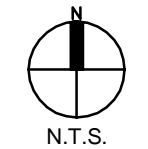


### IMPROVEMENT PRIORITIES

- 1A) ONSITE UDFCD DETENTION
- 1B) IMPROVED ONSITE CONVEYANCE ALONG SOUTH OF SITE
- 2A) DETENTION FACILITIES REGULATING OFFSITE FLOWS
- 2B) OFFSITE CONVEYANCE UPSIZING IMPROVEMENTS IN CROKE DR AND 103RD AVE
- 3A) DETENTION FACILITIES REGULATING OFFSITE FLOWS
- 3B) OFFSITE CONVEYANCE UPSIZING IMPROVEMENTS IN HURON ST
- 4) BOX CULVERT ACROSS HURON ST
- 5) STORM DRAIN FOR ONSITE AND THROUGH-SITE CONVEYANCE

### LEGEND

- PROPOSED LANDSCAPE AREA
- EXISTING/PROPOSED BUILDING
- EXISTING STORM DRAIN
- OVERALL PROPERTY LINE
- INTERIOR PROPERTY LINE



SCALE IN FEET  
100 0 100 200

DRAINAGE IMPROVEMENTS EXHIBIT  
MARCH 2016



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Conceptual Offsite Drainage Alternatives Memorandum  
Huron Promenade – West 104<sup>th</sup> Avenue & Huron Street



Prepared for:

Northglenn Urban Renewal Authority (NURA)

11701 Community Center Drive

Northglenn, Colorado 80233

Prepared By:

Kimley-Horn

4582 South Ulster Street

Suite 1500

Denver, CO 80237

**Kimley»»Horn**

KH Project Number 096508000

March 2016

Conceptual Offsite Drainage Alternatives Memorandum  
Huron Promenade – West 104<sup>th</sup> Avenue & Huron Street



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KH Project Number 096508000

March 2016

## DRAFT MEMORANDUM

To: Debbie Tuttle, NURA Executive Director  
From: Bryce Christensen, PE  
Matthew Steder, PE (CO, FL, NM, OK, TX)  
Date: March 8, 2016  
Subject: Huron Promenade – Conceptual Offsite Drainage Alternatives

### General Description

The Huron Promenade project area is located on the southwest corner of W. 104<sup>th</sup> Avenue and Huron Street in the City of Northglenn, Colorado. The area is bound by W. 104<sup>th</sup> Avenue to the north, an existing residential property to the south, Croke Drive to the west, and Huron Street to the east. Conceptual site redevelopment plans have been prepared for the Huron Promenade site.

Kimley-Horn and Associates, Inc. (Kimley-Horn) has been retained by the Northglenn Urban Renewal Authority (NURA) to review the South Outfall Drainage Study prepared by J&T Consulting, Inc. dated May 2009 (the “South Outfall Study”) to prioritize offsite improvements and alternatives to mitigate offsite drainage issues at and around Huron Promenade project. The purpose of this memorandum is to summarize these concept alternatives and prioritize these for further analysis.

### Data Collection and Review

The majority of the data collected for this project is from the South Outfall Study that identified multiple storm sewer improvements within the larger Grange Hall Creek drainage basin. The purpose of this study was to identify, analyze, and prioritize solutions to upgrade the storm drain systems immediately adjacent to the Huron Promenade site to improve the adjacent drainage conditions. As shown on the Delineation Exhibit in **Attachment F**, six subbasins were delineated in this study, with the majority of the project site located in Subbasin 51 identified in the South Outfall Study. The study determined existing and future conditions runoff for each subbasin, analyzed the existing storm drain system and developed recommendations including proposed drainage improvements for 104th Avenue, Huron Street, Croke Drive and 103rd Avenue. Peak runoff values and hydrographs determined for Subbasin 53, Subbasin 51, and Subbasin 45A were used in the analysis of alternate improvements around the Huron Promenade site.

Other studies reviewed include the Grange Hall Creek Watershed Major Drainageway Planning Study (February 1997) and the City Wide Drainage Study and Master Plan Update (July 2007)



## Drainage Concept Alternatives

Kimley-Horn reviewed five concept alternatives for potential mitigation of offsite drainage issues. The recommended drainage concept alternatives are shown below in order of priority. Prioritization of the concept alternatives is based on the ability to mitigate flooding and feasibility. Preliminary analysis of these alternatives is based on information in the South Outfall Study. A more detailed analysis will be needed in order to further define feasibility and estimate potential costs.

A more detailed summary of each concept is provided in its respective attachment. An exhibit showing these drainage concept alternatives is provided on Page 4.

### Priority 1

#### **Option 1A. Site Detention**

This option consists of improving the Huron Promenade onsite detention to the Urban Drainage Flood Control District (UDFCD) full spectrum detention standards over the ±10.45 acre site. This alternative comprises of onsite improvements only.

#### **Option 1B. Improved Onsite Conveyance**

This option includes constructing/improving conveyance along the south side of the building for areas that may not be able to be detained due to property area and grading constraints associated with keeping the existing buildings. This alternative is for onsite improvement conveyance only.

### Priority 2

#### **Option 2A. Detention Facilities Regulating Offsite Flows on West End of Site**

This option consists of providing detention basin(s) on the west side of the Huron Promenade site to mitigate offsite flows experienced through the site due to deficient offsite infrastructure. Providing detention would mitigate flooding downstream including Croke Drive, the southern portion of the site, the apartment buildings south of the site, Huron Street and the South Outfall channel. The feasibility of this option in lieu of Option 2B would require City and private developer agreement.

#### **Option 2B. Croke Drive and 103<sup>rd</sup> Avenue Storm Drain Improvements**

This option consists of improving the storm drain system in Croke Drive and W. 103<sup>rd</sup> Avenue per the South Outfall Study. Improving the storm drain system would also mitigate flooding downstream in the same locations as Option 2A

### Priority 3

#### **Option 3A. Detention Facilities Regulating Offsite Flows on North End of Site**

This option consists of providing a detention basin(s) on the north side of the Huron Promenade site to mitigate offsite flows. Doing so would help mitigate flooding at the intersection of 104<sup>th</sup> Avenue and Huron Street as well as downstream areas along Huron

Street and the South Outfall channel. The feasibility of this option in lieu of Option 3B would require City and private developer agreement.

### **Option 3B. 104<sup>th</sup> Avenue and Huron Street Storm Drain Improvements**

This option consists of improving the storm drain system from the north side of the site in 104<sup>th</sup> Avenue and Huron Street to South Outfall channel per the South Outfall Study. Doing so would also help mitigate flooding in the same locations as Option 3B.

### **Priority 4. Conveyance Across Huron Street**

This option consists of improving conveyance across Huron Street by adding a 125-ft-long 8-ft x 5-ft reinforced box culvert. This option would convey flows not captured by existing storm drains across Huron Street and into the South Outfall channel. Improvements will also be needed to existing drop inlets in Huron Street that will convey flows from Huron Street into the proposed box culvert.

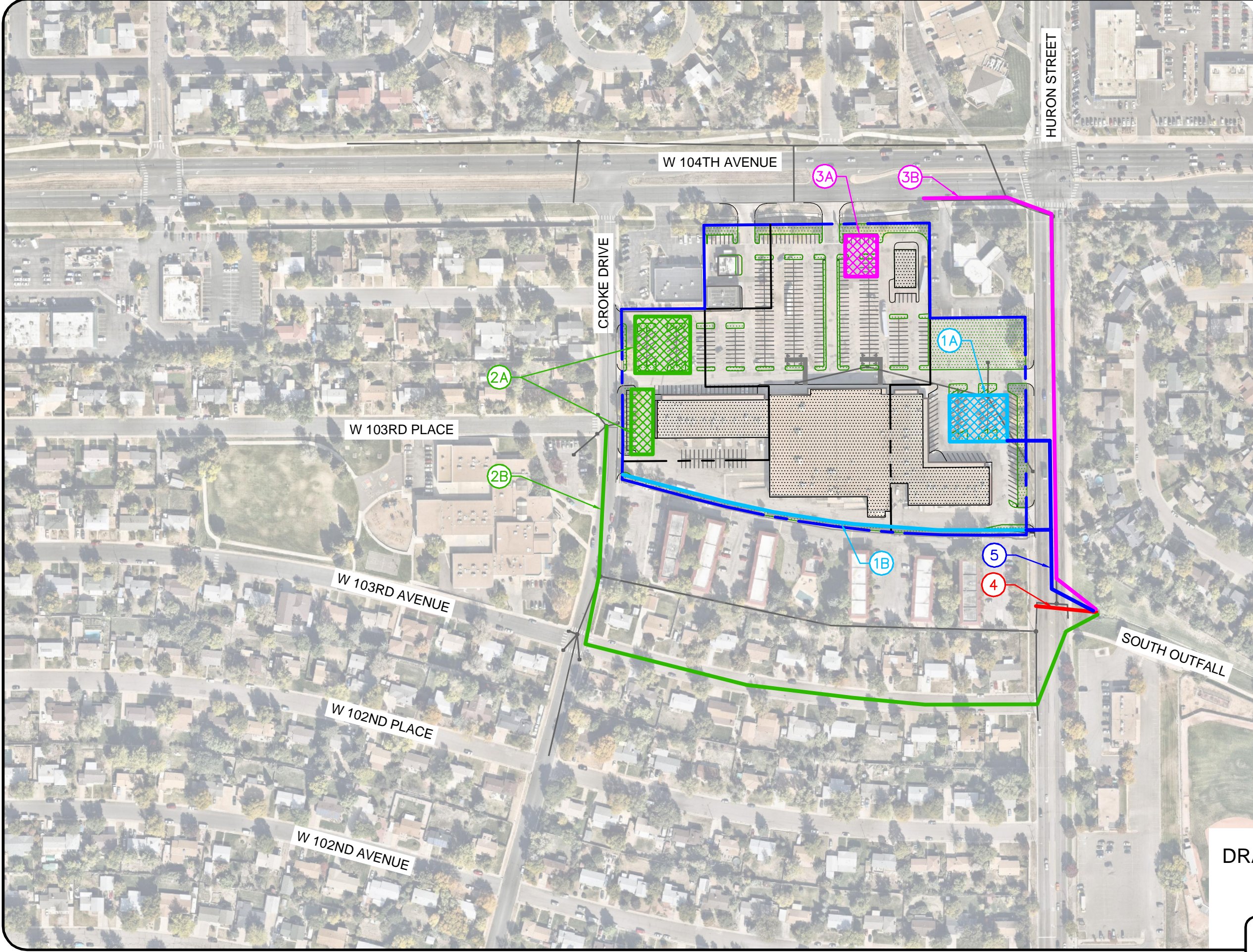
### **Priority 5. Piped Connection for Site Outfall to Huron Street**

This option consists of providing a 415-ft, 48-in reinforced concrete pipe (RCP) connection from the southeast corner of the Huron Promenade site across Huron Street and into the South Outfall channel. This storm drain would mitigate flooding in Huron Street. This would also replace the existing flume outfalls from the site and allow flows from Options 1A and 1B to be conveyed in a storm drain instead of Huron Street.

