Technical Memorandum 3.4

E Avenue NW Watershed Drainage Study
Modeling, Results, and Recommendations

City of Cedar Rapids, Iowa

September 8, 2017
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Appendices

Appendix A Windshield Survey Report
Appendix B Project Concept Development Details and Basis of Cost Estimates
Appendix C Results Maps
Appendix D Inundation Extent Comparison Maps
Appendix E Floodplain Impacts and Implications Memo
This Technical Memorandum (TM) presents the background, methodology, findings, and recommendations for the E Avenue NW Watershed Drainage Study. The objective of this study is to evaluate the existing stormwater infrastructure and make recommendations to reduce stormwater flood damages in the E Avenue NW watershed. The primary tool used for analyzing stormwater infrastructure in the watershed was a one-dimensional (1D) and two-dimensional (2D) hydrologic and hydraulic model. The TM is organized as follows:

1. Executive Summary
2. Objective
3. E Avenue Watershed Background
4. Model Development
5. Model Analysis
6. Project Development
7. Recommendations
8. Conclusions
9. References

1 Executive Summary

1.1 Model Approach

The City of Cedar Rapids, Iowa, (City) is in the process of updating the City’s Stormwater Master Plan. The City is implementing a phased planning approach, evaluating the major watersheds in Cedar Rapids one at a time with the ultimate goal of developing a citywide series of detailed stormwater models. The City is evaluating the E Avenue NW watershed, which primarily drains to Vinton Ditch.

As part of this effort, HDR has developed a basin-scale model of the City’s stormwater conveyance system in the E Avenue NW watershed. This roughly 2,800 acre area includes 14.5 miles of storm sewers, 3.4 miles of open channel, nine stormwater storage ponds, and two outfalls to the Cedar River. The model was developed based on geographic information systems (GIS) data provided by the City, including topography, soil type, land use, pipe network data, and additional survey data. The model calculates rainfall runoff, which is applied to the 1D network. The 1D network, developed from City GIS data and survey, simulates flow in pipes and open channels. A 2D model, developed from Light Detection and Ranging (LiDAR) and land use data, estimates overland flow and conveyance. The model was validated with the June 30, 2014 event and evaluated the 5-year and 100-year 24-hour nested events over the E Avenue watershed. Results from these simulations replicated staff’s recollections and damage reports of past stormwater complaints and damages from the 2014 event.
1.2 Results and Watershed Evaluation

Model results indicated that several locations in the watershed have inadequate storm sewer capacity based on 5-year event rainfall results. Areas experiencing surcharging and overland flow were similar for the 100-year event, with flooding depths and extents being larger in magnitude for the 100-year event.

HDR developed a recommended strategy to meet the City’s stormwater management objectives following the modeling and evaluation. Metro Area Standards (City of Cedar Rapids 2006) for stormwater quantity management include conveying the minor event (5-year) within the pipe network and minimizing the risk of damage outside of the right-of-way for the major event (100-year). Specifically for the E Avenue watershed, the City’s objectives include reducing peak flows in the Vinton Ditch and the Cedar River Flood Control System pump station at the outfall to the Cedar River.

1.3 Recommendations

HDR and the City reviewed and categorized future projects in three priority tiers:

- Tier 1: Projects that have been designated as Tier 1 have wide-spread benefits and impact the performance of the watershed significantly. The City should try to complete these projects before initiating other projects in the watershed.
- Tier 2: Projects that have been designated as Tier 2 have local benefit and are still considered to have high urgency. These projects address local drainage concerns and will reduce flood risk.
- Tier 3: Projects that have a Tier 3 designation are enhancements to the overall watershed stormwater plan. These are seen as low-priority, non-critical projects that should be implemented once Tier 1 and Tier 2 projects have been completed.

These projects, their estimated benefits, and planning-level cost estimates are summarized in Tables 1 through 3. The costs include an estimate of construction, materials, and design required to implement each project including land rights.

Table 1: Recommended E Avenue NW Watershed Tier 1 Projects, Benefits, and Associated Costs

<table>
<thead>
<tr>
<th>Projects</th>
<th>5-year event: 80 fewer residential properties and 2 fewer commercial properties within flooded area. Street flooding in B Ave, C Ave, 11th St., 10th St., 9th St. and 8th St less than 0.1 foot.</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-Connection Along 11th Avenue NW and 10th Avenue NW</td>
<td>100-year event: 8 fewer residential properties within flooded area, Flood depths reduced to less than a foot at C Ave. and 9th St.</td>
<td>$1,440,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Projects</th>
<th>5-year event: 20 fewer residential properties near 1st Avenue SW and 21st Street SW within flooded area. Flood depths reduced to less than 1 foot and half in parking lot east of Johnson Avenue Hy-Vee, half of lot no longer in flooded area. Johnson Ave., 18th St., and Burch Ave are no longer in flooded area.</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>25th Street SW and 1st Avenue SW Detention Basin</td>
<td>100-year event: 12 fewer residential properties near Johnson Avenue Hy-Vee within flooded area, flood depths in east Hy-Vee parking lot reduced to less than 1.0 foot in most locations.</td>
<td>$770,000</td>
</tr>
</tbody>
</table>
### Hagan’s 2nd Detention Basin Expansion

<table>
<thead>
<tr>
<th>Projects</th>
<th>Benefit</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5-year event</strong>: 5 fewer residential properties north and east of Hagan’s 2nd and 20-40 residential properties downstream of Vinton Ditch within flooded area. <strong>100-year event</strong>: 3 fewer residential properties north of Hagan’s 2nd within flooded area, depths over a foot reduced to city ROW in most areas downstream of 13th Street*</td>
<td>$2,490,000</td>
<td></td>
</tr>
</tbody>
</table>

### 29th Street and F Avenue NW Detention Basin

<table>
<thead>
<tr>
<th>Projects</th>
<th>Benefit</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5-year event</strong>: 3 fewer residential properties downstream of the detention basin and 20-40 residential properties downstream of Vinton Ditch within flooded area in flooded area <strong>100-year event</strong>: 3 fewer residential properties downstream of the detention basin in flooded area, depths over a foot reduced to city ROW in most areas downstream of 13th Street*</td>
<td>$6,670,000</td>
<td></td>
</tr>
</tbody>
</table>

### Total Cost

| Total Cost | $11.37 million |

* Benefits downstream of Vinton Ditch are related to peak flow reduction from both Hagan’s 2nd Detention Basin Expansion and the 29th Street and F Ave NW Detention Basin

### Table 2: Recommended E Avenue Watershed Tier 2 Projects, Benefits, and Associated Costs

<table>
<thead>
<tr>
<th>Projects</th>
<th>Benefit</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>12th Avenue and 31st Street SW Detention Basin</strong></td>
<td><strong>5-year event</strong>: 8 fewer residences near 12th Avenue SW and 31st Street SW in flooded area. Reduced flooding on 12th Avenue SW and 31st Street.</td>
<td>$1,330,000</td>
</tr>
<tr>
<td><strong>Permeable Paver Retrofit at Williams Boulevard and 16th Avenue SW</strong></td>
<td><strong>5-year event</strong>: 56% reduction in peak runoff to local storm sewer</td>
<td>$2,530,000</td>
</tr>
<tr>
<td><strong>Ditch Bank Erosion at Westwood Drive and F Avenue NW</strong></td>
<td>Address roadway maintenance issue</td>
<td>$200,000</td>
</tr>
<tr>
<td><strong>Wiley Boulevard Basin</strong></td>
<td><strong>5-year event</strong>: 2 fewer houses in flooded area, offsets increased peak flow from upstream conveyance improvements. Reduced street flooding at Jupiter Avenue NW.</td>
<td>$780,000</td>
</tr>
<tr>
<td><strong>Storage Expansion in Cherokee Park</strong></td>
<td><strong>5-year event</strong>: 2 fewer houses and Walgreens building no longer in flooded area. Approximately 0.3 acre reduction in flooded area at Walgreens parking lot <strong>100-year event</strong>: 2 fewer apartment buildings in flooded area</td>
<td>$1,190,000</td>
</tr>
</tbody>
</table>

| Total Cost | $6.03 million |
Table 3: Recommended E Avenue Watershed Tier 3 Projects, Benefits, and Associated Costs

<table>
<thead>
<tr>
<th>Projects</th>
<th>Benefit</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleveland Elementary Detention Basin</td>
<td>5-year event: 2 fewer houses in flooded area</td>
<td>$190,000</td>
</tr>
<tr>
<td>Conveyance Improvements at Edgewood Road and Johnson Avenue</td>
<td>5-year event: 3 fewer houses in flooded area. 0.4 acres of roadway/ and lots Walgreens no longer in flooded area</td>
<td>$1,290,000</td>
</tr>
<tr>
<td>Conveyance Improvements from West Post Road to Jacolyn Drive</td>
<td>5-year event: 11 fewer houses in flooded area. Street flooding reduced to less than 1.0 foot. 100-year event: Street flooding contained generally within City right-of-way.</td>
<td>$2,760,000</td>
</tr>
<tr>
<td>Conveyance Improvements East of 29th Street between E Avenue and F Avenue</td>
<td>5-year event: 3 fewer houses in flooded area. Reduced street flooding on 24th Street NW.</td>
<td>$410,000</td>
</tr>
<tr>
<td>Embankment at Edgewood Road and H Avenue NW</td>
<td>5-year event: 1 less house in flooded area. No roadway overtopping.</td>
<td>$190,000</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td></td>
<td><strong>$4.84 million</strong></td>
</tr>
</tbody>
</table>

The projects identified in this plan do not mitigate all flood risk or all of the deficiencies within the system. These projects address many of the major stormwater management concerns in the E Avenue watershed, especially the concerns that do not meet current City stormwater criteria. As projects are implemented, the model can be refined to reflect the projects as constructed and continue to refine and improve stormwater management in the E Avenue watershed and throughout the city.

2 Objective

The City is updating the City’s *Stormwater Master Plan* using a phased planning approach. This approach evaluates the stormwater infrastructure of each of major watershed within Cedar Rapids. As part of this effort, the City is developing a citywide series of hydraulic models to evaluate the stormwater collection and conveyance system. Model development includes two main steps: development of a macro-scale model and development of detailed basin-scale models.

The first modeling effort focused on modeling the large pipes (48 inches and larger), open channels, and major detention facilities of the City’s stormwater conveyance system. TM 3.1 (HDR 2016) details model development and findings from this effort, referred to as the macro-scale model. The macro-scale model is a 1D network model, simulating conveyance in the storm sewer and open channel networks. Figure 1 shows model results from the macro-scale model for the E Avenue NW watershed. This model is the foundation for the subsequent step, detailed basin-scale models.
The second step involves evaluating each major watershed within Cedar Rapids. The main analysis uses detailed stormwater basin-scale models to update and refine the macro-model. Detailed basin-scale models simulate ponding, overland flow, and a more extensive pipe network to evaluate specific project combinations in the context of the entire watershed. These models can be updated to reflect newly constructed stormwater infrastructure. The E Avenue NW watershed basin-scale model is the third basin-scale model developed as part of the stormwater master plan update.

The objective of this study is to evaluate the existing stormwater infrastructure and make recommendations to reduce stormwater flood damages in the E Avenue NW watershed. This TM presents the background, methodology, findings, and recommendations for the E Avenue NW Watershed Drainage Study. This document will be incorporated in the Stormwater Master Plan as TM 3.4.
3 E Avenue NW Watershed Background

3.1 Watershed Description

The E Avenue NW watershed is located in the northwestern quadrant of Cedar Rapids. The watershed begins west of West Post Road NW and follows Vinton Ditch, an open channel drainageway. Vinton Ditch daylights east of Jacolyn Park, near Jacolyn Drive NW and Johnson Avenue NW. It generally flows northeast, through a series of culverts and City-owned detention basins, and enters the storm sewer pipe network via culvert near E Avenue NW and 15th Street NW. The culvert starts as an 8-foot by 12-foot box and an 11-foot by 17-foot arch pipe, both running parallel to E Avenue. The 8-foot by 12-foot box turns east at 11th Street NW and runs parallel to D Avenue to its outlet to the Cedar River at E Avenue. The 11-foot by 17-foot arch pipe transitions to a 8-foot by 12-foot box near 8th Street NW and continues to run parallel to E Avenue until its outlet to the Cedar River. Figure 2 shows the location of the E Avenue watershed. Figure 3 provides a general overview of the E Avenue watershed stormwater system.

Table 4 describes the existing land use within the E Avenue NW watershed. Current land use contains residential, commercial, and paved areas. Those land uses cover more than 90 percent of the watershed. The potential development in the E Avenue NW basin was estimated based on the City’s future land use database for areas that are currently undeveloped/open space.

The existing impervious area is estimated at 1,085 acres, or 40 percent of the total watershed area. Total available future development areas are only 140 acres (13 percent of the watershed).

Table 4: E Avenue NW Watershed Land Use Characteristics

<table>
<thead>
<tr>
<th>Land Use Type</th>
<th>Total Area (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total watershed area (commercial, residential, undeveloped, and roads)</td>
<td>2,769</td>
</tr>
<tr>
<td>Total commercial</td>
<td>81</td>
</tr>
<tr>
<td>Total residential</td>
<td>1,803</td>
</tr>
<tr>
<td>Total undeveloped</td>
<td>260</td>
</tr>
<tr>
<td>Potential development</td>
<td>140</td>
</tr>
<tr>
<td>Roads/ other impervious</td>
<td>625</td>
</tr>
<tr>
<td>Total Impervious area – existing conditions (including residential and commercial)</td>
<td>1,085</td>
</tr>
</tbody>
</table>
Figure 2: Location of E Avenue NW Watershed within Cedar Rapids
3.2 Historic Flooding and Previous Studies

On June 29, 2014, heavy local rainfall resulted in widespread flooding throughout Cedar Rapids. Gauge-adjusted radar rainfall (GARR) records indicate that between 3.5 and 5.0 inches of rain fell, mostly within a 1-hour period. Peak 5-minute rainfall intensities exceeded 8 inches per hour in isolated areas. This event approximates a 100-year to 500-year, 1-hour duration rainfall event. Following the event, reports were received that water was approximately 6 feet above the Vinton Ditch banks (City of Cedar Rapids 2014), resulting in the flooding of basements and garages of several nearby property owners. Incident report locations and locations where residents requested additional solid waste pickups following the 2014 event are shown in Figure 4 and Figure 5, respectively. These figures identify areas most affected by heavy rainfall, which may be related to flash flooding.

