund is established in the state treasury under the control of the Flood Mitigation Board to provide funding to eligible political subdivisions of the state to implement flood response, flood recovery, or flood mitigation projects.

Eligibility:

1) An eligible applicant is a political subdivision of the state located in a county designated under presidential disaster declaration DR-4421-IA and also located in a county where the federal emergency management agency individual assistance program has been activated.

2) Eligible projects must support flood response, flood recovery, or flood mitigaiton. Eligible project types include construction and reconstruction of levees, embankments, impounding reservoirs, conduits or other means that are necessary for the protection from the effects of floodwaters and may include the deepening, widening, alteration, change, diversion, or other improvement of watercourses if necessary for the protection of such property from the effects of flood waters. A project may consist of one or more phases of construction or reconstruction that are contracted for separately if the larger project, of which the project is a part, otherwise meets the requirements of this subrule.

Application Process:

This application is designed to capture the necessary information to meet program requirements.

1) Description of the project and how the project supports flood response, flood recovery, or flood mitigation activities.

2) Description of financial assistance need through the Flood Recovery Fund.

3) Description of the necessary expense or serious need of the political subdivision.

4) Details on any additional funds to be applied to the project.

Flood Mitigation Board Process:

1) Review the application.

2) Approve, defer, or deny the application.

Iowa Flood Mitigation Program (FMP)
Flood Recovery Project Application

I. Applicant Information

A. Applicant/Community Name	B. Address		City, State, Zip Code
City of Buffalo	329 Dodge Street		Buffalo, IA 52728

C. Point of Contact (POC) Name for Project	POC Title	POC Agency	POC Email
Tanna Leoanrd	City Clerk	City of Buffalo	buffalocityhall@mchsi.com

POC PO Box and Zip Code	POC Street Address	POC City, State, Zip Code	POC Phone
PO Box 557 52728	329 Dodge Street	Buffalo, IA 52728	563-381-2226

Alternate POC Name or Authorized Representative	Alt POC Title	Alt POC Agency		Alternate POC Email

Alt POC PO Box and Zip Code	Alt POC Street Address	Alt POC City, State, Zip Code	Alt POC Phone
PO Box 557 52728	329 Dodge Street	Buffalo, IA 52728	563-381-2226

D. Federal Tax ID # / FEIN	E. County Name	F. US Congressional District(s)	State Legislative Districts	
			Senate	House
	Scott	2	45	90

G. Is the Applicant/Community participating in the National Flood Insurance Program (NFIP)?	Community's CID Number
Yes	**190241**

II. Project Cost Information

A. Identify the requested funding source: **Permanent Work**

B. Project Budget Summary

Engineering/Contractual Services	$ 39,458.00
Installation of outfalls	$ 683,200.00
Culverts, closure device, and pump stations	$ 3,410,425.00
Total Project Budget Summary	**$ 4,133,083.00**

C. Project Funding Source

Identify all anticipated funding sources for the project and the amounts.

State that you have applied for and/or received approved federal, state and/or local financial assistance.

Please insert additional rows as needed.

Identify source	Applied/ Received	Federal $	State $	Local $	TOTAL
City of Buffalo				$ 600,100.00	$ 600,100.00
Flood Recovery Fund			$ 3,532,983.00		$ 3,532,983.00
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
Total Project Funding Source		$ -	$ 3,532,983.00	$ 600,100.00	$ 4,133,083.00

III. Project Plan Summary

A. Provide a brief description of the project and how the project supported flood response or will support future flood recovery and flood mitigation activities. This is a summary of Tab B - Project Plan.

The installation of checkvalves, pumpstations, and closures will protect the city to approximately the 50-year Mississippi River level. Creating protections from damaging homes and businesses. This would also alow highway 22 to be protected to the 50-year protection level and permit local commerce from shut down and or delay.

B. Provide a brief description of the financial assistance need through the Flood Recovery Fund.

The price on this project is significant for a community of our size, however the influence that the project would have on commerce within our area would be significant. Within our community and the neighboring communities we are the shortest route for commerce with large commercial businesses relying on the utilization of this route. We annually earmark budget money for flood damages and recovery however; these monies set aside are used entirely for supplies during flooding and depleting any reserves.

C. Explain how financial assistance through the Flood Recovery Fund is essential to meet the necessary expenses or serious needs of the applicant related to flood response, flood recovery, and flood mitigation.

Funding for this project is on a larger scale than just the community of Buffalo. It is our main goal to protect local business, and residential properties however, we want to promote relationships with neighbors and assist them in sustaining business and quick recovering during a disaster.

D. Provide details of any additional funds that can be applied to the project.

At this point we do not have additional funds but plan on using our resources to find alternatives.

E . Description of Project Location (i.e. Latitude and Longitude (minimum 6 digits after the decimal), Neighborhood, Subdivision, Geographic Boundaries, Driving Directions, etc.)

Beginning at Lat/Lon 41.455156,-90.727454 and continuing east approximately one mile to Lat/Lon 41.456436,-90.717221 is the section of highway 22 and area that would be protected as well as approximately one-two blocks north of Highway 22

IV. Work Schedule

A. List the major milestones for this project.

Task	Months/Years from Award			Responsible Party
	Start	Complete		
Notice of Grant Award	1	1		HSEMD
Engineering & Design	2	4		City of Buffalo
Permitting	4	7		City of Buffalo
Construction contractor procurement, selection & contract	7	10		City of Buffalo
Construction	10	16		City of Buffalo
Project Acceptance	16	18		City of Buffalo
Project Closeout	18	20		City of Buffalo & HSEMD
Total Project Duration:	**20 Months**			

V. Certifications

To the best of my knowledge and belief, I certify that all data in this application packet is complete, true and correct. The governing body of the applicant has duly authorized this document and hereby applies for assistance as documented in this application. The applicant understands that the project shall not proceed until Flood Mitigation Board approval is granted.

Signature of the Chief Executive Officer	Signature of the Authorized Representative
Sally Rodriguez	Tanna Leonard
Name of the Chief Executive Officer	Name of Authorized Representative
Mayor	City Clerk
Title	Title
City of Buffalo	City of Buffalo
Organization	Organization
February 5, 2020	February 5, 2020
Date	Date
563-381-2226	PO Box 557 329 Dodge Street
Phone Number	PO Box / Street Address
	Buffalo, Iowa 52728
	City, State and Zip Code
	563-381-2226
	Phone Number
	buffalocityhall@mchsi.com
	Email Address

MSA Memo

To: City of Buffalo, IA

From: Nick Wagner, PE

Subject: Revised Cost Estimates, Flood Mitigation Alternatives Analysis

Date: December 3, 2019

The intent of this memo is to present updated project cost estimates for the report titled *Flood Mitigation Alternatives Analysis*, prepared by MSA Professional Services, Inc. dated August 2014 for the City of Buffalo, Iowa. The numbered tables included below are intended to replace like-numerated tables in the original report. Note however that "(Revised, December 2019)" has been added to each table title.

No further engineering, analysis, or planning was performed from the date of the original report to this memo; this is simply an update to cost estimates based on current construction costs and market changes.

Table 1 - Check Valve Cost Estimate (Revised, December 2019)

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS	UNIT PRICE	TOTAL PRICE
1.	Backflow Prevention Vault Structure	4	EA	$ 34,000.00	$136,000.00
2.	Flap Gate	4	EA	$ 3,500.00	$ 14,000.00
3.	Slide Gate	4	EA	$ 6,000.00	$ 24,000.00
4.	Portable Pump Station	4	EA	$ 110,000.00	$440,000.00
5.	Mobilization/Incidentals/Contingency (25%)	1		$ 153,500.00	$153,500.00
6.	Design Engineering (10%)	1		$ 61,400.00	$ 61,400.00
7.	Construction Engineering (5%)	1		$ 30,700.00	$ 30,700.00
	TOTAL: Items #1-#7				**$859,600.00**

2117 STATE STREET, SUITE 200 BETTENDORF, IA 52722
P (563) 445-3501 • TF (866) 732-6321 • F (563) 445-3503
WWW.MSA-PS.COM

Table 2 - Ash Street Culvert Cost Estimate (Revised, December 2019)

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS	UNIT PRICE	TOTAL PRICE
1.	Property Acquisition / Easement	1	AC	$ 15,000.00	$ 15,000.00
2.	Channel Clearing and Grubbing	400	LF	$ 38.00	$ 15,200.00
3.	Culvert Removal	1	LS	$ 7,500.00	$ 7,500.00
4.	Dual-Cell Box Culvert (6.5Hx8' W each cell)	60	LF	$ 1,400.00	$ 84,000.00
5.	Dual-Cell Box Culvert Endwall	2	EA	$ 20,000.00	$ 40,000.00
6.	Roadway Reconstruct (4" HMA on CABC)	350	SY	$ 80.00	$ 28,000.00
7.	Rip Rap (Large)	250	TON	$ 56.00	$ 14,000.00
8.	Salvage & Reinstall Guardrail	30	LF	$ 40.00	$ 1,200.00
9.	Install New Guardrail	30	LF	$ 70.00	$ 2,100.00
10.	Mobilization / Incidentals (15%)	1		$ 31,100.00	$ 31,100.00
11.	Design Engineering (10%)	1		$ 20,700.00	$ 20,700.00
12.	Construction Engineering (10%)	1		$ 20,700.00	$ 20,700.00
	TOTAL: Items #1-#12				**$ 279,500.00**

Table 3 – Highway 22 Culvert Cost Estimate (Revised, December 2019)

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS		TOTAL PRICE
1.	Bore 60" Dia RCP Culvert	160	LF	$ 1,850.00	$ 296,000.00
2.	60" Dia RCP Culvert Endwall	2	EA	$ 3,700.00	$ 7,400.00
3.	Rip Rap (Large)	25	TON	$ 56.00	$ 1,400.00
4.	Mobilization / Incidentals (15%)	1		$ 45,700.00	$ 45,700.00
5.	Design Engineering (10%)	1		$ 30,500.00	$ 30,500.00
6.	Construction Engineering (10%)	1		$ 30,500.00	$ 30,500.00
	TOTAL: Items #1-#6				**$ 411,500.00**

Table 4 - Pump Station / Closure Structures Cost Estimate (Revised, December 2019)

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS		TOTAL PRICE
1.	Storm Pumps - 87,500 gpm	2	EA	$ 430,000.00	$ 860,000.00
2.	48" Force Main (Directional Drill)	250	LF	$ 370.00	$ 92,500.00
3.	Instrumentation and Controls	1	LS	$ 185,000.00	$ 185,000.00
4.	Backup Power Generator	1	LS	$ 56,000.00	$ 56,000.00
5.	Pump Intake Structure / Building	1	LS	$ 430,000.00	$ 430,000.00
6.	Backflow Prevention Vault Structure	4	EA	$ 30,000.00	$ 120,000.00
7.	Flap Gate	4	EA	$ 3,500.00	$ 14,000.00
8.	Slide Gate	4	EA	$ 6,000.00	$ 24,000.00
9.	Portable Pump Station	4	EA	$ 110,000.00	$ 440,000.00
10.	Backflow Prevention Vault Structure (60" pipe)	1	EA	$ 50,000.00	$ 50,000.00
11.	Flap Gate (60" dia.)	1	EA	$ 6,500.00	$ 6,500.00
12.	Slide Gate (60" dia.)	1	EA	$ 12,000.00	$ 12,000.00
13.	Slide Gate (Box Culvert)	1	EA	$ 250,000.00	$ 250,000.00
14.	Mobilization/Incidentals (15%)	1		$ 381,000.00	$ 381,000.00
15.	Design Engineering (10%)	1		$ 254,000.00	$ 254,000.00
16.	Construction Engineering (10%)	1		$ 254,000.00	$ 254,000.00
	TOTAL: Items #1-#16				**$ 3,429,000.00**

Table 5 - Culvert Extension Cost Estimate (Revised, December 2019)

