City of Evans

Stormwater Utility Master Plan

December, 2016

MULLER ENGINEERING COMPANY

City of Evans, Colorado

DOLA CO

COLORADO Department of Local Affairs

EVANS 2016 STORMWATER UTILITY MANAGEMENT PLAN

Drainage Study Analysis

December 2016

Prepared for:

The City of Evans
1100 37th Street
Evans, CO 80620

Muller Project Number: 15-041.01

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1 INTRODUCTION

1.1 Authorization

The City of Evans contracted with Muller Engineering Company, Inc. to conduct a city-wide drainage study, replace the 1997 Master Drainage Plan, and integrate both into a stormwater master plan for the City. The work is authorized by City-Resolution 22-2015 adopted August 3, 2015. The study was funded by the Community Development Block Grant disaster recovery program (CDBG-DR), awarded to the City by the Colorado Department of Local Affairs. The funds were awarded to aid Evans in their recovery from the September 2013 floods.

1.2 Purpose and Scope

This report provides a comprehensive review and analysis of the existing stormwater system, and identifies the locations where critical stormwater improvements are necessary or may become necessary. Alternatives are provided for each of the improvements.

In addition to updating the hydrologic and hydraulic understanding of the City of Evans, project goals include:

- Take a holistic view of the City infrastructure to identify current flood risks
- Recommend alternative infrastructure or management practices that reduce the flood risk to the City caused by local drainage runoff during minor and major storms
- Protect the Evans Town Ditch, an irrigation canal, from stormwater infiltration
- Emphasize the Highway 85 corridor and Riverside Neighborhood

1.3 Planning Process

To fulfill the scope, and with input from the City of Evans, Muller addressed the following goals:

- Met and involved all necessary City staff to exchange information and receive input and direction
- Reviewed the 1997 Drainage Study
- Solicited public input by participating in a public meeting and providing information to the newsletter, or City website.
- Created a detailed map of the current infrastructure and drainageways. This was completed using GIS-based databases; however ground-based measurements were occasionally necessary.
- Coordinated with other planning and infrastructure projects including the Riverside Neighborhood Master Plan and the Riverside Park re-design.
- Provided a report to the City Council, the Water and Sewer Board and for public review at the 75%, and 100% complete stages. This report includes the inventory and analysis of existing infrastructure, the proposed system improvements, a resiliency analysis, a capital improvement plan, suggested development standards, system maintenance items, system management requirements, and funding options.

Periodic meetings were held to gather input from the City. A summary of project meetings is shown in Table B-1, in Appendix B.

1.4 Mapping and Surveys

Mapping of the existing drainageway and infrastructure used the following sources:

- 1-foot interval LIDAR contour data within the Urban Growth Area (UGA), obtained from the City of Evans
- 1-foot interval LIDAR contour data obtained from the City of Greeley extending along the northern edge of the UGA to up to approximately one mile north.
- Greeley's main storm sewer GIS data (in the southern area of Greeley, near the Greeley-Evans border), obtained from the City of Greeley.
- The southern boundaries of Greeley's drainage basins as identified in their Master Plan were obtained from Greeley to verify the northern boundaries of the basins delineated for the City of Evans.
- USGS Topographic map, obtained through ArcMap and added as a base-map. Major roads, drainageways, canals, and terrain features were included and labeled. The base map contours were at 10-foot intervals; these were used in areas outside of the UGA to determine where external stormwater may enter the project boundary and to facilitate basin delineation where necessary.
- A 2013 aerial was obtained from the City that encompasses most of the UGA. From the south and west, it extends from UGA limits to 0.65 miles north of US Hwy 34 and 0.13 miles east of County Road 45 (0.85 miles west of the eastern-most UGA boundary). This was used to verify the existing land use classifications, channel locations, and the presence of gutters.
- Existing and future zoning maps, obtained from the City of Evans.
- Storm line and storm node shapefiles, obtained from the City of Evans, contained the georeferenced locations of all City-maintained storm sewers, inlets, outlets, and manholes. Pipe diameters were included in the attribute tables; however invert elevations had to be inferred from the surface elevation, pipe diameter, and allowable cover.
- Locations of detention basins within Evans were obtained from the City. The attribute table included the pond surface areas, used to determine mowing requirements for the maintenance evaluation.
- The FEMA Floodplains shapefiles obtained from the City of Evans include the 100-year floodplain and additional floodway designations by FEMA.
- General information shapefiles were obtained from the City and included the Evans city limits, urban growth area, and streets.

1.5 Data Collection

Most of the data needed for the hydrologic and hydraulic analyses were available in the information provided in the map layers described previously. However, multiple drainage reports were reviewed to find the rating and storage curves for the detention ponds modeled in SWMM and reflected in the rational analysis. These reports are listed in Table A-1.

1.6 Acknowledgments

The stormwater master plan has been prepared with the input of multiple parties. Public input was sought out at a public meeting and through the City of Evans newsletter. These outreach attempts allowed for the input of multiple stakeholders to be heard, and for the inclusion of areas of concern not initially identified. The City of Evans staff also provided valuable input throughout the process based on their knowledge of the City. In addition to the mapping and city data, the City identified twenty-five areas of concern they had recently encountered.

2 STUDY AREA DESCRIPTION

2.1 Project Area

Evans is located in northern Colorado, south of Greeley and 60 miles north of Denver. It is a part of Weld County. The major highways through Evans are US Hwy 85 and US Hwy 34; the intersection of these is located near the heart of the historic and commercial center of the city.

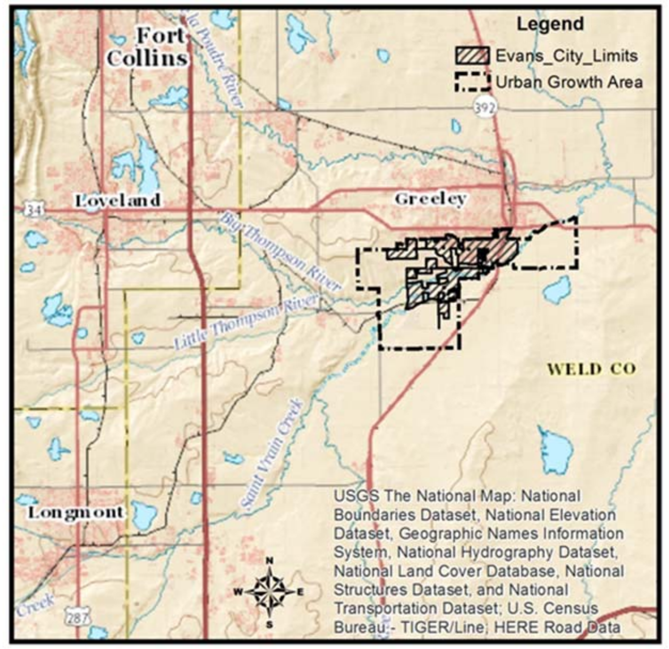


Figure 2-1: Vicinity Map

Approximately 22,700 acres are included in Evans' current city limits and future Growth Area combined. The South Platte River transverses the Urban Growth Area (UGA) from the southwest corner to the northeast. The Big Thompson River also enters at the western growth boundary and converges with the South Platte within the UGA.

Since the completion of the previous Master Drainage Plan in 1997, the City of Evans has grown from 7,374 residents to 19,944 residents in 2013. This is a growth rate 5.5 times greater than seen by the State of Colorado as a whole. Accordingly, the City boundary and predicted growth area have also expanded. Developments have changed the amount and course of runoff, producing recurrent flooding in several areas. New stormwater infrastructure has been constructed that has not yet been added to the Master Plan. Figure 2-1 vicinity map shows the existing City limits and UGA at the time of this report. More spatial detail is provided in Figure A-1 within Appendix A.

2.2 Land Use

Historical Evans is located north and west of the South Platte and east of US 85. It covers an area of approximately 1,100 acres. Approximately 2,400 acres of residential and residential-commercial developments have been built to the west of the historical downtown area. Much of the UGA, especially south of the river, is undeveloped and contains primarily agricultural or pastoral land. Please see Figure A-2 in Appendix A for a map of the existing land uses and Figure A-3 for a map of the proposed land uses.

2.3 Flood History

During the public meeting, several residents identified areas of frequent flooding and expressed their experiences regarding the frequency and severity of the events. All the comments received referenced areas within the Areas of Concern #9 and #16, east of US. Highway 85 and south of 37th Street. Properties in the southeast corner of that intersection have flooded at least four times, at depths between 14 and 18 inches, since 2001, although the property owners report that no flooding occurred at this property within the 34 years prior. Local flooding is reported by residents to occur frequently near the intersection of 39th Street and Boulder Street, and at 39th Street and Golden Street.

There are two sources of potential flooding risk in Evans: stormwater flooding from excessive precipitation and overflows from the South Platte, which can, and have, affected low-lying areas during high flow periods. The flooding risk to Evans along the South Platte River can be heightened even when little or no rainfall occurs over the city itself. Historical stream flows, measured at the USGS Fort Lupton gauge station, were obtained from the USGS Colorado Streamflow online database. Data records include daily measurements between May 1, 1929 and December 31, 2015. Fort Lupton is located upstream along the South Platte, approximately twenty miles south of Evans; its stream gauge is the closest to Evans. At the writing of this report, this is the closest stream gauge to Evans. Weld County has plans to install a new stream gauge closer to Evans. During the period of record, the highest stream flows at Fort Lupton have occurred almost exclusively in the early spring or late summer months. Between 1929 and 1948, April was consistently the month with the largest flows; between 1949 and 1968, it was June; however, between 1969 and 1988, May was the generally the month with the highest flows. More recently (since 1989), June has again been the month with the largest flows. A major exception to this was 2013, during which September rains caused the 6th highest flow measurement on record in the South Platte, at the Fort Lupton station. The Fort Lupton station is the nearest stream gauge station to Evans along the South Platte; however, it is upstream of the confluences with St. Vrain River and Big Thompson River. Therefore, the flooding in Evans was much higher than indicated by the gauge. South Platte flow during the 2013 flood was most likely the first or second highest in a comparable period (since 1929) by the point it borders Evans.

In addition to stream flow, recent historical precipitation measurements were obtained from NOAA's National Centers (NCEI) for Environmental Information online database (formerly NCDC). No data was available after December 9th 2013. The closest weather station to Evans is the Greeley UNC station, approximately three miles north of the Evans Community Center. The hourly precipitation depths were sorted by storm, assuming at least a 6 hour period of no-precipitation between individual events. The largest storm on record during this period was the June 13th 2001 storm, which produced 2.8 inches in three hours. The one-hour rainfall depth of a 100-year storm in Weld County is 2.81 inches. Since 1997, the storm with the greatest intensity was the August 22, 2013 event, in which rained 1.9 inches in 2 hours. Of the remaining ten largest storms – yielding 2 or more inches of total precipitation – seven occurred over eight or more hours. Of the highest intensity storms, besides the two largest already mentioned, all yielded 0.6 inches or less of rain in a one hour period.

None of the storms on record are greater than a 2-year storm. While Evans has seen large floods due to the high water of the South Platte flows, the city has not experienced a major storm in recent history. In fact, during the two weeks surrounding the September 2013 floods (September 13th – 27th), Evans received only 2.4 inches of rainfall. Comparing the recorded precipitation depths over the past eighteen years to the anecdotal evidence of frequent flooding in the historic downtown of Evans, it is clear that the City has not seen a large storm that would demonstrate what facilities are undersized.

3 DRAINAGE BASIN DESCRIPTIONS

Subcatchment delineations were made through the use of 2013 one-foot contours and aerial photography. In the areas characterized primarily by high-pervious land uses, the drainage basins were chosen based upon natural drainage ways; the existing storm sewer system and street layout were considered for subcatchment boundaries in the more developed areas. The northern boundary of the drainage area extends north of Evans' UGA along its entire length. Thus, several basins receive additional stormwater from Greeley or Weld County. These locations are described in more detail in the descriptions provided in this section.

Two hydrologic analysis methods were used for the project: the Colorado Urban Hydrograph Procedure (CUHP) and Stormwater Management Model (SWMM) were used to model the entire UGA, and a rational analysis was used to model smaller and specific areas of concern. Ninety-six individual CUHP basins were delineated, in addition to the basin encompassing the 100-yr floodplain of the South Platte. One-hundred and sixty-two basins were delineated for the rational analysis. In comparing the two groups and proceeding with the hydrologic analysis, several main outlet points into the South Platte were identified. Thus, the drainage area can be condensed to twelve aggregate basins that have internally consistent basin characteristics and flow direction. The CUHP basins were aggregated in the outer areas of the UGA, which contain primarily undeveloped or agricultural land. In the downtown and existing commercial/residential centers, it was more suitable to use the rational basins to create the aggregate basins. See Figure A-4 for the City of Evans Aggregate Basin Map. Following is a description of each of the aggregate basins; they are listed in no significant order.

It should be noted that the South Platte basin, incorporating the 100-Yr floodplain along the river, was not include in the hydrologic modeling; it's flows are determined by drainages upstream and are not a part of the scope of the study. It is to this basin that all existing and proposed stormwater infrastructure discharges.