A 2010 City study on the Vinton Ditch floodplain recommended either improving conveyance on Vinton Ditch with channel widening, channel deepening, and culvert improvements, or increasing storage south of E Avenue between 28th Street NW and 31st Street NW (Hagan’s 2nd detention basin) (Foth 2010). Neither alternative has been completed, but expansion of the Hagan’s 2nd detention basin is part of the City’s existing Capital Improvements Plan (CIP) project list.
Figure 4: Summary of Reported Stormwater Flooding Incidents, June 29-30, 2014
(Approximate E Avenue NW Watershed Location Highlighted in Red)
Figure 5: Locations of Extra Solid Waste Pickups Following June 29-30, 2014 Rainfall (Approximate E Avenue NW Watershed Location Highlighted in Red)
3.2.1 FEMA Flood Insurance Study

Vinton Ditch, the primary receiving watercourse in the watershed, has an associated Federal Emergency Management Agency (FEMA) regulatory floodplain that requires that the City actively manage changes and encroachments in the floodplain as a condition of being a participating community in the National Flood Insurance Program. The current floodplain mapping includes a detailed study (Zone AE) from 14th Street to Cherokee Trail Park and approximate hazard mapping starting at Cherokee Trail Park. The reach using approximate mapping shows two distinct areas of approximate 100-year flooding; one area with average depths that are determined to be greater than 1 foot (Zone A) and one areas of 100-year flooding where average depths of flooding were determined to be less than 1 foot (mapped as shaded Zone X) as shown in the following figure. Several residences are located within the Vinton Ditch Zone AE 100-year floodplain. This mapping (Zone A and Zone AE) is used to determine which residences near Vinton Ditch are required to carry flood insurance for federally insured loans based on the flood risk estimated in the effective Flood Insurance Study (FIS). The flood hazard area delineation along Vinton Ditch is shown in Figure 6.

Figure 6: FEMA Flood Hazard Area Map
4 Model Development

4.1 Modeling Approach

The primary tool for analyzing stormwater infrastructure in the watershed was a hydraulic model. The model simulates the major sewer and overland flow components of the watershed’s stormwater conveyance system. The stormwater model is a useful tool to evaluate the root cause of flooding and develop alternatives in the context of other projects and concerns in the watershed.

4.2 Software

InfoWorks ICM software was used for the stormwater master plan modeling effort. InfoWorks ICM, from Innovyze, provides a comprehensive, GIS-based, computational engine that is both stable and efficient. The model capabilities and HDR’s experience with this software make this selection an effective and fitting platform to analyze the City’s stormwater and sanitary collection systems. The Model Software Selection Technical Memorandum (Appendix A to the Stormwater Master Plan TM 3.1, HDR 2016) documents the software selection process.

4.3 Catchment Characteristics

HDR delineated 89 catchments within the E Avenue watershed using the ArcGIS ArcHydro toolbox. HDR manually edited those 89 catchments based on LiDAR topography, storm sewer data, and open channel alignments. Hydrologic characteristics were determined for each catchment. Runoff hydrographs from the catchments load the E Avenue watershed hydraulic model.

4.3.1 Topography (LiDAR)

LiDAR data collected in October 2012 was used to develop a digital elevation model (DEM) with a 3-foot grid cell size. The DEM, along with City-provided GIS data representing the City’s storm pipe network and open channels, confirmed catchment delineation.

4.3.2 Soil Type (Hydrologic Soil Group)

The United States Department of Agriculture (USDA) Soil Survey Geographic (SSURGO) Database for Linn County, Iowa, published August 10, 2016, was used to characterize hydrologic soil group conditions for each catchment. Table 5 summarizes hydrologic soil groups by area. The majority of the watershed soils (93 percent) is classified as Type C (slow infiltration rate) or Type D (very slow infiltration rate). The spatial distribution of soil types is shown in Figure 7.
Figure 7: Hydrologic Soil Group Type

Table 5: Hydrologic Soil Group Summary

<table>
<thead>
<tr>
<th>Hydrologic Soil Group</th>
<th>Percent of E Avenue Watershed Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3.6</td>
</tr>
<tr>
<td>B</td>
<td>2.9</td>
</tr>
<tr>
<td>C</td>
<td>65.0</td>
</tr>
<tr>
<td>C/D</td>
<td>26.5</td>
</tr>
<tr>
<td>D</td>
<td>2.0</td>
</tr>
</tbody>
</table>

4.3.3 Cover Type (Land Use)

The City provided existing land use GIS data from the Envision CR report (City of Cedar Rapids 2017). The data is maintained at the parcel level and includes descriptions of the associated land use category and links to the Envision CR website.

4.3.4 Rivers, Creeks, and Channels

There are approximately 3.4 miles of open channels within the E Avenue watershed. HDR used the open channel location and the City’s pipe network data to confirm the catchment delineation.
4.3.5 Windshield Survey

HDR conducted a windshield survey of several key locations within the E Avenue watershed on December 20, 2016. HDR used the information from this survey to verify field data collected by the survey crew and GIS data from the City’s database. The summary of this windshield survey is included in Appendix A.

4.4 Catchment Hydrology

Simulations evaluated existing and future hydrologic conditions. Existing hydrologic conditions were used for validation of the model, and future hydrologic conditions were used to evaluate system deficiencies and identify capital improvements.

4.4.1 Soil Conservation Service Curve Number Method

The Natural Resources Conservation Service (NRCS) Soil Conservation Service (SCS) curve number method was used to estimate direct runoff resulting from rainfall in each catchment based on rainfall amount, land use, and the hydrologic soil group. Composite (area-weighted) curve numbers were calculated for each catchment by intersecting hydrologic soil group and existing land use GIS data with catchment boundaries. The curve number is an empirical parameter describing the catchment’s soil moisture retention characteristics. A lower curve number indicates the land area will retain more water and produce less runoff than an area with a higher curve number. Impervious areas have curve numbers approaching 100. An aerial photograph taken on March 10, 2016, was used to compare existing land use GIS data. Based on this review, some existing land use types were reclassified to represent hydrologic conditions. Specifically, land use types such as civic and agricultural were reclassified to better match land use descriptions from the NRCS Technical Release 55 (TR-55) manual. In addition, the parcel-based land use layer was flattened to remove duplicate and overlapping polygons. These instances typically occur at multifamily (condominium) locations. Figure 8 shows the curve numbers calculated throughout the watershed. Figure 9 shows the composite curve numbers for each catchment.
Figure 8: Curve Numbers

Figure 9: Existing Conditions Composite Curve Number, by Subcatchment
The NRCS SCS runoff curve number transform method (NRCS TR-55) was used to develop hydrographs from each of the catchments. This method generates the runoff hydrograph based in the rainfall intensity and curve numbers.

### 4.4.2 Time of Concentration

The time of concentration influences the peak runoff rate and shape of the runoff hydrograph. The time of concentration for each subcatchment was computed using surface characteristics, slopes, and watershed geometry as outlined in NRCS TR-55. The time of concentration included components to represent the sheet flow, shallow concentrated flow, and channel flow, as applicable. Overland sheet flow was assumed to become shallow concentrated flow at a maximum of 100 feet.

### 4.4.3 Future Conditions Hydrology

Hydrologic parameters representing future development within the watershed were determined by assuming undeveloped areas would develop with similar zoning and density of adjacent developed areas. Assumptions about future land use were made based on the City’s parcel data. This data includes zoning information and the density of development. No reduction in runoff was assumed for local site detention.

### 4.4.4 Hydrology Assumptions

Further Refinements

Hydrologic model development used readily available data from the City’s GIS database to estimate runoff hydrology. Further refinements could be made to the hydrologic parameters in the model based on field verification and inclusion of specific data from stormwater flooding events as these become available. These refinements, which may result in changes to runoff rates, would improve the model representation of the condition resulting from rainfall events. However, the methods used in determining the hydrologic parameters are based on the best, readily available data, and are adequate for planning purposes.

#### West Side Flood Control System Interior Drainage

Changes to the storm sewer system at the downstream end of the watershed are expected with the construction of the City’s Cedar River Flood Control System (CRFCS). Improvements in E Avenue have been designed as part of the CRFCS project. HDR received data from the CRFCS design team (HR Green 2017) and included some interior drainage design components into the InfoWorks ICM model. These components included include storm sewer relocation and detention at the line of protection. Design refinements of these improvements may continue, but are beyond the scope of this study.

### 4.5 1D Flow Network

#### 4.5.1 Summary of Elements

The 1D flow network in the basin-scale model includes approximately 14.5 miles of pipe, more than 625 pipe junctions (connections), 3.4 miles of open channel, 9 stormwater storage ponds, and 2 outfalls to the Cedar River (see Figure 3). Inflow hydrographs determined for each catchment are applied directly to the 1D flow network at the appropriate location. Where the pipe is
conveyance-limited, water surcharges and flows in the 2D domain. The downstream boundary for
the model was modeled outfalls to the Cedar River at the E Avenue Bridge.

4.5.2 Data sources

Several sources provided data to develop the 1D flow network for the hydraulic basin-scale model.
They include GIS data and survey data for the closed conduits and LiDAR, aerial photography, and
survey data for open channels. Additional survey provided by the City confirmed and updated data
related to the pipe network and detention facilities in the model. Generally, the GIS database
provided pipe diameter and invert data for approximately 30 percent of the pipe junctions. Survey
data confirmed or documented select inverts and pipe diameters. In instances where the GIS
database and survey did not provide pipe characteristics, InfoWorks tools inferred characteristics
from the connecting pipe segments. Nearly 77 percent of the link segments had at least one invert
elevation inferred by InfoWorks. Forty-percent had both invert elevations inferred. Less than 4
percent of the link segments had inferred pipe sizes.

City Stormwater Network GIS Data

The City provided its GIS database of the storm sewer network to as the primary data source for
development of the hydraulic model. The most applicable information in the GIS data for the
hydraulic model is the network connectivity, pipe invert elevations, and pipe shapes and sizes.

Survey Data

Anderson-Bogert Engineers & Surveyors collected survey data on behalf of the City and HDR for the
current project to fill in gaps in the GIS data or replace the GIS data where applicable. The survey
data included pipe invert elevations, pipe shapes and sizes, and notes describing unique pipe
configurations or conflicts between field observations and the GIS data. Survey crews photographed
each surveyed structure and provided these to HDR. These photographs confirmed connectivity and
configuration.

Open Channel Data

Stormwater in the E Avenue watershed is conveyed through a series of pipes and open channels,
ultimately draining to the Cedar River. The hydraulic model includes open channels between closed
conduits. The most significant open channel in the watershed is Vinton Ditch, the primary receiving
watercourse in the watershed. Several smaller streams contribute to Vinton Ditch. Cross sections of
the ditch were surveyed at hydraulic structures (such as bridges and culverts) and approximately
every 300 feet from the start of Vinton Ditch (at Jacolyn Park) to its termination (at the intersection of
E Avenue and 15th Street NW). Beyond the channel areas and between surveyed cross sections,
overbank elevations were determined using LiDAR data.

Detention Facilities

Nine detention facilities were included in the hydraulic model. Several in-line ponds were modeled as
open channels. This method represents in-line storage areas as they transition from open-channel
flow to active storage. The detention facilities ranged in storage volume from less than 1 acre-foot to
86 acre-feet. Watershed characteristics were taken from design drawings where available or were
developed from LiDAR data. HDR measured outlet structure dimensions during the field
investigation and later surveyed to determine structure elevations.
The inline or other major detention facilities that were included in the E Avenue watershed basin-scale model are shown in Table 6.

**Table 6: E Avenue NW Watershed Model Detention Facilities**

<table>
<thead>
<tr>
<th>Detention Facility</th>
<th>Watershed ID</th>
<th>Estimated Storage Volume (acre-feet)</th>
<th>Modeled As</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cedar Hills</td>
<td>C-205</td>
<td>86</td>
<td>Storage Area</td>
</tr>
<tr>
<td>Bel Air West</td>
<td>C-207</td>
<td>14</td>
<td>Storage Area</td>
</tr>
<tr>
<td>Cherokee Park</td>
<td>C-208</td>
<td>5</td>
<td>In-line</td>
</tr>
<tr>
<td>Hagan’s 2nd Basin</td>
<td>C-209</td>
<td>23</td>
<td>In-line</td>
</tr>
<tr>
<td>Concordia Lutheran</td>
<td>C-211</td>
<td>5</td>
<td>In-line</td>
</tr>
<tr>
<td>16th Avenue SW #2</td>
<td>C-411</td>
<td>34</td>
<td>Storage Area</td>
</tr>
<tr>
<td>16th Avenue SW #1</td>
<td>C-422</td>
<td>13</td>
<td>Storage Area</td>
</tr>
<tr>
<td>CRFCS Proposed near I Ave NW and 6th St NW</td>
<td>--</td>
<td>21</td>
<td>Storage Area</td>
</tr>
<tr>
<td>Arrowridge Condo</td>
<td>18965</td>
<td>&lt;1</td>
<td>Storage Area</td>
</tr>
</tbody>
</table>

An elevation-area table was defined for each detention facility to represent the basin storage above the bottom of the pond for dry ponds or above the normal water level for wet ponds (with normal water level taken from LiDAR). The influence of other smaller detention facilities not included in Table 6 were not captured, but are partly accounted for in the 2D flow surface.

4.5.3 1D Network Hydraulics

**Energy Losses**

Manning’s Roughness Coefficients equation models major losses in open channels and pipe. The Manning’s Roughness Coefficients that were used are summarized in Table 7.