## **List of Attachments**

Attachment A	Priority 1
Attachment B	Priority 2
Attachment C	Priority 3
Attachment D	Priority 4
Attachment E	Priority 5
Attachment F	Subbasin Delineation Map



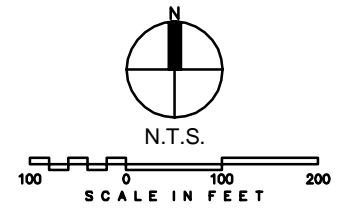


### IMPROVEMENT PRIORITIES

- 1A) ONSITE UDFCD DETENTION
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### LEGEND

- PROPOSED LANDSCAPE AREA
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DRAINAGE IMPROVEMENTS  
EXHIBIT  
MARCH 2016



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**Attachment A**

**Priority 1**



## Priority 1: Site Detention and Conveyance

### Option 1A

Option 1A consists of improving the Huron Promenade onsite detention to the Urban Drainage Flood Control District (UDFCD) full spectrum detention standards.

Site detention was determined using Equation 12-4 from the Urban Storm Drainage Criteria Manual (USDCM). Required 100-year detention for the 10.5 acre site was determined to be 1.6 ac-ft. The detention will mitigate flows in Huron Street. To determine ballpark flows effected by the detention, the hydrograph from Subbasin 51 of the South Outfall Study was altered to account for the site detention. Providing approximately 1.6 ac-ft of onsite detention will reduce peak flows to Huron Street from 530 cfs to approximately 405 cfs.

#### Advantages:

- Meets UDFCD criteria for the project site
- Mitigates flows from the site onto Huron Street

#### Disadvantages:

- Does not improve flooding on Croke Drive, project site or apartment complex.

### Option 1B

Option 1B includes constructing/improving conveyance along the south side of the site. This alternative comprises of onsite improvements only. To size the proposed swale/valley gutter, it was assumed that 72.9 acres of Subbasin 51 from the South Outfall Study is contributing to the site through-flow. This assumption was made based on existing topography. It was also assumed that existing storm drains capture the 2-year storm event. Flows from Subbasin 51 in the South Outfall Study were pro-rated based on these assumptions. The peak 100-year flow conveyed by the proposed valley gutter was determined to be 225 cfs, assuming onsite flows will be detained and not contributing. The proposed swale will have 3:1 side slopes and have a width of 10 feet and the gutter will have 6:1 side slopes and a width of 10 feet. In areas where space is not available between the site boundary and building, underground conveyance will be needed. The swale/gutter was sized in FlowMaster assuming an existing slope of 2.2%.

#### Advantages:

- Improved conveyance on the south side of the site will convey flows through the site in a controlled manner

#### Disadvantages:

- Very limited space in the southern portion of the site between the existing buildings and the property boundary. Portions of the valley gutter may require underground pipe.

- Relatively high velocities during major storms



Project **Huron Promenade - 104th Avenue & Huron Street Drainage Alternatives**

Subject **Option 1A - Site Detention per Urban Drainage Flood Control District (UDFCD) Requirements**

Designed by **AJV**

Date 3/3/2016

Project No. 096508000

Checked by **AOM**

Date 3/4/2016

**Objective:** To determine onsite detention volume required per UDFCD and the effects onsite detention has on Subbasin 51 flows

Required Detention Volume per UDFCD							
One-hour Rainfall Depth for 100-year Storm <sup>1</sup> [inches]	Site Area [acres]	Percentage of NRCS Soil Type A <sup>2</sup> [%]	Percentage of NRCS Soil Type B <sup>2</sup> [%]	Percentage of NRCS Soil Type CD <sup>2</sup> [%]	Impervious Ratio <sup>3</sup>	Detention Volume [in] <sup>4</sup>	Detention Volume [ac-ft]
2.65	10.5	0	0	100	0.95	1.8	1.6

Notes:

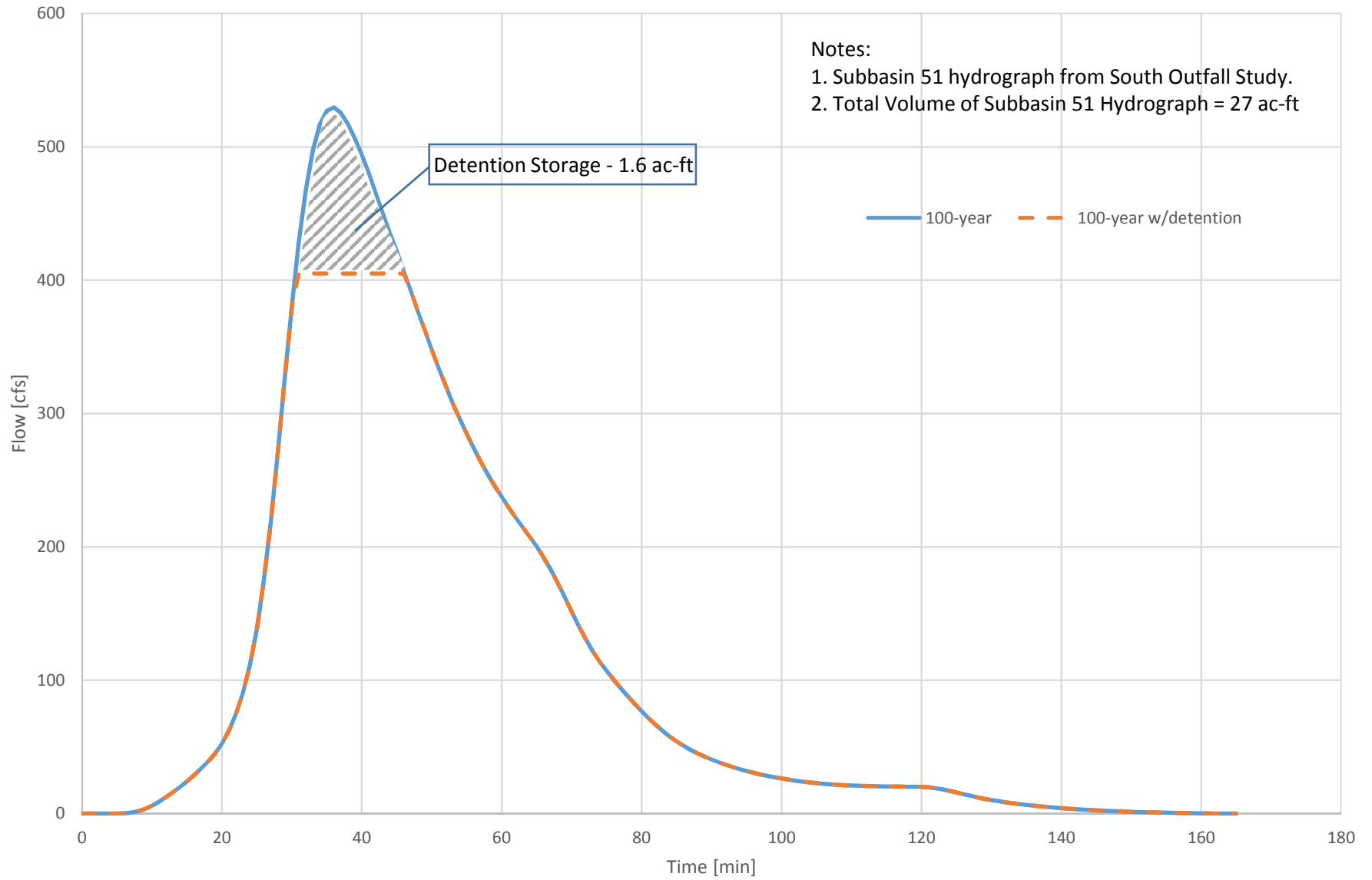
1. Determined from Figure 5-6 of UDFCD Urban Storm Drainage Criteria Manual (USDCM) Volume 1. See attached.
2. Determined from Natural Resources Conservation Service Web Soil Survey. See attached.
3. Determined from Table 6-3 of USDCM Volume 1. See attached.
4. Determined with Equation 12-4 from USDCM Volume 2. See attached.