23rd Avenue Drainage Area – 920 acres; incorporates all of Area of Concern #3 rational basins. This aggregate basin's land use is characterized predominantly by single-family residential neighborhoods, with several parks, open fields, and scattered commercial areas. The basin is bounded by 29th Avenue to the west, 23rd Avenue to the east, and 49th Street to the south. From the west to east, its northern boundary runs along W 29th Street, then across an open field, across the northern property edge of Walmart, and then to the intersection of 23rd Avenue and 30th Street. The UGA's northern boundary is 32nd Street, which is approximately 0.25 miles south of the basin's border. The main storm sewer system is a concrete pipe, varying in size from 54" to 72", along 23rd Avenue. The pipe discharges into the Prairie Ridge Detention Basin. Currently, there is a 72" concrete pipe outlet that is extended to just south of 49th Street, from which point the stormwater flows freely to the South Platte River approximately 0.3 miles to the south. Within the basin are several areas of known concern, including the inlets on Boardwalk Drive, a stormwater-infrastructure safety hazard on Anchor Drive and Harbor Lane, and storm drainage at the intersection of 29th Avenue and 32nd Street. In addition to these intra-basin concerns, the major storm sewer does not have capacity for the full 100-year pond release, and the discharged stormwater creates flooding hazards at 49th Street.

31st Street Drainage Area – 285 acres; this basin incorporates all of Area of Concern #8. The eastern area of the basin contains residential lots, including single-family homes, apartments, and trailer parks. There is a large open sports field and several smaller open areas interspersed. The western area is a commercial and residential area with several large paved parking lots. The northernmost section of the area is bounded by 28th Street Road. The southernmost section of basin is bounded by 32nd Street. The basin is bounded by 17th Avenue in the west and extends to Trinidad Street to the east. Within the 31st Street Drainage Area, the UGA turns north, such that the basin borders not only the northern UGA boundary but also part of its western boundary. The College Park Condominiums and the Ridge Run, Crest View, and Landmark subdivisions are all included in the basin but are within Greeley's city limits. Approximately 38% of the basin is actually part of the City of Greeley. Stormwater flows south and east and is collected into a triple pipe system approximately 825 feet in length and consisting of 48", 18", and 54" pipes. These discharge to a channel paralleling the railroad tracks north of 31st Street. In addition to the channel being undersized for the basin flow, the southeastern section of the basin does not have a direct outlet into the storm sewer system.

31st Street Offsite Drainage Area – 520 acres. Most of this aggregate basin (87.5% of it) is outside of the UGA, and is part of the City of Greeley. In addition to extending north to 26th Street, the basin extends east to 1st Avenue. This is further east than the UGA boundary, which at this section coincides with the Union Pacific Railroad tracks. In the western area of the basin, the land use is primarily composed of single-family and apartment residential lots. The eastern sections of the basin are commercial, and the US HWY 85 – US Hwy 34 interchange encompasses the central section. It is bound to the north by 26th Street and by 31st Street at its southern most section and to the west it is bounded by 8th Avenue. Although there are no areas of concern within the basin, the 31st Street Offsite Drainage Area contributes to flow in the channel downstream of the 31st Street Drainage Area discharge point. The channel here is undersized and flooding of the roadway and adjacent residences is a likely to occur in the major storm event.

37th Street Drainage Area – 505 acres; this aggregate basin covers all of Area of Concern #9 and contributing rational basins, and contains much of the historical parts of the City. The northwest section of the basin consists of single-family residential neighborhoods. The central area, along the US-Hwy 85 corridor, is primarily commercial area. The eastern part of the basin consists of single-family residences and trailer parks. It is bounded by 31nd street in its most northern section and by 39th Street in its most southern section. To the west, the area is bounded by 17th Avenue. The crossing of 37th Street over the South Platte is the area's easternmost point. Stormwater is routed east to a dual pipe system, ranging from 18" and 26" pipe to 42" and 54" pipe at the outfall into the South Platte. These pipes are undersized for both the minor and major storms. In addition to the major outfall, flooding in the minor and major storms occur at several locations along US Hwy 85, at the intersection of 37th Street and the railroad tracks, and within neighborhoods lacking stormwater infrastructure.

1st Avenue Drainage Area – 98 acres; this area is located northeast of the 37th Street Drainage Area; and consists of the wastewater treatment plant and some undeveloped land. It is bounded by 31st Street to the north and 37th Street to the south. The western boundary is Trinidad Street and its eastern boundary is the floodplain. Since it is largely undeveloped, no storm sewers exist within the basin. Stormwater flows east, but does not enter the wastewater facility due to berms around the ponds. Water flows across 1st Avenue and into the 100-YR floodplain of the South Platte. No areas of concern are located within the basin.

Industrial Parkway Drainage Area – 765 acres; this area encompasses Area of Concern #26. The Industrial Parkway drainage area is bounded to the south by 49th Street, to the west by 23rd Avenue, and to the east by 17th Avenue. Its northern boundary runs through the Greeley Mall. The UGA's northern boundary is 32nd Street, which is approximately 0.4 miles south of the mall. The area of the basin which includes the mall is composed primarily of commercial buildings and pavement. Between 30th Street and 42nd Street, most of the basin is comprised of residential lots for both single-family homes and apartment complexes, although there are also several neighborhood-commercial centers and parks. South of 42nd and to the floodplain is open space, agricultural land, and several scattered commercial buildings to the east. Stormwater flows east in neighborhood storm sewers and south in a pipe ranging from 24” to 60” in diameter. The pipe discharges to an open channel that crosses Evans Town Ditch and Industrial Parkway before ultimately discharging to the South Platte River. Several sections of this pipe are undersized and potentially cause flooding in the major storm event, although no pre-identified areas of concern are located in the basin. The southernmost area of the basin flows in a sheet-wise manner to the east and has the potential to overflow to the north, towards Industrial Parkway, before it reaches the South Platte. It is anticipated, and corroborated by on-site observation, that the channel conveying stormwater from the basin and to the floodplain is undersized.

Riverside Drainage Area – 345 acres; the area includes Area of Concern #12. The basin is a mix of residential, commercial, industrial, and open space. The basin is bounded by 39th Street in the north, Industrial Parkway in the west, and the South Platte floodplain to the south and east. Although stormwater infrastructure exists, there is no major pipe system within the basin that conveys all stormwater to a common discharge point. Instead, runoff is either collected in smaller pipes and conveyed to the nearest point along the South Platte or reaches the River as sheet flow. One area of concern is located within the basin, along Belmont Avenue. In this location, the stormwater draining to this point is not collected by any stormwater infrastructure.

Cave Creek Drainage Area – 326 acres; it includes areas of concern #21 and 22. The Cave Creek Drainage Area is located west of the 23rd Avenue Drainage Area. In the northern tip of the basin, it is characterized by commercial land use. The southern area, comprising most of the basin, is residential and undeveloped land. The basin extends from the 35th Avenue corridor to the South Platte floodplain boundary just south of 49th Street. It includes the subdivisions draining to Cave Creek Detention Pond, at Antelope Way. Stormwater in the northern area of the basin flows south and is collected into a storm sewer along 23rd Avenue. Fields and subdivisions to the west of this area drain south and west and into Ashcroft Draw. This yields the flag-pole configuration of the Cave Creek drainage basin. After receiving this area’s stormwater, the 23rd Avenue pipe only collects runoff originating from the roadway. Since it is not connected to any neighborhood collector pipes until the Cave Creek subdivision, this is the only stormwater it receives. The pipe ranges from 18” to 36” in size. At the outlet of the basin, located north of the South Platte but within the floodplain, the pipe is undersized. While the Cave Creek outlets are not undersized, the pond does not function properly due to inadequate maintenance.

Ashcroft Draw Drainage Area – 4,625 acres; Ashcroft Draw Basin is one of the larger aggregate basins and includes the area which drains to Ashcroft Draw. Approximately 1,600 acres of the basin lie outside of the UGA. Several subdivisions exist in the basin, but about half of the basin is undeveloped or used for agricultural land. Of the neighborhoods that have been developed, most are single-family homes. Several neighborhoods of larger estate houses, located in Weld County, are interspersed as well which are located in Weld County. Although not strictly bounded by any road, the northern boundary is in the vicinity (in some areas a few thousand feet north, in others a few thousand feet south) of US Hwy 34. Similarly, its southern boundary is not easily defined by roadways, as this area is primarily undeveloped. At its southern most point it is bounded by 54th St Road. Its westernmost point is the northwestern corner of the UGA. To the east, it is bounded by 35th Avenue. Stormwater flows towards Ashcroft Draw, whose tributaries exist north and east of 37th Street and 65th Avenue, then flows south and east to the South Platte. The Ashcroft Heights and Tuscany subdivisions, bounded to the south by 37th Avenue, to the north by the UGA, and to the west and east by 35th Avenue and 47th Avenue, contains a number of detention basins and neighborhood-level storm sewers. Several other storm sewers exist in the basin, one of which is undersized and is an area of concern. However, most of the subdivisions do not have storm sewer infrastructure and drain to the Draw via streets or open channels.

Big Thompson River Drainage Area – 4,380 acres. The Big Thompson River Drainage Area extends from the western UGA boundary (County Road 25) to 47th Avenue. It shares its northern boundary with the Ashcroft Draw Drainage Area’s southern boundary. To the south, the area is bounded by the South Platte floodplain. Approximately 9% of the basin is large lot, single-family estate residential neighborhoods. The rest of the basin is agricultural and open space, with a couple scattered energy industrial facilities. The Big Thompson River Drainage Area does not have one common discharge point; instead, several tributaries drain north-south to the Big Thompson River, which flows east and eventually discharges to the South Platte. The tributary streams within the basin include those from Kammerzell Lake, Spomer Lake, and Rehmer Lake. Three other tributary streams also drain to the river, but their names are unknown. Eight culverts in the subdivision north of 49th Street, ranging from 18” to 30” in size, are the only storm sewer infrastructure existing with the basin. Two of these culverts, across 49th Street, are undersized and are areas of concern.

Southwest Drainage Area – 5,330 acres. The Southwest Drainage Area is one of the two aggregate basins located south of the South Platte. It is bounded to the north and west by the floodplain and to the south and east by the UGA boundary (County Rd 44 and County Rd 35, respectively). The basin’s land use is almost exclusively agricultural and pastoral; a few homes and parcels for the oil and gas industry are located within the basin as well. Runoff flows north to the South Platte; no stormwater infrastructure exists in the basin, and stormwater does not collect at a specific point along the floodplain. Runoff flows over the basin in a sheet flow manner, until it reaches the River. In some locations the direction of flow is dictated by the direction of the fields and the plowing.

Southeast Drainage Area – 3,465 acres; this basin extends from the eastern UGA boundary to the South Platte 100-yr floodplain boundary. Its southern border is about 0.5 miles south of County Road 52. The entire basin is currently agricultural or pastoral land, and there is no stormwater infrastructure. Runoff flows north and west in a sheet-wise manner until it reaches the South Platte. As in the Southwest Drainage Area, the flow directions vary in part due to the direction land-owners plow their fields. Lantham drain starts in the northeastern section of the Southwest Drainage Area. The drain collects ground water and sheet flow north of the railroad and discharges it into the South Platte.

4 HYDROLOGIC ANALYSIS

4.1 Overview

Hydrologic basins were delineated and evaluated using version 1.4.4 of Urban Drainage and Flood Control District's (UDFCD's) Colorado Urban Hydrograph Procedure (CUHP) (released September 30, 2014) and version 5.1.1 of EPA's Stormwater Management Model (SWMM). Both were created with new basin delineations and not modifications of the previous drainage study.

In addition to the general basin hydrologic analysis, completed in CUHP/SWMM, twenty-five specific areas of concern were identified by the City of Evans staff. These were modeled with the rational method. Smaller drainage basins (less than 60 acres) were delineated for these areas and the smaller sewer systems ignored in SWMM were incorporated in the stormwater routing. Twenty-four areas were identified and included in this section of the analysis. Please note that area of concern numbering is not based upon a priority or any other comparative scale.

4.2 Design Rainfall

One-hour point rainfall depths for the 2-, 5-, 10-, 50-, and 100-year storm events were obtained from the 1997 Evans Stormwater Criteria Manual. These are the design-storm one-hour point rainfall depths from the NOAA Atlas 14 Point Precipitation Frequency Estimates database for the UNC Greeley weather station (05-3553). The same values are also listed in the Weld County Engineering and Construction Manual (Chapter 5: Drainage Criterial, Table 5-1) for Greeley rainfall depths, since specific values for Evans were not listed. A copy of these input values has been included in Table 4-1. The 25-yr one-hour point rainfall depth was not included in the previous drainage plan; however, the estimate from NOAA Atlas 14 is included in the table.

Table 4-1: Point Rainfall Depths

Storm Event	Point Rainfall Depths		
	One-Hour (1997 Drainage Plan)	One-Hour	Six-Hour
2-Yr	1.04	1.04	1.38
5-YR	1.49	1.49	1.8
10-YR	1.76	1.76	2.22
25-YR	*Not Defined*	1.86	2.58
50-YR	2.51	2.51	2.94
100-YR	2.78	2.78	3.42

The corresponding intensities were calculated with Equation 5-3 from the UDFCD 2016 Criteria Manual.

4.3 Subwatershed Characteristics

All subcatchments characteristics were defined according to the current mapping information. Watershed slopes, overland flow lengths, and channelized flow lengths were determined for both CUHP/SWMM and the rational method calculations. These values were calculated in ArcMap (a GIS mapping tool) using the 1-foot contour data obtained from the City. The typical depression losses and parameters for Horton's equation – used in SWMM – were determined for each subcatchment by referencing Tables 4-2 and 4-3.