**Table 7: Manning’s Roughness Coefficients**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Manning’s Roughness Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipes</td>
<td>0.013</td>
</tr>
<tr>
<td>Grass swale</td>
<td>0.030 to 0.040</td>
</tr>
<tr>
<td>Long grass, scattered brush</td>
<td>0.050</td>
</tr>
<tr>
<td>Wooded areas</td>
<td>0.080</td>
</tr>
</tbody>
</table>

InfoWorks computes energy losses at junctions using a built-in normal head loss relationship. This method calculates energy losses based on the velocity in the pipes upstream and downstream of the junction and ratio of flow surcharging from the junction compared to the flow conveyed through the junction in the pipe. Additional losses based on pipe entry or exit angles to the junctions were not considered. This simplification approximates headloss at each junction. Junctions in GIS data include well-constructed manholes, custom built transitions between box culvert segments, sweeping bends, blind taps—where smaller pipes are tapped directly into large box culverts—and other connection types. The difference in losses between various types of junctions is small in
comparison to losses in the pipe segments. For this reason, the simplification provides a reasonable approximation throughout this watershed.

**Boundary Conditions**

The E Avenue outfall to the Cedar River is downstream of the 5-in-1 dam. The water surface elevation for the outfall was 712.2 feet. This elevation, which represents a non-flooded condition on the Cedar River, is consistent with the gravity-flow condition elevation used in the interior drainage model for the west side CRFCS design (HR Green 2017).

**Open Channels**

There are 3.4 miles of open channel included in the E Avenue watershed basin-scale model. Open channels are represented by irregular cross sections, with elevation data determined using channel surveys and supplemented with LiDAR data. Each channel segment has an associated cross section and slope. Channel segments were chosen to provide a reliable estimate of water surface elevation at sewer outfalls and to capture the main hydraulic controls, such as major expansions in the width of the floodplain or obstructions in the floodplain.

**4.5.4 1D Model Network Assumptions**

**Network Development**

The 1D flow network was developed using available information from GIS and survey data. In some cases, the survey data conflicted with the GIS data. The following procedures and assumptions were used to develop the flow network.

- If a dimension, such as 48 inches by 72 inches, was reported in notes within the GIS data, it was assumed that the convention was height by width.
- If only one dimension was provided in City GIS data for pipes indicated to be arch, oval, or elliptical pipe, it was assumed that the size represented an equivalent circular pipe (for example, a 36-inch arch pipe was assumed to be 43 inches wide by 26 inches high).
- If one dimension was provided in the supplemental survey data, it was assumed that the dimension represented a height based on the method of survey. This assumption was typically confirmed with the photographs that accompanied the survey.
- In some cases, conflicts existed between survey data and GIS data. Generally, GIS data was given preference over survey data based on the rationale that in many cases it can be difficult to measure pipe diameters without entering the adjoining manhole.
- At pipe endwalls or box culverts, preference was given to survey data.
- In areas where the GIS data appeared errant and survey data appeared reasonable, the survey data was used.

Developing the 1D network requires engineering judgment. Some uncertainty related to pipe dimensions, junctions, and characteristics exists. However, the overall performance of the storm sewer system in the watershed is modeled with adequate detail for planning and prioritizing improvement projects in the E Avenue watershed.

Modeling efforts were focused on using available data from the City’s GIS database and supplemental survey data. Additional improvements to the storm sewer model can be made by
incorporating additional as-built data, especially in the larger sewers and other significant facilities. Any additional survey or field verification data could be incorporated as it becomes available. However, the level of detail incorporated in the model is sufficient for the development of project recommendations for the City’s capital improvements plan.

Inlet Capacity

Inlet details at each manhole (size and type), were either not included or not detailed completely in the City’s GIS database. Significant fieldwork would be required to document and confirm the size, type, and condition of every inlet. Furthermore, debris impacts are very difficult to predict accurately. The model uses a grouped-inlet approach, in which individual inlet limitations are not considered. This approach eliminates the possibility of a local inlet capacity limitation leading to surface ponding, which may eventually mask a conveyance capacity limitation downstream. For this reason, the grouped-inlet approach is useful for evaluating storm sewer conveyance independent of inlet capacity. Inlet capacity limitations cannot be identified using model results without comparison to observed conditions.

Inlet capacity is generally evaluated and designed based on Statewide Urban Design and Specifications (SUDAS). The model detail and additional field survey required to include each inlet in a stormwater model would require a significant effort. This level of effort is likely only warranted on a project-scale with complex street level flow or some other exceptional case where traditional methods may need refinement.

4.5.5 2D Flow Domain

Data Sources

The 2D flow domain, developed from City-provided GIS data, represents ponding, storage, and overland conveyance that occurs and interacts with the 1D storm sewer system. This 2D flow domain incorporated LiDAR topography, buildings, and pavement layers to depict the ponding and flow conditions at the ground surface in the E Avenue watershed.

LiDAR Data

The City’s GIS staff provided terrain elevation data for this study area. This dataset was collected for the City during the fall of 2012 using LiDAR and was processed for ground points and provided as a raster dataset. Vertical accuracy for individual LiDAR point elevations was reported by the City’s contractor to be within approximately 0.15 meters (0.5 feet), with points generally at a 0.7-meter (2.3-foot) horizontal spacing. This accuracy was not verified as part of this study, and is assumed adequate for the purposes of this planning-level study.

City GIS Planimetric Data

The City’s GIS staff provided planimetry data within the study area to HDR. These data detailed the plan-view spatial extent of pervious and impervious areas including buildings, sidewalks, roads, parking lots, and open areas. Figure 10 shows an example of the roadway coverage in the E Avenue watershed.
4.5.6 2D Flow Domain Development and Function

The 2D flow domain was created from the GIS data. Elevations are based on the LiDAR raster dataset provided by the City. Planimetry data defined the roadways areas. Roadway data assigned areas that required a finer computational mesh and associated Manning’s Roughness Coefficient of 0.015. Beyond roadway areas, a Manning’s Roughness Coefficient of 0.05 approximated overland roughness features. Figure 11 shows an example of the 2D mesh in the E Avenue watershed.
Flow is applied to the 2D domain when the flow in the pipe or open channel section exceeds capacity. Flow will be conveyed within the 2D domain and enter the 1D domain elsewhere if pipe or open channel capacity is available at that location. Incorporation of a 2D domain is useful in characterizing water flowing and ponding in streets or other overland areas. The 2D domain is necessary to evaluate system performance for the 100-year event, which is above the design level of service for storm sewer system.

The resulting mesh polygons generally represent the elevations present in overbank areas and roadways, but do not represent curb flow lines or other influential flow features. Resolution in roadway areas was increased (compared to other overland areas) to represent the roadway cross section geometry. Most roadway sections were represented by a minimum of three mesh elements across the width.

4.5.7 2D Flow Domain Assumptions

No buildings were included in the 2D domain. Buildings account for a small percentage of the total area of the watershed, and most buildings are less than 1,000 square feet in area. Small buildings are distributed throughout the watershed. Therefore, this assumption is not expected to affect findings or recommendations.

The 2D surface was entirely drained at the beginning of the simulation. This assumption disregards the influence of ponded water beyond ponds, and wet detention facilities in the watershed. The drained surface provides a reasonable starting condition for a design event, but would underestimate runoff volumes from consecutive events.
4.6 Rainfall

Nested design event hyetographs were developed from National Oceanic and Atmospheric Administration (NOAA) Atlas 14 rainfall depths for recurrence intervals of 5 and 100 years. The 5-year event hyetograph produces a total of 3.8 inches of rain with a peak intensity of 6.5 inches per hour. The 100-year event hyetograph produces a total of 7.4 inches of rain with a peak intensity of 11.5 inches per hour.

A nested event hyetograph embeds the rainfall totals for multiple durations, creating an event with a single steep curve (that is, the most intense 1 hour in the nested event would generate the rainfall depth entered for the 1-hour duration). The hyetographs for the 5- and 100-year, 24-hour events are shown in Figure 12. The simulated 24-hour hyetographs were generated using Hydrologic Engineering Center Hydrologic Modeling Software (HEC-HMS) using NOAA Atlas 14 rainfall depths for durations of 5 minutes, 15 minutes, 1 hour, 2 hours, 3 hours, 6 hours, 12 hours, and 24 hours.

Using a nested event pattern eliminates the need to run multiple simulations of different durations, producing a short, high-intensity period with the appropriate 24-hour event rainfall depth. For these reasons, the nested 24-hour distribution was used in this analysis.

![Figure 12: Rainfall Hyetographs for 5- and 100-year Nested Storms](image)

For comparison, the June 29 to June 30, 2014, rainfall hyetograph is shown in Figure 13. The June 2014 event had average rainfall depths of around 4.5 inches in Cedar Rapids, most of which fell in a 1-hour period. The event started on June 29 around 9:00 p.m. with the most significant portion of rainfall falling between 10:50 p.m. and midnight. The rainfall intensities peaked above 8 inches per
hour in some areas compared to the 100-year nested event with intensity of approximately 4 inches per hour at the peak.

![Figure 13: Rainfall Hyetographs for June 29-30, 2014 Event](image)

5 Model Validation and Analysis

The InfoWorks ICM model simulated rainfall and flow conditions in the E Avenue watershed for the June 30, 2014, event and the 5- and 100-year events. The 2014 event observations qualitatively validated model results. The model results from the 5-year and 100-year events were used for evaluating the stormwater conveyance system level of service compared to the City design standard. Two aspects of the results were evaluated: capacity in the 1D pipe network and surface ponding/flow on the 2D domain (ground surface). Figures and discussion of the results are based on the maximum flow in the sewer system and the maximum depth of ponding/flow on the 2D surface over the entire event. The model results figures do not illustrate these conditions at any specific time during the simulation but rather the maximum flow and inundation conditions that occurred at any point during the entire simulation.

5.1 Model Limitations

Model development is detailed in Section 4 of this report. Uncertainty in model inputs, including LiDAR terrain and roughness, can affect model results. Additionally, simplified components of the
system, such roadway sections modeled without a curb and gutter can affect depths by up to 0.5 foot. The uncertainty of modeled flow depths is roughly 1.0 foot.

This model was developed to facilitate planning-level evaluations in the E Avenue NW watershed, and was prepared with adequate detail to meet the study objectives. The depth plots show the maximum depth of water over the entire simulation. An area with the lightest contour has at least 0.1 foot of water average over 1 minute in the simulation. This depth is within the uncertainty of the model. Areas with less than 1.0 foot of depth may or may not experience flooding, based on local elevations and roadway flow conditions. Additionally, buildings were not included in the terrain, just ground elevations. Buildings are often built above the adjacent ground. Therefore, model results do not explicitly result in flood conditions in a building. The building elevation in relation to the flood elevation would determine flood risk at the building.

### 5.2 2014 Event

Radar rainfall records from the June 30, 2014, event recreated intensities across the watershed and were used to evaluate the E Avenue watershed response to the event. The GARR records provide rainfall intensities at a 250 meter scale for 5-minute intervals. Model results are shown in Figure 14.

The City provided a log of incident reports, as well as a density map from extra solid-waste pickup calls. These records and simulation results qualitatively validate model performance. Table 8 summarizes the comparisons made during model validation.

<table>
<thead>
<tr>
<th>Location</th>
<th>2014 Observation</th>
<th>Model Results in Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vinton Ditch</td>
<td>29 residents expressed concerns about impassible streets, cars moved by floodwaters, and flooded basements</td>
<td>Model results showed more than 3 feet of ponding in the area between E Avenue NW and F Avenue NW, and Westwood Drive NW and 29th Street NW.</td>
</tr>
<tr>
<td>Johnson Avenue Hy-Vee</td>
<td>$30,000 worth of damage, water completely surrounded the building, flowing in all doorways, covered entire floor, roof drains could not discharge and damaged ceiling.</td>
<td>Model results show flooding ranging from 0.5 foot to 2.5 feet surrounding the Johnson Avenue Hy-Vee building and parking lot.</td>
</tr>
<tr>
<td>2125 1st Avenue SW</td>
<td>Flooded basements and garages, sanitary sewer backups</td>
<td>Model results show flooding between houses located from 2121 to 2201 1st Avenue SW.</td>
</tr>
<tr>
<td>3016 - 3001 2nd Avenue SW, 421 31st Street SW</td>
<td>5 houses reported flooded basements</td>
<td>Model results show up to 1.0 foot of flooding at the houses located near the 2nd Avenue SW and 31st Street SW intersection.</td>
</tr>
<tr>
<td>D Avenue NW and 8th Street NW</td>
<td>Flooded intersection</td>
<td>Model results show widespread flooding at and around the D Avenue and 8th Street intersection.</td>
</tr>
<tr>
<td>I Avenue NW between Ellis Boulevard NW and 10th Street NW</td>
<td>Sanitary sewer backups</td>
<td>Model results show flooding ranging from 0.5 foot to 3.0 feet along I Avenue.</td>
</tr>
</tbody>
</table>

The model replicated observed conditions from the 2014 event. This comparison qualitatively validates the model to the extent possible, based on City damage reports and the City staff’s recollections from of conditions during the event.
FIGURE C1
MODEL RESULTS
JUNE 2014 FLOOD

Sub Catchment
Modeled Storage Area
Storm Pipe
Surcharge
Less than half full
More than half full
Full - Bottleneck Downstream
Full - Bottleneck Pipe

Ponding Depth (ft)
0.1 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1+

DATA SOURCE: City of Cedar Rapids
5.3 5-Year Event Results

The performance of the stormwater system in the E Avenue watershed was evaluated with the 5-year event. City design standards for new design (City of Cedar Rapids 2006) indicate that the minor storm drainage system (which consists of underground piping drainageways, and other required conveyance) should be designed against the minor event (defined as the 5-year event). Older sewers often do not provide this level of service. The results for the 5-year rainfall simulation were evaluated compared to the design standard. Any pipe flowing at capacity that results in sewer surcharging indicates a deficiency compared to the City’s design standard.
FIGURE 15
5-YEAR MODEL RESULTS
BASELINE CONDITIONS

Sub Catchment
Modeled Storage Area
Storm Pipe
Surcharge
Less than half full
More than half full
Full - Bottleneck Downstream
Full - Bottleneck Pipe

Ponding Depth (ft)

0.1- 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1+

DATA SOURCE: City of Cedar Rapids

CITY OF CEDAR RAPIDS
E AVENUE WATERSHED DRAINAGE STUDY

PATH: L:\CITY_OF_CEDAR_RAPIDS_E-AVENUE_DRAINAGE_STUDY\GIS-MODEL\MAP_DOCS\MXD\RESULTS_FINAL_20170522\BASELINE_5YEAR_RESULTS_20170522.MXD  -  USER: STHEN  -  DATE: 5/22/2017
5.3.1 11th Street NW to 5th Street Northwest, Between C Avenue NW and 1st Avenue SW

Model results show that the southern branch of the E Avenue watershed does not have enough capacity to convey the 5-year runoff hydrograph downstream of 11th Street NW. The peak overland flow rate downstream of 10th Street NW is approximately 150 cubic feet per second (cfs). Surcharging occurs between 11th Street NW and 5th Street NW, as far north as C Avenue NW and south as 1st Avenue SW. This surcharging is a result of pipe capacity deficiencies of 20 to 40 percent along B Avenue, from 11th Street NW to 6th Street NW.