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS		TOTAL PRICE
1.	Mobilization	1	LS	$ 6,500.00	$ 6,500.00
2.	Erosion Control	1	LS	$ 2,500.00	$ 2,500.00
3.	36" x 27" Box Culv Extension (Outfall 100)	145	LF	$ 220.00	$ 31,900.00
4.	36" x 27" Box Culv Extension (Outfall 150)	160	LF	$ 220.00	$ 35,200.00
5.	Rip Rap	100	TON	$ 37.00	$ 3,700.00
6.	Installation (Labor)	1	LS	$ 20,000.00	$ 20,000.00
7.	Design Engineering (10%)	1		$ 10,000.00	$ 10,000.00
8.	Construction Engineering (10%)	1		$ 10,000.00	$ 10,000.00
	TOTAL: Items #1-#8				**$119,800.00**

Flood Mitigation Alternatives Analysis

City of Buffalo
Scott County, Iowa

Project No. 10370014

August 2014

Flood Mitigation Alternatives Analysis

City of Buffalo
Scott County, Iowa

Project No. 10370014

Prepared by:

MSA Professional Services
Davenport, Iowa
Phone: (563) 445-3501

LICENSED PROFESSIONAL ENGINEER ERIC J. THOMPSON 18067 IOWA SEAL	I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Iowa. AUGUST 26, 2014 Eric J. Thompson, P.E., CFM — Date License Number 18067 My license renewal date is December 31, 2015 Pages or sheets covered by this seal: Entire Report

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I. EXECUTIVE SUMMARY

The City of Buffalo has commissioned this study to review and evaluate its existing storm outfalls, and to determine whether construction of closure structures on these outfalls would benefit the community. This report is a revision to another report titled, 'Hazard Mitigation Engineering Report' dated September 2012. This version of the report has been retitled 'Flood Mitigation Alternatives Analysis' to provide better initial definition of the scope of the study that this report documents. This revised study focuses on potential projects to reduce occurrences of flooding within the City due to high water conditions along the Mississippi River and high flows within Cedar Creek and provides cost estimates.

A. Mississippi River Flood Mitigation

The previous version of this report proposed the installation of closure devices on thirteen of seventeen existing storm sewer outfalls to the Mississippi River with the idea that these one-way flap gates would prevent river floodwaters from backing into the storm sewers and inundating low-lying areas of the City. It was then suggested that this would raise the elevation to which the City would have flood protection (from the Mississippi River) to that of the railroad embankment which parallels Highway 22 on the riverward side of the City (approximately 50-year flood protection). This approach has been abandoned for two reasons. The first reason is that placing closure devices on the riverward side of the railroad tracks could conceivably create a hydrostatic pressure imbalance across the railroad. It is likely that the railroad was not designed to accommodate this imbalance and therefore this situation could result in damage to the railroad bed. The second reason is that a certain portion of the upper layers of the railroad bed are constructed from crushed stone (ballast) which is expected to have a high rate of permeability. As such, the level of protection offered by the installation of flap gates will be substantially lower than the height of the tracks.

This report has reviewed three potential options for mitigating flooding from the Mississippi River. They include two options for large-scale floodwalls which include vaults for storm sewer closure devices on the landward side of the railroad tracks. These options would provide 100-yr flood protection for the City but are anticipated to be cost-prohibitive. A third, smaller option would involve the construction of three (3) storm sewer closure structures in vaults on the landward side of the railroad which would provide protection to approximately the 50-year Mississippi River level for the lower areas of the City south of 2nd Street at Main Street and Washington Street.

This report also considered the City's concept for extending several culverts past beach areas to improve the beach frontage.

It is recommended that the City pursue construction of the reduced-scope storm sewer closure plan under FEMA's Hazard Mitigation Grant Program (HMGP) or other disaster-related relief grants. It is possible that a project undertaking storm sewer closure may be incorporated as part of the Multi-Jurisdictional Mitigation Plan for Scott

County, which has been recently developed. The estimated cost of this project is $683,200. This estimate is presented in detail in Section V.A of this report.

B. Cedar Creek Flood Mitigation

The previous report also explored an option to make various improvements along Cedar Creek to reduce the frequency and severity of flooding from this source. In general, the concepts presented in the earlier report (that is, improvements to the culvert at Ash Street and construction of a large stormwater pump station at Highway 22) are carried forward in this revision, however, calculations have been revised and additional concept refinements have been prepared.

The existing culvert at Ash Street is a 78" diameter RCP. The previous version of the report suggested the installation of a second 78" RCP parallel to the structure currently in place. Since the publication of that report, additional information has become available regarding watershed terrain and elevation of the Ash Street roadway. Utilizing this information, it was determined that a dual box culvert, each cell being 6.5' high and 8' wide, would be an appropriate size to pass 100-year flood flows to keep Ash Street open in cases of flood emergencies.

The existing culvert at Highway 22 is a 6' wide by 10.5' high box culvert. The previous version of the report suggested the installation of a sluice gate to prevent Mississippi River backups, and provided an estimated capacity for a pump station to evacuate storm water runoff from Cedar Creek during situations where the river gate was closed. This report refines the pump capacity to 87,500 gpm by introducing a preliminary estimate of coincident frequency. This report also finds that an additional parallel 6' diameter RCP culvert would be required to provide the desired flood protection during times of high flow from Cedar Creek at normal Mississippi River levels.

It is recommended that the City pursue funding for construction of the culverts, closure device, and pump station under FEMA's Hazard Mitigation Grant Program (HMGP) or other disaster-related relief grants. It is possible that a project undertaking culverts, closure device, and pump station construction may be incorporated as part of the Multi-Jurisdictional Mitigation Plan for Scott County, which has been recently developed. The estimated cost of this project is $3,410,425. This estimate is presented in four subcomponents described in detail in Sections V.B through V.E of this report.

C. Flood Data Sources and Limitations

All references in this report to flood elevations, flood flow rates, annual-percent-chance flood hazards (t-year floods) or similar hazards are based on the FEMA Flood Insurance Study (FIS) for Scott County, Iowa dated 2/18/2011 *unless otherwise explicitly noted*. This FIS includes, by reference, studies conducted over several years dating back as early as mid-1970's. No hydraulic or hydrologic analyses were performed by MSA to verity the current validity of information contained in the FIS. All elevations presented on this report are referenced to NGVD 29 datum, to match the datum used on the FIS.

II. INTRODUCTION

A. Background

The City of Buffalo is situated along the Mississippi River, southwest of the Quad Cities metropolitan area in Scott County, Iowa. Map 1 in Appendix A identifies the location and municipal limits of the City of Buffalo. The City is not protected by a levee system, and has experienced historic flooding when the Mississippi River reached high water levels. During flooding conditions on the river, portions of the storm sewer system become surcharged and result in localized flooding of the community. Map 2 in Appendix A identifies the locations of the main portions of this system and the outfalls. Additionally, Cedar Creek, located on the western edge of the City, also causes flooding following periods of intense rainfall.

B. Flood Insurance Study

The Federal Emergency Management Agency (FEMA) published a Flood Insurance Study for Scott County Iowa on February 18, 2011. The study covers all of Scott County, including the City of Buffalo. Within the City of Buffalo, detailed flood elevation studies were completed for the Mississippi River and Cedar Creek.

According to the Flood Insurance Study (FIS), low-lying areas within the City of Buffalo are periodically subjected to extensive flooding from the Mississippi River. The flooding that occurs causes substantial property damage to the City and causes major road and highway closures, which in turn costs the City a substantial amount of money and resources. The majority of this flooding occurs due to river water backing up into the storm sewer system, before the railroad tracks are overtopped. The 1993 flood on the Mississippi River produced a record stage at Buffalo, at a stage of 560.9 feet, in which the railroad tracks were overtopped. This flood stage approximately corresponds to the 1% annual chance (100-year) event.

Based on information provided in the FIS, predicted flood elevations at Buffalo for various probability flood events are depicted on **Table 1** and **Table 2** below. *Note that FEMA's elevations in Table 2 do not correlate with MSA's findings regarding the Ash Street culvert discussed in III.D and IV.E of this report.*

Table 1 - Mississippi River @ Confluence of Cedar Creek (Outfall 15)

Annual Chance Flood	Predicted Flood Elevation (ft.)
10%	556.8
2%	559.9
1%	561.1
0.2%	563.7

Note: Flood elevations given are NGVD29 datum.

Table 2 - Cedar Creek @ Ash Street

Annual Chance Flood	Predicted Flood Elevation (ft.)
10%	586.2
2%	587.7
1%	588.4
0.2%	589.6

Note: Flood elevations given are NGVD29 datum.

The FEMA-mapped 1% chance (i.e. 100 year) flood plain limits for the Mississippi River and Cedar Creek is included as Exhibit 3 in Appendix A.

C. Objective and Scope

This evaluation was initiated to provide a review of the existing potential flood conditions within the community to identify a practical solution to minimize flood damage, inconveniences, road closures, and staff's time and resources required to respond to the flooding conditions. Specifically, this evaluation was intended to evaluate alternatives and develop cost estimates to limit the effect of Mississippi River and Cedar Creek flooding on the community.

The scope of this Evaluation included the following work:

1. Review of the MS4 report materials developed by the City.
2. Visual inspection of each storm water outfall to verify outfall size, type and condition.
3. Evaluation of alternatives to reduce the frequency and magnitude of localized flooding, including installation of check valve types for each of the outfalls.
4. Development of recommendations for each outfall, including recommended valve type, estimated cost to furnish and install the check valve, and other necessary construction.
5. Preparation of preliminary calculations to determine the approximate capacity requirements and layout of a storm water pump station at outfall 15 on Cedar Creek.
6. Preparation of preliminary calculations to determine the required capacity size of a replacement culvert at Ash Street on Cedar Creek.
7. Preparation of detailed cost estimates for the work described above.

   Information presented within this analysis is based upon field investigations, reference documentation obtained from City employees and previous flood studies prepared for the community.

III. EVALUATION

A. Past Reports

MSA reviewed storm sewer documentation provided by the City of Buffalo to obtain background information relative to the City's storm sewer system. Materials provided and reviewed included the following:

- Illicit Discharge Detection Report – Buffalo, Iowa, dated October 19, 2009. This report included a summary of the inspection of each of the outfalls in the community.
- Illicit Discharge Detection Report – Buffalo, Iowa, dated September 21, 2010. This report included a summary of the inspection of each of the outfalls in the community.
- 2010 Storm Water Management Program Annual Report prepared by Veenstra & Kimm, Inc. This report provided a summary of MS4 compliance activities completed in 2010.

B. Site Visit

An MSA Professional Services (MSA) representative performed a site visit on March 24, 2011 and July 13, 2012. During the site visits, the condition of each of the outfalls was documented and photographed. Photographs of the outfalls are included in Appendix B. The railroad tracks were also surveyed to verify the overtopping elevation of approximately 560.

In addition, MSA performed a cursory review of the City's storm sewer system. The intent of this review was to determine the area contributing to each of the storm outfalls. The storm sewer configuration is depicted on the Storm Sewer System Map included as Exhibit 2, Appendix A.

A table summarizing the notes and conditions of each of the outfalls is presented in **Table 3**. The outfall numbers presented in the table are consistent with the numbering convention included with the MS4 map documentation.

Table 3 – Outfall Information

Outlet Number	Size	Type/Material	Comments/Condition
10	12"	RCP	Exits side of box culvert
15	6'x10.5'	Box Culvert	Serves Cedar Creek
20	36"	RCP	
30	36"	RCP	
40	36”	RCP	Partially buried in sand
50	36"	RCP	
60	24"	RCP	
70	Unknown	Box Culvert	Buried in sand, couldn’t determine size
80	24"	RCP	
90	36"	Steel Casing	
100	36"x27"	Box Culvert	Mostly buried. City would like to pipe to river, bury and extend beach area.
110	Unknown	Unknown	Under water at time of site visits
115	3'x2.5'	Box Culvert	Installed in 2005, good condition, undersized based on recent observation during storms
120	34"	Steel Casing	
130	15" double	RCP	
140	8' wide, 6' tall Oval	Oval CMP	Pipe flush with concrete abutment
150	Unknown	Box Culvert	Full of brush. City would like to pipe to river, bury and extend beach area.