Table 4-2: Typical Depression Losses

Typical Depression Losses for Various Land Covers (All Values in Inches)		
Land Cover	Range in Depression (Retention) Losses	Recommended
Impervious:		
Large paved areas	0.05 - 0.15	0.1
Roofs-flat	0.1 - 0.3	0.1
Roofs-sloped	0.05 - 0.1	0.05
Pervious:		
Lawn grass	0.2 - 0.5	0.35
Wooded areas and open fields	0.2 - 0.6	0.4

Table 4-3: Horton's Equation Parameters

Recommended Horton's Equation Parameters			
NRCS Hydrologic Soil Group	Infiltration (inches per hour)		Decay Coefficient - a
	Initial - f_i	Final - f_o	
A	5.0	1.0	0.0007
B	4.5	0.6	0.0018
C	3.0	0.5	0.0018
D	3.0	0.5	0.0018

Both CUHP and the rational calculations required soil type data as input. A soils report was obtained for the UGA through the NRCS Web Soil Survey. The majority of the study area is characterized by soil group A, which is comprised of sandy soil types that have relatively high infiltration rates and low runoff potentials. Soil group B was the second-most common soil type; these loamy soils are generally well-drained with moderate infiltration rates. See Figure C-1 for a copy of the soil maps.

The percent impervious values assigned to each of the land use categories in the existing and future land use zoning GIS files are listed in Table 4-4. The designation and number of land use zoning classes differed between the two files. To determine their appropriate counterparts, the future zoning classes were compared with the existing land use zoning classes in areas already fully developed.

Table 4-4: Impervious and Land Use Categories

Pct. Impervious	Land Use Description	
	Existing	Future
2	Agricultural District Undeveloped Open Land	River Habitat Open Space
30	Single-family Estate Residential District	Residential - Rural Neighborhood
50	Single-family Residential District	Residential - Urban Neighborhood
60		Neighborhood Retail Commercial
65	Two-family Residential District	
70	Public Facilities Planned Unit Development Residential Manufactured Housing District Residential Mobile Home District	Public Facilities
75	Light Intensity Commercial District Multifamily Residential District Residential Commercial District	Residential - High Density
80	Medium Intensity Commercial District Light Industrial District	Industrial - Energy
85	US 85 Retail & Commercial - Neighborhood US 85 Retail & Commercial - Regional Corridor High Intensity Commercial District Medium Industrial District	Park-n-Ride Historic Mixed Use High Retail Commercial Industrial - Rail Access
90	Heavy Industrial District	Industrial - Business Park
95	US 85 Office District US 85 Retail & Commercial - Auto	Office Automotive Commercial Commercial
100	Pavement/Roads	Pavement/Roads

While development is predicted for the areas west, east, and south of the current city limits, the basin delineations for these areas were not changed based upon the land use zoning maps. For the future analysis, the land use zoning designations were used to change only the impervious land use parameters.

4.4 Hydrograph Routing

4.4.1 CUHP/SWMM

Ninety-seven subcatchments were delineated for the CUHP/SWMM analysis. The areas ranged from 12 to 1,120 acres. The Multiple Run option was utilized in CUHP to run the existing and future zoning SWMM models, for the 100-, 50-, 25-, 10-, and 5- year storms, concurrently.

In this study, major drainageways – including Ashcroft Draw – were incorporated into the model. These are located primarily in the undeveloped areas to the west. Constructed channels in developed areas were also included, as well as wide channels – simulating overland flow – between undeveloped basins. Major storm sewer pipes are included in the model; open-channel overflow conduits were included in areas where flooding was expected or modeled to occur. Overland channel dimensions were determined from the contour and land-use observations. Frequently, the overflow is carried along a street or in grass buffer zones. The only open channels included in the 1997 study were the Evans Town Ditch and the Riverside Park Ditch.

The main storm sewers included in the model are those located within the Ashcroft Heights neighborhood and along:

- 37th Street
- 31st Street
- 17th Avenue
- W. Service Road (adjacent to Hwy 85)
- Harbor Lane/Prairie Ridge
- 35th Avenue

Smaller systems were not included in the SWMM model, as they routed stormwater within a basin but not out of it (for example, this was the case for the pipes along 11th Avenue and 15th Street). In cases where dual pipe systems occurred, one of the pipes was connected to the other as an overflow conduit in SWMM.

Nodes were placed in SWMM at subcatchment outflow points, at conduit entrances and outfalls, junctures of changing conduit type or dimension, and at diversion points between dual conduit systems. See Figure C-2 for the SWMM basins and see Table C-1 for the CUHP Input values. A SWMM schematic is included in Figure C-3.

Twelve detention ponds were included in the CUHP/SWMM model. There are numerous other detention ponds; in the inventory (shapefile) received from the City, there are 64 located throughout Evans. The ponds which were included were chosen based on their size, drainage area and who was responsible for the maintenance on them. Since the target size for CUHP basins is between 90 and 100 acres, the smaller drainage areas for each detention pond were not delineated or included in the model. Detention ponds that were greater than one acre in size and that received significant flow from their basin were considered for the model. Most of the ponds are detention ponds maintained by the City of Evans. There are a few exceptions to this, including Chappelow Pond, which is a regional detention basin maintained by Evans and some of the larger ponds which are currently privately maintained but act as regional facilities. The ponds chosen for final inclusion are:

- Grapevine Hollow Pond #2
- Ashcroft Heights Pond #3
- Ashcroft Heights Pond #8
- Hunters Reserve Pond #1
- Hunters Reserve Pond #2
- Hunters Reserve Pond #3
- Cave Creek
- Willow Brook
- Landings

- Chappelow – referred to in the 1997 Drainage Study as the 17th Avenue Detention Pond; there was little information available for the Chappelow Pond. Therefore, storage information was inferred from depths and storage areas measured through GIS. The outlet structure was observed in-situ, and the partial-flow pipe capacity was estimated using Manning's Equation for incremental depths.
- North Point
- Ridge at Prairie View

The detention pond rating curves and sizing information were obtained from the City of Evans for all the mentioned ponds. A thorough review of all the City's files was completed by Muller staff to maximize the number of ponds included. There were also discussions with City staff about all of the facilities. See Table C-2 for additional details on the ponds and Appendix C for a copy of this information

4.4.2 Rational Analysis

Twenty-five pre-identified areas of concern were provided by the City; including the Industrial Parkway area and the Ashcroft Channel area. These were modeled by the rational method using 163 individual basins. Each area of concern has between one and 30 contributing basins, ranging from 0.62 and 108 acres in area. Basins were labeled with their "area of concern" number, followed by a letter – basins at the upstream point in the basin contain the early letters in the alphabet with those at the outlet have the last letter.

The 5-, 10-, 25-, 50-, and 100-year storms were modeled with the rational method. Flow was routed through streets, channels, and pipes where appropriate. In several areas, including areas #3, #18, #20, and #26, the flow was modified to reflect attenuation in a detention pond along the flow path. In these cases, the flow rate from the detention pond was equal to the difference between the calculated basin flow and the design pond inflow, and the maximum outflow of the pond for the specified design storm. The last two variables were attained from drainage reports and are listed with the SWMM pond information in **Table C-2**. A copy of the Rational Analysis is included in Table C-3.

4.5 1997 Drainage Study

A previous drainage study was done for the City of Evans in 1997. This study was completed using 10-foot contours to delineate and define basin properties. These were used as a guide for basin characterization in this study; however, changes were necessary due to new development and the use of higher resolution contour data. The historical basin boundaries closely match those drawn for this study, especially in the western (more undeveloped) regions; however, some of the larger basins of the older study were divided into smaller basins to better represent differences in slope, land use characteristics, and soil groups (see next section for specifics).

Differences in the basin delineations are also due to a significant difference in study area size – the UGA boundary grew to the east, west, and south. In addition, the 100-year floodplain of the South Platte was designated as its own basin. Thus, the floodplain line is a boundary for adjoining basins. Several basins include area north of the UGA where stormwater flows from Greeley into Evans. Stormwater flow in both the southernmost and easternmost areas of the UGA, which are currently undeveloped, are largely controlled by the plowing patterns of each field. The natural drainage way in these locations is very flat. Therefore, the basin boundaries here align with property boundaries and the borders of the UGA.

The 1997 study characterized the basins' soil types as primarily Group B, based upon information from the Soil Conservation Service and the Soil Survey Maps of Weld County. In this analysis, it was found that most basins were better characterized as having Type A soils. The resolution of the soils data was generally much smaller than the size of both the CUHP and rational basins; therefore, the percentage of each soil group within each basin was calculated. For simplicity in the rational analysis the soil for each basin were described as one of the four types (and not, for instance, as a weighted average). Therefore, the soil group assigned to the basin was that which covered the greatest percentage of its area.

As with this evaluation, the 1997 Drainage Study used CUHP to calculate the volume and flowrate of basin runoff, and modeled these in SWMM.

4.6 Model Comparisons

The 1997 Drainage Study divided the City of Evans into 17 basins. Although the UGA and current city limits have grown since 1997, these basins roughly overlap with those delineated for this study. The previous basins and their "new" counterparts are listed below, though the boundaries do not align perfectly in nearly any case. Many of the older basins are much larger than the average basin delineated for this report; therefore, one 1997 basin may describe several basins for this study. In several areas, the boundary of a previous basin cuts a new basin in half, but is still encompassed by one of the aggregate basins described previously.

- Urban Growth Area West Basin – overlaps with the central basins of the Big Thompson Tributary aggregate Basin, specifically BTT-130, BTT-140, BTT-150, BTT-240, BTT-250, BTT-330; new area is incorporated into the new basin to cover the expanded UGA and outside contributing drainage area
- 65th Avenue Basin – overlaps with the southwest section of the Big Thompson Tributary aggregate Basin, specifically BTT-340
- Rehmer Lake Basin – overlaps with the central-eastern section of the Big Thompson Tributary aggregate Basin, specifically BTT-160, BTT-170, BTT-180, BTT-350, BTT-360
- Urban Growth Area Central Basin – overlaps with the eastern section of the Big Thompson Tributary aggregate Basin, specifically BTT-190, BTT-280, BTT-370
- Ashcroft Draw Basin – overlaps with Ashcroft Draw Basin (new), new area is incorporated into the new basin to cover the expanded UGA and outside contributing drainage area.
- Urban Growth Area East Basin – overlaps with the Cave Creek Drainage Area
- 23rd Avenue Basin – overlaps with the 23rd Avenue Drainage Area
- 17th Avenue Detention Pond Basin – Overlaps with the northern section of the Industrial Parkway Drainage Area, specifically CB-150 and CB-180
- 17th Avenue Basin – overlaps with the central area of the Industrial Parkway Drainage Area, specifically CB-230
- Evans Town Ditch Basin – overlaps with the western section of the 37th Street Drainage Area, specifically CB-190. Because one of the directives of the study was to protect the Evans Town Ditch from stormwater infiltration, the irrigation ditch was not relied upon for stormwater conveyance or used in basin delineation.
- Industrial Parkway Basin – overlaps with the southern section of the Industrial Parkway Drainage Area and a small southwestern section of the Riverside Drainage Basin , specifically CB-270.

- Southeast Platte Basin – overlaps with the northern section of the Riverside Drainage Area, specifically CB-240.
- River Bend Basin – overlaps with the southeastern area of the Riverside Drainage Area, specifically the southern section of the H-140 basin.
- Riverside Park Basin – overlaps with the eastern area of the Riverside Drainage Area, specifically the central area of the H-140 basin
- 37th Street Basin – overlaps with the 37th Street Drainage Area
- 31st Street Basin - overlaps with the 31st Street Drainage Area
- East Platte Basin – overlaps with the northern area of the 37st Street Drainage Area and the southern section of the 1st Avenue Drainage Area, and specifically with H-120

A rough comparison of the 1997 historical flows and the 2016 existing flows is provided in Table C-4. See Figure C-3 for a figure which graphically shows the difference between the 1997 basins and the 2016 basins. Most of the areas see an increase in both flow rate and area. Two major basins show a decreased peak flow rate. In the first of these cases, Urban Growth Area East, there is approximately 40 acres of residential area not included in the new area (for the basin comparison); however, there is an additional 145 acres included in the original basin that is undeveloped area in the floodplain. The difference may be due to differing land use assumptions or percent impervious values (only the existing land use, not zoned land use). In the second case – the East Platte basin – approximately 69 acres of open space was included in the new basin, reducing the overall percent imperviousness value.

A direct comparison between the two studies is not entirely practical due to the changes in basin delineation, land use, and CUHP/SWMM model versions. Particularly in the central-eastern section of the UGA – generally, between 35th and 23rd Avenue – considerable development has occurred since 1997. Basins in areas such as this were delineated along natural drainageways for the 1997 study, but along streets and stormwater infrastructure for this study.

4.7 Results of Analysis

Flow rates generated from CUHP and calculated with the rational method were compared with the existing stormwater infrastructure capacities. The capacities of the major pipes, channels, and detention ponds included in SWMM were calculated directly in the program and the results indicated for each scenario whether flooding occurred at each juncture and link. These areas of flooding overwhelmingly overlapped with the already identified areas of concern, which were analyzed with greater resolution in the rational analyses. Several additional areas of potential flooding were revealed, including pipes and channels along or discharging to Ashcroft Draw and the pipe system along 17th Avenue.