5.3.2 Johnson Avenue Hy-Vee (Johnson Avenue and 18th Street NW)

Model results show that storm sewers near the Johnson Avenue Hy-Vee do not have enough capacity to convey the peak 5-year event runoff. Pipe capacity deficiencies range from 30 percent at Burch Avenue NW and 19th Street NW to more than 50 percent at B Avenue NW and 18th Street NW. This deficiency causes surcharging and flooding from 20th Street NW and Burch Avenue NW to B Avenue and 17th Street NW. Street flooding in excess of 1 foot continues east along B Avenue NW downstream to 13th Street NW.

5.3.3 Southwest of 1st Avenue SW and 21st Street SW

The model indicates that the parallel 54-inch storm sewers between 25th Street SW and 21st Street SW have conveyance deficiencies of 20 percent for the 5-year event peak runoff. Depth plots show that water generally flows in back yards, between houses. From Cleveland Street SW to 21st Street SW, surcharged water abuts the houses on the south side of the 2100 block of 1st Avenue SW.

5.3.4 12th Avenue SW and 31st Street SW

Model results show that the 54-inch storm sewer along 12th Avenue SW between LaSalle Drive SW and 31st Street SW does not have adequate capacity for the 5-year rainfall event peak runoff. Water surcharges along this reach with depths over 1 foot on 12th Avenue SW. Depth plots show that yards and houses on 31st Street SW between 2nd Avenue SW and 12th Avenue SW may experience flooding during these conditions.

5.3.5 Vinton Ditch at Johnson Avenue and Edgewood Road

Model results show that Vinton Ditch overtops Edgewood Road NW and Johnson Avenue NW west of the Edgewood Road NW intersection. Depths over Edgewood Road NW and Johnson Avenue NW are generally less than 1.0 foot. These areas experience flooding because storm sewers have inadequate capacity to convey 5-year event peak runoff and the surrounding businesses are built low in comparison to the hydraulic grade line of the storm sewers.

5.3.6 Vinton Ditch at Wiley Boulevard

Model results indicate that Vinton Ditch floods Jupiter Avenue NW and Wiley Boulevard NW during a 5-year rainfall peak event. Flooding occurs because entrance losses to the 72-inch reinforced concrete pipe (RCP) culvert restrict flow through the culvert. As the water surface elevation increases, the Wiley Boulevard NW detention basin overtops and water flows across Wiley Boulevard NW at the road sag near the Wiley Boulevard NW and Jupiter Avenue NW intersection.
5.3.7 Jacolyn Drive to West Post Road

Model results show the storm sewer alignment that runs from West Post Road NW and 1st Avenue SW to Gordon Avenue NW and Jacolyn Drive NW does not have enough capacity to convey the 5-year event peak runoff. The capacity in the storm sewer ranges from 55 cfs to 180 cfs, which is roughly 40 percent below the 5-year event peak runoff.

5.3.8 27th Street NW between E Avenue and F Avenue

Model results show that 5-year event peak runoff at F Avenue NW and 29th Street NW flow over F Avenue and along Henry Court, 27th Street NW, 26th Street NW, and E Avenue NW. Inadequate upstream storage and sewer capacity, as well as inadequate capacity between F Avenue NW and E Avenue NW cause flooding with depths up to 1 foot.

5.3.9 Edgewood Road near H Avenue NW

Model results show that 5-year event peak runoff may overtop Edgewood Road NW north of H Avenue. Depth of flooding over Edgewood Road would be less than 1 foot. Insufficient downstream sewer capacity causes the flooding to occur at Edgewood Road.

5.4 100-Year Event Results

In addition to the 5-year event, the E Avenue watershed was evaluated with the 100-year event. City design standards for new design (City of Cedar Rapids 2006) state that the major storm drainage system (overland flow pathways) should be designed to prevent major damages or loss-of-life from runoff from the major event (defined as the 100-year event) (City of Cedar Rapids 2006). Evaluation of the 100-year event results was focused on surface flow and ponding that extends beyond the City right-of-way with potential to cause significant damages.
FIGURE 2
100-YEAR MODEL RESULTS
BASELINE CONDITIONS

<table>
<thead>
<tr>
<th>Sub Catchment</th>
<th>Modeled Storage Area</th>
<th>Storm Pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surcharge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than half full</td>
<td></td>
<td></td>
</tr>
<tr>
<td>More than half full</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full - Bottleneck Downstream</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full - Bottleneck Pipe</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ponding Depth (ft)
- 0.1 - 1.0
- 1.1 - 2.0
- 2.1 - 3.0
- 3.1 - 4.0
- 4.1 - 5.0
- 5.1+

DATA SOURCE: City of Cedar Rapids
5.4.1 East of 13th Street NW

Model results indicate that large areas east of 13th Street NW may experience up to 1 foot or more of flooding during the 100-year event. Flooded areas extend beyond the right-of-way and into residential and commercial properties. Most of the inundated areas beyond City right-of-way have less than 1 foot of depth. Areas with deeper depths often include parking lots and private drives. The maximum depth plots indicate that the Time Check neighborhood (East of Ellis Boulevard, North of I Avenue NW) contains blocks that have depths greater than 1 to 2 feet. Flood risk reduction in this area and other areas near the CRFCS line of protection should be incorporated into the interior drainage design of the levee.

5.4.2 End of Vinton Ditch Channel

The two culverts downstream of Vinton Ditch (starting at 15th Street and E Avenue NW) have a flow capacity of roughly 2,500 cfs. The peak flow during the 100-year event at the end of Vinton Ditch is 4,100 cfs. This leads to roughly 97 acre-feet of water flowing in and across E Avenue NW downstream of these culverts.

5.4.3 Vinton Ditch and E Avenue

Model results indicate that the 100-year event peak flow at Vinton Ditch downstream of E Avenue is roughly 1,900 cfs. The flow in Vinton Ditch, in combination with the depth of contributing flow from the north (F Avenue) can flood residences north of Vinton Ditch to F Avenue. Maximum depth plots indicate that flood depths would be between 1 and 2 feet at several of the residences.

5.4.4 Vinton Ditch at Johnson Avenue and Edgewood Road

Model results indicate that 100-year event peak flows in and to Vinton Ditch at the intersection of Edgewood Road and Johnson Avenue may overtop and flood Edgewood Road and Johnson Avenue. Maximum depths over both roads for the 100-year event exceed 2 feet. Depth contours suggest that businesses on the northeast, northwest, and southwest corners of the intersection would be flooded.

5.4.5 Vinton Ditch at Wiley Boulevard

Model results indicate that Vinton Ditch floods Jupiter Avenue NW and Wiley Boulevard NW during a 100-year event. Although the streets would be inundated, maximum depth of flooding at the residences to the north of Jupiter Avenue NW are less than 1 foot.

5.4.6 Jacolyn Drive to West Post Road

Maximum depth plots from the 100-year event simulation shows flooding beyond the right-of-way. Residences on Leroy Street, Rich Mar Lane, and Harbet Drive may experience up to 1 foot of flooding at the peak of the 100-year event.

5.4.7 27th Street NW between E Avenue and F Avenue

Runoff from north of F Avenue overtops F Avenue and floods approximately 70 residences and 3 businesses south of F Avenue and North of E Avenue between 29th Street NW and 24th Street NW.
The maximum depth on F Avenue and at the affected residences and businesses are generally 1 foot or less.

5.4.8 Edgewood Road near H Avenue NW

Peak 100-year event runoff overtops Edgewood Road at H Avenue by approximately 1 foot. Downstream (east) of Edgewood Road, approximately 5 to 7 houses could be flooded with a depth less than 1 foot.

6 Project Development

6.1 Project Identification

The City and HDR participated in a model results evaluation workshop on March 22, 2017. The workshop participants reviewed 5-year event and 100-year event model results and identified 15 projects that address stormwater management deficiencies in the watershed. These projects included regional detention facilities, conveyance improvements, green infrastructure retrofits, and local site detention (see Table 9). The location number in Table 9 references a location on the map in Figure 17.

Table 9: Summary of Identified Projects, Model Results Evaluation Workshop

<table>
<thead>
<tr>
<th>No.</th>
<th>Location*</th>
<th>Type**</th>
<th>Description and Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>O</td>
<td>Cross connection between North and South branches, along 11th Avenue NW between B Street and D Street</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>D/GI</td>
<td>Cleveland Elementary - detention basin in ball field and green infrastructure. Possible partnership with school</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>D</td>
<td>Channel expansion and detention at 1st Street and 25th Street SW</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>LD</td>
<td>Detention north of 12th Avenue and west of 31st Street SW</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>LD</td>
<td>Remove pavement and/or add detention at former K-Mart lot</td>
</tr>
<tr>
<td>6</td>
<td>6-9</td>
<td>D</td>
<td>Additional storage in upper reaches of Vinton Ditch – add detention anywhere that open space is available</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>C</td>
<td>Drainage improvements to reduce erosion caused by flow down Westwood north of F Avenue. Consider additional sewer connection across F Avenue to connect to Vinton Ditch. Should evaluate inlet capacity if/when there is a related project</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>RD</td>
<td>Expand Hagan's 2nd Basin</td>
</tr>
<tr>
<td>9</td>
<td>11</td>
<td>C/D</td>
<td>Improve conveyance from Walgreen's parking lot to parking lot east side Edgewood Road</td>
</tr>
<tr>
<td>10</td>
<td>12</td>
<td>LD</td>
<td>Expand detention in Cherokee Park</td>
</tr>
<tr>
<td>11</td>
<td>13</td>
<td>LD</td>
<td>Expand detention upstream of Edgewood road</td>
</tr>
<tr>
<td>12</td>
<td>14</td>
<td>C</td>
<td>Upsize storm sewer between West Post Road and Jacolyn Drive SW</td>
</tr>
<tr>
<td>13</td>
<td>15</td>
<td>RD</td>
<td>Detention basin northwest of F Avenue and 28th Street NW</td>
</tr>
<tr>
<td>14</td>
<td>16</td>
<td>C</td>
<td>Upsize storm sewer between F Avenue at 29th Street and E Avenue</td>
</tr>
<tr>
<td>15</td>
<td>17</td>
<td>RD</td>
<td>Detention west of Edgewood Road or conveyance improvement at Edgewood Road</td>
</tr>
</tbody>
</table>

*Location number based on list in Results Evaluation Section
**Type: C=Conveyance, GI=Green Infrastructure, RD=Regional Detention, LD=Local/Site Detention, O=Other
FIGURE 17
NETWORK OVERVIEW
PROBLEM AND PROJECT AREAS

Sub Catchment
Problem and Project Areas
Modeled Detention Pond
Modeled Open Channel
Modeled Storm Pipe
Storm Pipe

DATA SOURCE: City of Cedar Rapids

CITY OF CEDAR RAPIDS
E AVENUE WATERSHED DRAINAGE STUDY
6.2 Project Concept Development

Concepts were developed for each of the 15 projects and evaluated the performance of each project individually. Based on modeled performance, these projects were prioritized and refined in the context of upstream and downstream projects. Projects were prioritized in three tiers:

- **Tier 1 Projects** - These are the foundation of the watershed improvements. During project development, these were considered baseline projects because they have downstream benefit that reduces the need and scale of downstream projects. Other projects were developed to address deficiencies in the context of these.

- **Tier 2 Projects** - These projects address local aspects of the E Avenue NW stormwater management strategy. These projects are considered with Tier 1 projects implemented.

- **Tier 3 Projects** - These projects are enhancements to the E Avenue NW watershed management strategy. These projects are considered with Tier 1 and Tier 2 projects implemented.

Project tiers were modeled progressively. For example, the simulations with Tier 2 projects also included Tier 1 projects and the simulations with Tier 3 projects also included Tiers 1 and 2. This shows how the projects in Tiers 2 and 3 compliment Tier 1 projects.

The City and HDR discussed and confirmed project prioritization at the May 10, 2017, Alternatives Evaluation workshop. Project descriptions and budget-level cost estimates are included in Appendix B. Budget-level cost estimates apply RS Means Site Work and Landscape Cost Data unit rates to quantities obtained from the model. Standard percentage markups for contractor direct costs, contractor fees, insurance and bonds, construction contingency, construction observation, geotechnical analysis, and engineering are included where applicable. Budget-level cost estimates are not meant to replace detailed construction estimates.

Property acquisition is required for the construction of several proposed projects. For this study, potentially affected properties were identified along with their current assessed value obtained from the Cedar Rapids City Assessor. For projects that require the acquisition of less than 50% of a parcel, the assessed value was prorated based on the percentage of the parcel needed. For projects that require greater than, or equal to, 50% of a parcel, the full assessed value was estimated as the required costs. An additional 20% was added to all property acquisition cost estimates to account for uncertainty and additional cost associated with acquiring land for infrastructure projects.