C. Mississippi River Flood Assessment

City staff were interviewed to determine locations where historical flooding affected the City. One of the remarks from staff was that the railroad embankment appeared to serve as a ‘de-facto’ levee providing protection up to Mississippi River flood stages of approximately elevation 560 (approximately corresponding to a 50-year flood). It was determined that this elevation more closely corresponds with ground elevations in the area between the levee and the highway, and that there is likely a high rate of seepage through the railroad ballast. *It should be noted that MSA cautions against referring to the railroad as a ‘levee’ as it is likely not engineered in such a way to accommodate the hydrostatic pressure imbalances for which true levee structures are designed. The railroad more closely meets the description of ‘non-levee embankment’ (NLE) used in FEMA terminology.*

Historic flooding in the City of Buffalo was researched to determine at what river level interior flooding could have been reduced or prevented if the storm outfalls had closures on them. The historic flood elevations and recurrence intervals are shown in **Table 4**.

Table 4 – Historic Flood Elevations and Recurrence Intervals at Buffalo, IA

Year	Approximate Peak River Elevation (feet NGVD 29)[1]	Approximate Recurrence Interval (t-Year Flood)[2]	Railroad Embankment Overtopped?
1951	556.7	10	No
1965	560.9	80	Yes
1969	557.5	15	No
1973	557.9	25	No
1975	557.2	12	No
1993	561.1	100	Yes
1997	558.1	30	No
2001	560.2	60	Yes
2008 [3]	560.0	---	No
2011 [3]	558.5	---	No

[1] *Approximate peak river elevations for events through 2001 were estimated from the US Army Corps of Engineers' historic river profiles at river mile 473 in Pool 16 of the Mississippi River (website: http://rivergages.mvr.usace.army.mil/WaterControl/Districts/MVR/profiles/pool16.gif) .*
[2] *Approximate recurrence interval was determined by interpolating between recurrence interval profile lines from Panel 25P at river mile 473 of the Mississippi River profile published in the Scott County FIS.*
[3] *Approximate peak river elevations from 2008 and 2011 were estimated by translating the recorded high river stage at Pool 16 upstream to Buffalo using an approximation of river gradient of previous floods, and DO NOT represent actual recorded elevations from the ACOE or City. No recurrence interval is estimated for these floods.*

D. Cedar Creek Flood Assessment

The Cedar Creek watershed was analyzed explicitly due to its relatively large 493-acre watershed and its flooding history at two important locations: Ash Street and Highway 22.

Approximately 1,400 feet upstream of Highway 22 (Outfall 15) there is a 78" RCP culvert that runs underneath Ash Street. Historically, Ash Street has been overtopped and has resulted in road closure and damage to the roadway, indicating that this culvert is undersized. The Ash Street culvert on Cedar Creek presents a major concern to the City of Buffalo, because this is the only through street in town, other than Highway 22, that connects the east and west sides of the community. If Highway 22 was closed due to Mississippi River flooding or road construction, Ash Street would need to be passable for emergency vehicles and as a detour route.

At Highway 22 (Outfall 15) there is a 6'Wx10.5'H box culvert that runs underneath the highway and railroad tracks. At this location, there is a unique challenge to flood mitigation. Construction of a gate closure on this culvert could protect low-lying areas from Mississippi River stages of less than elevation 560 (approximately a 50-year event); however, if the gate is closed at the same time that a storm occurs in the Cedar Creek

watershed, creek runoff would need to be pumped to the river to prevent overtopping of Highway 22.

In order to analyze the Cedar Creek watershed, peak runoff flow rates were calculated to size the culvert underneath Ash Street and to size a pump station at Outfall 15. A computer model, HydroCAD 10.00, was used to prepare peak discharge runoff calculations. HydroCAD uses the TR-55: Urban Hydrology for Small Watershed (USDA, 1986) methodology of calculating runoff volumes and routing operations. The TR-55 method for calculating peak runoff rates takes rainfall depth, rainfall distribution, land use, and watershed slope into account in the calculation. Recurrence-interval-based modeling was completed using 24-hour rainfall depths as published in NOAA Atlas 14 Volume 2 Version 3.0, last revised in 2006. Rainfall intensities were determined for each event by applying the SCS Type II synthetic rainfall intensity distribution. Runoff calculations from HydroCAD were checked for reasonableness by two regression-equation methods. Results are included in Appendix C. Peak runoff flow rates and volumes computed with the TR-55 method at the Ash Street culvert and at Outfall 15 (Highway 22) are shown in **Table 5** and **Table 6**.

Table 5 - Peak Flow Rates to Ash Street

Watershed	Drainage Area (acres)	Runoff CN	Frequency (t-year Flood)	Peak Flow (cfs)	Runoff Volume (ac-ft)
To Ash St. Culvert	448	80	10	528	90.6
			25	723	123.4
			50	892	152.3
			100	1,071	183.2

Note: These peak flows were calculated by MSA using TR-55. Flow rates differ from those reported in the Scott County Flood Insurance Study.

Table 6 - Peak Flow Rates to Outfall 15

Watershed	Drainage Area (acres)	Runoff CN	Frequency (t-year Flood)	Peak Flow (cfs)	Runoff Volume (ac-ft)
To Outfall 15 – Highway 22	493	80	10	550	99.4
			25	753	135.5
			50	930	167.2
			100	1,116	201.2

Note: These peak flows were calculated by MSA using TR-55. Flow rates differ from those reported in the Scott County Flood Insurance Study.

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IV. ALTERNATIVES

A. Do Nothing

In the evaluation of flood mitigation alternatives, one option is to simply "do nothing". The "do nothing" alternative will not require capital expenditures by the City, but the City would then remain subject to the following impacts from floods:

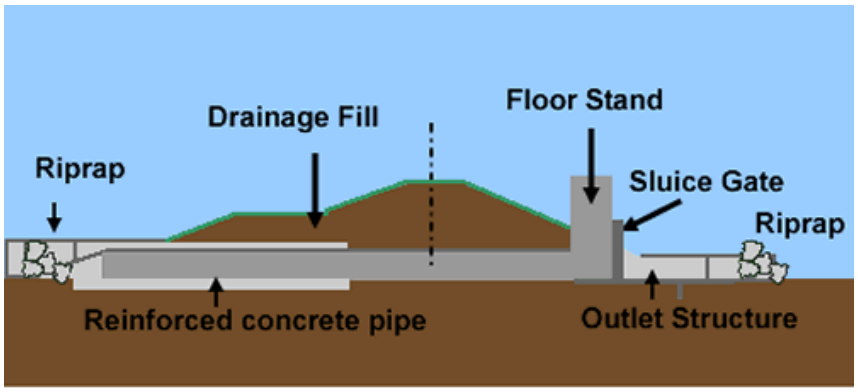
- periodic costs associated with City staff time and resources to manage flooding
- significant damages to residential properties, local businesses, and public properties from flooding (total dwelling/improvement values in areas subject to 50-year flood is approximately $6,000,000 based on year 2011 assessor's data)
- closed roads including the main highway through town, costing the City significant time and money due loss of business revenue and general commerce.

B. Installation of Backflow Prevention – Mississippi River Outfalls

In evaluating potential options for preventing backups of river water through the existing storm sewer outfalls, two general categories of devices were evaluated. These include boot-type or flap-type check valves and gate closure structures.

Installation of check valves on the storm sewer outfalls would provide a relatively manual-free prevention against flooding in the City caused by backups from during high water on the Mississippi River. This is an end-of-pipe device that is normally closed, but is pushed open by stormwater discharging from the landward side to the waterward side, as occurs during a localized rainstorm. While this is a more-or-less automatic device, it can be subject to malfunction by debris either by building up on the outside and preventing opening or by incomplete flushing from the inside and preventing closure.

Gate closure structures are the type typically constructed on river levees. For this type of closure structure, a gate within a concrete structure is manually operated, providing a positive closure. This type of closure is generally more costly, but offers a more reliable closure. A typical gate closure configuration is shown below.



Gatewell Structure

With either type of closure device, reliable flood protection against flooding events on the Mississippi River with a recurrence interval of approximately 50-years or less can be provided for Buffalo due to elevation limitations. Flood events with a recurrence interval of greater than 50-years would result in localized flooding and road closures in the community, as exhibited in past flooding.

C. Culvert Extensions – Mississippi River Outfalls

In the evaluation of culverts, several factors help determine if it is feasible to extend and or replace culverts. Some of these factors are condition, accessibility for maintenance, accessibility for inspection, potential for erosion, safety, and lastly and most importantly is capacity.

There are two culvert outfalls in Buffalo that may warrant extensions: Outfalls 100 and 150. These outfalls terminate immediately south of the railroad tracks and are surrounded by brush, partially buried with sand, and discharge to a public beach.

D. Floodwall Construction – Mississippi River

As previously indicated, the railroad embankment is not considered to be useable as a levee. This is due to several factors. Primarily, the fill used in railroads is generally not designed to withstand differential hydrostatic pressures that are required of levees. In addition, it lacks the elevation, width, and side-slopes that are usually required of certified levees.

To provide 100-yr flood protection for the entire City of Buffalo would require the construction of a floodwall system. An earthen levee is not an option due to ACOE/FEMA requirements for levee widths and side slopes and the limited amount of land between the railroad and Highway 22; however, a floodwall could be constructed, particularly if it were a sheet-pile structure rather than a wall with a spread footing.

The first option would be to construct a floodwall that could be certified by FEMA for protection against the 100-year flood event and removal of lands from floodplain zoning and insurance requirements. For certification of this type, the top of the wall would need to be built 3' above the 100-year flood elevation. The 100-year flood elevation is approximately 561, requiring a top of wall elevation of 564. Ground elevation varies along the route from about 561 on the east end of the City near Dodge Street to about 558 on the west end near Elm Street. To tie in to ground elevations of 564 or above, this wall would need to:

- Begin at a point just east of the City Hall / library building,
- Continue in a line southwards across Highway 22 to a point between the highway and the railroad tracks,
- Continue westerly parallel with the river between the highway and the railroad tracks through town to just past the intersection with Elm Street,
- Turn and run northerly across the highway again to tie in to high ground northwest of the Elm Street / Highway 22 intersection.

The described route is a total length of approximately 5,900 feet. The estimated cost for such a floodwall is approximately $6,000,000. Adding in possible costs for floodwall closures for openings necessary to access properties on the riverward side of the levee, the cost for a permanent pump station to provide stormwater drainage for lands inside the levee, or previously discussed flap gates for existing storm sewer outfalls could increase this cost by as much as $3,000,000, for an anticipated total of $9,000,000.

A second option would be to construct a floodwall to the elevation of the 100-year flood, that is, 561. This would provide a level of protection nominally for the 100-year flood but would lack the freeboard required for FEMA certification and the associated removal of buildings from floodplain insurance requirements. The estimated cost for such a floodwall is approximately $3,000,000 plus costs for stormwater drainage for lands inside the levee, closures, flap gates, etc. again on the order of an additional $3,000,000, for an anticipated total of $6,000,000.

The level of effort required to more accurately define these costs is beyond the scope of this current project. Regardless, the sheer magnitude of these costs and land acquisition requirements for a project of this size is anticipated to make this scale project out of reach for the City.