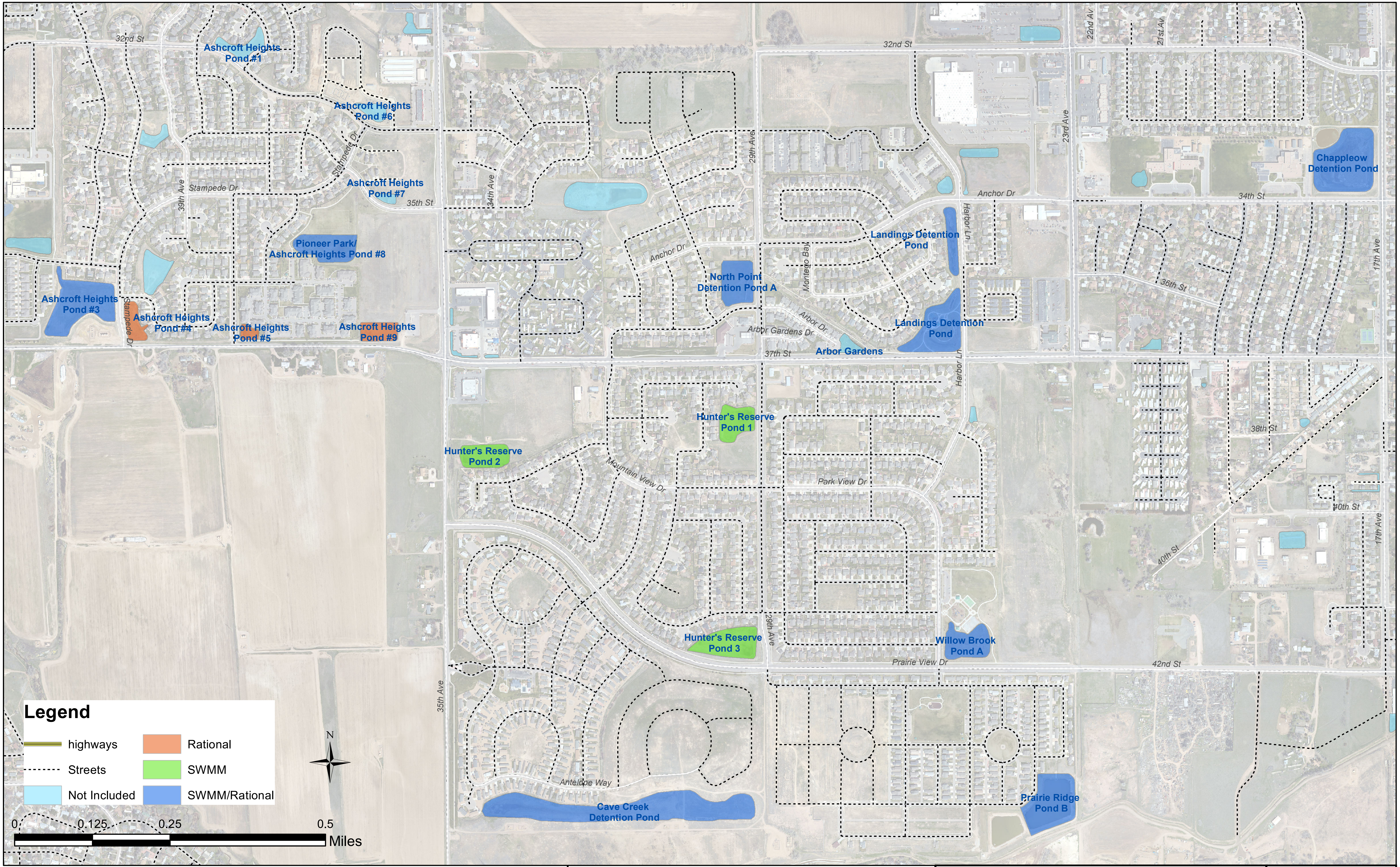
On average throughout the study area, the flow rates increase by 163.3% from the existing hydrologic conditions to the predicted (zoned) future conditions.

The comparison between the existing conditions model and the future conditions model is shown in Table 4-5.

Table 4-5: Existing and Future Flowrate Comparison

Basin*	Total Q_{100}, cfs	
	Existing	Future
Urban Growth Area West	1411	3429
65th Avenue	460	719
Rehmer Lake	847	1832
Urban Growth Area Central	672	1111
Ashcroft Draw	2379	3302
Urban Growth Area East	133	193
23rd Avenue	713	1341
17th Ave. Detention	514	559
Evans Town Ditch	569	577
Southeast Platte	728	776
Industrial Parkway	435	485
Riverside Park, River Bend	510	556
31st Street	1108	1135
37th Street	558	559
17th Avenue	278	691
East Platte	238	576

* As outlined in the 1997 Drainage Study



Evans 2016 Stormwater Utility Master Plan Drainage Study Analysis	Detention Ponds in the City of Evans	December 2016 Figure 4-1

5 HYDRAULIC ANALYSIS

5.1 Evaluation of Existing Infrastructure

Existing and required conduit or channel capacities were calculated in FlowMaster V8i. FlowMaster uses Manning's equation to calculate the flow capacity of a conduit given its dimensions, slope, and roughness coefficient. It can also calculate the normal depth or any of the other parameters listed, given a steady flow rate. A minimum slope of 0.005 ft./ft. was assumed in the initial hydraulic analysis, since it is the most conservative value; this is a valid supposition because most pipe and channel standards require at a minimum a 0.5% slope. In areas where surface slope is steeper, the measured slope was used for the analysis of the pipe. In the modeling of alternatives, the surface slope along the proposed length of conduit was used as the conduit slope even if it was less than 0.005 ft./ft. to be conservative in the size estimate. Also without site-specific survey and analysis, the full pipe design constraints are unknown. Pipe size changes, or transitions between one type of conduit to another, were considered in the hydraulic analysis. All flow was assumed to remain non-pressurized, including when the pipe flow approaches full capacity.

Street flow capacities were estimated using the UD-Inlet spreadsheet (prepared by UDFCD), which provides a conservative flow rate by incorporating a safety reduction factor and by calculating and comparing the maximum flow rate based on allowable depth and on allowable spread. Maximum depths within the gutter for the minor and major storms were 6" and 12", respectively. This is consistent with the updated criteria manual street flow specifications. The resultant flow rates from the updated criteria were smaller for the major storm, but larger for the minor storms.

Each street was individually inspected via the aerial photo to determine if these depths were appropriate. When the 12" did not seem feasible, a maximum depth of 9" was assumed. It is recommended that prior to the implementation of improvements, a site-specific survey be conducted to verify all street capacity assumptions. It was found that many streets in the historic downtown areas, in eastern Evans, cannot convey either the major or minor storm flows since many of the streets in this area do not have curb and gutter. In these areas, the pipes were commonly found to be undersized.

Concern areas #2 and #24 were modeled hydrologically but not hydraulically. Area #2 is a channel along US Hwy 85 and in a segment of highway that is planned for re-design in the near future. Area #24 is a safety hazard whose solution requires the introduction of a specialty structure, but not the elimination of flooding.

5.2 Flood Hazards

After the 1997 hydrologic analysis, several flood hazards were identified: the intersection of 37st Street and Highway 85, the intersection of 31st Street and Highway 85, the "Old Town" section of Evans, and the Evans Town Ditch overflows. As part of this study, the following locations were checked:

- The intersections of 31st Street and 37th Street at Highway 85 are no longer identified as specific problem areas, but in both cases downstream infrastructure was identified to be undersized for the predicted flow rates.
- Within the older Riverside Neighborhood, there are a number of problem areas that still exist and that were identified in this study. These arise primarily due to the flat slopes, lack of infrastructure, and undersized infrastructure in areas where it has been instituted.
- Evans Town Ditch overflows were not evaluated in this study; however, one of the objectives of the project was to eliminate stormwater flows discharged into the Evans Ditch. Several locations exist where significant flows are currently discharged to the ditch, and these have been addressed in the hydraulic and alternatives analysis.

Table D-1 (in Appendix D) provides a list and summary of the infrastructure predicted by SWMM to flood in the existing and future conditions. In both the existing and future 2016 model runs (for the major storm analysis), the same areas of concern are identified. The extents to which they flood differ due to increased peak flow rates in the more developed scenario; however, no additional areas were identified. This may be because the routed paths, slopes, and basin delineations were not altered. The areas identified by the CUHP/SWMM analysis corresponded well with information previously provided by the City. Only one area within the current City limits was classed as flooding that was not already flagged as an area of concern: 23rd Avenue, from 32nd to 42nd Street.

Nineteen of the twenty-five identified flooding hazards are located between 35th Avenue and the South Platte, and ten of these are located east of 11th Avenue. This section of Evans is the most historical and much of it was initially developed without stormwater infrastructure or considerations to Evans' future growth. These areas are relatively more difficult to renovate retroactively due to the higher development density private land ownership. There is little open space strategically located or sized for stormwater detention or open channels and recommended pipe capacities must therefore be greater to accommodate the greater impervious and lack of surface attenuation. There are fewer stormwater issues identified in the areas of Evans recently developed. In these areas the detention ponds are functioning efficiently and having a positive effect when maintained properly.

5.3 Previous Analyses

In the 1997 drainage study, no reporting of the hydraulic analysis was included. Hydrology results are included and summarized (in the previous section of this report); however, flow rates of pipes are provided in a table without discussion of specific or general analyses done to obtain those values. Therefore, the current hydraulic analyses on existing infrastructure were not compared with the results from previous studies.

5.4 Existing Capacities

The existing infrastructure capacities – including both pipe and street flow – are graphically summarized in Figure 5-1, which is color-coded to indicate the maximum design storm the pipe(s) can handle. All major pipe systems were included in the analysis. The scope of the study did not allow us to analyze each neighborhood system, but smaller systems that were a part of specific areas of concern are included in the map. Greeley's pipe system was not analyzed, although several of their pipes connect or otherwise discharge stormwater into Evans.

There are several areas where the analysis indicates the major storms can be handled safely by the existing infrastructure and street flow, but minor storms cannot. This can occur because the permissible street capacity is greater for major storm events than for minor events. The difference between the major and minor peak flow rates will depend on several factors including the basin area, detention capacity, and which design storm is used in each case. Finding that a system can handle the major storm does not guarantee that it has the capacity for the minor storm. In these areas, the pipe systems are shown as having the capacity of the largest of the minor storms that it can safely handle. Such areas include:

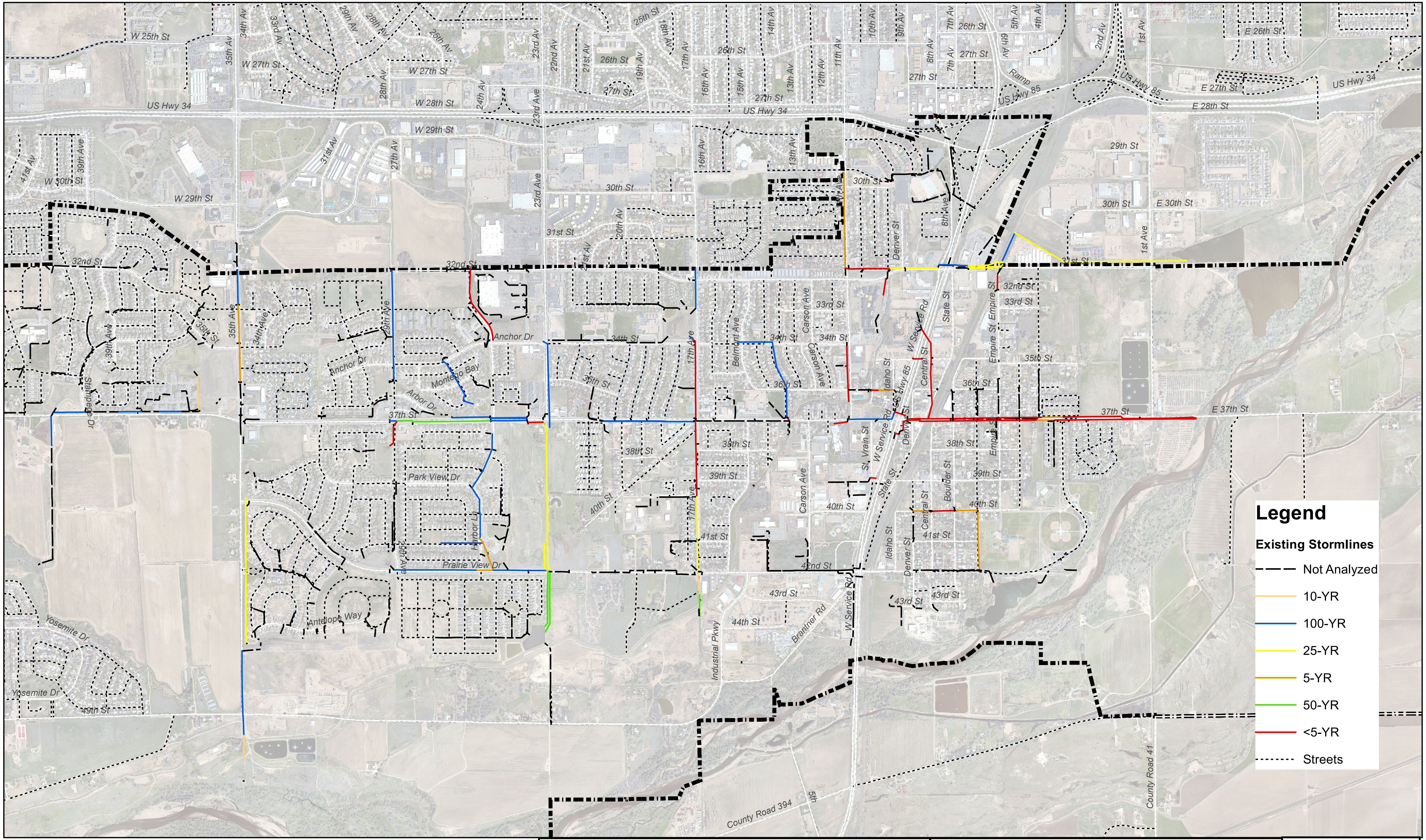
- Industrial Parkway (immediately downstream of the Chappelow detention pond)
- Concern Area #12 along both Belmont Avenue and 42nd Street near their intersection
- 42nd Street at the intersection of Harbor Lane (in this case, the system capacity is 4.1 cfs short of handling the 10-year storm, but is capable of handling the other design storms)

This list does not include systems that cannot handle the minor, 50-yr, or 100-yr storms, but can safely handle the 25-yr storm.