Peak Flows from Subbasin 51 Hydrograph <sup>A</sup>	
Q <sub>100</sub> without Detention [cfs]	Q <sub>100</sub> with Detention [cfs]
530	405

Notes:

- A. See attached graph for hydrograph of Subbasin 51

Option 1A: 100-year Flow for Subbasin 51





Project **Huron Promenade - 104th Avenue & Huron Street Drainage Alternatives**

Subject **Option 1B -Conveyance on South Side of Huron Promenade Site**

Designed by **AJV**

Date 3/3/2016

Project No. 096508000

Checked by **AOM**

Date 3/4/2016

**Objective:** To determine alternative for conveyance on south side of Huron Promenade site.

Flow Table to Size Conveyance Channel						
Location	Comment	Area [acres]	Q <sub>2</sub> [cfs]	Q <sub>100</sub> [cfs]	Unit Q <sub>2</sub> [cfs/ac]	Unit Q <sub>100</sub> [cfs/ac]
Subbasin 51	From South Outfall Study	139.59	100	530	0.72	3.80
Southeast Corner of Huron Promenade Site	Pro-rated based on contributing area to that point and Subbasin 51	72.9	52	277	-	-
Overland Flow at Southeast Corner of Huron Promenade Site	Assumed storm drain system in 103rd Ave will convey 2-year storm per South Outfall Study. Removed pro-rated 2-year flow from 10 & 100-year storm to determine flow through site. Assumed all onsite flows will be detained.	72.9	0	225	-	-

Design Flow <sup>1</sup> [cfs]	Channel Size <sup>2</sup>
225	20 ft wide, 1.6 ft deep

Notes:

A. Overland flow at Croke Drive and Huron Promenade Site

B. Channel sized in FlowMaster based on V-channel with 6:1 slopes. See attached FlowMaster calculations.

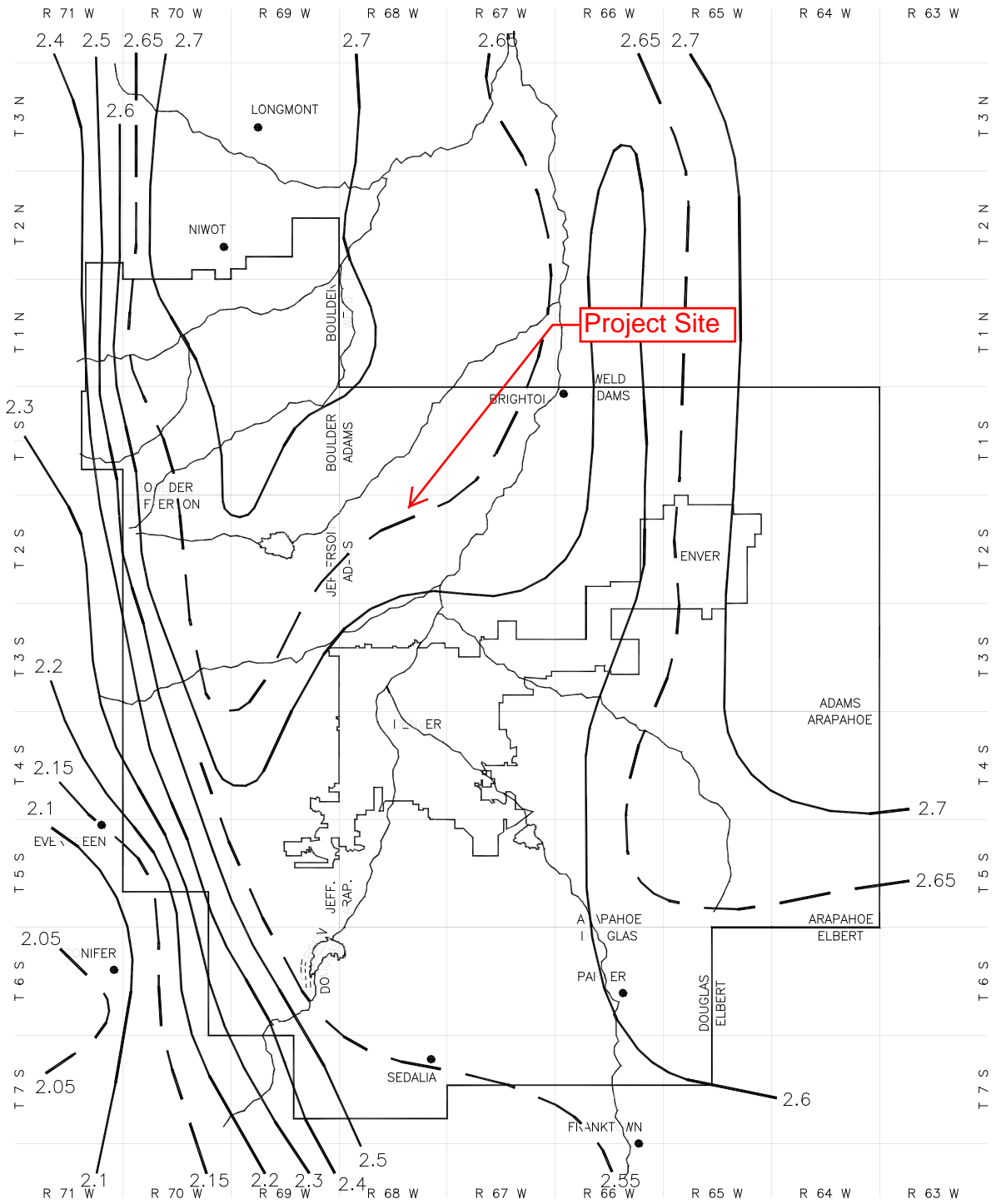
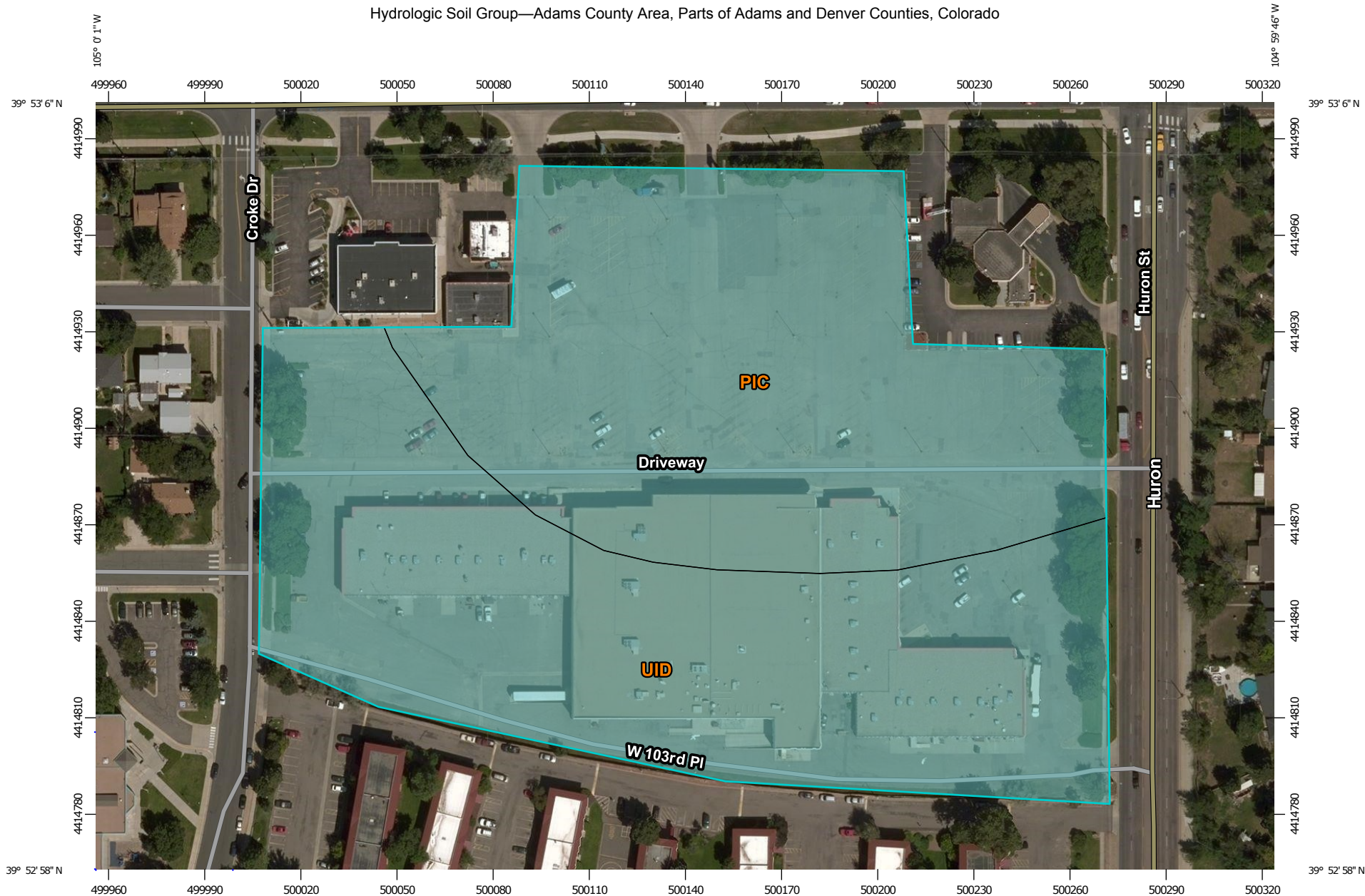


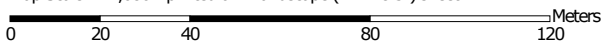
Figure 5-6. Rainfall depth-duration-frequency: 100-year, 1-hour rainfall



Hydrologic Soil Group—Adams County Area, Parts of Adams and Denver Counties, Colorado



Map Scale: 1:1,680 if printed on A landscape (11" x 8.5") sheet.




Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84



## MAP LEGEND

### Area of Interest (AOI)









 Area of Interest (AOI)

### Soils

#### Soil Rating Polygons





 A  
 A/D  
 B  
 B/D  
 C  
 C/D  
 D  
 Not rated or not available

#### Soil Rating Lines


 A  
 A/D  
 B  
 B/D  
 C  
 C/D  
 D  
 Not rated or not available

#### Soil Rating Points






 A  
 A/D  
 B  
 B/D

 C  
 C/D  
 D  
 Not rated or not available


### Water Features

 Streams and Canals

### Transportation

 Rails  
 Interstate Highways  
 US Routes  
 Major Roads  
 Local Roads

### Background

 Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service  
 Web Soil Survey URL: <http://websoilsurvey.nrcs.usda.gov>  
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Adams County Area, Parts of Adams and Denver Counties, Colorado  
 Survey Area Data: Version 12, Sep 22, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 30, 2014—Sep 18, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

## Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Adams County Area, Parts of Adams and Denver Counties, Colorado (CO001)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
PIC	Platner loam, 3 to 5 percent slopes	C	4.9	48.6%
UID	Ulm loam, 5 to 9 percent slopes	C	5.2	51.4%
<b>Totals for Area of Interest</b>			<b>10.2</b>	<b>100.0%</b>

### Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.



## Rating Options

*Aggregation Method:* Dominant Condition

*Component Percent Cutoff:* None Specified

*Tie-break Rule:* Higher

**Table 6-3. Recommended percentage imperviousness values**

Land Use or Surface Characteristics	Percentage Imperviousness (%)
<b>Business:</b>	
Downtown Areas	95
Suburban Areas	75
<b>Residential:</b>	
Single-family	
2.5 acres or larger	12
0.75 – 2.5 acres	20
0.25 – 0.75 acres	30
0.25 acres or less	45
Apartments	75
<b>Industrial:</b>	
Light areas	80
Heavy areas	90
<b>Parks, cemeteries</b>	10
<b>Playgrounds</b>	25
<b>Schools</b>	55
<b>Railroad yard areas</b>	50
<b>Undeveloped Areas:</b>	
Historic flow analysis	2
Greenbelts, agricultural	2
Off-site flow analysis (when land use not defined)	45
<b>Streets:</b>	
Paved	100
Gravel (packed)	40
Drive and walks	90
Roofs	90
Lawns, sandy soil	2
Lawns, clayey soil	2

Within the ranges identified in Table 12-5, these volumes may be determined using simplified equations, as described below.

**WQCV.** The water quality capture volume for each of the five types of water quality facilities shown in Section 3.4 can be calculated based on the procedures described in Volume 3 of the USDCM.

**EURV.** Equations 12-1, 2 and 3 may be used to find EURV in watershed inches for specific soil types.

$$\text{EURV}_A = 1.68i^{1.28} \quad \text{Equation 12-1}$$

$$\text{EURV}_B = 1.36i^{1.08} \quad \text{Equation 12-2}$$

$$\text{EURV}_{CD} = 1.20i^{1.08} \quad \text{Equation 12-3}$$

Where:

$\text{EURV}_K$  = Excess urban runoff volume in watershed inches ( $K$  indicates NRCS soils type),  
 $i$  = Imperviousness ratio (a decimal less than or equal to 1)

The derivation of these equations is documented in a Technical Memorandum entitled *Determination of the EURV for Full Spectrum Detention Design*, dated March 23, 2015. This is available at [www.udfcd.org](http://www.udfcd.org). Apply the equations above for each of the soil types found in the watershed and then calculate a weighted average value based on the relative area proportion of each soil type. Convert the EURV in watershed inches to a volume multiplying it by the watershed area.

Whenever NRCS soil surveys are not available for a catchment area, soils investigations are recommended to estimate equivalent soil type.

**100-Year Volume.** A simplified equation can be used to determine the required 100-year full spectrum detention volume for tributary areas less than 10 acres. This volume includes the EURV (and the EURV includes the WQCV). UDFCD does not recommend adding additional volume above that provided in Equation 12-4. The derivation of this equation is documented in a Technical Memorandum entitled *Estimation of Runoff and Storage Volumes for Use with Full Spectrum Detention*, dated March 26, 2015 (available at [www.udfcd.org](http://www.udfcd.org)). If a more detailed analysis is desired, see Table 12-5. The 100-year volume in watershed inches is converted to cubic feet or acre-feet by multiplying by watershed area and converting units.

$$V_{100} = P_1 \left[ \begin{aligned} &(0.728i^{1.258} + 0.150i^{0.258})A\% + (0.364i^{1.286} + 0.381i^{0.286})B\% \\ &+ (0.306i^{1.286} + 0.402i^{0.286})CD\% \end{aligned} \right] \quad \text{Equation 12-4}$$

Where:

$V_{100}$  = detention volume in watershed inches

$P_1$  = one-hour rainfall depth (inches)

$i$  = imperviousness ratio (a decimal less than or equal to 1)

$A\%$ ,  $B\%$ , and  $CD\%$  = indicates percentage of each NRCS soils type (expressed as a decimal)

## Worksheet for Option 1B

### Project Description

Friction Method                      Manning Formula  
 Solve For                              Normal Depth

### Input Data

Channel Slope    0.02200    ft/ft  
 Discharge    225.00    ft<sup>3</sup>/s  
 Section Definitions

Station (ft)	Elevation (ft)
0+00	3.33
0+00	1.66
0+05	0.00
0+10	1.66
0+20	3.33

### Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 3.33)	(0+10, 1.66)	0.033
(0+10, 1.66)	(0+20, 3.33)	0.013

### Options

Current Roughness Weighted Method              Pavlovskii's Method  
 Open Channel Weighting Method                  Pavlovskii's Method  
 Closed Channel Weighting Method                Pavlovskii's Method

### Results

Normal Depth    2.81    ft  
 Elevation Range                                        0.00 to 3.33 ft  
 Flow Area    23.74    ft<sup>2</sup>  
 Wetted Perimeter                                        18.66    ft  
 Hydraulic Radius                                        1.27    ft  
 Top Width    16.88    ft  
 Normal Depth    2.81    ft



---

## Worksheet for Option 1B

---

### Results

Critical Depth	3.22	ft
Critical Slope	0.01071	ft/ft
Velocity	9.48	ft/s
Velocity Head	1.40	ft
Specific Energy	4.21	ft
Froude Number	1.41	
Flow Type	Supercritical	

### GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

### GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.81	ft
Critical Depth	3.22	ft
Channel Slope	0.02200	ft/ft
Critical Slope	0.01071	ft/ft

---

## Cross Section for Option 1B

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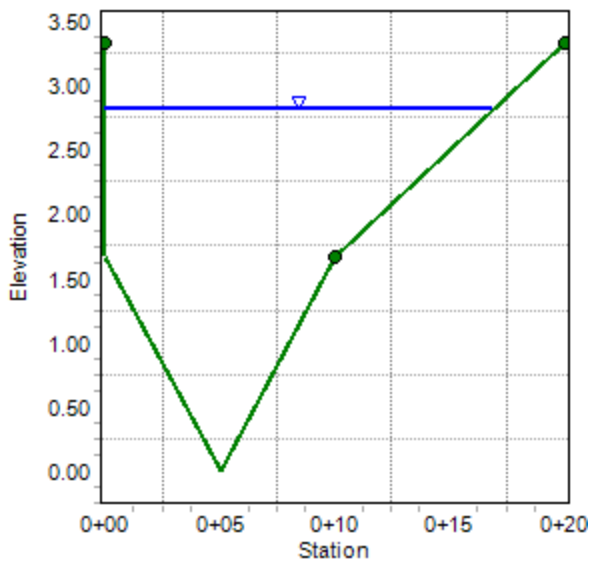
### Project Description

Friction Method                      Manning Formula  
Solve For                                Normal Depth

### Input Data

Channel Slope	0.02200	ft/ft
Normal Depth	2.81	ft
Discharge	225.00	ft <sup>3</sup> /s

### Cross Section Image



**Attachment B**

**Priority 2**

## Priority 2: Croke Drive and 103<sup>rd</sup> Avenue Storm Drain Improvements or Offsite Detention at West End of Site

### Option 2A: Offsite Detention at West End of Site

Option 2A consists of providing two offsite detention basins on the west side of the Huron Promenade site. This alternative will capture and detain approximately 2.3 acre-feet (ac-ft) of offsite flow at the southwest corner of the site. Providing detention would reduce offsite flow, which would ultimately mitigate flooding downstream including Croke Drive, the southern portion of the site, the apartment buildings south of the site, Huron Street and the South Outfall channel.

To determine ballpark flows, the hydrograph from Subbasin 51 of the South Outfall Study was pro-rated based on the contributing drainage area of 72.9 acres to Croke Drive on the west side of the site. Underground detention basins were conceptually located on the west side of the site, and a depth of five feet for each basin was assumed. Providing approximately 2.3 ac-ft of detention for offsite flows in the area could potentially reduce peak flows in the existing Croke Drive storm drain system from 277 cfs to as little as approximately 160 cfs.

#### Advantages:

- Mitigation of flooding in Croke Drive, the southern portion of the site, the apartment complex south of the site, Huron Street and the South Outfall Channel.
- Accounts for the 4.5 acre area on the Huron Promenade site that cannot be captured for detention

#### Disadvantages:

- Possible utility conflicts
- Underground retention may not be desirable

### Option 2B: Croke Drive and 103<sup>rd</sup> Avenue Storm Drain Improvements

Option 2B consists of improving the storm drain system in Croke Drive and 103<sup>rd</sup> Avenue to convey the 10-year or 100-year storm. Per the South Outfall Study, improving the storm drain in Croke Drive and 103<sup>rd</sup> Avenue to convey the 100-year storm would consist of 184 ft of 96-in x 72-in box culvert, 1048 ft of 96-in x 60-in box culvert, and 433 ft of 60-in pipeline. Improving this section to the 10-year storm would consist of 254 ft of 60-in x 48-in box culvert, 978 ft of 48-in pipeline, and 433 ft of 36-in pipeline.

#### Advantages:

- Mitigation of flooding in Croke Drive, the southern portion of the site, the apartment complex south of the site, Huron Street and the South Outfall Channel.