Appendix C includes results overview maps the E Avenue watershed with Tier 1, 2, and 3 projects modeled. These figures show a summary of maximum pipe flow condition and depth of flow on the ground surface during the simulation. These results are also provided to the City in a Google Earth compatible KMZ file.

Appendix D compares inundated areas for the 5- and 100-year events with baseline conditions and Tier 1, 2, and 3 projects modeled. These plots overlay flooded areas from these four conditions with greater than 0.1 foot and 1.0 foot maximum depth for these four conditions. The existing conditions inundation is shown below the Tier 1, 2, and 3 results. By overlaying inundated areas, incremental benefits of these three project Tiers are shown. Figure 18 shows an example of the plots.
Figure 18: Example of inundation plots (Appendix D).

6.2.1 Tier 1 Projects

Tier 1 projects were identified during the May 10, 2017 alternatives evaluation workshop with City and HDR staff. These projects, which include regional detention basins and one conveyance improvement, have widespread benefit are have the greatest priority for stormwater projects in the E Avenue watershed. These projects are summarized in Table 10.
Table 10: Recommended E Avenue NW Watershed Tier 1 Projects, Benefits, and Associated Costs

<table>
<thead>
<tr>
<th>Projects</th>
<th>Benefits</th>
<th>Cost</th>
</tr>
</thead>
</table>
| Cross-Connection Along 11th Avenue NW and 10th Avenue NW                 | **5-year event:** 80 fewer residential properties and 2 fewer commercial properties within flooded area. Street flooding in B Ave, C Ave, 11th St., 10th St., 9th St. and 8th St less than 0.1 foot.  
**100-year event:** 8 fewer residential properties within flooded area, Flood depths reduced to less than a foot at C Ave. and 9th St. | $1,440,000 |
| 25th Street SW and 1st Avenue SW Detention Basin                        | **5-year event:** 20 fewer residential properties near 1st Avenue SW and 21st Street SW within flooded area. Flood depths reduced to less than 1 foot and half in parking lot east of Johnson Avenue Hy-Vee, half of lot no longer in flooded area. Johnson Ave., 18th St., and Burch Ave are no longer in flooded area.  
**100-year event:** 12 fewer residential properties near Johnson Avenue Hy-Vee within flooded area, flood depths in east Hy-Vee parking lot reduced to less than 1.0 foot in most locations. | $770,000 |
| Hagan’s 2nd Detention Basin Expansion                                   | **5-year event:** 5 fewer residential properties north and east of Hagan’s 2nd and 20-40 residential properties* downstream of Vinton Ditch within flooded area.  
**100-year event:** 3 fewer residential properties north of Hagan’s 2nd within flooded area, depths over a foot reduced to city ROW in most areas downstream of 13th Street* | $2,490,000 |
| 29th Street and F Avenue NW Detention Basin                            | **5-year event:** 3 fewer residential properties downstream of the detention basin and 20-40 residential properties* downstream of Vinton Ditch within flooded area in flooded area  
**100-year event:** 3 fewer residential properties downstream of the detention basin in flooded area, depths over a foot reduced to city ROW in most areas downstream of 13th Street* | $6,670,000 |
| **Total Cost**                                                           |                                                                                                                                          | $11.37 million |

Cross-Connection along 11th Street NW and 10th Street NW (Project 1)

The model indicates that flooding occurs in an area west of 11th Street NW, bounded on the north and south by D Street NW and 1st Avenue SW. The capacity of the existing storm sewer is exceeded. Excess flow surcharges, resulting in street flooding during the 5-year event and 100-year event. For the 5-year event, there is unused capacity in the existing 8-foot by 12-foot box reinforced concrete box culvert at D Street. The invert elevation of the D Street NW box culvert is approximately 6 feet below the invert of the 6-foot by 8-foot reinforced concrete box culvert along B Avenue NW. There is a 27-inch diameter pipe on 13th Street NW connecting these two conduits. However, the pipe capacity is limited to 80 cfs.

The proposed project is to construct one 54-inch RCP conduit on 11th Street NW and another 54-inch RCP conduit on 10th Street NW to connect the B Avenue NW conduit to the D Avenue NW conduit. Including pipes both 10th Street NW and 11th Street NW collect surcharged flow from upstream along 11th Street and from 10th Street NW and eliminate all downstream surcharging for the 5-year event. The general layout of this project is shown in Figure 19.
Another alternative of the concept would be incorporating either two parallel pipes or a larger diameter circular, elliptical, or box culvert along either 10th Avenue or 11th Avenue. This alternative would provide a similar level of benefit at a lower cost.

The proposed conduits connecting B Avenue NW to D Avenue NW would divert approximately 310 cfs (about half of the total flow) eliminating surcharging and local flooding during the 5-year event. The proposed cross-connection pipe has limited benefit during the 100-year event because the flow through the proposed cross-connection (420 cfs) is less than one-third of the total 100-year event flow rate. During this larger event, the D Street NW box culvert and the B Avenue NW conduit are at capacity. The downstream flow rates for this project concept are summarized in Table 11.

Table 11: Flow Rates, Cross-Connection along 11th Avenue NW and 10th Avenue NW

<table>
<thead>
<tr>
<th></th>
<th>Baseline Conditions</th>
<th>With Project Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5-year</td>
<td>100-year</td>
</tr>
<tr>
<td><strong>Downstream Peak Flows (cubic feet per second [cfs])</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-year</td>
<td>560</td>
<td>1,100</td>
</tr>
<tr>
<td>100-year</td>
<td>1,100</td>
<td>100-year</td>
</tr>
<tr>
<td><strong>Cross Connection Flow (cfs)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-year</td>
<td>30</td>
<td>80</td>
</tr>
<tr>
<td>100-year</td>
<td>80</td>
<td>100-year</td>
</tr>
</tbody>
</table>

The concept-level cost for this project is $1,440,000. A more detailed account of the assumptions used to develop this estimate is provided in Appendix B.
Incidental flood storage occurs in the area west of 25th Street SW and south of 1st Avenue SW. This is a depressed area where two open channels converge into twin 54-inch reinforced concrete storm sewer pipes. During the 5-year event, these pipes fill with some surcharging into low-lying backyard areas adjacent to the twin 54-inch pipes and overtop Cleveland Street SW. Storm sewers further downstream (near the Johnson Avenue Hy-Vee) do not have adequate capacity to convey the 5-year event flow, resulting in surcharging and flooding. Increasing the amount of storage in the area west 25th Street SW and south of 1st Avenue SW can to reduce peak flows and reduce downstream flooding.

The proposed project would consist of raising 25th Street SW approximately 5 feet and excavating to increase the storage volume behind the raised roadway embankment. The overflow would be 100 feet wide and would pass the 100-year event flow without overtopping the street. The concept layout is shown in Figure 20.

![Figure 20: 25th Street SW and 1st Avenue SW Detention Basin Concept](image)

The proposed detention basin would reduce downstream flow to, eliminate the overland flow below the watershed from 25th Street SW to Burch Avenue NW during the 5-year event and reducing flood depths at the Johnson Avenue Hy-Vee by approximately 0.3 foot. The detention basin would reduce flow to about 730 cfs, reducing flood depths at the Johnson Avenue Hy-Vee by approximately 0.7 foot. The storage volumes and flow rates for this project are summarized in Table 12.
Table 12: Storage Volume and Flow Rates, 25th Street SW and 1st Avenue SW Detention Basin

<table>
<thead>
<tr>
<th></th>
<th>Baseline Conditions</th>
<th>With Project Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Storage Volume (acre-feet) 2.3 acre-feet available</td>
<td>Storage Volume (acre-feet) 20.5 acre-feet available</td>
</tr>
<tr>
<td>5-year Used</td>
<td>1.8</td>
<td>8.3</td>
</tr>
<tr>
<td>100-year Used</td>
<td>4.8</td>
<td>20.5</td>
</tr>
<tr>
<td>Downstream Peak Flow (cfs)</td>
<td>5-year</td>
<td>100-year</td>
</tr>
<tr>
<td></td>
<td>370</td>
<td>1,100</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>730</td>
</tr>
</tbody>
</table>

The concept-level cost for this project is $770,000. A more detailed account of the assumptions used to develop this estimate is provided in Appendix B.

Hagan’s 2nd Basin Expansion (Project 8)

Hagan’s 2nd Basin is an on-line detention facility on Vinton Ditch on the south side of E Avenue NW between 28th Street NW and 31st Street NW. A north tributary enters the Hagan’s 2nd Basin under E Avenue NW. The water level in Hagan’s 2nd Basin is controlled by a reinforced concrete weir. The 45-foot-long weir crest is about 4 feet above the channel invert elevation and has a notch with an invert elevation at the channel bottom, so normally the facility is drained between events. A pedestrian bridge spans the weir on an abutment at each to connect to the concrete paths end of the weir. The upstream railing of the bridge is about 1 foot downstream of the weir wall.

Figure 21: Hagan’s 2nd Basin Expansion Concept
The proposed modifications to Hagan’s 2nd Basin consist of raising the weir crest elevation by 0.7 feet, modifying the notch to a 6-foot width, and excavating additional storage into existing detention flow on the north side of the channel and into the undeveloped land on the south. This concept would include rerouting flow from the north tributary downstream of Hagan’s 2nd Basin. Drainage from the existing streets south of Hagan’s 2nd Basin would be collected in areas drains and conveyed in surface swales.

The proposed Hagan’s 2nd Basin expansion would reduce flow in Vinton Ditch to approximately 990 cfs reducing the water surface elevation in Vinton ditch just downstream of Hagan’s 2nd Basin by 0.4 feet during the 5-year event. During the 100-year event, flow in Vinton Ditch just downstream of Hagan’s 2nd Basin would be reduced to about 3,100 cfs reducing the water surface elevation by 0.4 foot in Vinton Ditch. Table 13 summarizes the storage volumes and flow rates for this project.

Table 13: Storage Volume and Flow Rates, Hagan’s 2nd Basin Expansion

<table>
<thead>
<tr>
<th></th>
<th>Baseline Conditions</th>
<th>Tier 1 Project Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Storage Volume</strong></td>
<td>14.5 acre-feet</td>
<td>42.6 acre-feet</td>
</tr>
<tr>
<td><strong>Used</strong></td>
<td>5-year</td>
<td>100-year</td>
</tr>
<tr>
<td><strong>5-year</strong></td>
<td>16.4</td>
<td></td>
</tr>
<tr>
<td><strong>100-year</strong></td>
<td></td>
<td>42.6</td>
</tr>
<tr>
<td><strong>Used</strong></td>
<td>27.9</td>
<td>42.6</td>
</tr>
<tr>
<td><strong>Downstream Peak Flow</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>5-year</strong></td>
<td>1,100</td>
<td>990</td>
</tr>
<tr>
<td><strong>100-year</strong></td>
<td>3,500</td>
<td>3,100</td>
</tr>
</tbody>
</table>

The concept-level cost for this project is $2,490,000. A more detailed account of the assumptions used to develop this estimate is provided in Appendix B.

29th Street and F Avenue NW Detention Basin (Project 13)

Incidental flood storage occurs in the open area in the northwest quadrant of 29th Street and F Avenue. This is a relatively large and open area. Downstream residences and business may be affected by the 5- and 100-year events. There is an opportunity to build a region detention facility at this location. Detention storage near 29th Street NW and F Avenue NW intersection would be an online detention facility to reduce peak flow rates in the north tributary to Vinton Ditch, see Figure 22.

The proposed detention basin concept is assumed to:

- Be regulated by Iowa DNR Dam Safety Criteria as a high hazard dam
- Have a principal spillway conduit greater than the minimum allowable 30-inch diameter
- Be normally dry between storms
- Have no riser (water level control structure)
- Have the auxiliary spillway (AS) crest set so the 100-year event would route through the dam without operating the AS
- Have upstream and downstream slopes with 3:1 slope ratios, with a 20-foot-wide berm shown on the upstream side
- Have a top width of 12 feet
Additional flood routing would be required for design to set the AS width and to determine top of dam (TOD) elevation, but for concept level estimation of land rights, a 70-foot AS width was assumed with TOD 3 feet above AS crest elevation.

Figure 22: 29th Street and F Avenue NW Detention Basin Concept

The proposed detention basin would reduce flow in the north tributary to Vinton Ditch to approximately 230 cfs reducing the water surface elevation at F Avenue NW and 29th Street NW and at E Avenue NW by 1.0 foot during the 5-year event. The height of the dam is limited by the upstream properties and crossing at Edgewood Road. The detention basin would reduce flow to about 460 cfs and reduce the water surface elevation at F Avenue NW and 29th Street NW and at E Avenue NW by 0.8 foot during the 100-year event. The project would reduce the size of proposed storm sewer conduit on Project 14 along at 27th Street NW, between F Avenue NW and E Avenue NW that eliminates overland flow during the 5-year event and reduces overland flow by 20 percent during the 100-year event. The storage volumes and flow rates for this project are summarized in Table 14.

Table 14: Storage Volume and Flow Rates, 29th Street and F Avenue NW Detention Basin

<table>
<thead>
<tr>
<th></th>
<th>Baseline Conditions</th>
<th>Tier 1 Project Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Storage Volume (acre-feet)</strong></td>
<td>N/A¹ acre-feet available</td>
<td><strong>Storage Volume (acre-feet)</strong> 22.0 acre-feet available</td>
</tr>
<tr>
<td>5-year</td>
<td>Used</td>
<td>5-year</td>
</tr>
<tr>
<td>100-year</td>
<td>N/A</td>
<td>100-year</td>
</tr>
<tr>
<td>Used</td>
<td>N/A</td>
<td>Used</td>
</tr>
<tr>
<td></td>
<td>13.5</td>
<td>22.0</td>
</tr>
<tr>
<td><strong>Downstream Peak Flow (cfs)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-year</td>
<td>330</td>
<td>5-year</td>
</tr>
<tr>
<td>100-year</td>
<td>860</td>
<td>100-year</td>
</tr>
<tr>
<td></td>
<td>230</td>
<td></td>
</tr>
<tr>
<td></td>
<td>460</td>
<td></td>
</tr>
</tbody>
</table>

¹. Not Applicable
The concept-level cost for this project is $6,670,000. A more detailed account of the assumptions used to develop this estimate is provided in Appendix B.