Detention pond attenuation was included in the capacity determinations. However, only the 100-year design outflow rate is known for several of the ponds, including the Chappelow detention pond. In these cases, the 100-year outflow rate was assumed for all storms, including the minor storms. In the case of the 17th Avenue / Industrial Parkway analysis, this assumption resulted in the pipe immediately downstream of the pond being undersized for the minor storms, but adequate for all three larger storms with the allowable street capacity. It is recommended that prior to implementing the recommended improvements to the system, along 17th Avenue and in other areas of concern, that the ponds be inspected and verified to attenuate the 100-year discharge to the design value. During these site-specific investigations, the release rate during the minor storms should be determined as well.

Area of Concern #8, along 31st St, may have unaccounted for mitigating conditions that cause the 30" pipe between High Dr. and Lakeside Dr. to appear in worse condition than it is. There's an open lot just south of 31st St Lane, along which the pipe is located. This lot slopes toward the intersection of Lakeside Dr. and 31st Street at the same grade as the road. Therefore, additional flow could be contained within the lot or spill over to 31st Street. Taking both of these additional flow paths into account, the system would function as a 50-yr storm sewer. However, the street capacity downstream would not be able to handle the combined street flow and open space flow.

Inlet capacities were not determined in this analysis, or in the analysis of individual areas-of-concern (with the exception of Area #1). During the engineering design of these improvements, the inlet capacities will need to be examined in detail.



Evans 2016 Stormwater Master Plan **Drainage Study Analysis**	EXISTING PIPE CONDITIONS - STORM CAPACITIES	October 2016 *Figure 5-1*

6 ALTERNATIVE ANALYSIS

With the hydrology and hydraulics complete, the alternatives for each Area of Concern were explored. As mentioned, there were 25 areas of concern that needed to be addressed. They are numbered as brought up in meetings with the City staff, but are not in any otherwise significant order. The extent of improvement varies on the magnitude of the flows as well as the existing infrastructure in place. Figure 6-1 shows the locations and identification numbers of the areas of concern within the context of the Urban Growth Area and current city limits. Table 6-1 lists the concerns and provides a description of the location and the concern. In the following pages is a summary of each area, an evaluation of the possible alternatives and finally a cost estimate for the improvements based on 2016 construction costs. Also included for each area is a map that shows the area of concern in more detail as well as the suggested improvements.

In addition to the improvement required to address the flooding concerns, suggestions are included to improve resiliency and incorporate green infrastructure. These are not incorporated in the cost estimates, which take into account only capacity-related improvements unless otherwise stated. One of its main focuses of green infrastructure is improving stormwater water quality before it is discharged into waters of the US. This is also the aim of the MS4 permit requirements. Resiliency, green infrastructure, and permit requirements are all discussed in depth in later sections of this report. At a minimum, it is beneficial to treat stormwater, by means of a wetland or detention facility, immediately before it enters the South Platte River. In many cases, the floodplain already contains natural wetlands, and reducing the required construction and maintenance effort to employ a constructed wetland. In areas where this is applicable, recommendations for such improvements are included in this report.

6.1 Assumptions

For each area of concern, it was first determined through the existing infrastructure analysis whether system improvements were necessary. Detention from ponds less than an acre was disregarded for this determination and in the sizing of proposed infrastructure. This allowed for conservative alternative recommendations that will be appropriate if the ponds are plugged, not properly maintained, or undersized. Alternatives that assume detention, for instance from regional detention basins, are noted specifically in the description for that area.

Design flow rates from the rational analyses were used both to evaluate and size the infrastructure. CUHP/SWMM basins were in general too coarsely delineated to represent each area of concern individually. Attenuation within the basin (between sub-basins) from street, pipe, or channel flow was included in the rational analysis. This and other model differences resulted in CUHP/SWMM consistently having 1.5 times greater peak flow rates than those determined through the rational method. This is a well-known phenomenon.

Pipes were assumed to have slopes matching those of the surface grades unless specified otherwise. When one end of the pipe was a Flared End Section, then the opposite end's invert elevation was calculated as the difference between the surface elevation and the sum of the minimum cover and the pipe diameter. These assumptions frequently resulted in slopes milder than the recommended minimum of 0.5%. Required pipe diameters in these instances can be quite large; during final design it may be discovered that surcharging the pipe is feasible and can allow a smaller diameter pipe. It was assumed that all proposed pipe, whether new or replacement, is reinforced concrete with a roughness coefficient of 0.015. This is a conservative value, and is identified in the Evans Stormwater Criteria Manual as the required design roughness coefficient to be used for pipe design.

Proposed channel slopes were similarly assumed to match the surface slopes; this is generally the case unless the channel depth changes along its length. A minimum bottom width of 4 feet was used to size proposed channels. Widths smaller than this are more difficult to construct. Similarly, the default side slopes were 4:1 (H:V). Steeper slopes were used where space was limited, but are not generally recommended due to safety and stability considerations. Challenges with attaining adequate vegetation growth also arise on steeper slopes.

6.1.1 Curb and Gutter and Street Flow Capacities

Street capacities were taken into account when practicable; however, in areas where the back-of-the-curb flow would drain away from the street, the street flow capacity was re-calculated in FlowMaster. The allowable street capacity was calculated for both the major and minor storms. Both were compared to the existing pipe capacities and stormwater inflow rates; since the allowable street capacity in the major storm is large, the minor storm sometimes produced flooding where the major storm did not. Proposed infrastructure was sized based upon the largest shortfall of capacity in these situations.

Several streets are currently unpaved or are paved but without curb-and-gutter. This was taken into account as well.

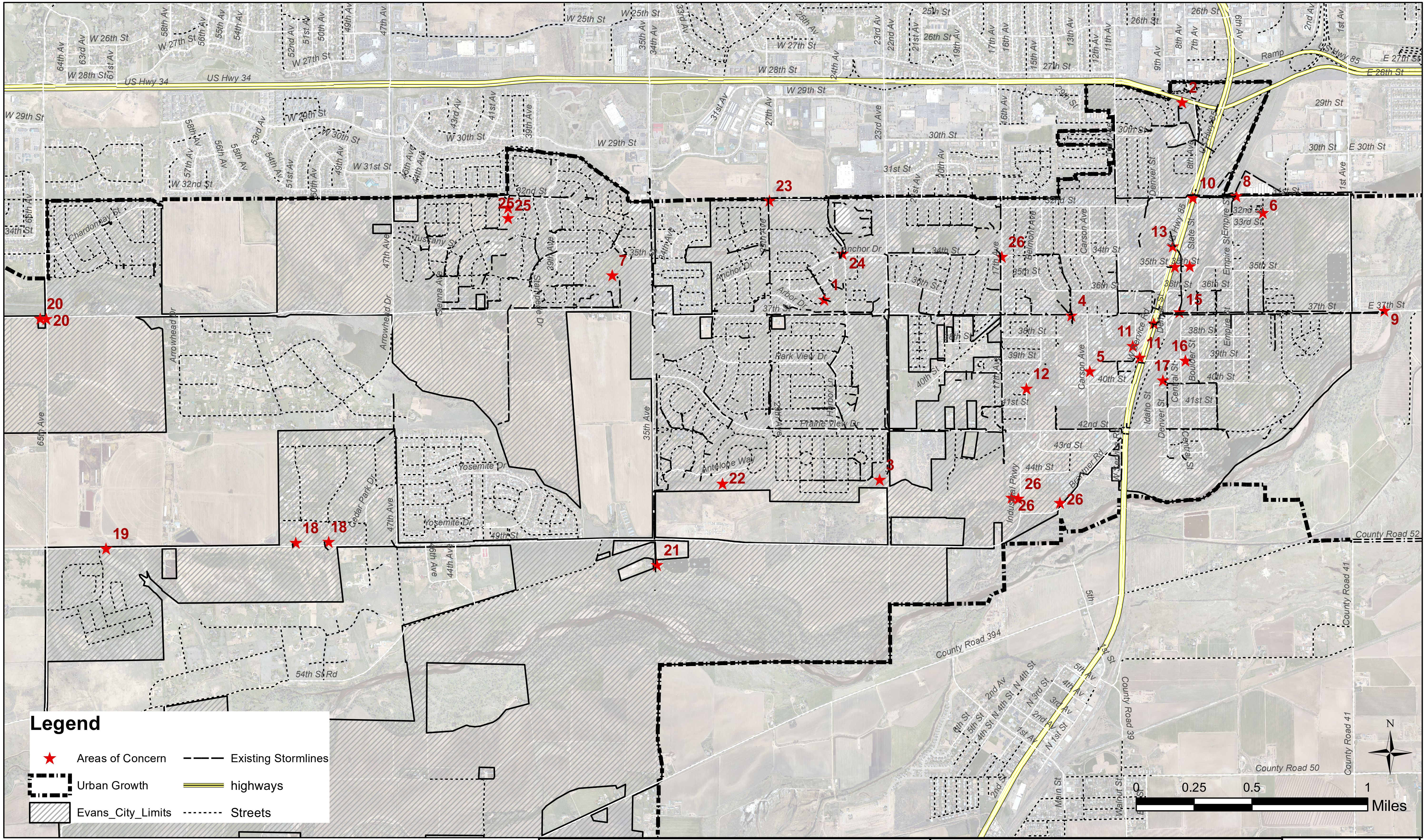
6.2 Alternative Identification

Alternatives were developed in collaboration with the City of Evans. While design-level studies were not performed for these items, a preliminary evaluation verified that each alternative is viable. For each alternative, the following was considered:

- Available cover over proposed pipes
- Encroachments on private property or outside of the right-of-way
- Available space, when considering open channels
- Necessary grading to existing surfaces, when considering detention

Cost was also considered in the alternatives identification. Lower cost approaches to system improvements were pursued where appropriate. Once an approach was identified, however, conservative design and cost assumptions were made. The alternatives considered were also adjusted based on input from City staff. In addition to capital costs, the estimated annual maintenance costs are included for each area of concern.

For several areas of concern, the required system improvements depend on the assumed future street capacities or upstream detention. In these cases, several infrastructure sizes are provided and the recommended option is contingent upon more detailed surveys during design and the City's assessment of detention pond maintenance concerns.



Evans 2016 Stormwater Utility Master Plan Drainage Study Analysis	Areas of Concern	October 2016
		Figure 6-1

Table 6-1: Summaries and Locations of Areas of Concern

ID*	Location	Problem Description	ID	Location	Problem Description
1	Montego Bay (North of 37th St.)	Stormwater falls on 29th Ave. floods Montego Bay Subdivision	14	Hwy 85 and 35th St.	Culvert under Hwy 85 doesn't go anywhere; ditch is routinely plugged
2	US Hwy 34 Roadside Ditch (23rd Ave.to 8th Ave.)	Ditch along US85 is in terrible shape, with vertical banks; it is located along the border of Evans and Greeley and receives stormwater from both municipalities	15	37th St. and State St.	Power pole was placed directly into pipe and blocks a portion of the storm drain
3	Ridge at Prairie View	Detention pond does not have a well-defined path to the River. It currently goes to drainage ditch S of 49th (but too much will likely flood road) and floods to Evans Ditch	16	39th St. (Boulder to Denver St.)	French drains always back up
4	37th St. and Valmont Ave.	SW flows in to Evans Ditch	17	Railroad Park	Detention pond has no function right now
5	Carson St. and 40th St.	Private detention pond does not connect to storm drainage	18	Neville's Crossing Ponds along 49th St.	Culverts south of Neville's Crossing are undersized and just flow out across a farm field
6	N Trinidad St. at Monico Gardens Dr.	Stormwater drains into Monico Drive Subdivision; there is no infrastructure at 32nd and 33rd	19	65th Avenue upstream of Rehmer Lake	Undersized, probably should be box culverts
7	Pioneer/Fox Crossing	The detention pond at Pioneer Park has an undersized outlet and a mildly sloping outlet pipe	20	37th St. and 65th Ave. (East of Prairie Heights MS)	Undersized steel pipe, drainage compromised by local agricultural tail water
8	31st St. east of Trinidad St.	There's only one outlet, and it is undersized	21	35th Ave. and 49th St.	Drainage issues as roads flow into outlet of WWTP #2
9	37th St. at River	Whenever the river floods (even minor floods), stormwater must be pumped out into the river to avoid backflow onto roads	22	Cave Creek (east of 35th Ave)	Maintenance status and responsibility unknown, detains stormwater from Hunter's Reserve and 29th St.
10	Hwy 85 and 31st St.	Verifying that recently installed infrastructure safely conveys stormwater flows	23	29th Avenue and 32nd Street	This concern has already been addressed by the city and will not be included in later sections of this report
11	St. Vrain St and W. Service Rd	Undersized outlets; outlet from detention pond just goes into street	24	Harbor Ln and Anchor Dr.	Existing Infrastructure functions well but is a safety hazard
12	Belmont St. (39th St. to 42nd St.)	SW drains directly into Evans Ditch or into swale that doesn't go anywhere else	25	Channel between 32nd St. and Milan St. (west of Cody Ave)	Drop structures are failing
13	Heritage Inn Parking Lot (adjacent to Highway 85)	The pipe conveying stormwater under Highway 85 is undersized	26	Industrial Parkway	Pipes are undersized and there is flooding on Industrial Parkway

* There is no significance to the numbering of the areas, and the IDs do not reflect location or priority

PREPARED UNDER THE SUPERVISION OF

DESIGNED: SEB
DRAWN: MAB
CHECKED: ALR

PROJECT NO. 15-041.01

SHEET REVISIONS

NO.	DATE	DESCRIPTION	BY

MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

AREA OF CONCERN 1
MONTEGO BAY AND ANCHOR/MONTEREY INTERSECTION

DATE: NOV 2016

DRAWING NO.