**Disadvantages:**

- Possible utility conflicts

Project **Huron Promenade - 104th Avenue & Huron Street Drainage Alternatives**

Subject **Option 2A - Offsite Detention on West Side of Site**

Designed by **AJV**

Date 3/3/2016

Project No. 096508000

Checked by **AOM**

Date 3/4/2016

**Objective:** To determine how detention on the west side of the Huron Promenade site will effect flows in Croke Drive

Flow Table						
Location	Comment	Area [acres]	Q <sub>100</sub> [cfs]	V <sub>100</sub> [ac-ft]	Unit Q <sub>100</sub> [cfs/ac]	Unit V <sub>100</sub> [ac-ft/ac]
Subbasin 51	From South Outfall Study	139.59	530	25.7	3.80	0.18
Croke Drive & Huron Promenade Site	Pro-rated based on contributing area to that point and Subbasin 51	72.9	277	13	-	-

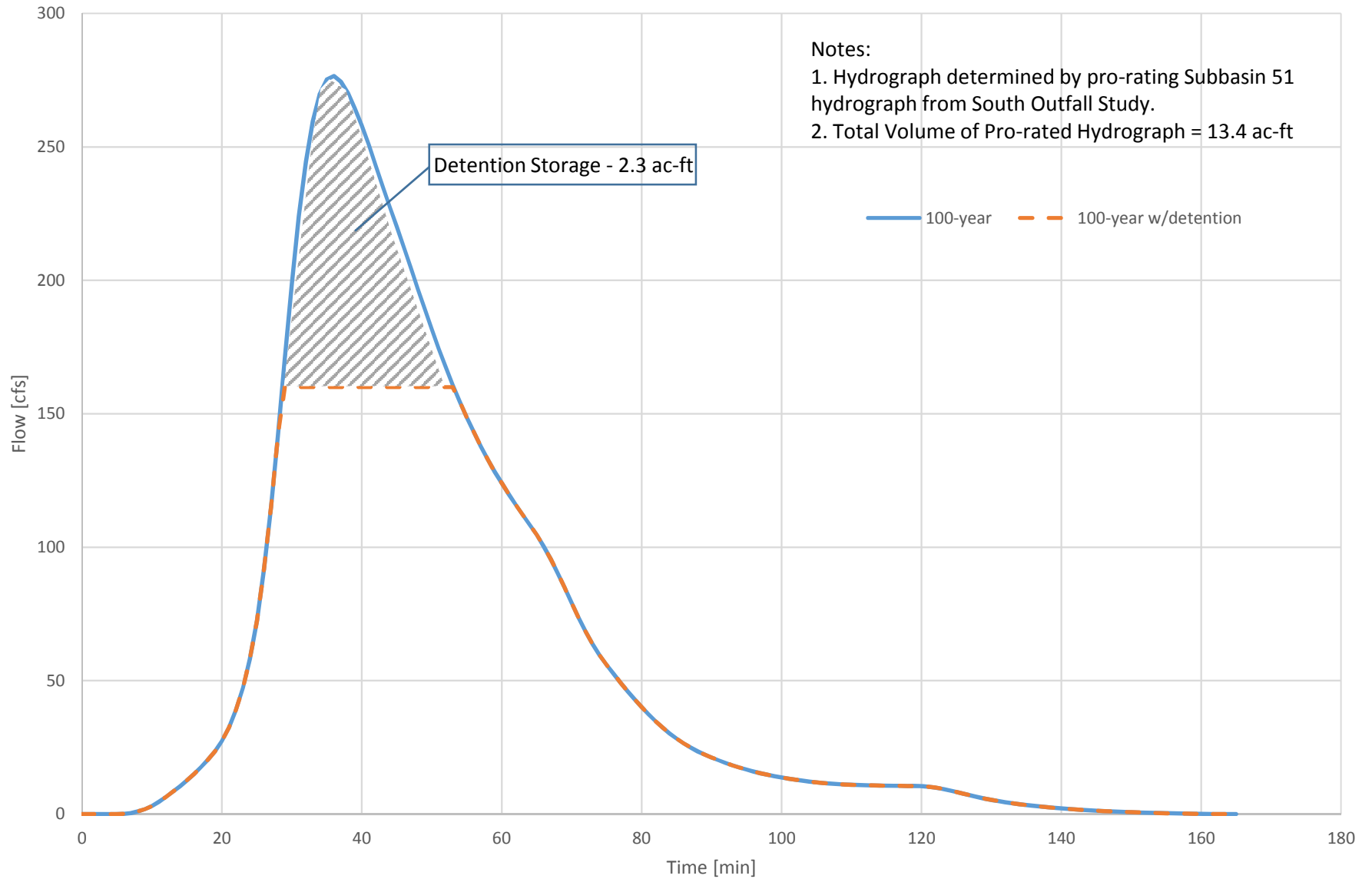
Detention Basin Design	
5-ft Deep Basin <sup>1</sup>	Storage Provided [ac-ft]
North Basin	1.5
South Basin	0.8
Total	2.3

Peak Flows from Subbasin 51 Hydrograph <sup>2</sup>	
Q <sub>100</sub> without Detention [cfs]	Q <sub>100</sub> with Detention [cfs]
277	160

Notes:

1. Location and size of basins assumed from Conceptual Plans
2. See attached graph for pro-rated hydrograph of Subbasin 51

Option 2A: 100-year Pro-rated Flow at Croke Drive and Huron Promenade site



**Attachment C**

**Priority 3**

## Priority 3: Offsite Detention at North End of Site or Storm Drain Improvement to 104<sup>th</sup> Ave and Huron St

### Option 3A

Option 3A consists of providing an offsite detention basin on the north side of the Huron Promenade site. This alternative will capture and detain approximately 0.7 acre-feet of offsite flow at the north side of the site. Doing so would help mitigate flooding at the intersection 104<sup>th</sup> Avenue and Huron St as well as downstream areas along Huron St and the South Outfall channel.

To determine ballpark flows, the hydrograph from Subbasin 53 of the South Outfall Study was combined with the hydrograph of Subbasin 45A. The hydrograph for Subbasin 45A was developed by pro-rating Subbasin 53 to the 12 acres of Subbasin 45A. The hydrographs were combined and it was assumed that existing storm drains capture the 2-year storm event. The combined hydrograph was reduced based on this assumption. Underground detention basins were conceptually located on the north side of the site, and a depth of five feet for each basin was assumed. Providing approximately 0.7 ac-ft of detention for offsite flows in the area could reduce overland peak flows to the intersection of Huron Street and 104<sup>th</sup> Avenue from 410 cfs to approximately 340 cfs.

### Advantages:

- Mitigates flooding in the intersection of Huron Street and 104<sup>th</sup> Avenue as well as downstream areas along Huron St and the South Outfall Channel
- Helps account for the 4.5 acre area on the Huron Promenade Site that cannot be captured for detention

### Disadvantages:

- Underground retention may not be desirable

### Option 3B

Option 3B consists of improving the storm drain system from the north side of the site in 104<sup>th</sup> Avenue and Huron Street to the South Outfall Channel. Per the South Outfall Study, improving the storm drain in 104<sup>th</sup> Avenue and Huron Street from the site to the South Outfall Channel to convey the 100-year storm consists of 963 ft of 120-in x 72-in box culvert and 180 ft of 96-in x 48-in pipeline. Improving this to convey the 10-year storm consists of 164 ft of 96-in x 60-in of box culvert, 799 ft of 72-in x 60-in box culvert, and 180 ft of 60-in pipeline.

### Advantages:



- Mitigates flooding in the intersection of Huron Street and 104<sup>th</sup> Avenue as well as downstream areas along Huron St and the South Outfall Channel

**Disadvantages:**

- Possible utility conflicts

Project **Huron Promenade - 104th Avenue & Huron Street Drainage Alternatives**

Subject **Option 3A - Offsite Detention on North Side of Huron Promenade Site**

Designed by **AJV**

Date 3/3/2016

Project No. 096508000

Checked by **AOM**

Date 3/4/2016

**Objective:** To determine how detention on the north side of the Huron Promenade site will effect flows at 104th Ave and Huron St.

Flow Table								
Location	Comment	Area [acres]	Q <sub>2</sub> [cfs]	Q <sub>100</sub> [cfs]	V <sub>100</sub> [ac-ft]	Unit Q <sub>2</sub> [cfs/ac]	Unit Q <sub>100</sub> [cfs/ac]	Unit V <sub>100</sub> [ac-ft/ac]
Subbasin 53	From South Outfall Study	139.59	100	530	25.7	0.72	3.80	0.18
Subbasin 45a	From South Outfall Study	11.96	16	48	-	-	-	-