6.2.2 Tier 2 Projects

Tier 2 projects were identified during the May 10, 2017 alternatives evaluation workshop with City and HDR staff. These projects, which include detention basins and one large green infrastructure installation, have local benefits and are high priority stormwater projects in the E Avenue watershed. These projects are summarized in Table 15.

Table 15: Recommended E Avenue Watershed Tier 2 Projects, Benefits, and Associated Costs

<table>
<thead>
<tr>
<th>Projects</th>
<th>Benefit</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>12th Avenue and 31st Street SW Detention Basin</td>
<td>5-year event: 8 fewer residences near 12th Avenue SW and 31st Street SW in flooded area. Reduced flooding on 12th Avenue SW and 31st Street.</td>
<td>$1,330,000</td>
</tr>
<tr>
<td>Permeable Paver Retrofit at Williams Boulevard and 16th Avenue SW</td>
<td>5-year event: 56% reduction in peak runoff to local storm sewer</td>
<td>$2,530,000</td>
</tr>
<tr>
<td>Ditch Bank Erosion at Westwood Drive and F Avenue NW</td>
<td>Address roadway maintenance issue</td>
<td>$200,000</td>
</tr>
<tr>
<td>Wiley Boulevard Basin</td>
<td>5-year event: 2 fewer houses in flooded area, offsets increased peak flow from upstream conveyance improvements. Reduced street flooding at Jupiter Avenue NW.</td>
<td>$780,000</td>
</tr>
<tr>
<td>Storage Expansion in Cherokee Park</td>
<td>5-year event: 2 fewer houses and Walgreens building no longer in flooded area. Approximately 0.3 acre reduction in flooded area at Walgreens parking lot 100-year event: 2 fewer apartment buildings in flooded area</td>
<td>$1,190,000</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td></td>
<td><strong>$6.03 million</strong></td>
</tr>
</tbody>
</table>

12th Avenue and 31st Street Detention Basin (Project 4)

The proposed detention basin would be an on-line facility on a vacant portion of a lot north of 12th Avenue near 31st Street SW, see Figure 23. An 18-inch RCP crosses the proposed detention site to the west property lines of adjacent lots to an area inlet then proceeds south and connects to the 54-inch RCP along 12th Street. There is likely some incidental storage due to surcharging of the area inlet.

The proposed detention basin would be excavated approximately 5 feet deep. Approximately 390 feet of the 18-inch RCP and the area inlet would be removed. An outlet structure with energy dissipation would be constructed at the 18-inch RCP at the north end and a water level control structure constructed on the south end. The detention basin floor would slope from north to south to provide positive drainage and would be dry between events. An additional 54-inch equivalent reinforced concrete arch pipe will be added in parallel downstream of the proposed detention basin along 12th Avenue SW.
The proposed detention basin would reduce 5-year event peak flows to the storm sewer from the upstream drainage area by approximately 22 percent. There would be no flooding on 31st Street SW (ground elevation is approximately 798.7 feet) and the water surface elevation on 12th Street SW would be reduced from 801.4 feet to 800.3 feet (ground elevation on 12th Avenue SW is approximately 800.0 feet). The peak downstream flow for the 100-year event would be reduced by 50 percent. The water surface elevation for the 100-year event would be reduced by 1.0 foot and 0.6 foot on 12th Avenue SW and 31st Street SW, respectively. The storage volumes and flow rates for this project are summarized in Table 16.

### Table 16: Storage Volume and Flow Rates, 12th Avenue and 31st Street Detention Basin

<table>
<thead>
<tr>
<th></th>
<th>Tier 1 Project Conditions</th>
<th>Tier 2 Project Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Storage Volume (acre-feet)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tier 1 Project Conditions</td>
<td>Tier 2 Project Conditions</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>100-year</td>
</tr>
<tr>
<td>Used</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>100-year</td>
</tr>
<tr>
<td></td>
<td>180</td>
<td>300</td>
</tr>
</tbody>
</table>

1. Not Applicable

The concept-level cost for this project is $1,330,000. A more detailed account of the assumptions used to develop this estimate is provided in Appendix B.
Permeable Paver Retrofit at Williams Boulevard and 16th Avenue (Project 5)

This proposed project would remove approximately 102,000 square feet of impervious pavement and replace the same area with permeable pavement on the southeast corner of Williams Boulevard and 16th Avenue (MidAmerican Aerospace, former K-Mart parking lot). This project was not specifically modeled in InfoWorks, but included as revisions (improvements) to the hydrology characteristics of the subcatchment. The greatest benefit would be observed immediately downstream of parking lot, on the northwest corner of Williams Boulevard and 16th Avenue. The apartment complex has reported problematic flooding in their parking lot during high-intensity storms. This area is not explicitly represented in the InfoWorks Model.

Permeable paving reduces the peak flow rate by temporarily storing direct rainfall and runoff from adjacent surfaces in an aggregate matrix under the paving, see Figure 25. The paving can be pervious concrete or pervious paver blocks. Asphaltic pervious pavement has also been used in some parts of the county.

The SCS Curve Number Method was used to estimate direct runoff from the former K-Mart parking lot drainage area to local storm sewer. The existing concrete pavement correlates to a curve number of 98. The Iowa Stormwater Management Manual (ISWMM 2009) identifies a typical permeable paver CN ranges from 30 to 35. Using the 5-year nested rainfall event, the pre- (existing conditions) and post- (permeable pavers retrofit) project peak runoff is estimated to be 3.6 inches and 1.6 inches, respectively. The permeable pavers retrofit would reduce the peak runoff to local storm sewer by 56 percent.
Figure 25: Typical Permeable Paver Profile (ISWMM, 2009)

The concept level cost for this project is $2,530,000. The City is investigating various mechanisms to fund this kind of conversion, including building incentives into the owner’s stormwater utility fee. A more detailed account of the assumptions used to develop this estimate is provided in Appendix B.

Storage Expansion at Cherokee Trail Park (Project 10)

Cherokee Trail Park detention basin is an on-line facility on Vinton Ditch on the south side of Midway Drive NW between Harnett Street NW and Shelley Lane NW and bounded on the south by Cox Avenue NW. Upstream flow enters the northwest corner of the facility. A reinforced concrete box culvert controls the water level. Detention storage in the upper reach of Vinton Ditch at this location does not appear to cause flooding for the 5-year or the 100-year events. Flooding of property adjacent to the detention site appears to be due to upstream overland flow. This portion of the project proposes to increase storage volume accompanied by water level control structure revisions to reduce peak flow rates in Vinton Ditch at downstream locations.
Figure 26: Storage Expansion at Cherokee Trail Park Concept

Figure 26 shows the proposed storage area concept. Along Midway Drive, a grading plan could be refined to reduce or eliminate removal of existing trees and to avoid removal of the existing concrete path where feasible. No modifications are proposed to the basin outlet structure. Further evaluation is required during design to identify and mitigate any increased flood risk to the apartment complex southeast of the proposed project location.

The proposed Cherokee Trail Park Basin would reduce flow in Vinton Ditch from 840 cfs to approximately 620 cfs during the 5-year event. The 100-year flow would be approximately 1,500 cfs in Vinton Ditch. This basin and the Wiley Boulevard Basin offset the increased runoff from upstream conveyance improvements. The storage volumes and flow rates for this project are summarized in Table 17.

### Table 17: Storage Volume and Flow Rates, Storage Expansion in Cherokee Trail Park

<table>
<thead>
<tr>
<th></th>
<th>Tier 1 Project Conditions</th>
<th></th>
<th>Tier 2 Project Conditions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Storage Volume (acre-feet)</td>
<td>35.6</td>
<td>Storage Volume (acre-feet)</td>
<td>47.9</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>23.1</td>
<td>100-year</td>
<td>38.8</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>Used</td>
<td>35.4</td>
<td>100-year</td>
</tr>
<tr>
<td></td>
<td>100-year</td>
<td>1,500</td>
<td></td>
<td>1,500</td>
</tr>
<tr>
<td></td>
<td>Downstream Peak Flow (cfs)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>840</td>
<td></td>
<td>620</td>
</tr>
<tr>
<td></td>
<td>100-year</td>
<td>1,500</td>
<td></td>
<td>1,500</td>
</tr>
</tbody>
</table>

The concept-level cost for this project is $1,190,000. A more detailed account of the assumptions used to develop this estimate are provided in Appendix B.
Wiley Boulevard Basin (Project 11)

Wiley Boulevard NW Detention Basin (Wiley Boulevard Basin) is an on-line detention facility on Vinton Ditch west of Wiley Boulevard NW (Figure 27). Flood storage occurs at this location for the 5-year and 100-year events. The conduit under Wiley Boulevard NW is a single 78-inch diameter RCP conduit with headwall on the west side and becomes a twin 72-inch diameter RCP conduit at an inlet/manhole on Wiley Boulevard NW before exiting through a headwall on the east side into Cherokee Trail Park.

The rainfall runoff of the 5-year event inundates a residential garage and is adjacent to two homes, one at intersection of Jupiter Avenue NW and Bernita Drive NW the other at the intersection of Jupiter Avenue NW and Lynda Drive NW. There is flooding in Wiley Boulevard NW at the intersection with Jupiter Drive NW, but it appears to be overland flow to the north on Wiley Boulevard NW. It appears the 100-year event on Vinton Ditch would flood multiple homes and would overtop Wiley Boulevard NW with approximately a 1-foot flow depth.

Figure 27: Wiley Boulevard Basin Concept

The proposed modifications at Wiley Boulevard Basin consist of constructing a short berm parallel to Jupiter Drive NW and under the west sidewalk along Wiley Boulevard NW to increase storage volume and allowable head water elevation. The existing 78-inch RCP would not reach full capacity at the proposed berm crest elevation. Removing the 78-inch RCP and extending the twin 72-inch RCP conduit would increase pipe capacity by 25 percent at proposed berm crest elevation.

Storage volume can be increased by excavating the overbanks excavating to add storage. Excavation in this concept was limited to open space shown in Figure 27.

A conveyance improvement project is located upstream from this site. This project would result in an increased peak flow rate for the 5-year and 100-year events entering the Wiley Boulevard Basin. The improvements at Wiley Boulevard Basin offset the proposed peak flow rates.
The proposed Wiley Boulevard Basin would reduce flow overtopping Wiley Boulevard by approximately 32 percent. The storage volumes and flow rates for this project are summarized in Table 18.

Table 18: Storage Volume and Flow Rates, Wiley Boulevard Basin

<table>
<thead>
<tr>
<th></th>
<th>Baseline Conditions</th>
<th>Post-Project Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Storage Volume (acre-feet)</strong></td>
<td>5.4 acre-feet available</td>
<td>15.0 acre-feet available</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>100-year</td>
</tr>
<tr>
<td>Used</td>
<td>7.9</td>
<td>12.7</td>
</tr>
<tr>
<td>Downstream Peak Flows (cfs)</td>
<td>5-year</td>
<td>100-year</td>
</tr>
<tr>
<td>72-inch reinforced concrete pipe</td>
<td>330</td>
<td>380</td>
</tr>
</tbody>
</table>

1. With Tier 2 and Tier 3 projects in place

The concept-level cost for this project is $780,000. A more detailed account of the assumptions used to develop this estimate is provided in Appendix B.

Westwood Drive and F Avenue NW Drainage Improvements and Ditch Bank Erosion Protection

City staff indicated that local runoff patterns in Westwood Drive NW contribute to local roadway deterioration and ditch erosion. Modeling results in this area do not replicate the observed conditions. A local inlet capacity limitation, debris blockage, or flow path not identified in the watershed model may be the root cause of the local maintenance concerns. A local drainage evaluation should be conducted to identify the root cause of these maintenance concerns and develop the solution to reduce roadway deterioration and erosion concerns at this intersection. The planning level cost for completing this study and following project is estimated as $200,000. The cost may be significantly greater or less, depending on the project identified in the local study.
6.2.3 Tier 3 Projects

Tier 3 projects were identified during the May 10, 2017 alternatives evaluation workshop with City and HDR staff. These projects, which include detention basins and conveyance improvements, have local benefits and are medium to low priority stormwater projects in the E Avenue watershed. These projects are summarized in Table 19.

Table 19: Recommended E Avenue Watershed Tier 3 Projects, Benefits, and Associated Costs

<table>
<thead>
<tr>
<th>Projects</th>
<th>Benefit</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleveland Elementary Detention Basin</td>
<td>5-year event: 2 fewer houses in flooded area</td>
<td>$190,000</td>
</tr>
<tr>
<td>Conveyance Improvements at Edgewood Road and Johnson Avenue</td>
<td>5-year event: 3 fewer houses in flooded area. 0.4 acres of roadway/ and lots Walgreens no longer in flooded area</td>
<td>$1,290,000</td>
</tr>
<tr>
<td>Conveyance Improvements from West Post Road to Jacolyn Drive</td>
<td>5-year event: 11 fewer houses in flooded area. Street flooding reduced to less than 1.0 foot. 100-year event: Street flooding contained generally within City right-of-way.</td>
<td>$2,760,000</td>
</tr>
<tr>
<td>Conveyance Improvements East of 29th Street between E Avenue and F Avenue</td>
<td>5-year event: 3 fewer houses in flooded area. Reduced street flooding on 24th Street NW.</td>
<td>$410,000</td>
</tr>
<tr>
<td>Embankment at Edgewood Road and H Avenue NW</td>
<td>5-year event: 1 less house in flooded area. No roadway overtopping.</td>
<td>$190,000</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td></td>
<td><strong>$4.84 million</strong></td>
</tr>
</tbody>
</table>

Cleveland Elementary Detention Basin (Project 2)

The project concept at Cleveland Elementary School is an off-channel detention for runoff hydrographs in excess of the 5-year event. Flows would be diverted to the detention pond at a manhole on the twin 54-inch RCP storm sewer near 21st Street NW and 1st Avenue NW to a detention facility excavated into the open field area in the south two-thirds of the site. The limits of excavation and project concept are shown in Figure 28.
Figure 28: Cleveland Elementary Detention Basin Concept

The pipe connecting the diversion manhole and the pond would be a 30-inch diameter RCP. Given the very low flow rate, an equalization manhole connecting each 54-inch RCP is not proposed at the facility outlet.