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6.3 Area of Concern #1 – Montego Bay Inlets

Area of Concern #1 is located northeast of the intersection of 37th Street and 29th Avenue, at the sump along Boardwalk just west of the Landings Detention Pond. Three storm inlets are situated in this sump and are Denver No. 16 Combination inlets. A 42" pipe connects the inlets and discharges the stormwater to the Landings Pond. Three sub-basins were delineated that drain to this point, which can be described in reference to the 36" pipeline under Boardwalk. The pipeline starts at the intersection of Anchor Drive and Chesapeake Bay/Boardwalk, where four inlets collect stormwater from the neighborhoods around Monterey Bay and Chesapeake Bay and from the north gutter along Anchor Drive. The area draining to these inlets is the first sub-basin. The second two basins are placed south of Anchor Drive and split the neighborhoods and streets into one area that drains to the on-grade inlets along Boardwalk and one whose stormwater flows along Montego Bay and Boardwalk and into the sump inlets. All three basins are characterized by Group A soils and primarily residential land use. Percent impervious values range between 62% and 67% for the three areas.

The four inlets at Anchor Drive have a combined capacity of 9.4 cfs; this is 58% of the minor storm and 23% of the major storm runoff produced in the first sub-basin. These flows continue south to the sump. Additional street flow is introduced as the pipe enters the downstream sub-basins. Approximately 51% and 19% of the flow along Boardwalk is captured by the two on-grade inlets. The street has an average slope of 1.3% and the lots have been designed to allow for ponding to occur above the curb during large storms; these permit adequate street capacity for the major storm. The concern arises when the stormwater reaches the sump at the base of the hill, which has the additional flow from the final sub-basin. Only 36% of the major-storm street flow can be captured by the inlets, resulting in a significant amount of ponded water at this location. Minor and major storm flow rates are shown in Table 6-2.

Table 6-2: Area of Concern #1 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
Anchor Dr.	40.2	34.5	24.5	21.2	16.3
Boardwalk	78.4	67.4	48.1	41.7	32.0

The capacity of the pipe is adequate to convey all of the stormwater generated during the major storm. Therefore, the proposed solution for this area is to replace the inlets at the Anchor Bay and Boardwalk sumps with larger inlets. There are four inlets at the Anchor Drive/Boardwalk intersection; replacing each with a 5-foot Type R inlet increases the individual inlet capacities to 5 cfs and the total to 20 cfs. All of the minor flows are collected and 10 cfs bypass the inlets and flow south along Boardwalk. The capacities of the on-grade inlets along Boardwalk cannot be improved upon appreciably by changing the inlet type; we recommend the existing inlets remain in place. The Boardwalk sump inlets require a total inlet capacity of 51.8 cfs. It is recommended, therefore that the existing inlets be replaced with Type R inlets.

- The configuration that captures all of the stormwater entails one 5' and two 10' Type R inlets. This yields a total capacity that is 11.5 cfs in excess of what is required.
- Installing one 5' and one 15' inlet results in total inlet capacity of 51.4 cfs, leaving 0.4 cfs to pool on Boardwalk until the street flow reduces.
- A third alternative is to install two 10' Type R inlets. The total capacity would be 51 cfs, leaving 0.8 cfs on the street until flow to the inlets reduces.

The latter two of these configuration alternatives involve two inlets; one of the three existing inlets would not be replaced. With final design, a more thorough evaluation of the magnitude of flow in each curb will help the City determine which of the three alternatives will work best. In addition, the size of the inlets may help dictate the final locations based upon existing utilities and driveways.

For budgeting purposes, it was assumed that only two of the three inlets would be replaced. The total length of inlet needed is 20' and the cost different between a 5' and 15' versus two 10' inlets should be comparable. Following is the expected cost for the improvements:

The cost estimate shows a total capital improvement cost of $110,992. This will include final engineering design, construction administration and provides for a 25% contingency.

The additional inlets planned with this option provide an example of resiliency. By replacing the inlets at the intersection of Anchor Drive and Boardwalk we are taking care of the stormwater at the source instead of letting it travel through the subdivision south of Anchor Drive. All of the inlets will minimize the flooding impact to the surrounding properties, making recovery from major events easier and quicker.

RECOMMENDATIONS	✓ **Replace the existing inlets at the intersection of Anchor Drive and Chesapeake Bay with 5' Type R inlets** ✓ **Keep the existing on-grade inlets along Boardwalk (between Anchor Drive and the sump) in place** ✓ **Remove the existing inlets in the sump along Boardwalk and replace them with one 5' and two 10' Type R inlets**

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

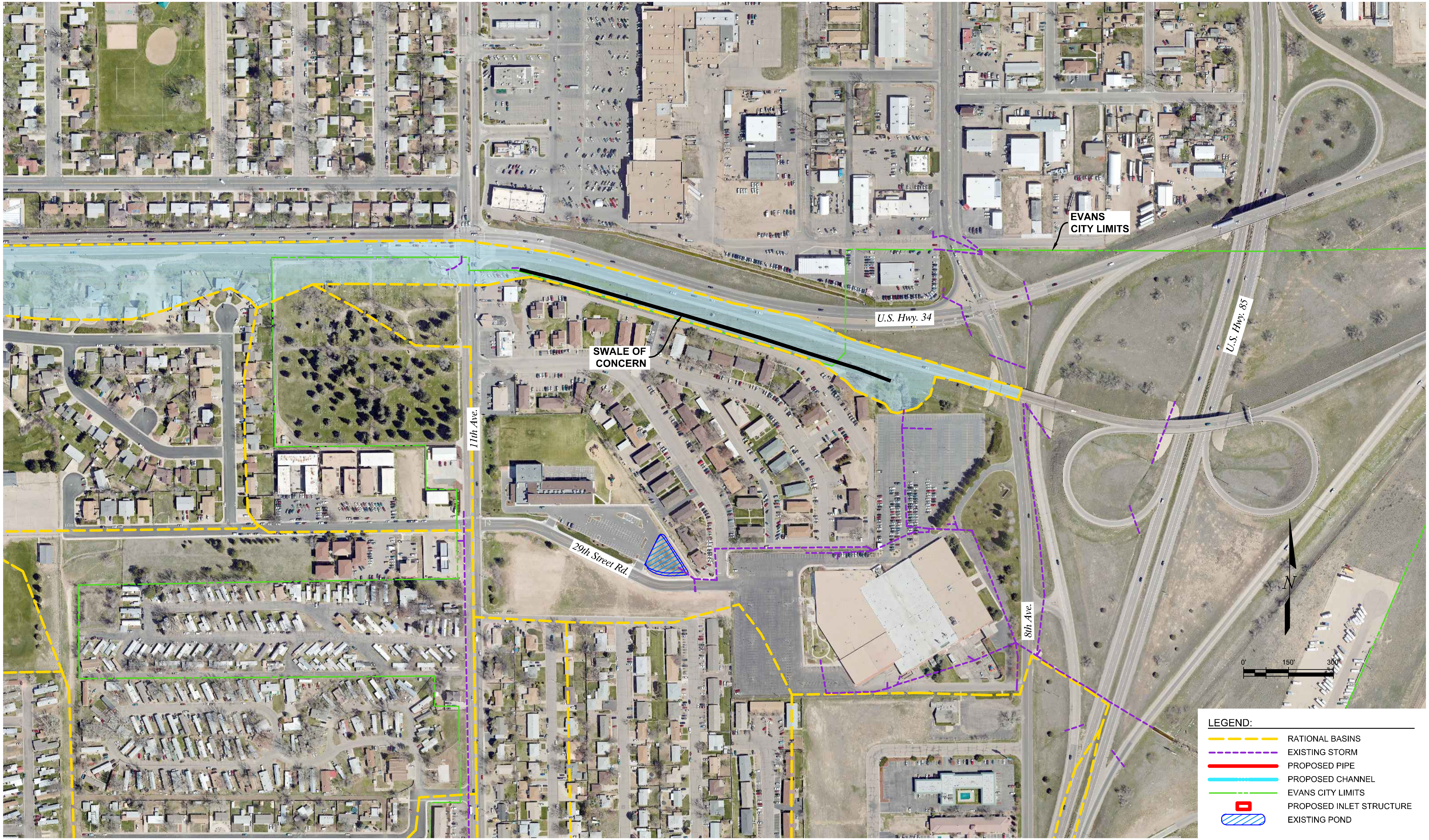
PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 1
ALTERNATIVE :	1
JURISDICTION :	Evans
SUB-BASIN ID:	Montego Bay-Reach1
DATE :	5/2/2016

DESCRIPTION		QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains					
Manholes and Inlets					
Storm Inlet, Type R/Type 14, 5-foot		8	EA	$5,910.00	$47,280.00
Special Items (User Defined)					
Removal of Inlet	<---User Defined Items	6	EACH	$1,000.00	$6,000.00

Master Plan Capital Improvement Cost Summary			
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$47,280.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$0.00
Removals			$0.00
Landscaping and Maintenance Improvements			$0.00
Special Items (User Defined)			$6,000.00
Subtotal Capital Improvement Costs			**$53,280.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$2,664.00
Traffic Control	$8,000.00	L.S.	$8,000.00
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00
Stormwater Management/Erosion Control	5%		$2,664.00
Subtotal Additional Capital Improvement Costs			**$18,328.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$10,741.00
Legal/Administrative	5%		$3,580.00
Contract Admin/Construction Management	10%		$7,161.00
Contingency	25%		$17,902.00
Subtotal Other Costs			**$39,384.00**
Total Capital Improvement Costs			**$110,992.00**

For cost purposes, each 10 and 15 foot inlet was assumed to be equivalent to 2 and 3 (respectively) 5 foot inlets

Master Plan Operation and Maintenance Cost Summary				
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Annual Cost**
Manhole and Inlet Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	8	EA	$64.00	$512.00
Total Annual Operation and Maintenance Cost				**$512.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$25,600.00**



PREPARED UNDER THE SUPERVISION OF	DESIGNED: SEB		SHEET REVISIONS	MULLER ENGINEERING COMPANY 777 S. WADSWORTH BLVD. 4-100 LAKEWOOD, COLORADO 80226	City of Evans, Colorado	CITY OF EVANS STORMWATER ALTERNATIVES	DATE NOV 2016
	DRAWN: MAB		NO. / DATE / DESCRIPTION / BY				DRAWING NO.
	CHECKED: ALR	PROJECT NO. 15-041.01				AREA OF CONCERN 2 HIGHWAY 34 ROADSIDE DITCH	PAGE NO. AC2-1

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6.4 Area of Concern #2 – US Highway 34 Roadside Ditch

Area of Concern #2 is an open-channel prone to flooding, positioned south of US Hwy 34. The portion of the channel that is of interest is just west of the Hwy 34 intersection and 8th Avenue. It receives runoff from a 13.4 acre drainage basin which includes the east-bound lanes of US 34. An additional 63 acres drain to connected pipes and channels upstream of the channel. This basin envelops US Hwy 34, extending west to east from 23rd Avenue to 11th Avenue. Both sub-basins are characterized by Type A soil groups and primarily commercial land use. The percent impervious of the sub-basins is 58% and 81%, respectively. A large percentage of the area of the latter sub-basin is the Greeley Mall; its parking lots results in an overall basin pavement area of 65%.