E. Culvert Improvements – Cedar Creek

The culvert on Cedar Creek under Ash Street has flared headwalls in poor condition and does not appear to have adequate capacity for flood flows. The existing culvert has a capacity of about 320 CFS before overtopping the roadway, insufficient to pass even the 10-year flood event of 528 CFS. Because of the importance of Ash Street in providing an east-west transportation route (particularly during flooding events on the Mississippi River), the Ash Street Culvert should be sized for a 100-year runoff event. Preliminary evaluation of this culvert has determined that replacing the 78-inch pipe culvert with a dual 6.5'Hx8'W box culvert would be required to provide the 100-year capacity. In conjunction with the culvert improvement work, the existing headwall structure should be removed and replaced to provide adequate stability for the roadway embankment. Incidental bank shaping and erosion control work should be completed upstream and downstream of the new culvert.

At Highway 22 (Outfall 15), flood elevations of approximately 557 or greater threatened damage to nearby homes; elevations of approximately 558 or greater pose a risk of inundating the intersection of Franklin Street and Highway 22. The existing culvert can pass a about 15-year flood event generated by the Cedar Creek watershed without presenting risk to homes, if the Mississippi is between normal level up to an elevation of about 554. This capacity becomes compromised at river levels higher than 554, dropping to zero when the Mississippi is at the home-damage-risk elevation of 557. To provide a 50-year flood protection level on Cedar Creek (*the largest flood event that is*

practical to address, due to limitations from Mississippi River flooding – see section G, below) when river levels are below 554, an additional 6' diameter RCP culvert should be installed parallel with the existing box culvert.

F. Pump Station – Cedar Creek

At Cedar Creek, a pump station will be required if a gate closure is constructed on Outfall 15 (the box culvert under Highway 22), which will prevent the creek from discharging to the Mississippi River when closed. Ideally, flood elevations near the intersection of Highway 22 and Franklin Street would be kept to elevations of 557 or less, which appears to avoid damage to nearby homes.

The pumping station would be designed to keep flood elevations below 557 in the event that the gate closure on Outfall 15 is shut. Construction of a pump station would require a storm water holding pond upstream of the culvert at Highway 22. This location appears to have enough space to construct a holding pond with approximately 16 acre-feet of storage.

Considering that the installation of a gate on the culvert provides 50-year (i.e. a 2% annual chance) protection from Mississippi River flooding, it is reasonable to provide similar protection from flooding on Cedar Creek. Assuming that flooding on the Mississippi River and on Cedar Creek are caused by independent events, and considering that the gate would be closed only when Mississippi levels reach the 10-year flood level or higher, the likelihood of a 5-year flood on Cedar Creek occurring at the same time is also approximately a 2% annual chance. Therefore, providing pumping for the 5-year flood event would provide a similar level of protection as installing the culvert gate. Taking this available storage into account, and assuming that the 24-hour storm event analyzed in Section III.D of this report is the critical duration event for the watershed, the required pumping capacity of this station for a 5-year storm event is approximately 87,500 gallons per minute (gpm). *The annual-percent-chance of flooding for coincident events stated herein are a simple independent-event estimate. Prior to undertaking full design, a multiple discrete event analysis or a coincident frequency analysis following ACOE Engineering Manual 1110-2-1413 should be conducted in order to more precisely establish the level of risk reduction that would be associated with the infrastructure described above.*

In addition to pumps, instrumentation and controls necessary to control pump operations, and a backup generator would be required. A detailed operation plan for the pump station and flood gate would need to be prepared and an operator trained in their use.

V. FLOOD MITIGATION PLAN

The following mitigation actions are recommended to be constructed in the order given (i.e. Section A is highest priority):

A. Storm Outfall Backflow Prevention – Mississippi River Outfalls

The storm inlets and manholes were studied to determine which outfalls should have closures installed on them so that the city is better protected from flooding to elevation 560 – the point at which river levels appear to either overtop or seep through the railroad embankment. The construction of four (4) storm sewer closure structures in vaults on the landward side of the railroad at Outfalls 60, 70, 80, and 90 would provide protection to approximately the 50-year Mississippi River level for the lower areas of the City south of 2nd Street at Main Street and Washington Street, and would give the City the ability to maintain through traffic on Highway 22 from Main Street to points east. Storm sewer outfalls for which it was determined would benefit from a closure are shown on Exhibit 4 in Appendix A.

These storm sewer outfalls should be outfitted with a vault structure on the line between the railroad and Highway 22, within which would be a wall separating the inlet side of the culvert from the outlet side. Within this structure, BOTH types of backflow prevention can be accommodated – a flap gate would be placed on the outlet side of this wall to automatically control backflow, and a slide gate would be placed on the inlet side to provide a manual control for backflow in the case the flap gate does not function properly. Additionally, a dry hydrant fixture should be constructed on the inlet side of the vault, so that stormwater can be pumped out with a portable pump. The cost estimates to furnish and install the recommended closure are shown in **Table 7**.

Table 7 - Check Valve Cost Estimate

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS	UNIT PRICE	TOTAL PRICE
1.	Backflow Prevention Vault Structure	4	EA	$ 25,000.00	$ 100,000.00
2.	Flap Gate	4	EA	$ 2,500.00	$ 10,000.00
3.	Slide Gate	4	EA	$ 4,500.00	$ 18,000.00
4.	Portable Pump Station	4	EA	$ 90,000.00	$ 360,000.00
5.	Mobilization/Incidentals/Contingency (25%)	1		$ 122,000.00	$ 122,000.00
6.	Design Engineering (10%)	1		$ 48,800.00	$ 48,800.00
7.	Construction Engineering (5%)	1		$ 24,400.00	$ 24,400.00
	TOTAL: Items #1-#7				**$ 683,200.00**

Each installation would require some preparation work including digging out and cleaning of the pipes and outfall locations. Additionally, during the final design stage, the storm sewer system should be studied in further detail to determine whether

reconfiguring, consolidating, or resizing components of the storm sewer system could further reduce the flooding risk.

Under current conditions, the areas of the City south of 2nd Street at Main Street and Washington Street have a risk of flooding during approximately the 20-year flood; the adjacent State Highway 22 has a risk of flooding during approximately the 35-year flood. The proposed improvements would lessen the flooding risk to the highway and properties to an approximately 50-year flood.

B. Culvert Improvements – Cedar Creek at Ash Street

Ash Street is one of two east-west thru roadways that provide connectivity across the community. Because of its importance, it is vital that the Ash Street culvert be sized to handle a 100-year runoff event. It is recommended that a dual 6.5'Hx8'W concrete box culvert be constructed, and the roadway be widened to accommodate traffic as a detour when Highway 22 is closed. Construction of the new Ash Street culvert will require removal and replacement of the existing culvert. Additionally, some incidental grading of the stream channel will be required upstream and downstream of the culvert.

The locations of these improvements are shown on Exhibit 5 of Appendix A. The cost to replace the culvert at Ash Street is shown in **Table 8**

Table 8 - Ash Street Culvert Cost Estimate

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS	UNIT PRICE	TOTAL PRICE
1.	Property Acquisition / Easement	1	AC	$ 15,000.00	$ 15,000.00
2.	Channel Clearing and Grubbing	400	LF	$ 30.00	$ 12,000.00
3.	Culvert Removal	1	LS	$ 6,000.00	$ 6,000.00
4.	Dual-Cell Box Culvert (6.5Hx8' W each cell)	60	LF	$ 1,200.00	$ 72,000.00
5.	Dual-Cell Box Culvert Endwall	2	EA	$ 15,000.00	$ 30,000.00
6.	Roadway Reconstruct (4" HMA on CABC)	350	SY	$ 50.00	$ 17,500.00
7.	Rip Rap (Large)	250	TON	$ 45.00	$ 11,250.00
8.	Salvage & Reinstall Guardrail	30	LF	$ 30.00	$ 900.00
9.	Install New Guardrail	30	LF	$ 50.00	$ 1,500.00
10.	Mobilization / Incidentals (15%)	1		$ 24,900.00	$ 24,900.00
11.	Design Engineering (10%)	1		$ 16,600.00	$ 16,600.00
12.	Construction Engineering (10%)	1		$ 16,600.00	$ 16,600.00
	TOTAL: Items #1-#12				**$ 197,250.00**

Under current conditions, the Ash Street culvert has an overtopping risk during approximately the 5-year flood. The proposed improvements would lessen the flooding risk to the roadway to an approximately 100-year flood. If these improvements are done

in conjunction with those recommended in Section V.A, above, emergency management access is provided throughout the City in the case of a Mississippi River flood.

C. Culvert Improvements – Cedar Creek at Highway 22

Highway 22 is the second of two east-west thru roadways that provide connectivity across the community. In the vicinity of Highway 22 and Franklin Street, damage to home structures occurs when high volumes of Cedar Creek runoff exceed elevation 557 and encroachment of water onto the highway occurs when high volumes of Cedar Creek runoff exceed elevation 558. Because of its importance to the main thoroughfare and protection of private property, it is vital that the Highway 22 culvert be sized to handle 50-year runoff from the Cedar Creek watershed. *This is the largest flood event that is practical to address, due to limitations from Mississippi River flooding.* It is recommended that a parallel 60-inch RCP culvert be constructed alongside of the existing box culvert. Construction of this culvert will require some incidental grading of the stream channel upstream of the culvert.

The locations of these improvements are shown on Exhibit 5 of Appendix A. The cost to construct an additional culvert at Highway 22 is shown in **Table 9**.

Table 9 – Highway 22 Culvert Cost Estimate

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS	UNIT PRICE	TOTAL PRICE
1.	Bore 60" Dia RCP Culvert	160	LF	$ 1,500.00	$ 240,000.00
2.	60" Dia RCP Culvert Endwall	2	EA	$ 3,000.00	$ 6,000.00
3.	Rip Rap (Large)	25	TON	$ 45.00	$ 1,125.00
4.	Mobilization / Incidentals (15%)	1		$ 37,100.00	$ 37,100.00
5.	Design Engineering (10%)	1		$ 24,700.00	$ 24,700.00
6.	Construction Engineering (10%)	1		$ 24,700.00	$ 24,700.00
	TOTAL: Items #1-#6				**$ 333,625.00**

Under current conditions, the areas of the City along Cedar Creek near Franklin Street and Highway 22 have a risk of flooding during approximately the 15-year flood from Cedar Creek. The proposed improvements would lessen the flooding risk to the highway and properties to an approximately 50-year flood.

D. Pump Station and Closure Structures – Cedar Creek Outfall

To protect the low-lying areas on Cedar Creek when the Mississippi River has flood conditions exceeding the 10-year frequency, but less than the 50-year frequency, a gate closure would be required to be constructed on Outfall 15. Because of the potential for large volumes of runoff from Cedar Creek even during relatively small (high frequency) storms, a pump station would be required to be constructed on Outfall 15 to provide protection from internal drainage on Cedar Creek when the gates on the pipes are closed.

The gate closure would get closed manually during high water levels in the Mississippi River, and the pump station would have automated controls to pump the runoff from Cedar Creek.

In addition to the immediate location of Cedar Creek, there are low-lying areas just to the east of the creek along Hacker, Franklin, and Jefferson Streets that are affected by high Mississippi River levels backing up through the storm sewer system, similar to those discussed in Section V.A, above. The construction of four (4) storm sewer closure structures in vaults on the landward side of the railroad at Outfalls 20, 30, 40, and 50 would supplement the protection provided by the closure on Outfall 15, as these low areas are somewhat interconnected to the creek area. This would result in protection to approximately the 50-year Mississippi River level and would give the City the ability to access the Cedar Creek pump station in cases of emergency.

The locations of these improvements are shown on Exhibit 5 of Appendix A. The estimated cost for the pump station is shown in **Table 10**.