The proposed detention basin would not divert flows for the 5-year event and would reduce flow in the twin 54-inch RCP to approximately 650 cfs. This reduction in peak flow lowers flood elevations at the Johnson Avenue Hy-Vee by less than 0.1 foot during the 100-year event. Because the measurable benefit during the major flood downstream is not very significant, this is a low priority project from a flooding standpoint. However, this project would be an opportunity to incorporate low-impact development retrofits into existing open space and partner with the school district on a local drainage improvement project. The storage volumes and flow rates for this project are summarized in Table 18.

Table 20: Summary of Storage Volumes and Project Flow Rates, Cleveland Elementary Detention Basin

<table>
<thead>
<tr>
<th></th>
<th>Tier 2 Project Conditions</th>
<th>Tier 3 Project Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Storage Volume (acre-feet)</strong> N/A¹ acre-feet available</td>
<td><strong>Storage Volume (acre-feet)</strong> 20.5 acre-feet available</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>100-year</td>
</tr>
<tr>
<td>Used</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Downstream Peak Flow (cfs)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-year</td>
<td>100-year</td>
<td>5-year</td>
</tr>
<tr>
<td>320</td>
<td>710</td>
<td>320</td>
</tr>
</tbody>
</table>

1. Not Applicable
The concept-level cost for this project is $190,000. A more detailed account of the assumptions used to develop this estimate is provided in Appendix B.

Vinton Ditch at Edgewood Road NW Conveyance Improvements

This project improves the conveyance of the Vinton Ditch Conduit under Edgewood Road NW. Vinton Ditch enters two existing conduits at Midway Drive NW upstream of Edgewood Road NW and exits approximately 80 feet downstream of Edgewood Road NW. The left conduit consists of multiple pipe sizes and shapes, not always increasing in size progressing downstream. The right conduit starts as a 78-inch equivalent elliptical reinforced concrete pipe and increases to an 84-inch equivalent elliptical reinforced concrete pipe. The inlet end of each pipe projects from the slope.

The 5-year flood is less than 1 foot deep in Midway Drive NW, about 2 feet deep in the Walgreen’s parking lot, and less than .5-foot deep in Edgewood Road Park. The 100-year flood is about 2 feet deep in Midway Drive NW, about 4 feet deep in the Walgreen’s parking lot, and about 2 feet deep on Edgewood Road NW. Based on the Effective FIS FIRM, it appears the Vinton Ditch Floodway generally follows the existing conduits.

Figure 29: Vinton Ditch at Edgewood Road NW Conveyance Improvements Concept

Conveyance improvements consist of adding a third parallel conduit. The developed concept duplicates the left-hand (north) conduit sizes to reduce conflict with existing utilities crossing the storm system. The alignment follows the same alignment as the two existing conduits, as shown in Figure 29.

The proposed project would reduce the water surface elevations by about 2 feet during the 5-year event and reduces the water surface elevation upstream of Edgewood Road by about 0.3 foot during the 100-year event. The downstream flow rates for this project are summarized in Table 21.
Table 21: Downstream Flow Rates, Vinton Ditch at Edgewood Road Conveyance Improvements

<table>
<thead>
<tr>
<th></th>
<th>Existing Conditions</th>
<th>Post-Project Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pipe Flow (cfs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5-year 100-year</td>
<td>5-year 100-year</td>
</tr>
<tr>
<td></td>
<td>430 520</td>
<td>770 1,300</td>
</tr>
<tr>
<td></td>
<td>Overland Flow (cfs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5-year 100-year</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 2,000</td>
<td>0 1,600</td>
</tr>
</tbody>
</table>

The concept-level cost for this project is $1,290,000. A more detailed account of the assumptions used to develop this estimate is provided in Appendix B.

West Post Road to Jacolyn Drive Conveyance Improvements

This project would improve the conveyance of the storm sewer system between West Post Road SW and Jacolyn Drive. This system conveys runoff to Vinton Ditch upstream of Wiley Boulevard NW. Jacolyn Park is located between Harbet Avenue NW and Jacolyn Drive NW. The 5-year runoff surcharges local sewer and contributes to street flow along the entire length of this storm sewer system and in Jacolyn Park. Conveyance improvements along this system consist of increasing conduit conveyance to reduce the magnitude of overland flow. Figure 30 illustrates the conveyance improvement concept.

![Figure 30: West Post Road to Jacolyn Drive Conveyance Improvements](image-url)
The proposed project would reduce, but not eliminate, overland flow in the streets along the storm sewer system but flooding would still occur in Jacolyn Park for the 5-year 24-hour event. Flooding in the park is due to surcharging that occurs in the storm sewer sections along Jacolyn Drive NW to the north.

Overland flow would be contained generally within the street right-of-way during the 100-year event. Due to the improved system conveyance, peak flow rates increase by 160 cfs for the 5-year event and by 180 cfs for the 100-year event at the downstream end of the project. Table 22 summarizes downstream flows with and without this project in place. Downstream peak flow increases can be offset by the proposed detention basins at Wiley Boulevard and Cherokee Trail Park.

Table 22: Summary of Downstream Flows, Conveyance Improvements from West Port Road to Jacolyn Drive

<table>
<thead>
<tr>
<th></th>
<th>Existing Conditions</th>
<th>Post-Project Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pipe Flow (cfs)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-year</td>
<td>200</td>
<td>360</td>
</tr>
<tr>
<td>100-year</td>
<td>200</td>
<td>380</td>
</tr>
<tr>
<td><strong>Overland Flow (cfs)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-year</td>
<td>160</td>
<td>40</td>
</tr>
<tr>
<td>100-year</td>
<td>510</td>
<td>400</td>
</tr>
</tbody>
</table>

1. With Tier 1 and 2 projects

The concept-level cost for this project is $2,760,000. A more detailed account of the assumptions used to develop this estimate is provided in Appendix B.

26th Street NW Conveyance Improvements

26th Street NW conveyance improvements consist of adding an additional 36-inch RCP between F Avenue NW and E Avenue NW. Proposed Project 14 Detention located upstream near F Avenue NW and 29th Street NW is the major factor in eliminating or reducing the overland flooding between F Avenue NW and E Avenue NW.

This section of storm sewer along 26th Street NW conveys runoff from a small ditch along the north side of F Avenue NW south into Vinton Ditch. The 5-year event causes surcharging in this section of storm sewer and flooding throughout the area west of the 26th Street NW and there is overland flow during the 5-year event and the 100-year event. Figure 31 shows the alignment for the 26th Street NW conveyance improvement.
Figure 31: 26th Street NW Conveyance Improvements Concept

This project would eliminate overland flow for the 5-year event and reduce overland flow for the 100-year event by 20 percent along the sewer between F Avenue NW and E Avenue NW. Table 23 summarizes downstream flows.

Table 23: Downstream Flows, 26th Street NW Conveyance Improvements

<table>
<thead>
<tr>
<th></th>
<th>Existing Conditions</th>
<th>Post-Project Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pipe Flow (cfs)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-year</td>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td>100-year</td>
<td>50</td>
<td>130</td>
</tr>
<tr>
<td><strong>Overland Flow (cfs)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-year</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>100-year</td>
<td>250</td>
<td>200</td>
</tr>
</tbody>
</table>

1. With Tier 1 and 2 projects

The concept-level cost for this project is $410,000. A more detailed account of the assumptions used to develop this estimate is provided in Appendix B.

Edgewood Road NW near H Street NW Conveyance Improvements

Edgewood Road near H Street NW conveyance improvements consists of constructing a low berm on the west side of Edgewood Road NW with sides extending approximately 80 feet upstream on each side of the existing channel. The berm would increase allowable head water elevation on the inlet to use the unused capacity of the existing 48-inch culvert under Edgewood Road NW extending approximately 400 feet east.
Figure 32: Edgewood Road NW near H Street NW Conveyance Improvements Concept

This project would eliminate overtopping of Edgewood Road NW and downstream overland flow along the conduit for the 5-year event and reduce overland flow for the 100-year event by 20 percent along the conduit. The upstream water surface elevation would increase by 1.3 feet and 2.2 feet for the 5- and 100- year rainfall events, respectively. This may cause an increased flood risk to houses located north of the open channel; survey of the surrounding houses and channel would be needed to confirm.

Table 24: Downstream Flow Rates, Edgewood Road NW near H Street NW Conveyance Improvements

<table>
<thead>
<tr>
<th></th>
<th>Existing Conditions</th>
<th>Post-Project Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pipe Flow (cfs)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-year</td>
<td>190</td>
<td>210</td>
</tr>
<tr>
<td>100-year</td>
<td>210</td>
<td>240</td>
</tr>
<tr>
<td><strong>Overland Flow (cfs)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-year</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>100-year</td>
<td>360</td>
<td>300</td>
</tr>
</tbody>
</table>

The concept-level cost for this project is $190,000. A more detailed account of the assumptions used to develop this estimate is provided in Appendix B.
6.3 Watershed-Level Evaluation

The 5- and 100-year event simulations representing Tier 1, Tier 2 (in combination with Tier 1), and Tier 3 (in combination with Tier 1 and 2) projects were used to evaluate system performance and benefits from the proposed projects. Watershed inundation maps are shown in Appendix C and comparative inundation mapping is shown in Appendix D.

Hydraulic model results at key locations in the watershed show the watershed-level benefits of projects in the watershed. Flow hydrographs at critical locations and inundation extents demonstrate the effectiveness of Tier 1, 2, and 3 projects in implementing watershed-wide stormwater improvements.

6.3.1 Peak Flow Reduction in Vinton Ditch

The upstream detention projects in Tier 1 and Tier 2 and conveyance improvement projects in Tier 3 influence the hydrograph in Vinton Ditch. The 5-year and 100-year event hydrographs (Figure 33 and Figure 34) illustrate the influence of these projects on flows in Vinton Ditch. In the 5-year event hydrograph, the existing (baseline) peak flow in Vinton Ditch at the end of the open channel section is 1,450 cfs. The Hagan’s 2nd Basin Expansion and 29th Street and F Avenue NW Detention Basin decrease the peak flow in Vinton Ditch to 1,200 cfs. These projects add storage to both the north and main branches of the watershed. Tier 2 detention projects further reduce the peak and flatten out the hydrograph. Tier 3 conveyance improvements increase flow in Vinton Ditch from Tier 2, but the peak does not exceed 1,200 cfs.

In the 100-year event hydrograph, the existing (baseline) peak flow in Vinton Ditch at the end of the open channel section is 4,110 cfs. The Tier 1 regional detention projects upstream of Vinton Ditch reduce the 100-year event peak flow to 3,490 cfs. The additional detention incorporated in Tier 2 projects further reduces peak flows in Vinton Ditch to 3,180 cfs. Tier 3 projects do not significantly change the 100-year event hydrograph. This peak flow reduction reduces the 100-year event profile on Vinton Ditch by more than 1.0 foot.
Figure 33: Flow Hydrograph Comparison at the End of Vinton Ditch, 5-year Event

Figure 34: Flow Hydrograph Comparison at the End of Vinton Ditch, 100-year Event
6.3.2 Peak Flow Reduction in South Branch

The 5-year and 100-year event hydrographs (Figure 35 and Figure 36) illustrate the influence the three detention projects have on flows just before the 11th Street NW storm sewer cross-connection. The 5-year baseline event has a peak runoff of 610 cfs. Approximately 19 percent of the peak runoff is overland flow. The Tier 1 detention project, 25th Street SW and 1st Avenue SW detention basin, reduces the peak runoff to 555 cfs and reduces the overland flow by 95 percent. The Tier 2 and Tier 3 detention basins have little impact on the hydrograph at the 11th St NW storm sewer cross-connection.

The 100-year baseline event has a peak runoff of 1,400 cfs, with overland flow contributing to more than 60 percent of the peak runoff. The Tier 1 detention project reduces the peak runoff by 62 cfs and reduces the overland flow by 10 percent. The Tier 2 and Tier 3 detention basins to do not reduce the peak runoff for the 100-year event.

![Figure 35: Flow hydrograph comparison before the South Branch Cross-connection, 5-year Event](image-url)
6.3.3 E Avenue Cedar River Outfall

The 5-year event flow to E Avenue Cedar River outfall will be used by the west-side CRFCS design team to design and determine the suitability of interior drainage components. Model results indicate that upstream peak reductions at Vinton Ditch, coupled with the cross-connection along 11th Avenue NW and 10th Avenue NW, result in little change to the peak flow. However, the volume distribution in the hydrograph shifts substantially. With Tier 1, 2, and 3 projects, the hydrograph peak falls sooner (800–850 minutes into the event), and a higher flow is observed later in the hydrograph (870–1,100 minutes into the event). Upstream detention facilities reshaped the hydrograph. Longer periods of lower flow may reduce the ponded volume behind the line of protection during a blocked gravity-flow event. For example, if the storm water pumping station had capacity to pump 750 cfs, the baseline hydrograph shows a volume of roughly 200 acre-feet above the 750 cfs flow rate. With E Avenue projects included, the volume above 750 cfs is reduced by more than 10 percent to 178 acre-feet.
6.4 Green Infrastructure Suitability

Green infrastructure (GI) includes a number of retrofit measures that reduce runoff and increase infiltration, including bio-retention, permeable/green pavement, and downspout collection or redirection (for example, rain barrels). GI has the added benefit of improving water quality. For this suitability screening, areas where GI would be most effective in reducing runoff volume were characterized as having a high percentage of impervious area (greater than 30 percent) and a significant amount of hydrologic soil types A or B (greater permeability). Areas with these characteristics could experience a runoff reduction of roughly 1 inch across the project area through GI implementation. In developed areas with less suitable soils, GI retrofits (such as downspout collection/redirection and permeable pavers) can still be used to reduce runoff. The screening assumes GI retrofits in areas with less suitable soils could capture the first inch of runoff from impermeable areas within the catchment with approximately 50 percent efficiency.