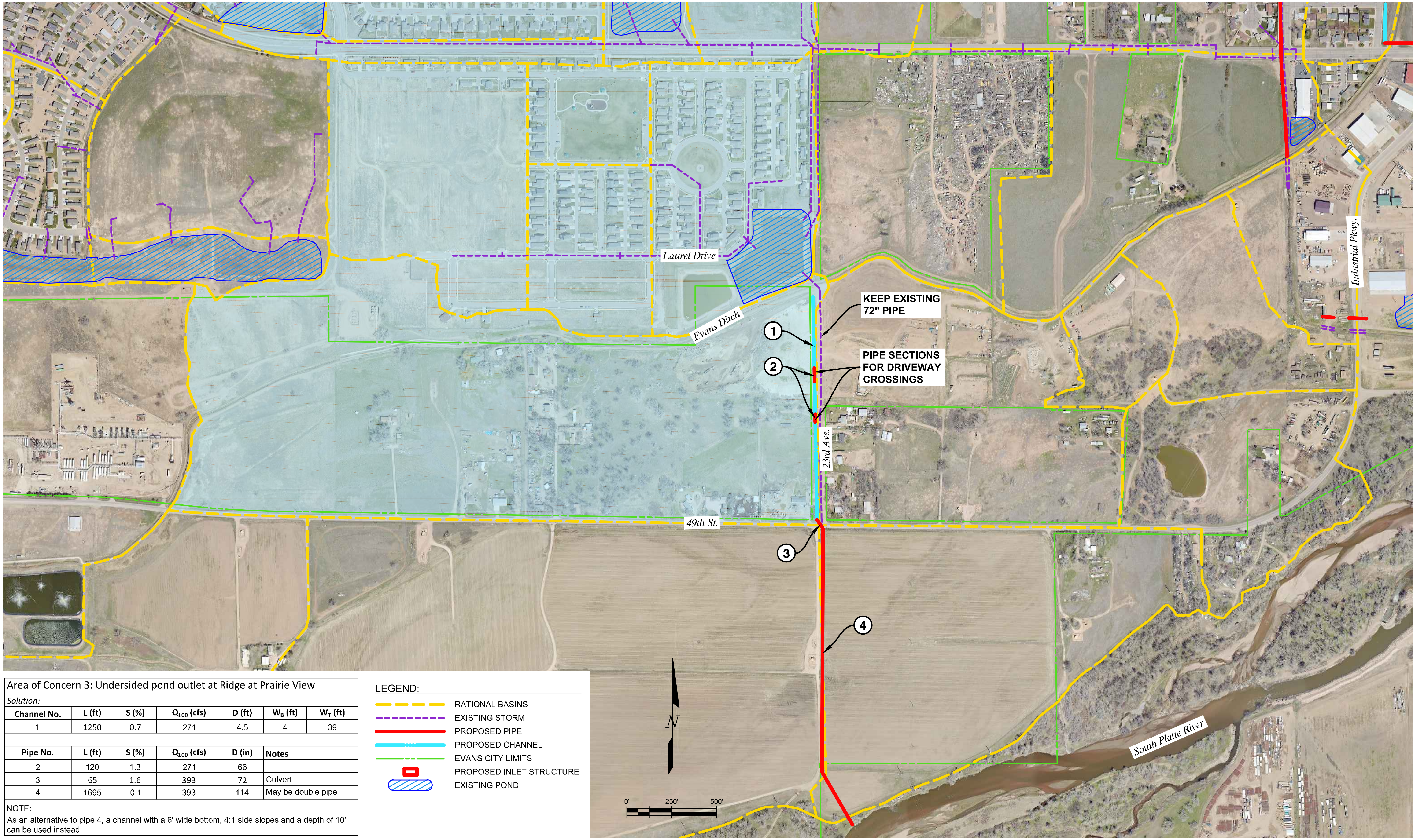
The channel is, in most areas, 2 feet wide at its base and four feet deep. Its side slopes on the south are about 1.7 ft/ft (H:V); on the north the slopes are about 3:1 ft/ft (H:V). The channel has an overall slope of 1.1% and flow capacity of 277 cfs. There is a buffer of approximately 25 feet between the channel and US Hwy 34. The peak flows expected from the design storms are listed in Table 6-3.

Table 6-3: Area of Concern #2 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
US Hwy 34 & 11th Ave.	193.1	169.1	123.2	111.1	87.8
US Hwy 34 & 8th Ave.	223.0	194.8	141.1	126.5	99.3

Although the channel is within Evans' UGA, the majority of the contributing area to Concern Area #2 is outside of the Evans UGA and current city limits. The pipes and channels in the second sub-basin that connect to the channel are owned by Greeley as well. Because of these property issues, and because the intersection of Hwy 34 and Hwy 85 (immediately east of the channel) is being re-designed in the near future, no solutions are being put forth at this time. Any alternatives will be, by necessity, a joint effort between Evans, Greeley, and CDOT.

RECOMMENDATIONS	✓ **Coordinate with CDOT and Greeley during the improvement of the US Hwy 85 and US Hwy 34 interchange** ✓ **Ensure the resulting channel capacity has a capacity of at least 225 cfs**



Area of Concern 3: Undersided pond outlet at Ridge at Prairie View

Solution:

Channel No.	L (ft)	S (%)	Q_{100} (cfs)	D (ft)	W_B (ft)	W_T (ft)
1	1250	0.7	271	4.5	4	39

Pipe No.	L (ft)	S (%)	Q_{100} (cfs)	D (in)	Notes
2	120	1.3	271	66	
3	65	1.6	393	72	Culvert
4	1695	0.1	393	114	May be double pipe

NOTE:
As an alternative to pipe 4, a channel with a 6' wide bottom, 4:1 side slopes and a depth of 10' can be used instead.

LEGEND:
- RATIONAL BASINS
- EXISTING STORM
- PROPOSED PIPE
- PROPOSED CHANNEL
- EVANS CITY LIMITS
- PROPOSED INLET STRUCTURE
- EXISTING POND

PREPARED UNDER THE SUPERVISION OF	DESIGNED: SEB	
	DRAWN: MAB	
	CHECKED: ALR	PROJECT NO. 15-041.01

SHEET REVISIONS

NO.	DATE	DESCRIPTION	BY

MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

AREA OF CONCERN 3
THE RIDGE AT PRAIRIE VIEW

DATE: NOV 2016

DRAWING NO.

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6.5 Area of Concern #3 – Ridge at Prairie View Outfall

At the southeast corner of Heather Lane and Laurel Drive is the Prairie Ridge Detention Pond. The pond is the outlet point of several stormwater systems, and forty-three sub-basins are included in its complete drainage area. This area extends from the agricultural and commercial areas north of 32nd Avenue – outside of the UGA – to the pond itself, 0.16 miles from the South Platte floodplain boundary. From west to east it extends from 35th Avenue to 23rd Avenue. The total basin area is 916.6 acres and includes Areas of Concern #1, #23, and #24. Most of the drainage area is comprised of single-family residential lots, although the sub-basins for Areas #23 and #24 are largely agricultural. The eastern sub-basins of Area #3 contain much more open land than the central or western sub-basins. The basins south of 42nd Street are residential or soon-to-be developed for that use. The overall percent impervious of the area is 41.1%; however, of the forty-three sub-basins, twelve have an impervious value between 50% and 60%. The most impervious sub-basin has a value of 87%, while that of the least impervious sub-basin is 6%. Thirty-four sub-basins –79% of the sub-basins – are characterized primarily by soil group type A. Four sub-basins are characterized by soil type B; five basins are primarily soil type D.

In addition to the Prairie Ridge Detention Basin there are eight smaller detention ponds in the overall basin, including:

- Landings detention pond,
- Willow Brook detention pond,
- North Point Pond A,
- Hunters Reserve Pond #1, and
- Hunters Reserve Pond #3
- Arbor Gardens
- Un-named detention ponds #1
- Un-named detention ponds #2

The first six of the listed ponds are included in the SWMM and rational models of the basin (Hunters Reserve Pond #2 discharges into the Cave Creek system). Arbor Gardens and the un-named detention ponds near Mariner's Landing Drive are also within the Area #3 drainage area, but are smaller and thus not included in the hydrologic models.

Since the drainage area is so large, it encompasses several distinct stormwater pathways. From Area #24, stormwater is conveyed through a 24" pipe under Harbor Lane to Landings detention pond. Runoff from the Area #23 sub-basins is collected and conveyed in a 30" storm sewer under 29th Avenue. North Point detention pond, which collects stormwater from the most western-most sub-basins, also ultimately discharges to the 29rd Ave. storm pipe. This pipe eventually discharges to an open channel adjacent to Area #1 which terminates into a 36" pipe under 37th Street. A parallel 30" pipeline collects stormwater from Hunters Reserve Pond #1. At the intersection of 23rd Avenue and 37th Street, the Landings detention pond and the 37th Street pipes juncture with a 10" pipe running under 23rd Ave. This pipe continues south, under an open field and increases in diameter to 54". South of 37th Street, a 48" pipe starting along Harbor Drive and continuing along Park View Drive collects stormwater from several neighborhoods and discharges to the Willow Brook detention pond. Hunters Reserve Pond #3 is located approximately 0.3 miles west of Willow Brook. Both ponds discharge into a 54" pipe under Prairie View Drive and are conveyed east and then south, parallel to the 54" pipe conveying stormwater from the northern basins. These two pipes are the main inlets into the Prairie View detention pond; however, the neighborhoods south of Prairie View Drive are collected into a 36" pipe which has its own inlet into the pond. The outlet from the Prairie View pond is a 72" pipe that continues south. It currently ends with a flared end section (FES) immediately after crossing 49th Avenue in the south roadside ditch. Stormwater flows east in the ditch before eventually ponding and spilling into the South Platte, approximately 0.3 miles south.

Two approaches were taken in the Area #3 hydrologic model regarding the many ponds, since the detention provided has a large impact on the peak flow rates estimated throughout the basin and at the outlet. Although the City has reviewed and approved the use of the detention ponds in SWMM, their state of repair and design assumptions were not readily available in every case. Table 6-4 compares the drainage report design flows with those calculated by SWMM and the rational method.

Table 6-4: Detention Ponds in Area of Concern #3

Detention pond	Area (ac)	Volume (AF)	Design Q (cfs)		Calculated Q (CFS)		
			Q_{IN}	Q_{OUT}	$Q_{IN,SWMM}$	$Q_{IN,Rational}$	$Q_{OUT,SWMM}$
Landings	4.88	5.37		38	557.6	348.8	488.2
Willow Brook	10.5	10.53	283	76	457.4	372.7	310.5
Prairie Ridge Pond B*	3.94	52.8	836	54	1343.2	1053.2	753.6
North Point	3.34	13.16	412	71.7	601.8	209.4	408.4
Hunters Reserve #1	1.73	4.46		54.9	71.7	75.9	20.9
Hunters Reserve #3	2.62	9.61		24.1	103.6	84.3	15.8
Arbor Gardens	0.46	1.09		1.73	430.2	353.5	NA
Mariner's Landing Dr. Pond	2.24				NA	335.4	NA

** per drainage report; there is a much smaller, local detention pond named "Pond A"*

For other areas of concern, the detention ponds in their drainage ways were assumed to be clogged, overwhelmed, or off-line. The same assumption was made for Area #3. This is a conservative approach, but one that is justified when the design contributing areas for ponds are compared with the actual areas delineated for this analysis. In most cases where the drainage report included the anticipated inflow, it was found that the modeled inflow is considerably larger. Table 6-5 displays the calculated flow rates at several juncture points, both for when ponds are assumed to function correctly, and with no detention assumed.

Table 6-5: Area #3 Detention Pond Design Outflow

Junction	100-Yr Flow Rate (cfs)	
	Functioning	No Ponds
Hunters Reserve Pond #1	76	75.9
Hunters Reserve Pond #1 Outflow	55	NA
Hunters Reserve Pond #3	84	84.3
Hunters Reserve Pond #3 Outflow	24	NA
Willow Brook	78	77.7
Willow Brook Outflow	76	NA
Landing Inflow	349	349
Landings Outflow	38	349
North Point Inflow	209	209.4
North Point Outflow	72	NA
Harbor and 37th St. (Pond)	198	336
Arbor Gardens	216	353
Arbor Gardens Outflow	2	NA
Junction at 23rd Ave.	389	669.6
Inflow to Prairie View (1)	665	954
Total Inflow to Prairie Ridge	765	1053
Prairie Ridge Outflow	271	NA
To South Platte	328	1131.9

The initial concern within this area is that the path to the river is not well-defined. However, in the CUHP and rational analyses, it was determined that the Prairie Ridge outlet pipe is undersized for the flowrate coming from the pond in a major storm event. The total pipe capacity is 328 cfs, or 30% of the 1132 cfs expected in the 100-year storm. The drainage report calculations indicate the pond was designed for a contributing basin area of 237 acres, so it is not surprising that its outlet is overwhelmed by the stormwater it currently receives. Overflow from the pond spills into the Evans Town Ditch if it is not running full. This discharge into the irrigation ditch is not permitted under Evans' stormwater policies. The design inflow rate to the Landings detention pond – the largest pond in the drainage area besides Prairie Ridge – is unknown. Therefore, the full flow was assumed for the major storm and pipe sizing calculations. Table 6-6 summarizes the flows throughout the basin at major points, assuming no pond attenuation.