Table 10 - Pump Station / Closure Structures Cost Estimate

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS	UNIT PRICE	TOTAL PRICE
1.	Storm Pumps - 87,500 gpm	2	EA	$ 350,000.00	$ 700,000.00
2.	48" Force Main (Directional Drill)	250	LF	$ 300.00	$ 75,000.00
3.	Instrumentation and Controls	1	LS	$ 150,000.00	$ 150,000.00
4.	Backup Power Generator	1	LS	$ 45,000.00	$ 45,000.00
5.	Pump Intake Structure / Building	1	LS	$ 350,000.00	$ 350,000.00
6.	Backflow Prevention Vault Structure	4	EA	$ 25,000.00	$ 100,000.00
7.	Flap Gate	4	EA	$ 2,500.00	$ 10,000.00
8.	Slide Gate	4	EA	$ 4,500.00	$ 18,000.00
9.	Portable Pump Station	4	EA	$ 90,000.00	$ 360,000.00
10.	Backflow Prevention Vault Structure (60" pipe)	1	EA	$ 40,000.00	$ 40,000.00
11.	Flap Gate (60" dia.)	1	EA	$ 5,000.00	$ 5,000.00
12.	Slide Gate (60" dia.)	1	EA	$ 9,000.00	$ 9,000.00
13.	Slide Gate (Box Culvert)	1	EA	$ 200,000.00	$ 200,000.00
14.	Mobilization/Incidentals (15%)	1		$ 309,300.00	$ 309,300.00
15.	Design Engineering (10%)	1		$ 206,200.00	$ 206,200.00
16.	Construction Engineering (10%)	1		$ 206,200.00	$ 206,200.00
	TOTAL: Items #1-#16				**$ 2,783,700.00**

Under current conditions, the areas of the City along Cedar Creek near Franklin Street and Highway 22 have a risk of flooding during approximately the 15-year flood from the Mississippi River. The proposed improvements would lessen the flooding risk to the highway and properties to an approximately 50-year flood.

E. Outfall Extensions – Mississippi River

Outfalls 100 and 150 should be extended to provide accessibility for maintenance and inspection. We recommend that these culverts get extended to the river to provide better accessibility for maintenance, better accessibility for inspection, less potential for erosion, and improved safety. The estimated cost to construct the recommended culvert extensions are shown on **Table 11**.

Table 11 - Culvert Extension Cost Estimate

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS	UNIT PRICE	TOTAL PRICE
1.	Mobilization	1	LS	$ 5,000.00	$ 5,000.00
2.	Erosion Control	1	LS	$ 2,000.00	$ 2,000.00
3.	36" x 27" Box Culv Extention (Outfall 100)	145	LF	$ 175.00	$ 25,375.00
4.	36" x 27" Box Culv Extention (Outfall 150)	160	LF	$ 175.00	$ 28,000.00
5.	Rip Rap	100	TON	$ 45.00	$ 4,500.00
6.	Installation (Labor)	1	LS	$ 15,000.00	$ 15,000.00
7.	Design Engineering (10%)	1		$ 7,987.50	$ 7,987.50
8.	Construction Engineering (10%)	1		$ 7,987.50	$ 7,987.50
	TOTAL: Items #1-#8				**$ 95,850.00**

While this recommendation improves the outfalls in the manner noted above, it does not substantially reduce the flood risk to roads or property.

VI. POST MITIGATION DAMAGES

It is noted that the storm sewer closure structures will not protect the community from the 1% annual flood (100-year) event, as the railroad embankment will be subject to seeping and/or overtopping. During high water events on the Mississippi River (yet below the elevation where Mississippi River flood waters seep through the railroad track embankment into the City), internal storm drainage will be required to be pumped to the river, as the high water will prevent drainage from within the city through the check valves.

The final paragraph in each of the subsections in Section V., above, states an estimate of both the current level of flood risk and the level of flood risk after the mitigation strategy is employed.

Following implementation of all mitigation strategies discussed in this report, flooding will occur in the community under three circumstances:

1. Flooding events on the Mississippi River in excess of the 50-year recurrence interval
2. Flooding events on Cedar Creek in excess of the 50-year recurrence interval
3. Flooding events on the Mississippi River exceeding the 10-year frequency, but less than the 50-year frequency (gate would be closed) combined with simultaneous flooding on Cedar Creek in excess of the 5-year event.

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VII. RESIDUAL RISK

The storm sewer check valves that are recommended would always present a risk of clogging with debris, and cause backup in the storm sewers. This would not be a major concern, as city staff would notice the backup and clear the check valve.

After construction of a pump station, there is a risk of equipment or controls failure. Equipment failure would primarily be related to mechanical failure in the pumps. These failures are fairly common during the startup of the pump station, but would be resolved before the station is online. Throughout the life of the pump station there would continue to be a risk a failure, but can be minimized by routine inspection and maintenance.

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VIII. ENGINEERING PRACTICES

This report was completed by referencing the Scott County Flood Insurance Study (FIS) and the US Army Corps of Engineers (USACE) Mississippi River data. Storm water runoff calculations were completed utilizing Urban Hydrology for Small Watersheds (TR-55) method, developed by the US Department of Agriculture.

IX. PROJECT FINANCING

There are a number of methods by which capital improvement projects may be financed. Each method has its own particular advantages and disadvantages. It is important that the selected method of financing for a given capital improvement project be consistent with current municipal fiscal policies, as well as with the current financing capability of the municipality.

A. FEMA Disaster Recovery

In conjunction with our evaluation, MSA contacted the Iowa Homeland Security and Emergency Management Division to determine the potential for covering the costs associated with the closure devices. In conversation with Mathew Nobel of this department, he indicated there is a potential for funding if these projects are included in the Multi-Jurisdictional Mitigation Plan for Scott County, which is currently in development. It is recommended that the City include the proposed projects within the County mitigation plan if possible. Additionally, future funding through other FEMA disaster recovery programs such as the Hazard Mitigation Grant Program are possible.

B. General Obligation Bonds

General Obligation Bonds are payable from all general municipal revenues and are considered an obligation on the total assessed valuation of the municipality. The issuance of such bonds must be authorized by the elected governing body of the municipality concerned, and the amount of outstanding bonded indebtedness is limited by Illinois state statute. General Obligation Bonds are generally issued for street improvements, sanitary sewerage, and stormwater drainage system improvements, and public building and related facility improvements. An advantage of the General Obligation Bond is that the improvements may be constructed and then used during the time they are being paid for. The principal disadvantage of the General Obligation Bond is the interest cost which is added to the amount to be paid back to the bond purchasers.

C. Bank Loans

Bank loans may be made directly to a municipality by a local bank. The major advantage of this financing method is that a municipality may be able to receive a more favorable interest rate from a local banker. The only limit to this type of borrowing is the municipality's ability to pay the interest and repay the principal.

D. Special Levies

Special levies are also a form of "pay-as-you-go" method of financing capital improvements. Special levies are typically used to secure monies for seldom made capital improvement expenditures. Special levies tend to be used in financing the

purchase of major pieces of public works department equipment and firefighting equipment.

E. Special Assessments

Special assessments provide another method by which public improvements may be financed. The special assessments method of financing can be particularly appropriate in instances where public improvements will benefit a limited area of a community. When improvements are financed by the special assessment method, the owner of the benefited property pays the "private benefit" portion attendant to the improvement. The municipality pays the "public benefit" portion attendant to the improvement.

F. Stormwater Utility

A stormwater utility is a method to generate income based on a fee structure based on demand placed on a community's stormwater facilities by a utility customer. Typically, stormwater utility fees are based on a property's potential for stormwater runoff – as this runoff rate (and/or volume) affects the size of infrastructure required to collect, convey, and manage stormwater. In this case, however, proposed improvements are, in part, planned to prevent flooding damage from stormwater generated outside the City's boundary (Mississippi River flood waters). It could be argued, however, that the storm sewer exists because of the need to convey runoff from developed portions of the City and therefore that required modifications to the storm sewer to offset the 'side effects' of the existence of the storm sewer can be prorated back to property owners.

It is crudely estimated that a stormwater utilty for the City of Buffalo could generate approximately $70,000 annually (assuming an 'equivalent residential unit' rate structure and a $50/ERU annual fee). While this is not an insubstantial level of revenue, it would take many years to fund a project of the magnitude suggested by this evaluation.

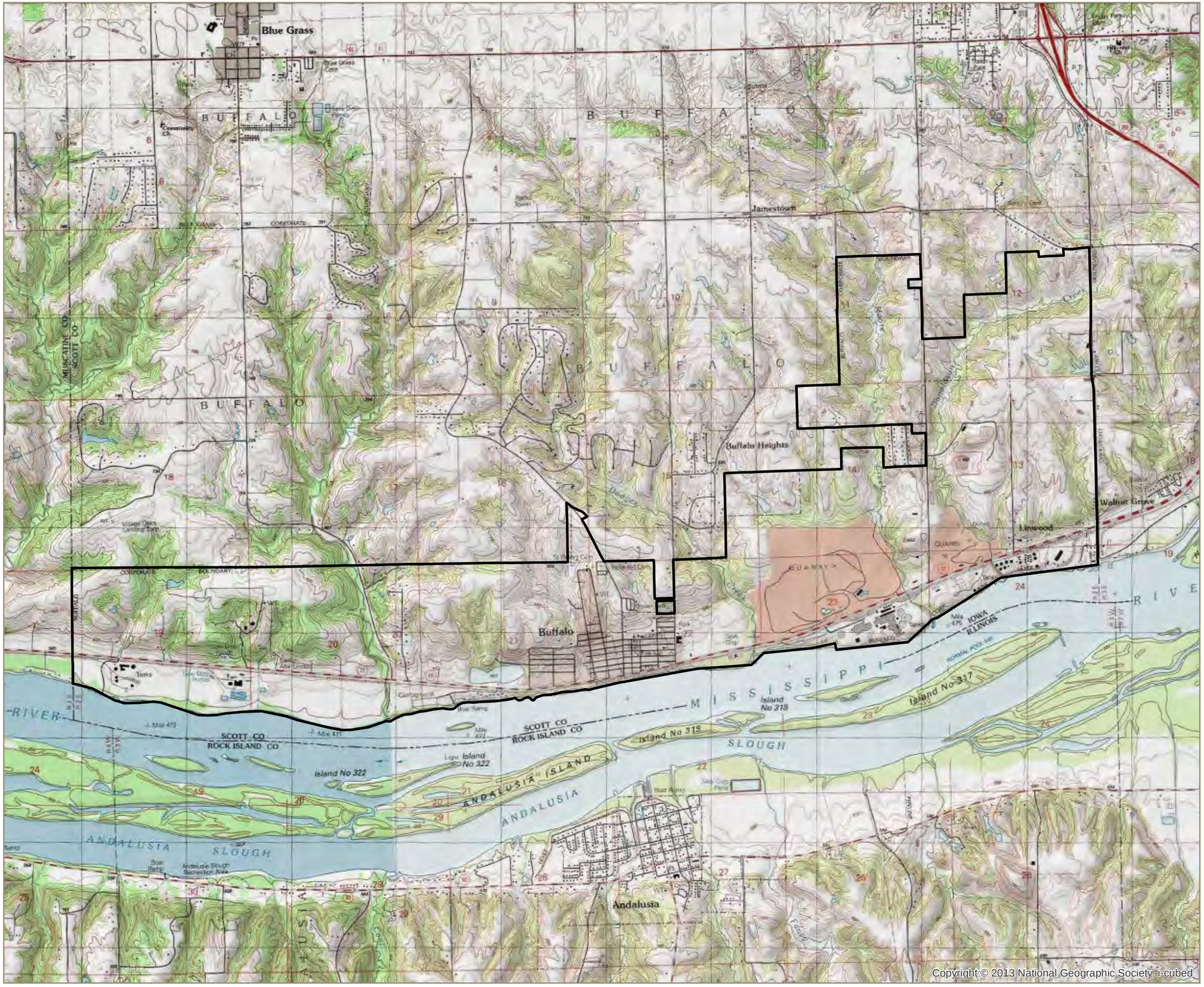
APPENDIX A

Exhibit 1 – Buffalo USGS Map
Exhibit 2 – Buffalo Storm Water System Map
Exhibit 3 – DFIRM Flood Map
Exhibit 4 – Flood Mitigation Plan – Proposed Outfall Check Gates
Exhibit 5 – Flood Mitigation Plan – Proposed Cedar Creek Improvements

LOCATION MAP

EXHIBIT 1

City of Buffalo



DATA SOURCES:
MUNICIPAL LIMITS PROVIDED BY THE US CENSUS (2013).
TOPO DERIVED FROM USGS QUADRANGLES.