Soil data in the NRCS national soil database (see Figure 7) indicates the soils in the E Avenue watershed, like much of Cedar Rapids, are mostly type C and D. This limits the amount of infiltration and runoff reduction that can be achieved by incorporating GI retrofits throughout the watershed. GI can be incorporated in areas of the watershed with type C and D soils for limited reduction of runoff and improved water quality benefits. Over excavation and improving soils may be necessary to incorporate GI in these areas.

Areas where GI retrofits are feasible are shown on Figure 38 and summarized in Table 25. The most significant benefits can be realized seven catchments with a high percentage of impervious area and Type A or B soils. In the E Avenue watershed, these areas are located near the Cedar River and the
proposed line of protection for the CRFCS west-side levee and floodwall alignment. GI could be leveraged in these areas to improve infiltration, which reduces runoff and improves water quality. Based on the assumptions previously outlined, retrofits in these areas, approximately 162 acres in total, could reduce runoff volumes by roughly 7 acre-feet. This reduction in runoff volume would be downstream of Vinton Ditch and would not directly address flood risk at that location. GI could be considered in the design of interior drainage improvements as part of the design of the CRFCS.

Table 25: Estimated Runoff Reductions for Green Infrastructure Retrofits

<table>
<thead>
<tr>
<th>Catchment ID</th>
<th>Estimated Runoff Reduction (inches)</th>
<th>Estimated Runoff Reduction (acre-feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EAve_81</td>
<td>0.47</td>
<td>1.8</td>
</tr>
<tr>
<td>EAve_82</td>
<td>0.36</td>
<td>0.8</td>
</tr>
<tr>
<td>EAve_83</td>
<td>0.33</td>
<td>0.2</td>
</tr>
<tr>
<td>EAve_84</td>
<td>0.48</td>
<td>1.1</td>
</tr>
<tr>
<td>EAve_87</td>
<td>0.61</td>
<td>1.4</td>
</tr>
<tr>
<td>EAve_88</td>
<td>0.76</td>
<td>0.4</td>
</tr>
<tr>
<td>EAve_89</td>
<td>0.59</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Figure 38: Suitable Areas for Green Infrastructure Retrofits
Additionally, several other areas with less favorable soils but a high percentage of impermeable surfaces could benefit from GI retrofits such as disconnections of downspouts from the storm sewer system and installation of permeable pavement. In the E Avenue watershed, most of the watershed is built out with more than 30 percent impervious areas. In this estimate, it is assumed that these retrofits will only be 50 percent effective in capturing the first inch of runoff. Based on this assumption, if GI retrofits were implemented over these 2,130 acres in total, these measures may reduce runoff by an estimated 38 acre-feet.

GI retrofits in the E Avenue watershed can reduce runoff during large events and improve water quality during minor events. GI retrofits should be part of the City’s stormwater management strategy in the E Avenue watershed.

6.5 Integration with City Programs

6.5.1 Paving for Progress

The City’s ongoing Paving for Progress (PFP) program funds rehabilitation and reconstruction of roadways throughout the city that are in need of urgent repair. The City completes 20 to 30 roadways projects per year as part of this program. There will be opportunities to save pavement associated with storm sewer replacement projects that can be incorporated with PFP projects.

Additionally, these projects provide an opportunity to address less-urgent conveyance deficiencies in the City’s storm sewer system. The following reaches of storm sewer do not have adequate flow capacity to convey 5-year event runoff, but surcharged flow is conveyed in the street without widespread effects. Larger storm sewers should be considered along the following areas if the road is being repaired as part of the PFP program.

- Jacolyn Drive from Midway Drive NW to Gordon Avenue NW
- Wellesley Court NW and Rollingwood Drive NW
- Burch Avenue NW from 24th Street NW to 21st Street NW
- E Avenue NW from 22nd Street NW to Vinton Ditch Culvert
- Johnson Avenue NW from 18th Street NW to 17th St NW and 17th Street NW from Johnson Avenue NW to B Avenue NW
- I Avenue NW from 10th Street NW to 6th Street NW

6.5.2 Pollinator Initiative

The City, along with Linn County Conservation and the City of Marion, is committed to increasing pollinator habitat by 1,000 acres. The City of Cedar Rapids Parks and Recreation Department has identified 400 acres within the city that would be suitable for conversion from turf grass to wild flower and natural vegetation. Many of these areas are within drainage easements and detention basins. Several projects identified in this plan would include acquiring private land. The City may be able use the additional land to increase pollinator habitat. Table 26 shows projects and estimates an increase in available land that can be converted to pollinator habitat. Estimated habitat area does not include side slopes of excavated detention basins or of berms.
Table 26: Estimated Potential Increase in Available Land for Pollinator Initiative

<table>
<thead>
<tr>
<th>Project</th>
<th>Possible Additional Pollinator Habitat Area (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25th Street SW and 1st Avenue SW Detention Basin</td>
<td>0.7</td>
</tr>
<tr>
<td>Hagan’s 2nd Detention Basin Expansion</td>
<td>1.5</td>
</tr>
<tr>
<td>29th Street and F Avenue NW Detention Basin</td>
<td>0.7</td>
</tr>
<tr>
<td>12th Avenue and 31st Street SW Detention Basin</td>
<td>0.3</td>
</tr>
<tr>
<td>Cleveland Elementary School Basin</td>
<td>0.3</td>
</tr>
</tbody>
</table>

6.5.3 Ash Tree Removal

The city anticipates removing ash trees on city property in response to the invasive emerald ash borer. Upon removal, the city identified an opportunity to site planter-boxes, bio-swales, or other tree-based low-impact stormwater features in the locations of removed ash trees. Areas for potential application of this strategy would have the following characteristics:

- City-owned ash trees located near an existing storm sewer
- Downstream or local conveyance limitation
- Located in a location with roadway maintenance access.

Several areas in the E Avenue Basin exist with the basic characteristics that would make the area suitable for this application. These areas include:

- North of F Avenue between 13th Street NW and 3rd Street NW (PFP in 2018)
- C Avenue between 13th Street SW and 5th Street SW
- B Avenue between 18th Street SW and 15th Street SW
- Wellesley Ct NW
- 1st Avenue SW between Jacolyn Drive and Wiley Boulevard
- Autumn Woods Drive and Roxbury Drive
- 1st Avenue SW between Cherry Hill Road and Leroy Street
- Rich Mar Lane and Harbert Avenue

One of these areas (North of F Avenue between 13th Street NW and 3rd Street NW) have areas that will be reconstructed as part of the PFP program (F Ave NW from 13th St to Railroad Tracks, H Ave NW from Ellis Blvd to 10th St). This would be one area where a pilot project is feasible. The next steps in applying this strategy would include identifying a pilot study area and establishing criteria. Ideally, the pilot would be in a highly visible area to promote public interest and feedback. Runoff reduction and treatment goals would be set and monitored in the area. Construction and maintenance of these could be refined at the pilot-scale. This concept could be expanded throughout the City in similar locations where ash trees are planned to be removed. Figure 39 shows the locations of ash trees in the E Avenue basin.

Depending on the storm water BMP systems installed, maintenance of the system will vary. Bioswales, planted boxes, and rain gardens require regular cleaning and maintenance to remove fines and debris. Maintenance will also vary based on location-specific characteristics, such as
nearby land use, debris and sediment sources, and vegetation. Implementation of pilot studies will help determine proper maintenance of these systems.

A pilot could be funded through a number of programs, including community development block grant (CDBG) or state revolving fund (SRF) sources. The requirements for these and other programs will be discussed in the 2018 storm water masterplan update.

Adequate tree cover reduces the volume of runoff and slows flow accumulation during rain events. Prairie vegetation commonly found in rain gardens and bioswales does not mitigate the increase in runoff volume through evapotranspiration at the same rate as trees. Incorporating trees in green infrastructure retrofits is recommended for improved stormwater management. Additionally, the city can reduce runoff in private properties by encouraging private property owners to treat or replace ash trees as opposed to removing them.

Figure 39: Ash Tree Locations in the E Avenue Basin
7 Recommendations

7.1 Project Implementation

HDR and the City categorized projects into three priority tiers. These tiers do not necessarily dictate the order in which these projects should be completed. However, implementing these projects should follow a logical progression.

- Tier 1: Projects that are designated as Tier 1 have wide-spread benefits and impact the performance of the watershed significantly. Generally, the City should try to complete these projects first. If design constraints lead to major changes in the design of these facilities, Tier 2 and 3 project design considerations may change. For example, if the 29th Street and F Avenue NW Detention Basin cannot be constructed as planned, more substantial conveyance improvements may be required upstream.

- Tier 2: Project that are designated as Tier 2 have a significant local benefit and are still considered to have high urgency. These projects address local drainage concerns and will significantly reduce flood risk. A Tier 2 project should be accelerated if the property acquisitions and easements are readily available, funding is available, or if the project can be combined with another project.

- Tier 3: Projects that are designated as Tier 3 are enhancements to the overall watershed stormwater plan. These are seen as low-priority, non-critical projects that should be implemented once Tier 1 and Tier 2 projects have been completed. If there is an opportunity to implement these as part of another project or program (such as PFP), it would be reasonable to complete the project before Tier 1 and 2 projects are done.

7.2 Policy and Maintenance Considerations

7.2.1 Revise and Replace Flood Insurance Study and Flood Insurance Rate Maps for Vinton Ditch

The proposed stormwater system improvements projects in the E Avenue NW watershed reduce the existing flood risk along Vinton Ditch. The hydrologic methods used in the effective FIS cannot represent the reduced flood risk associated with upstream projects. Therefore, a more advanced hydrologic method that can estimate upstream storage and routing is required. More advanced hydraulic modeling, based on a high-quality terrain data set and using more robust bridge and culvert routines would improve floodplain mapping on Vinton Ditch and should be completed. A complete revision and replacement of the FIS on Vinton Ditch is recommended. Appendix E discusses the implications these projects have on the floodplain and the steps involved in filling a letter of map revision with FEMA.

7.2.2 Storm Inlet Design

Following the May 10, 2017, workshop, HDR completed a windshield survey through the E Avenue watershed. On this day, nearly 1 inch of rain fell. HDR estimated in several areas that canted/horseshoe style inlets captured less than 50 percent of flow in the gutter. The City has expressed that these inlets are generally problematic for snow removal crews as well. HDR
recommends that the City replace the horseshoe/canted inlet design with curb-cut or combination inlets with similar capacity when these structures are affected by roadway or storm sewer projects.

7.2.3 Televised Inspection of Major Sewers

The large box culverts along E Avenue NW and B Avenue NW have many sewers that connect to them with a blind tap (a connection without a manhole structure). Because there are no manholes above these connections, the condition of the storm sewer is difficult to monitor. Because there are open-channels upstream of these culverts, there is greater potential for debris to flow into and collect inside these culverts. These culverts convey significant flow during both the 5-year and 100-year events, and should be considered critical flood control infrastructure. The importance of these culverts warrants routine inspection. It is recommended that the City conduct a closed circuit televised inspection in the major sewers in the E Avenue NW Watershed to affirm current asset conditions.

7.3 Future Design Considerations

7.3.1 Model Utility for Preliminary and Final Design

The concepts presented in this report are developed at a planning level to inform the City’s capital improvements plan and should not be considered final designs. Further project development and design is required. The E Avenue NW watershed basin-scale model developed for this study can be used in the design process. For example, proposed conveyance improvements can be checked with the model to ensure they work as intended within the overall system or hydrographs from the model can be used in detailed pond/dam routing and design. However, the model is to be used as a tool and responsibilities for the design remain with the certifying professional engineer.

7.3.2 Project Impacts on Interior Drainage Design

Projects in the watershed may affect the CRFCS interior drainage design. Model results including upstream runoff calculations, flow routing, and model result can be shared with the CRFCS west side design team. The project engineer should evaluate the suitability of the model results for this application.

7.3.3 Limitations

Hydrologic and Hydraulic Analysis

HDR developed an integrated hydrologic and hydraulic model to facilitate planning-level analysis and decision making in the E Avenue watershed. The inputs and assumptions used to develop the model are described in Section 4. Section 5.1 discusses uncertainty in model results based on uncertainty in model inputs. Overall, the model was developed using available data to facilitate planning and develop a tool that can be refined as more data are available. Future climate change considerations were not incorporated in this analysis.

The conclusions and recommendations in this report are based on existing available data for the E Avenue watershed at the time of the study. Any modifications to the sites, man-made or natural, could alter the analysis, findings, and recommendations contained herein and could invalidate the analysis, findings, and recommendations. Site conditions, completion of upstream or downstream projects, upstream or downstream land use changes, climate changes, vegetation changes,
maintenance practice changes, or other factors may change over time. Additional analysis or updates may be required in the future as a result of these changes.

Cost Estimates

The opinion of probable project cost is based on the information available to the engineer at the time of writing this report, and on the basis of the engineer’s experience and qualifications, and represents their judgment as an experienced and qualified professional engineer. However, since the engineer has no control over the cost of labor, materials, equipment or services furnished by others, or over the contractor(s’) methods of determining prices, or over competitive bidding and market conditions, the engineer does not guarantee that proposals, bids, or actual project construction cost will not vary from opinions of probable cost the engineer prepares.
8 References


HDR. 2016. Stormwater Master Plan Technical Memorandum 3.1; City of Cedar Rapids. May.