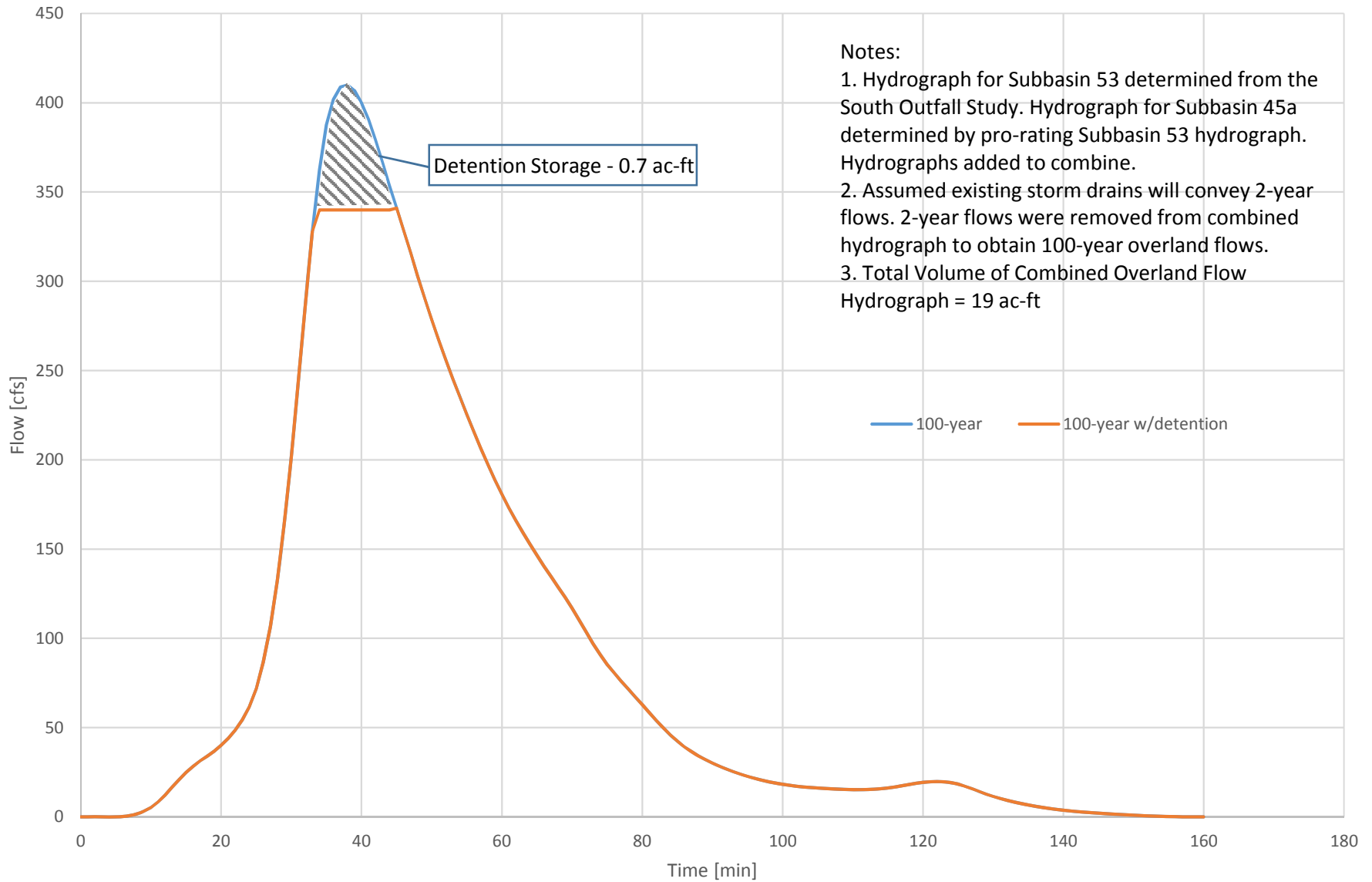
Detention Basin Design	
5-ft Deep Basin <sup>1</sup>	Storage Provided [ac-ft]
North Basin	0.7
Total	0.7

Peak Flows from Combined Hydrographs for Subbasins 45a & 51 <sup>2</sup>	
Q <sub>100</sub> without Detention <sup>3</sup> [cfs]	Q <sub>100</sub> with Detention <sup>3</sup> [cfs]
410	340

Notes:

1. Location and size of basin assumed from Conceptual Plans
2. See attached graph for combined hydrograph. Subbasin 53 hydrograph was determined from South Outfall Study. Subbasin 45a hydrograph was pro-rated based on Hydrograph 53.
3. It was assumed existing storm drains have capacity for 2-year storm. 2-year storm flows were removed from combined hydrographs.

Option 3A: 100-year Overland Flow for Combined Subbasin 45a & 53



Notes:

1. Hydrograph for Subbasin 53 determined from the South Outfall Study. Hydrograph for Subbasin 45a determined by pro-rating Subbasin 53 hydrograph. Hydrographs added to combine.
2. Assumed existing storm drains will convey 2-year flows. 2-year flows were removed from combined hydrograph to obtain 100-year overland flows.
3. Total Volume of Combined Overland Flow Hydrograph = 19 ac-ft

— 100-year — 100-year w/detention

**Attachment D**

**Priority 4**

**Priority 4: Conveyance Across Huron Street**

Option 4 consists of improving conveyance across Huron Street by adding a 125-ft-long 8-ft x 5-ft reinforced box culvert. This option would convey flows not captured by existing storm drains across Huron Street and into the South Outfall Channel. Improvements will also be needed to existing drop inlets in Huron Street that will convey flows from Huron Street into the proposed box culvert.

To size the proposed box culvert, it was assumed that existing storm drains capture the 2-year storm event, as stated in the South Outfall Study. Flows from J2 in the South Outfall Study were pro-rated based on this assumption. The peak 100-year flow conveyed by the proposed culvert was determined to be 441 cubic feet per second (cfs). The box culvert was sized in FlowMaster assuming a slope of 0.5

**Advantages:**

- Mitigates flooding at Huron Street and the South Outfall Channel

**Disadvantages:**

- Does not address flooding across the site and at 104<sup>th</sup> Avenue
- Storm drains in 104<sup>th</sup> Avenue and 103<sup>rd</sup> Avenue will still be undersized for 100-year event and will not alleviate street flooding
- Potential for utility conflicts in Huron Street
- Relatively high cost



Project **Huron Promenade - 104th Avenue & Huron Street Drainage Alternatives**

Subject **Option 4 - Conveyance Across Huron Street**

Designed by **AJV**

Date 3/3/2016

Project No. 096508000

Checked by **AOM**

Date 3/4/2016

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**Objective:** To determine box culvert size for conveying flows in Huron Street to South Outfall Channel.

Flow Table (Flows from South Outfall Study)					
Location	Area [acres]	Q <sub>2</sub> [cfs]	Q <sub>100</sub> [cfs]	Unit Q <sub>2</sub> [cfs/ac]	Unit Q <sub>100</sub> [cfs/ac]
J2 (South Outfall)	-	184	625	-	-

Design Flow <sup>1</sup> [cfs]	Pipe size <sup>2</sup>
441	8' x 5' box culvert

Notes:

1. Assumed existing storm drain will convey 2-year storm per the South Outfall Study.
2. Box culvert sized in FlowMaster. See attached FlowMaster calculations.

---

## Worksheet for Option 4

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### Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

### Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00500	ft/ft
Height	5.00	ft
Bottom Width	8.00	ft
Discharge	441.00	ft <sup>3</sup> /s

### Results

Normal Depth	4.22	ft
Flow Area	33.77	ft <sup>2</sup>
Wetted Perimeter	16.44	ft
Hydraulic Radius	2.05	ft
Top Width	8.00	ft
Critical Depth	4.55	ft
Percent Full	84.4	%
Critical Slope	0.00409	ft/ft
Velocity	13.06	ft/s
Velocity Head	2.65	ft
Specific Energy	6.87	ft
Froude Number	1.12	
Discharge Full	430.85	ft <sup>3</sup> /s
Slope Full	0.00477	ft/ft
Flow Type	Supercritical	

### GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

### GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	84.42	%
Downstream Velocity	Infinity	ft/s

---

## Worksheet for Option 4

---

### GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	4.22	ft
Critical Depth	4.55	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.00409	ft/ft

### Messages

#### Notes

Concrete box culvert.  
Invert in = 13.3  
Invert out = 12.7  
Length = 125 ft  
Assumed Slope = 0.005  
Flow prorated = 441 cfs

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## Cross Section for Option 4

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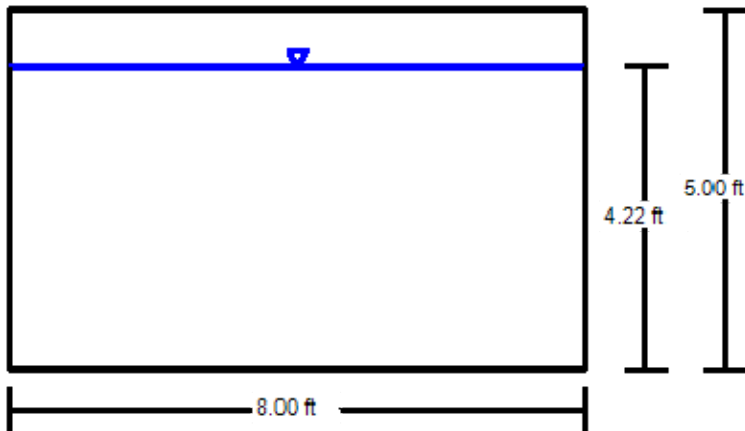
### Project Description


Friction Method                      Manning Formula  
Solve For                                Normal Depth

### Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00500	ft/ft
Normal Depth	4.22	ft
Height	5.00	ft
Bottom Width	8.00	ft
Discharge	441.00	ft <sup>3</sup> /s

### Cross Section Image



V: 1   
H: 1



**Attachment E**

**Priority 5**

**Priority 5: Piped Connection for Site Outfall to Huron Street**

Option 5 consists of providing a 240-ft, 48-in reinforced concrete pipe (RCP) connection from the southeast corner of the Huron Promenade site across Huron Street and into the South Outfall Channel. This storm drain would convey onsite flows and through-site flows across Huron Street, mitigating flooding in Huron Street. This would also replace the existing flume outfalls from the site.

To size the proposed storm drain, it was assumed that 72.9 acres of Subbasin 51 from the South Outfall Study is contributing to the site through-flow. This assumption was made based on existing topography. It was also assumed that existing storm drains capture the 2-year storm event. Flows from Subbasin 51 in the South Outfall Study were pro-rated based on these assumptions. Flows from the Huron Promenade site were also determined by pro-rating Subbasin 51 to the contributing 8.6 acres of the south side of the site. Pro-rated flows were combined and the peak 100-year flow conveyed by the proposed RCP was determined to be 257 cfs. The RCP was sized in FlowMaster assuming a slope of 0.5%.