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CITY OF BUFFALO
SCOTT COUNTY, IOWA

MSA PROFESSIONAL SERVICES

N

0 750 1,500 3,000 Feet

STORMWATER SYSTEM

EXHIBIT 2

- Stormline
- Intake
- Manhole
- Outfall (#)
- Topographical Bowl

Contour

- Index (10 ft)
- Intermediate

DATA SOURCES:
STORMWATER INFRSTRUCTURE PROVIDED BY THE CITY.
ROAD NAMES PROVIDED BY THE IOWA DNR.
AERIAL IMAGERY PROVIDED BY ESRI.

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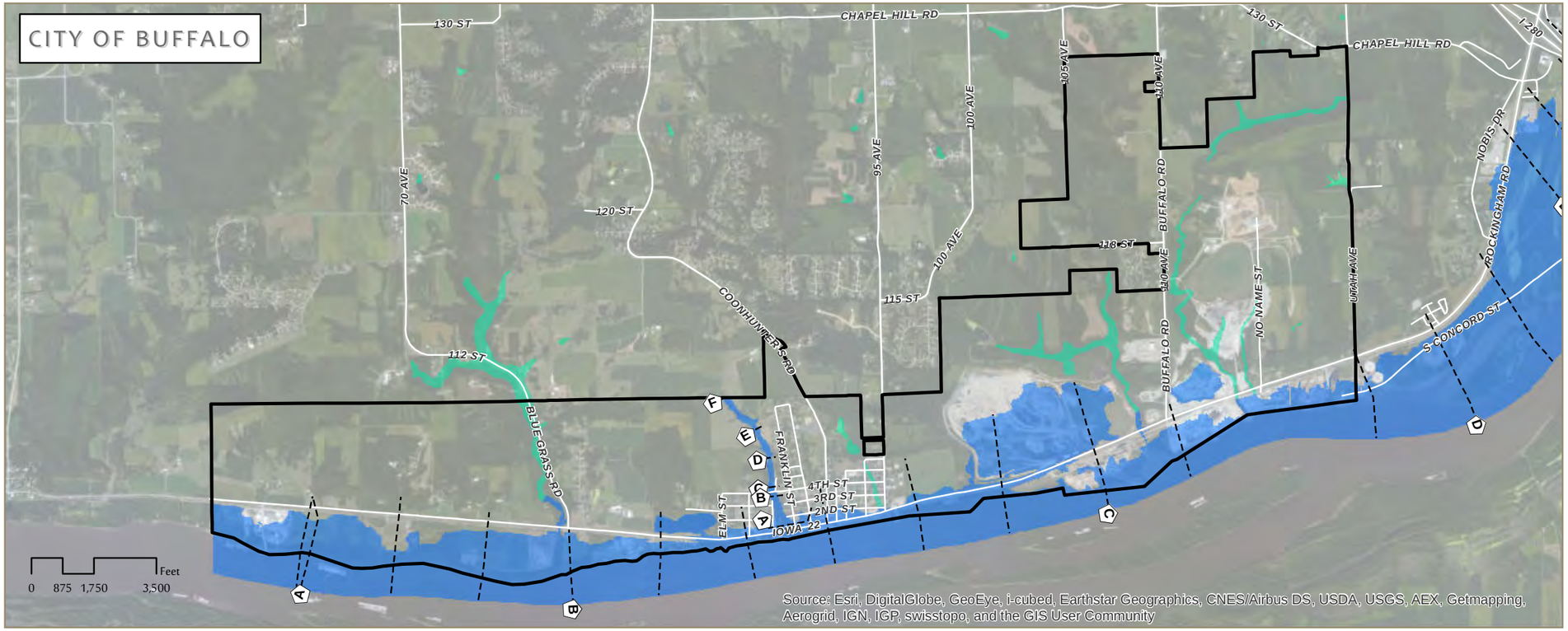
CITY OF BUFFALO
SCOTT COUNTY, IOWA

MSA PROFESSIONAL SERVICES

N

0 100 200 400 Feet

2011 DFIRM FLOOD MAP



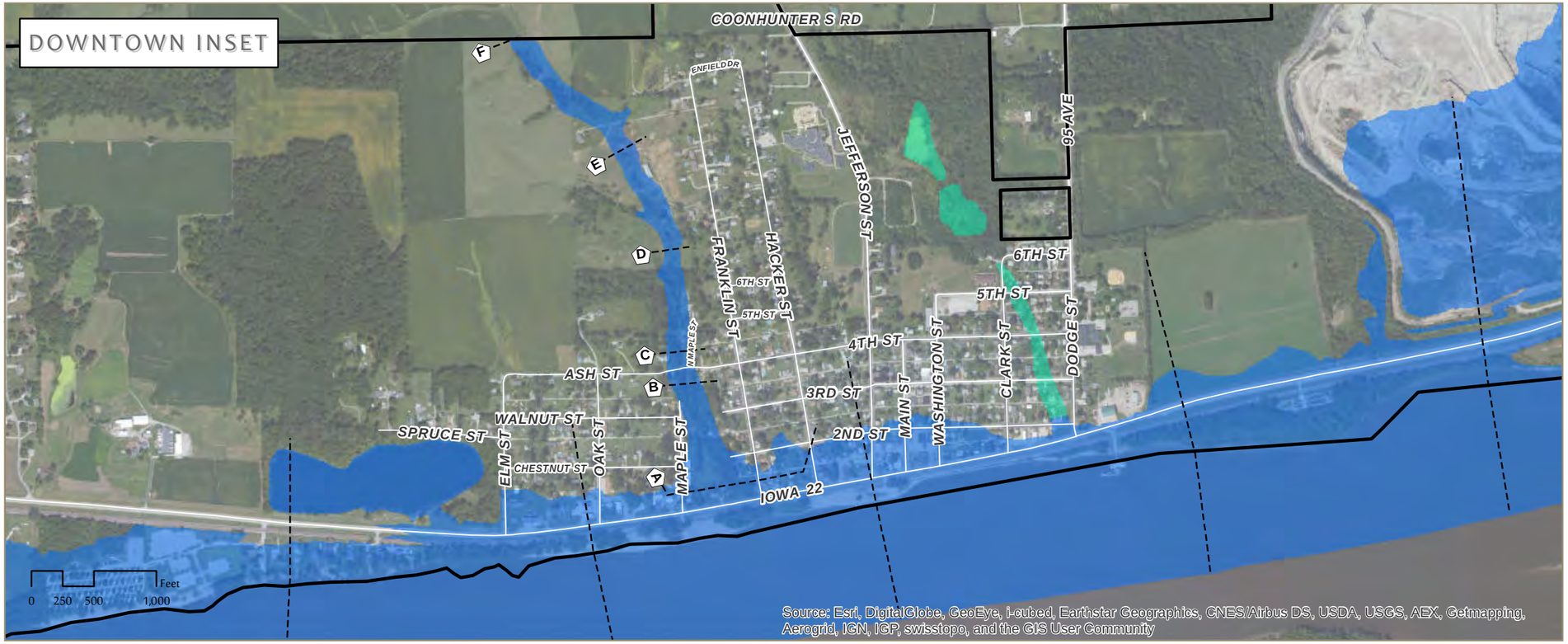


EXHIBIT 3

City of Buffalo

Flood Insurance Study Cross Section

FEMA Flood Zones

A: 100-yr Floodplain

AE: 100-yr Floodplain

Zone A
Areas subject to inundation by the 1-percent-annual-chance flood event generally determined using approximate methodologies.

Zone AE
Areas subject to inundation by the 1-percent-annual-chance flood event determined by detailed methods.

DATA SOURCES:
MUNICIPAL LIMITS PROVIDED BY THE US CENSUS (2013).
ROAD NAMES PROVIDED BY THE IOWA DNR.
FLOOD ZONES AND CROSS SECTIONS PROVIDED BY FEMA (2011).
AERIAL PROVIDED BY ESRI.

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CITY OF BUFFALO
SCOTT COUNTY, IOWA

MSA PROFESSIONAL SERVICES

PROPOSED GATE INSTALLATION

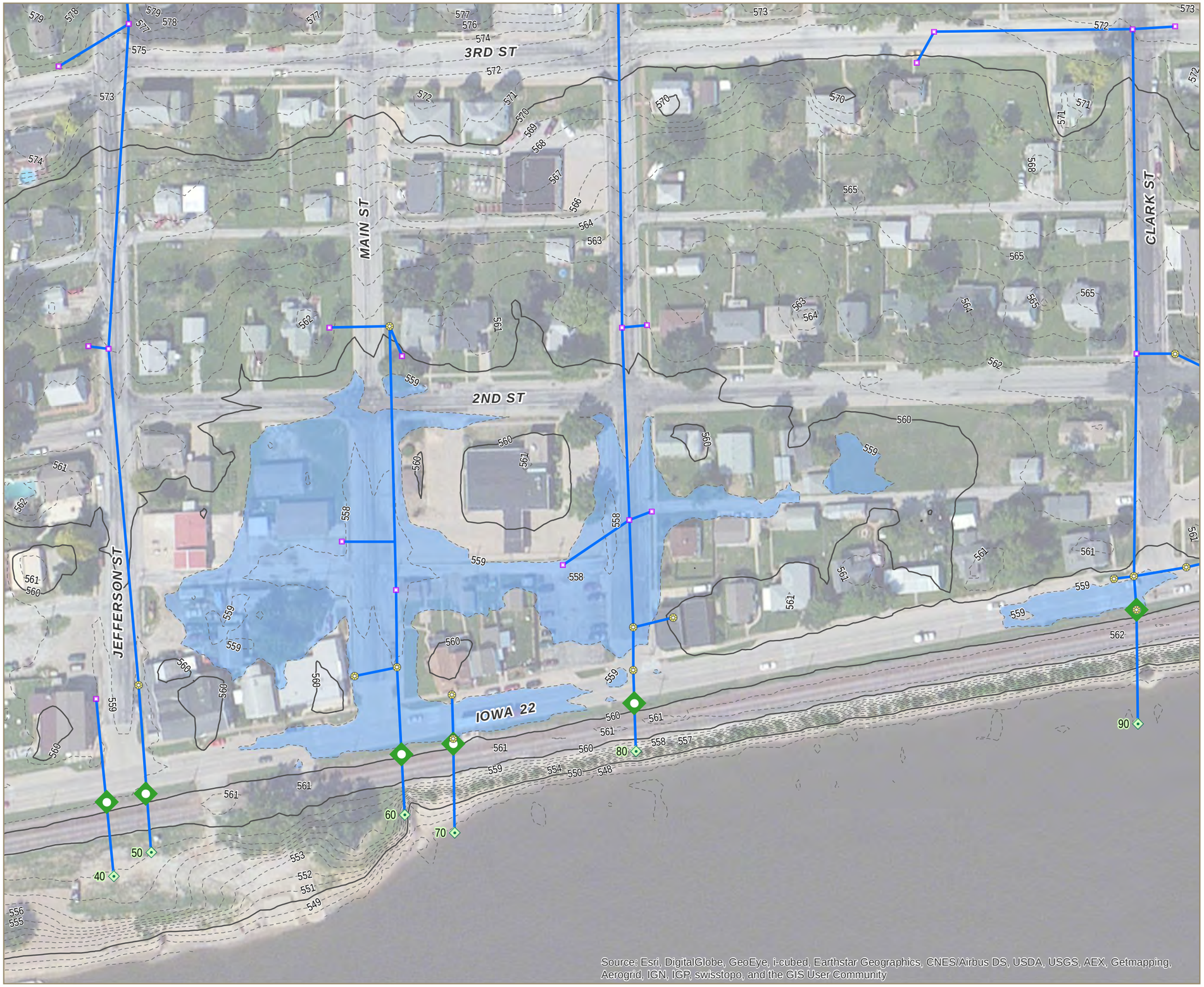

EXHIBIT 4

- Stormline
- Intake
- Manhole
- Outfall (#)
- Proposed Gate Installation
- Reduced flooding benefit area

DATA SOURCES:
STORMWATER INFRSTRUCTURE PROVIDED BY THE CITY.
ROAD NAMES PROVIDED BY THE IOWA DNR.
AERIAL IMAGERY PROVIDED BY ESRI.