**Advantages:**

- Improve flooding in Huron Street.
- Replace existing flume outfalls in Huron Street.
- Allow flows from Options 1A and 1B to be conveyed in a storm drain instead of Huron Street.

**Disadvantages:**

- Does not improve flooding on Croke Drive, project site or apartment complex.
- Relatively high cost
- Potential utility conflicts

Project **Huron Promenade - 104th Avenue & Huron Street Drainage Alternatives**

Subject **Option 5 - Piped Connection Across Huron for Flows Through Site**

Designed by **AJV**

Date 3/3/2016

Project No. 096508000

Checked by **AOM**

Date 3/4/2016

**Objective:** To determine the size of the piped connection needed to convey onsite and through-site flows across Huron Street.

Flows						
Location	Comment	Area [acres]	Q <sub>2</sub> [cfs]	Q <sub>100</sub> [cfs]	Unit Q <sub>2</sub> [cfs/ac]	Unit Q <sub>100</sub> [cfs/ac]
Subbasin 51	Flows from South Outfall Study	139.59	100	530	0.72	3.80
Croke Drive and Huron Promenade Site	Flows west of Croker Drive being conveyed through site. Pro-rated based on Subbasin 51.	72.9	52	277	-	-
Overland Flow at Croke Drive and Huron Promenade Site	Assumed storm drain system in 103rd Ave will convey 2-year storm per South Outfall Study. Removed pro-rated 2-year flow from 10 & 100-year storm to determine flow through site.	72.9	0	225	-	-
Onsite Flow	Portion of Huron Promenade site flowing south. Pro-rated from Subbasin 51	8.55	6	32	-	-

Design Flow <sup>1</sup> [cfs]	Pipe size <sup>2</sup>
257	48" RCP

**Notes:**

1. Design flow determined by combining overland flow at Croke Drive and Huron Promenade site and Onsite Flow
2. RCP sized in FlowMaster. See attached FlowMaster calculations.

---

## Worksheet for Option 5

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### Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

### Input Data

Roughness Coefficient	0.013	
Channel Slope	0.05000	ft/ft
Diameter	4.00	ft
Discharge	257.00	ft <sup>3</sup> /s

### Results

Normal Depth	2.71	ft
Flow Area	9.05	ft <sup>2</sup>
Wetted Perimeter	7.73	ft
Hydraulic Radius	1.17	ft
Top Width	3.74	ft
Critical Depth	3.94	ft
Percent Full	67.7	%
Critical Slope	0.02906	ft/ft
Velocity	28.40	ft/s
Velocity Head	12.53	ft
Specific Energy	15.24	ft
Froude Number	3.22	
Maximum Discharge	345.49	ft <sup>3</sup> /s
Discharge Full	321.18	ft <sup>3</sup> /s
Slope Full	0.03201	ft/ft
Flow Type	SuperCritical	

### GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

### GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	67.67	%
Downstream Velocity	Infinity	ft/s



---

## Worksheet for Option 5

---

### GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	2.71	ft
Critical Depth	3.94	ft
Channel Slope	0.05000	ft/ft
Critical Slope	0.02906	ft/ft

### Messages

Notes

RCP  
Assumed Slope = 0.005  
Pro-rated Flow = 257 cfs

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## Cross Section for Option 5

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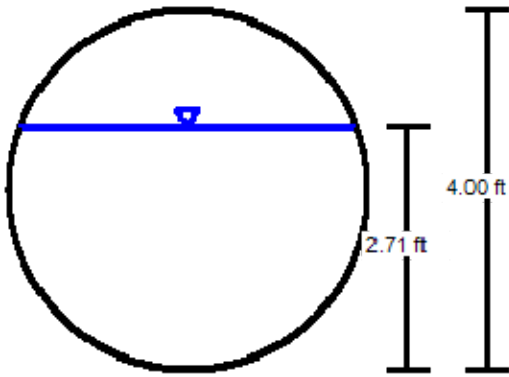
### Project Description


Friction Method	Manning Formula
Solve For	Normal Depth

### Input Data

Roughness Coefficient	0.013
Channel Slope	0.05000 ft/ft
Normal Depth	2.71 ft
Diameter	4.00 ft
Discharge	257.00 ft <sup>3</sup> /s

### Cross Section Image

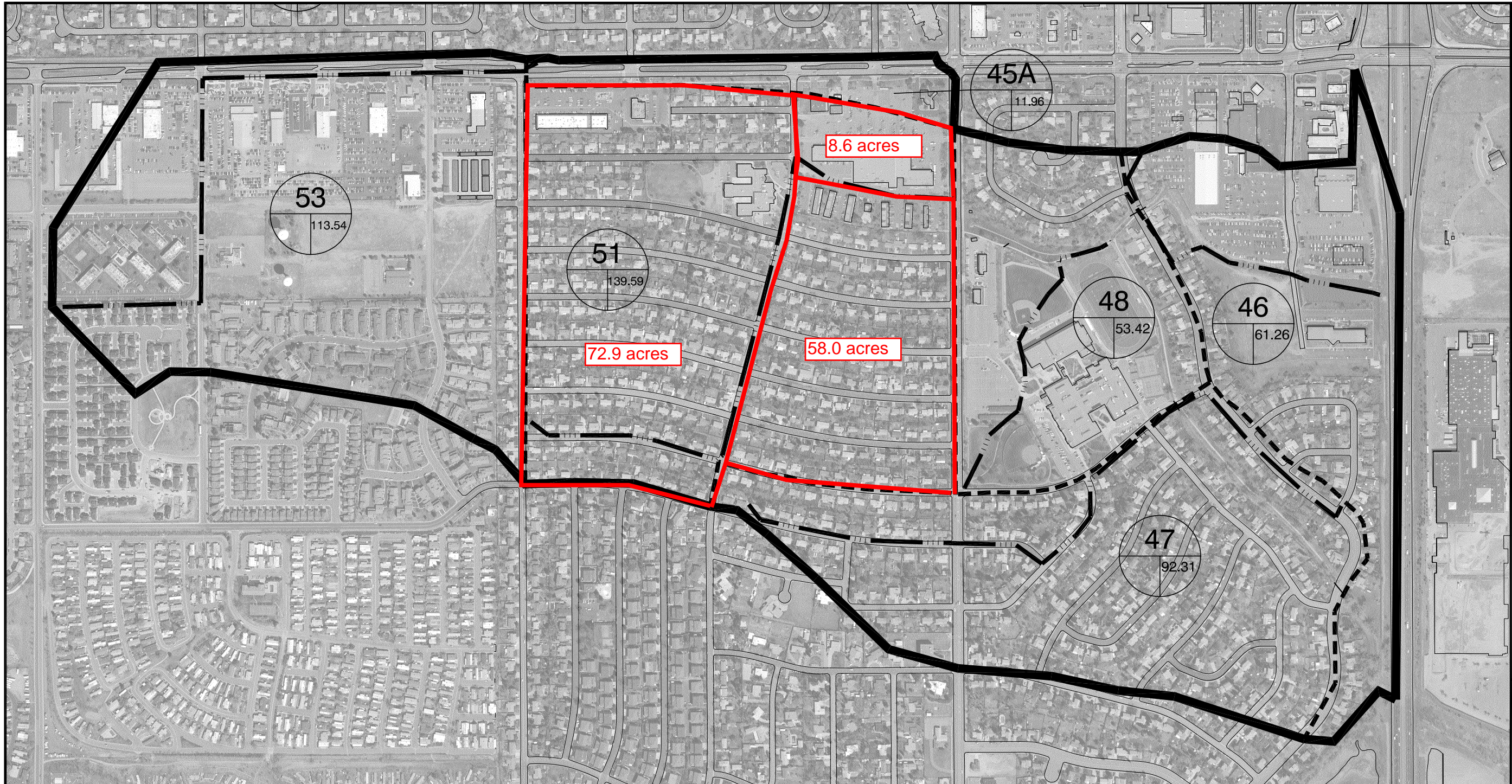


V: 1   
H: 1

**Attachment F**

**Subbasin Delineation Exhibit**

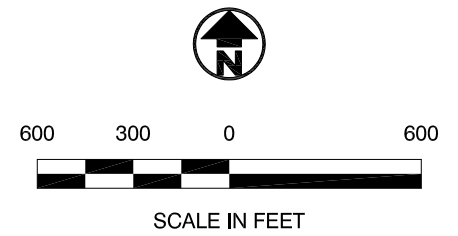
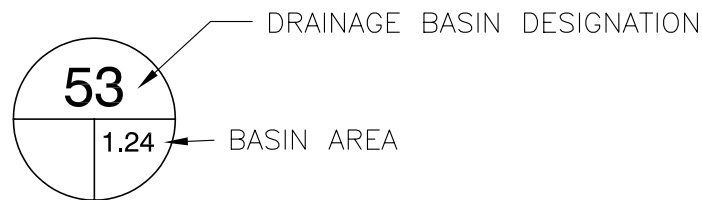




Kimley-Horn Delineation

**LEGEND:**

- BASIN DELINEATION
- BASIN TRAVEL PATH
- SUB BASIN DELINEATION



REVISIONS		Description
No	Date	By



## DRAFT MEMORANDUM

To: Debbie Tuttle, NURA Executive Director  
From: Bryce Christensen, PE  
Matthew Steder, PE (CO, FL, NM, OK, TX)  
Date: March 8, 2016  
Subject: Huron Promenade – Conceptual Offsite Drainage Alternatives

### General Description

The Huron Promenade project area is located on the southwest corner of W. 104<sup>th</sup> Avenue and Huron Street in the City of Northglenn, Colorado. The area is bound by W. 104<sup>th</sup> Avenue to the north, an existing residential property to the south, Croke Drive to the west, and Huron Street to the east. Conceptual site redevelopment plans have been prepared for the Huron Promenade site.