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CITY OF BUFFALO
SCOTT COUNTY, IOWA

MSA PROFESSIONAL SERVICES

N

0 25 50 100 Feet

CEDAR CREEK FLOOD IMPROVEMENTS

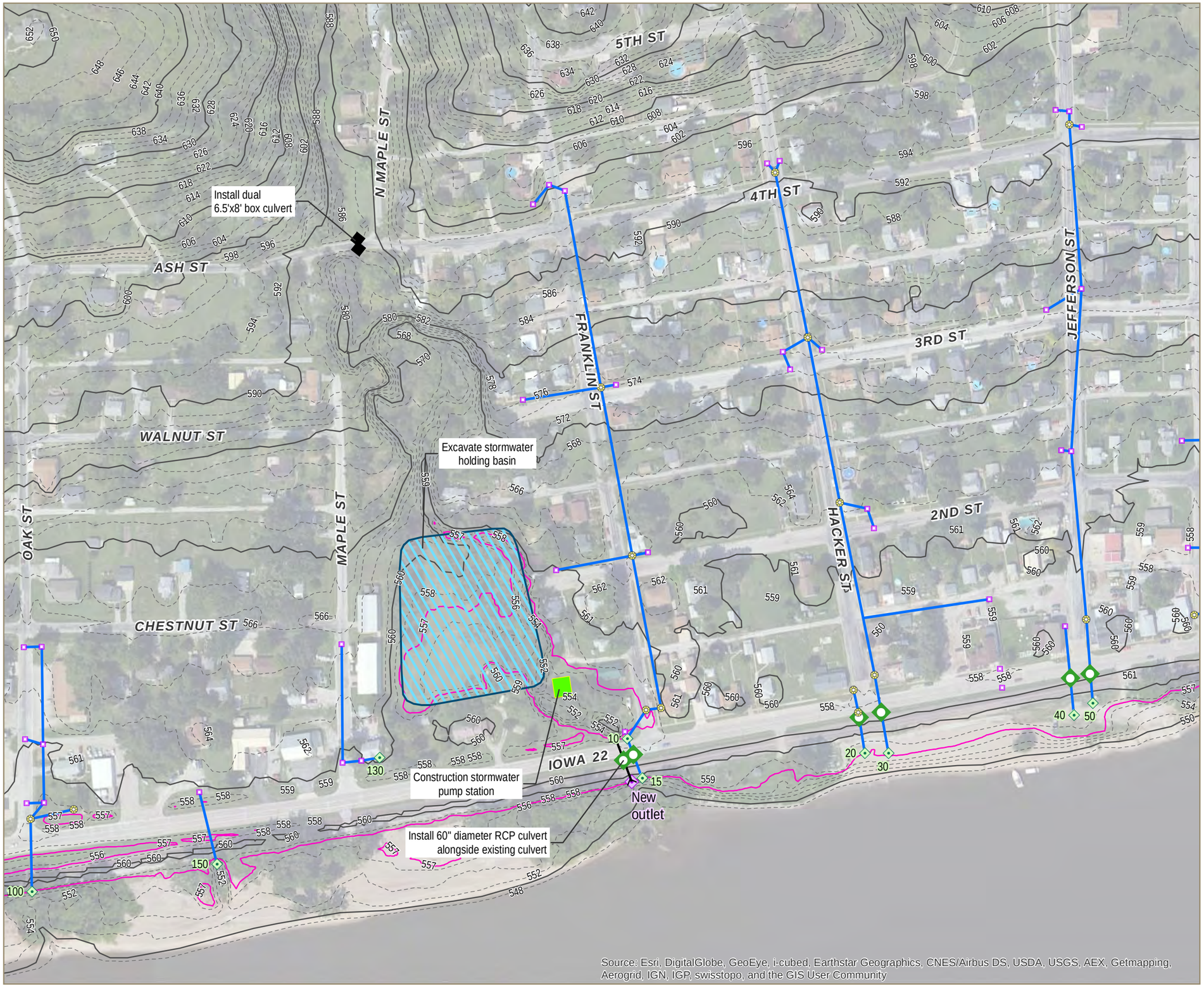

EXHIBIT 5

- Stormline
- Intake
- Manhole
- Outfall (#)
- Proposed New Outfall
- Proposed Gate Installation
- Proposed Culvert
- Proposed Dual Box Culvert
- Proposed stormwater pump station
- Proposed stormwater holding basin

Contour

- Index (10 ft)
- Intermediate
- 557' contour

DATA SOURCES:
STORMWATER INFRSTRUCTURE PROVIDED BY THE CITY.
ROAD NAMES PROVIDED BY THE IOWA DNR.
AERIAL IMAGERY PROVIDED BY ESRI.

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CITY OF BUFFALO
SCOTT COUNTY, IOWA

MSA PROFESSIONAL SERVICES

N

Feet
0 25 50 100

APPENDIX B

Photographs

Buffalo Storm Water Outfall Evaluation

Outfall 150

Outlet 15 (2)

Outlet 15

Outlet 50

Buffalo Storm Water Outfall Evaluation

Outlet 60

Outlet 90

Outlet 100

Outlet 115 (2)

Buffalo Storm Water Outfall Evaluation

Outlet 115 (3)

Outlet 115

Outlet 120

Outlet 140

Buffalo Storm Water Outfall Evaluation

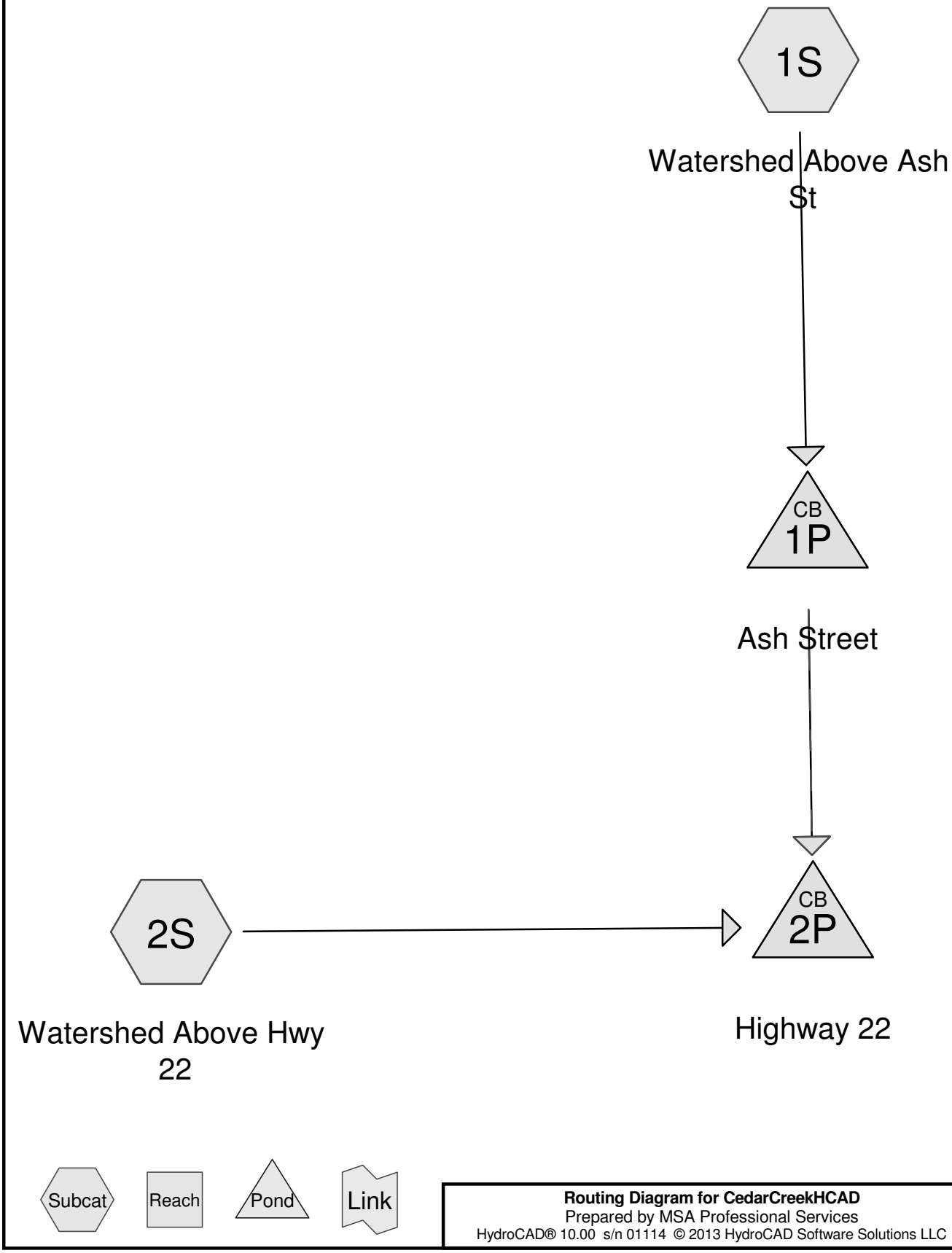
Outlet 150

Outlet 100

Outlet 70

APPENDIX C

Cedar Creek Hydrologic Calculations



Routing Diagram for CedarCreekHCAD
Prepared by MSA Professional Services
HydroCAD® 10.00 s/n 01114 © 2013 HydroCAD Software Solutions LLC

Summary for Subcatchment 1S: Watershed Above Ash St

Runoff = 1,071.47 cfs @ 12.73 hrs, Volume= 183.157 af, Depth= 4.91"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YEAR Rainfall=7.23"

Area (ac)	CN	Description
0.443	72	Small grain, C + CR, Good, HSG B
381.877	80	Small grain, C + CR, Good, HSG C
24.990	80	Small grain, C + CR, Good, HSG C
1.486	83	Small grain, C + CR, Good, HSG D
37.660	83	1/4 acre lots, 38% imp, HSG C
0.780	83	1/4 acre lots, 38% imp, HSG C
0.644	98	Water Surface, 0% imp, HSG D
0.014	98	Water Surface, 0% imp, HSG D
447.894	80	Weighted Average
433.287		96.74% Pervious Area
14.607		3.26% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
41.5	300	0.0067	0.12		**Sheet Flow,** Cultivated: Residue>20% n= 0.170 P2= 3.03"
4.0	264	0.0150	1.10		**Shallow Concentrated Flow,** Cultivated Straight Rows Kv= 9.0 fps
5.4	614	0.0450	1.91		**Shallow Concentrated Flow,** Cultivated Straight Rows Kv= 9.0 fps
3.4	1,970	0.0290	9.53	714.42	**Trap/Vee/Rect Channel Flow,** Bot.W=10.00' D=3.00' Z= 5.0 '/' Top.W=40.00' n= 0.040
5.3	2,062	0.0136	6.52	489.24	**Trap/Vee/Rect Channel Flow,** Bot.W=10.00' D=3.00' Z= 5.0 '/' Top.W=40.00' n= 0.040
3.5	1,225	0.0106	5.76	431.92	**Trap/Vee/Rect Channel Flow,** Bot.W=10.00' D=3.00' Z= 5.0 '/' Top.W=40.00' n= 0.040
2.0	922	0.0184	7.59	569.06	**Trap/Vee/Rect Channel Flow,** Bot.W=10.00' D=3.00' Z= 5.0 '/' Top.W=40.00' n= 0.040
2.8	962	0.0104	5.70	427.83	**Trap/Vee/Rect Channel Flow,** Bot.W=10.00' D=3.00' Z= 5.0 '/' Top.W=40.00' n= 0.040
67.9	8,319	Total			

Summary for Subcatchment 2S: Watershed Above Hwy 22

Runoff = 211.20 cfs @ 12.17 hrs, Volume= 18.011 af, Depth= 4.80"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YEAR Rainfall=7.23"

Area (ac)	CN	Description
22.560	75	1/4 acre lots, 38% imp, HSG B
20.471	83	1/4 acre lots, 38% imp, HSG C
2.041	83	1/4 acre lots, 38% imp, HSG C
45.072	79	Weighted Average
27.945		62.00% Pervious Area
17.127		38.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.0	185	0.0650	0.21		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.03"
0.3	68	0.0290	3.46		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.7	166	0.0420	4.16		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
1.3	388	0.0620	5.05		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.7	418	0.0167	2.62		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
4.6	1,260	0.0070	4.60	110.51	**Trap/Vee/Rect Channel Flow,** Bot.W=4.00' D=2.00' Z= 4.0 '/' Top.W=20.00' n= 0.030
24.6	2,485	Total			

Summary for Pond 1P: Ash Street

Inflow Area = 447.894 ac, 3.26% Impervious, Inflow Depth = 4.91" for 100-YEAR event
Inflow = 1,071.47 cfs @ 12.73 hrs, Volume= 183.157 af
Outflow = 1,071.47 cfs @ 12.73 hrs, Volume= 183.157 af, Atten= 0%, Lag= 0.0 min
Primary = 385.79 cfs @ 12.73 hrs, Volume= 134.003 af
Secondary = 685.67 cfs @ 12.73 hrs, Volume= 49.153 af

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 590.03' @ 12.73 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	580.70'	**78.0" Round RCP_Round 78"** L= 60.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 580.70' / 580.10' S= 0.0100 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 33.18 sf
#2	Secondary	588.50'	**Asymmetrical Weir, C= 3.10** Offset (feet) -89.00 -70.00 0.00 68.00 102.00 Height (feet) 1.50 0.50 0.00 0.50 1.50

Primary OutFlow Max=385.63 cfs @ 12.73 hrs HW=590.02' (Free Discharge)
└─**1=RCP_Round 78"** (Barrel Controls 385.63 cfs @ 11.62 fps)

Secondary OutFlow Max=685.23 cfs @ 12.73 hrs HW=590.02' (Free Discharge)
└─**2=Asymmetrical Weir** (Weir Controls 685.23 cfs @ 2.64 fps)

Summary for Pond 2P: Highway 22

Inflow Area = 492.966 ac, 6.44% Impervious, Inflow Depth = 4.90" for 100-YEAR event
Inflow = 1,116.35 cfs @ 12.69 hrs, Volume= 201.168 af
Outflow = 1,116.35 cfs @ 12.69 hrs, Volume= 201.168 af, Atten= 0%, Lag= 0.0 min
Primary = 908.99 cfs @ 12.69 hrs, Volume= 193.737 af
Secondary = 207.36 cfs @ 12.69 hrs, Volume= 7.431 af

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 560.30' @ 12.69 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	545.00'	**72.0" W x 126.0" H Box Box Culvert** L= 160.0' Box, 30-75° wingwalls, rounded crown, Ke= 0.200 Inlet / Outlet Invert= 545.00' / 545.00' S= 0.0000 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 63.00 sf
#2	Secondary	560.00'	**500.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=908.95 cfs @ 12.69 hrs HW=560.30' (Free Discharge)
└─**1=Box Culvert** (Barrel Controls 908.95 cfs @ 14.43 fps)

Secondary OutFlow Max=206.91 cfs @ 12.69 hrs HW=560.30' (Free Discharge)
└─**2=Broad-Crested Rectangular Weir** (Weir Controls 206.91 cfs @ 1.38 fps)

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Watershed Above Ash Runoff Area=447.894 ac 3.26% Impervious Runoff Depth=2.43"
Flow Length=8,319' Tc=67.9 min CN=80 Runoff=528.01 cfs 90.605 af

Subcatchment 2S: Watershed Above Hwy Runoff Area=45.072 ac 38.00% Impervious Runoff Depth=2.34"
Flow Length=2,485' Tc=24.6 min CN=79 Runoff=103.30 cfs 8.800 af

Pond 1P: Ash Street Peak Elev=589.30' Inflow=528.01 cfs 90.605 af
Primary=346.06 cfs 82.211 af Secondary=181.95 cfs 8.394 af Outflow=528.01 cfs 90.605 af

Pond 2P: Highway 22 Peak Elev=556.01' Inflow=550.44 cfs 99.405 af
Primary=550.44 cfs 99.405 af Secondary=0.00 cfs 0.000 af Outflow=550.44 cfs 99.405 af

Total Runoff Area = 492.966 ac Runoff Volume = 99.405 af Average Runoff Depth = 2.42"
93.56% Pervious = 461.231 ac 6.44% Impervious = 31.735 ac

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Watershed Above Ash Runoff Area=447.894 ac 3.26% Impervious Runoff Depth=4.08"
Flow Length=8,319' Tc=67.9 min CN=80 Runoff=892.21 cfs 152.295 af

Subcatchment 2S: Watershed Above Hwy Runoff Area=45.072 ac 38.00% Impervious Runoff Depth=3.98"
Flow Length=2,485' Tc=24.6 min CN=79 Runoff=175.34 cfs 14.933 af

Pond 1P: Ash Street Peak Elev=589.82' Inflow=892.21 cfs 152.295 af
Primary=374.09 cfs 117.985 af Secondary=518.12 cfs 34.310 af Outflow=892.21 cfs 152.295 af

Pond 2P: Highway 22 Peak Elev=560.09' Inflow=929.61 cfs 167.228 af
Primary=888.42 cfs 166.488 af Secondary=41.19 cfs 0.740 af Outflow=929.61 cfs 167.228 af

Total Runoff Area = 492.966 ac Runoff Volume = 167.228 af Average Runoff Depth = 4.07"
93.56% Pervious = 461.231 ac 6.44% Impervious = 31.735 ac

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Watershed Above Ash Runoff Area=447.894 ac 3.26% Impervious Runoff Depth=4.91"
Flow Length=8,319' Tc=67.9 min CN=80 Runoff=1,071.47 cfs 183.157 af

Subcatchment 2S: Watershed Above Hwy Runoff Area=45.072 ac 38.00% Impervious Runoff Depth=4.80"
Flow Length=2,485' Tc=24.6 min CN=79 Runoff=211.20 cfs 18.011 af

Pond 1P: Ash Street Peak Elev=590.03' Inflow=1,071.47 cfs 183.157 af
Primary=385.79 cfs 134.003 af Secondary=685.67 cfs 49.153 af Outflow=1,071.47 cfs 183.157 af

Pond 2P: Highway 22 Peak Elev=560.30' Inflow=1,116.35 cfs 201.168 af
Primary=908.99 cfs 193.737 af Secondary=207.36 cfs 7.431 af Outflow=1,116.35 cfs 201.168 af

Total Runoff Area = 492.966 ac Runoff Volume = 201.168 af Average Runoff Depth = 4.90"
93.56% Pervious = 461.231 ac 6.44% Impervious = 31.735 ac

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Watershed Above Ash Runoff Area=447.894 ac 3.26% Impervious Runoff Depth=7.14"
Flow Length=8,319' Tc=67.9 min CN=80 Runoff=1,545.72 cfs 266.452 af

Subcatchment 2S: Watershed Above Hwy Runoff Area=45.072 ac 38.00% Impervious Runoff Depth=7.01"
Flow Length=2,485' Tc=24.6 min CN=79 Runoff=305.50 cfs 26.340 af

Pond 1P: Ash Street Peak Elev=590.91' Inflow=1,545.72 cfs 266.452 af
Primary=421.41 cfs 174.530 af Secondary=1,124.31 cfs 91.922 af Outflow=1,545.72 cfs 266.452 af

Pond 2P: Highway 22 Peak Elev=560.63' Inflow=1,612.15 cfs 292.792 af
Primary=939.48 cfs 254.910 af Secondary=672.67 cfs 37.882 af Outflow=1,612.15 cfs 292.792 af

Total Runoff Area = 492.966 ac Runoff Volume = 292.792 af Average Runoff Depth = 7.13"
93.56% Pervious = 461.231 ac 6.44% Impervious = 31.735 ac

USGS Iowa StreamStats

Streamstats Ungaged Site Report

Date: Thu Jul 17 2014 08:54:25 Mountain Daylight Time
Site Location: Iowa
NAD27 Latitude: 41.4580 (41 27 29)
NAD27 Longitude: -90.7287 (-90 43 43)
NAD83 Latitude: 41.4580 (41 27 29)
NAD83 Longitude: -90.7289 (-90 43 44)
Drainage Area: 0.67 mi2

Peak Flows Region Grid Basin Characteristics			
10-85 stream slope method in feet per mile.=98			
100% Peak Region 2 2013 5086 (0.67 mi2)			
Parameter	Value	Regression Equation Valid Range	
		Min	Max
Drainage Area (square miles)	0.67	0.08	7783
Des Moines Lobe (percent)	0.000	0	100
Basin Shape Factor (dimensionless)	3.52	0.806	13.94

Peak Flows Region Grid Streamflow Statistics					
Statistic	Flow (ft^3/s)	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
				Minimum	Maximum
PK2	125	47		59.3	264
PK5	278	26		181	427
PK10	430	21		301	614
PK25	666	19		475	933
PK50	825	20		580	1170
PK100	984	22		670	1450
PK200	1290	25		840	1970
PK500	1420	28		881	2290

USGS Iowa StreamStats

Streamstats Ungaged Site Report

Date: Thu Jul 17 2014 08:50:55 Mountain Daylight Time
Site Location: Iowa
NAD27 Latitude: 41.4549 (41 27 18)
NAD27 Longitude: -90.7267 (-90 43 36)
NAD83 Latitude: 41.4549 (41 27 18)
NAD83 Longitude: -90.7268 (-90 43 36)
Drainage Area: 0.71 mi2

Peak Flows Region Grid Basin Characteristics			
10-85 stream slope method in feet per mile.=94.3			
100% Peak Region 2 2013 5086 (0.71 mi2)			
Parameter	Value	Regression Equation Valid Range	
		Min	Max
Drainage Area (square miles)	0.71	0.08	7783
Des Moines Lobe (percent)	0.000	0	100
Basin Shape Factor (dimensionless)	4.84	0.806	13.94

Peak Flows Region Grid Streamflow Statistics					
Statistic	Flow (ft^3/s)	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
				Minimum	Maximum
PK2	130	47		61.4	273
PK5	273	26		178	421
PK10	420	21		294	599
PK25	644	19		459	903
PK50	793	20		557	1130
PK100	943	22		641	1390
PK200	1230	25		802	1890
PK500	1350	28		835	2180

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TRANSPORTATION • MUNICIPAL
DEVELOPMENT • ENVIRONMENTAL

Sheet____ of____
Project Buffalo Comp. by WPM
Date 7/18/14 Ckd. by____
Proj. No. 10370014

Check of flowrate on Cedar Creek using 1987 USGS regression equations for Iowa (AKA "Lara Method"):

Equation for Region 2	Area: Above Hwy 22	Area: Above Ash St	Flow: At Hwy 22	Flow: At Ash St
10 year: $570\ A^{0.55}$	0.77 sq.mi.	0.70 sq.mi.	494	469
25 year: $821\ A^{0.54}$			713	677
50 year: $1020\ A^{0.53}$			888	844
100-year: $1230\ A^{0.53}$			1071	1017

Note: Standard errors of estimate are:

10 year: 34%

25-year: 32%

50 year: 33%

100 year: 36%