Kimley-Horn and Associates, Inc. (Kimley-Horn) has been retained by the Northglenn Urban Renewal Authority (NURA) to review the South Outfall Drainage Study prepared by J&T Consulting, Inc. dated May 2009 (the “South Outfall Study”) to prioritize offsite improvements and alternatives to mitigate offsite drainage issues at and around Huron Promenade project. The purpose of this memorandum is to summarize these concept alternatives and prioritize these for further analysis.

### Data Collection and Review

The majority of the data collected for this project is from the South Outfall Study that identified multiple storm sewer improvements within the larger Grange Hall Creek drainage basin. The purpose of this study was to identify, analyze, and prioritize solutions to upgrade the storm drain systems immediately adjacent to the Huron Promenade site to improve the adjacent drainage conditions. As shown on the Delineation Exhibit in **Attachment F**, six subbasins were delineated in this study, with the majority of the project site located in Subbasin 51 identified in the South Outfall Study. The study determined existing and future conditions runoff for each subbasin, analyzed the existing storm drain system and developed recommendations including proposed drainage improvements for 104th Avenue, Huron Street, Croke Drive and 103rd Avenue. Peak runoff values and hydrographs determined for Subbasin 53, Subbasin 51, and Subbasin 45A were used in the analysis of alternate improvements around the Huron Promenade site.

Other studies reviewed include the Grange Hall Creek Watershed Major Drainageway Planning Study (February 1997) and the City Wide Drainage Study and Master Plan Update (July 2007)

## Drainage Concept Alternatives

Kimley-Horn reviewed five concept alternatives for potential mitigation of offsite drainage issues. The recommended drainage concept alternatives are shown below in order of priority. Prioritization of the concept alternatives is based on the ability to mitigate flooding and feasibility. Preliminary analysis of these alternatives is based on information in the South Outfall Study. A more detailed analysis will be needed in order to further define feasibility and estimate potential costs.

A more detailed summary of each concept is provided in its respective attachment. An exhibit showing these drainage concept alternatives is provided on Page 4.

### Priority 1

#### **Option 1A. Site Detention**

This option consists of improving the Huron Promenade onsite detention to the Urban Drainage Flood Control District (UDFCD) full spectrum detention standards over the ±10.45 acre site. This alternative comprises of onsite improvements only.

#### **Option 1B. Improved Onsite Conveyance**

This option includes constructing/improving conveyance along the south side of the building for areas that may not be able to be detained due to property area and grading constraints associated with keeping the existing buildings. This alternative is for onsite improvement conveyance only.

### Priority 2

#### **Option 2A. Detention Facilities Regulating Offsite Flows on West End of Site**

This option consists of providing detention basin(s) on the west side of the Huron Promenade site to mitigate offsite flows experienced through the site due to deficient offsite infrastructure. Providing detention would mitigate flooding downstream including Croke Drive, the southern portion of the site, the apartment buildings south of the site, Huron Street and the South Outfall channel. The feasibility of this option in lieu of Option 2B would require City and private developer agreement.

#### **Option 2B. Croke Drive and 103<sup>rd</sup> Avenue Storm Drain Improvements**

This option consists of improving the storm drain system in Croke Drive and W. 103<sup>rd</sup> Avenue per the South Outfall Study. Improving the storm drain system would also mitigate flooding downstream in the same locations as Option 2A

### Priority 3

#### **Option 3A. Detention Facilities Regulating Offsite Flows on North End of Site**

This option consists of providing a detention basin(s) on the north side of the Huron Promenade site to mitigate offsite flows. Doing so would help mitigate flooding at the intersection of 104<sup>th</sup> Avenue and Huron Street as well as downstream areas along Huron



Street and the South Outfall channel. The feasibility of this option in lieu of Option 3B would require City and private developer agreement.

### **Option 3B. 104<sup>th</sup> Avenue and Huron Street Storm Drain Improvements**

This option consists of improving the storm drain system from the north side of the site in 104<sup>th</sup> Avenue and Huron Street to South Outfall channel per the South Outfall Study. Doing so would also help mitigate flooding in the same locations as Option 3B.

### **Priority 4. Conveyance Across Huron Street**

This option consists of improving conveyance across Huron Street by adding a 125-ft-long 8-ft x 5-ft reinforced box culvert. This option would convey flows not captured by existing storm drains across Huron Street and into the South Outfall channel. Improvements will also be needed to existing drop inlets in Huron Street that will convey flows from Huron Street into the proposed box culvert.

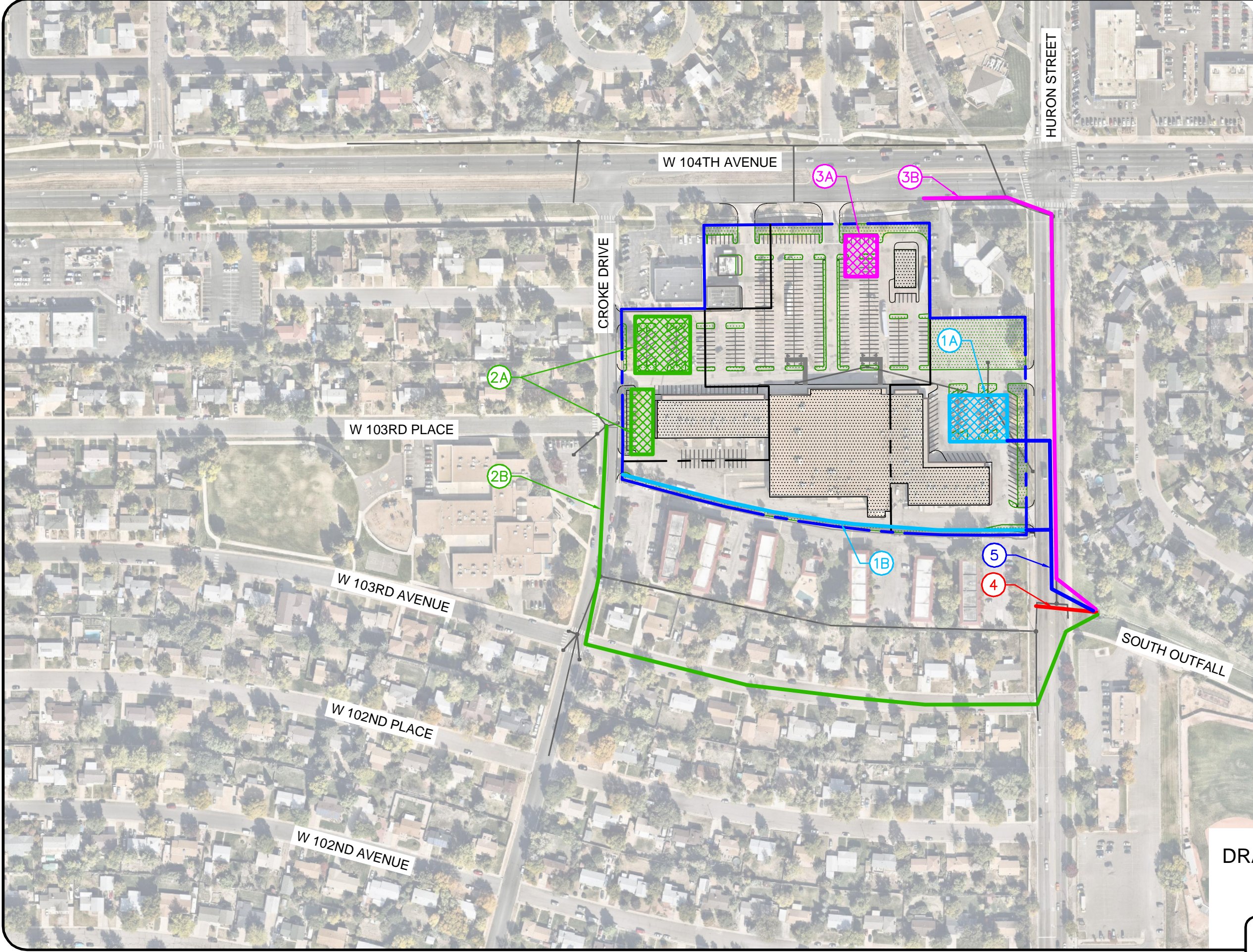
### **Priority 5. Piped Connection for Site Outfall to Huron Street**

This option consists of providing a 415-ft, 48-in reinforced concrete pipe (RCP) connection from the southeast corner of the Huron Promenade site across Huron Street and into the South Outfall channel. This storm drain would mitigate flooding in Huron Street. This would also replace the existing flume outfalls from the site and allow flows from Options 1A and 1B to be conveyed in a storm drain instead of Huron Street.

## **List of Attachments**

Attachment A	Priority 1
Attachment B	Priority 2
Attachment C	Priority 3
Attachment D	Priority 4
Attachment E	Priority 5
Attachment F	Subbasin Delineation Map





### IMPROVEMENT PRIORITIES

- 1A) ONSITE UDFCD DETENTION
- 1B) IMPROVED ONSITE CONVEYANCE ALONG SOUTH OF SITE
- 2A) DETENTION FACILITIES REGULATING OFFSITE FLOWS
- 2B) OFFSITE CONVEYANCE UPSIZING IMPROVEMENTS IN CROKE DR AND 103RD AVE
- 3A) DETENTION FACILITIES REGULATING OFFSITE FLOWS
- 3B) OFFSITE CONVEYANCE UPSIZING IMPROVEMENTS IN HURON ST
- 4) BOX CULVERT ACROSS HURON ST
- 5) STORM DRAIN FOR ONSITE AND THROUGH-SITE CONVEYANCE

### LEGEND

- PROPOSED LANDSCAPE AREA
- EXISTING/PROPOSED BUILDING
- EXISTING STORM DRAIN
- OVERALL PROPERTY LINE
- INTERIOR PROPERTY LINE



SCALE IN FEET  
100 0 100 200

DRAINAGE IMPROVEMENTS EXHIBIT  
MARCH 2016