Table 6-6: Area of Concern #3 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
37th St. & 23rd Ave.	669.6	607.7	516.7	480.9	431.2
Prairie View Dr.	953.5	898.3	716.1	642.9	546.9
Prairie View Detention Pond	1131.9	1043.0	810.1	712.5	586.4

As part of the alternatives analysis, an additional outlet structure and channel were sized to convey the overflow from Prairie Ridge Detention pond to 49th Street. A 108" pipe would be required; this pipe would convey the overflow under Evans Town Ditch into an open channel that is at least 6.5 feet deep and 4 feet wide at its invert. The total top width required would be 54 feet, assuming typical side slopes.

It is the City's intent to extend the pipe all the way to the river. The equivalent pipe diameter required to convey all of the flow to the River is 150"; however, due to cover and slope constraints, a multiple pipe system would likely be required. All of the area south of 49th Street is located in the floodplain and there are no developments near the conveyance zone. Therefore, an alternative to the dual pipe system is a single open channel. The required channel dimensions for the existing slope are:

- 3.5 foot depth
- 4.5:1 side slopes (assumed)
- 20 foot bottom width

Other channel configurations are possible as well; however, the bottom width and depth were optimized to achieve the minimum top width. The estimated velocity of the channel is 4.7 ft/s, so minimal channel protection would likely be needed.

For the purposes of the cost estimate, costs are provided for both the channel and the pipe. Since a multiple pipe system would be necessary south of 49th Street, 54" and 60" pipes were used. The cost for the improvements as shown and discussed (for the pipe alternative) is $1,991,458. As an alternative, if a channel were to be built south of 49th Street, the project would be significantly cheaper. The cost for the channel south of 49th Street is $543,144. It should be noted that in either situation, an easement would be necessary through this property. Current property values from the Weld County Assessor's office were used to estimate the cost.

Depending on the alternative chosen, there are some ways that the proposed design is resilient. The channel option will allow for infiltration and water quality. It also takes pressure off the culverts under Industrial Parkway that in turn provides a benefit to the rest of the surrounding infrastructure. The channel/pipe south of the detention pond helps protect the Evans Town Ditch as well as the residents directly south of the pond. Since the outfall discharges directly in to the South Platte, it is recommended that a constructed wetland be placed at the outlet. To treat the water quality capture volume (WQCV) of the entire watershed, the area of a 1.5 foot deep wetland should be 6.5 acres. Alternatively, a wetland channel could be constructed in place of all or a portion of the recommended channel.

RECOMMENDATIONS	✓ **Construct a grass-lined or wetland overflow channel from the Prairie Ridge detention pond to the 49th Street intersection** ✓ **Construct a channel or 114" (equivalent) pipeline to the South Platte from 49th Street to the South Platte** ✓ **Connect the existing pipe to the channel or pipeline at 49th Street**

Alternative 1 Cost Estimate

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 3
ALTERNATIVE :	1
JURISDICTION :	Evans
SUB-BASIN ID:	Ridge at Prairie View-Reach3
DATE :	5/2/2016

DESCRIPTION	SUPPORTING DATA (USER DEFINED AND CALCULATED)						QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains										
Circular Pipes										
Diameter (in)	Length (ft)	No. of Barrels								
54-inch	120	1					120	L.F.	$277.00	$33,240.00
78-inch	65	1					65	L.F.	$501.00	$32,565.00
54-inch	1695	1					1695	L.F.	$277.00	$469,515.00
60-inch	1695	1					1695	L.F.	$308.00	$522,060.00
Headwalls										
Diameter (in)	Applicable	No. of Barrels	U/S Headwall	D/S Headwall	Concrete (C.Y.)	Steel (lbs)				
78-inch	Yes	1	Yes	Yes	3.11	306.00	2	EA	$2,703.81	$5,408.00
54-inch	Yes	1	Yes	Yes	2.12	209.00	2	EA	$1,843.52	$3,687.00
60-inch	Yes	1	Yes	Yes	2.35	236.00	2	EA	$2,047.85	$4,096.00
Wingwalls (includes concrete apron)										
Diameter (in)		No. of Barrels	Interior Span (ft)	Length (ft)	Concrete (C.Y.)	Steel (lbs)				
78-inch		1	11.75	20	20.85	927.23	2	EA	$17,004.17	$34,008.00
54-inch		1	8.75	16	13.80	633.11	2	EA	$11,271.99	$22,544.00
60-inch		1	9.50	16	14.03	644.91	2	EA	$11,460.50	$22,921.00
Landscaping and Maintenance Improvements										
Reclamation & seeding (native grasses)							2	ACRE	$1,285.00	$2,570.00
Land Acquisition										
Easement/ROW Acquisition							2.00	ACRE	$1,500.00	$3,000.00

Master Plan Capital Improvement Cost Summary

Capital Improvement Costs			
Pipe Culverts and Storm Drains			$1,150,044.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$0.00
Removals			$0.00
Landscaping and Maintenance Improvements			$2,570.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$1,152,614.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$57,631.00
Traffic Control	$10,000.00	L.S.	$10,000.00
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00
Stormwater Management/Erosion Control	5%		$57,631.00
Subtotal Additional Capital Improvement Costs			**$130,262.00**
Land Acquisition Costs			
ROW/Easements			$3,000.00
Subtotal Land Acquisition Costs			**$3,000.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$192,431.00
Legal/Administrative	5%		$64,144.00
Contract Admin/Construction Management	10%		$128,288.00
Contingency	25%		$320,719.00
Subtotal Other Costs			**$705,582.00**
Total Capital Improvement Costs			**$1,991,458.00**

Master Plan Operation and Maintenance Cost Summary

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	3575	L.F.	$1.00	$715.00
Total Annual Operation and Maintenance Cost				**$715.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$35,750.00**

Alternative 2 Cost Estimate

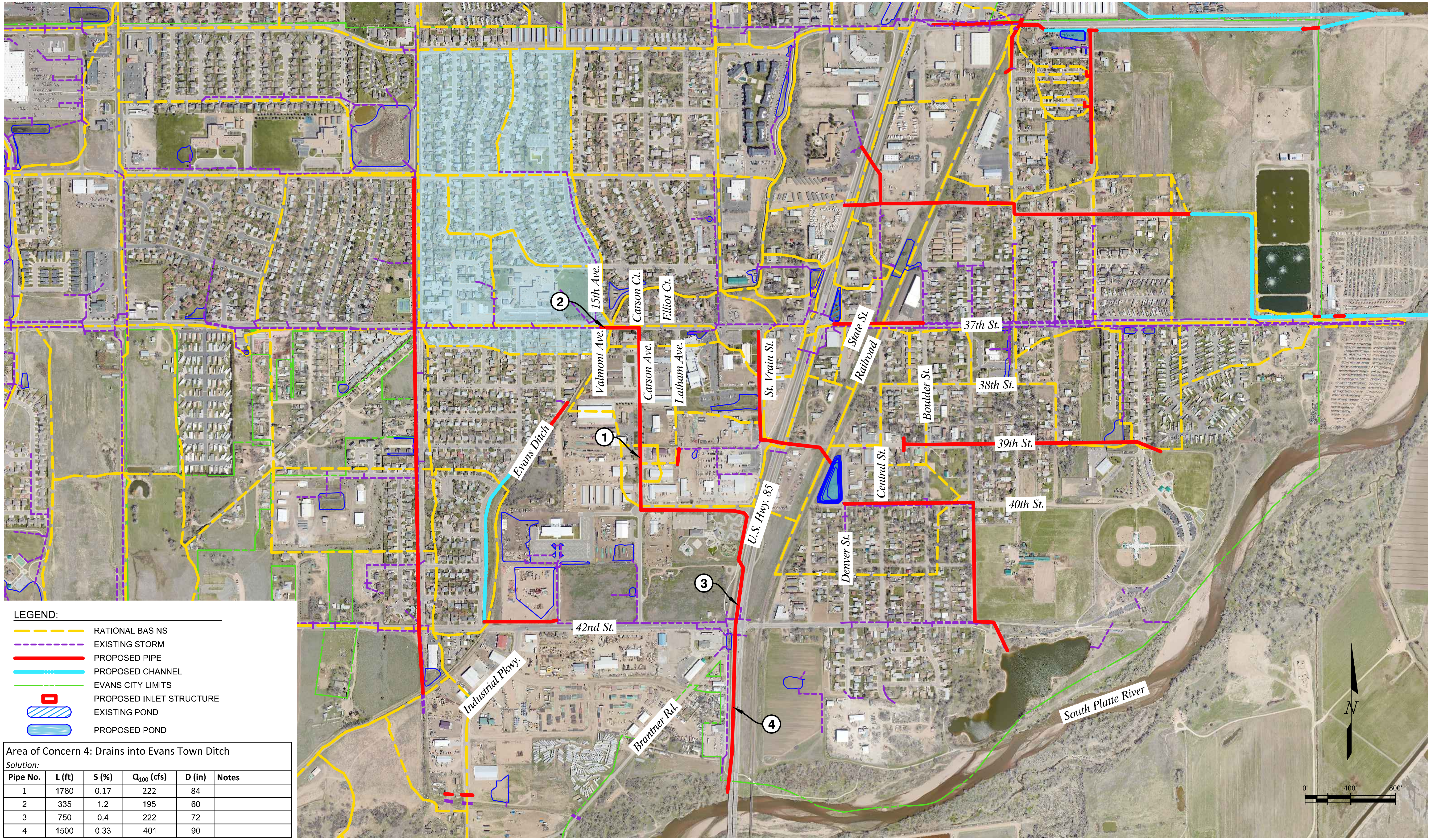
MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 3
ALTERNATIVE :	2
JURISDICTION :	Evans
SUB-BASIN ID:	Ridge at Prairie View-Reach3a
DATE :	5/2/2016

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	Length (ft)	No. of Barrels				
54-inch	120	1	120	L.F.	$277.00	$33,240.00
78-inch	65	1	65	L.F.	$501.00	$32,565.00
Headwalls						
Diameter (in)	Applicable	No. of Barrels				
78-inch	Yes	1	2	EA	$2,703.81	$5,408.00
Wingwalls (includes concrete apron)						
Diameter (in)		No. of Barrels				
78-inch		1	2	EA	$17,004.17	$34,008.00
Detention/Water Quality Facilities						
Detention (User Entered Quantities)						
Excavation, Mid Range			6296	C.Y.	$31.00	$195,185.00
Landscaping and Maintenance Improvements						
Reclamation & seeding (native grasses)			2	ACRE	$1,285.00	$2,758.00
Land Acquisition						
Easement/ROW Acquisition			2.00	ACRE	$1,500.00	$3,000.00

an Capital Improvement Cost Summary			
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$105,221.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$195,185.00
Removals			$0.00
Landscaping and Maintenance Improvements			$2,758.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$303,164.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$15,158.00
Traffic Control	$10,000.00	L.S.	$10,000.00
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00
Stormwater Management/Erosion Control	5%		$15,158.00
Subtotal Additional Capital Improvement Costs			**$45,316.00**
Land Acquisition Costs			
ROW/Easements			$3,000.00
Subtotal Land Acquisition Costs			**$3,000.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$52,272.00
Legal/Administrative	5%		$17,424.00
Contract Admin/Construction Management	10%		$34,848.00
Contingency	25%		$87,120.00
Subtotal Other Costs			**$191,664.00**
Total Capital Improvement Costs			**$543,144.00**

Master Plan Operation and Maintenance Cost Summary				
Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	185	L.F.	$1.00	$37.00
Channel Maintenance (e.g. sediment & debris removal, erosion, tree & weed removal, etc.)	1695	L.F.	$3.00	$5,085.00
Mowing (e.g. channels, ponds, etc.)	3.89	ACRE	$64.00	$498.00
Total Annual Operation and Maintenance Cost				**$5,620.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$281,000.00**



Area of Concern 4: Drains into Evans Town Ditch

Solution:

Pipe No.	L (ft)	S (%)	Q_{100} (cfs)	D (in)	Notes
1	1780	0.17	222	84	
2	335	1.2	195	60	
3	750	0.4	222	72	
4	1500	0.33	401	90	

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PREPARED UNDER THE SUPERVISION OF

DESIGNED: SEB

DRAWN: MAB

CHECKED: ALR

PROJECT NO. 15-041.01

SHEET REVISIONS

NO.	DATE	DESCRIPTION	BY

MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

AREA OF CONCERN 4
37TH STREET NEAR VALMONT AVENUE

DATE: NOV 2016

DRAWING NO.

PAGE NO. AC4-1

6.6 Area of Concern #4 – 37th Street and Valmont Avenue

Area of Concern #4 is located along Valmont Street where it terminates at the Evans Town Ditch, near the intersection of 37th Street and 15th Avenue. From this point, it extends west to 17th Street and north to 32nd Street. Six sub-basins were delineated for the discharge point on Valmont Street. The majority of the drainage area – 82% – is single-family residential lots. At the northwest corner of 37th Street and 15th Ave. there is a large commercial building with a 3.0 acre open field to its east. The overall imperviousness of the basin is 61.6%, with a maximum sub-basin value of 65% and a minimum of 58%. Half of the sub-basins soils are predominately of group A; the three most northern sub-basins have primarily type B soils.

Runoff from the two northern sub-basins drains south to a 27” storm sewer under 34th Street. This pipe turns south and runs under 15th Avenue until 37th Street. Stormwater from the western most area of the drainage area is collected into a 27” pipe under 37th Street and runs east until it junctions with the 15th Avenue pipe. A 24” pipe carries the stormwater from these systems south along Valmont Street and discharges into the Evans Town Ditch. In all basins, the stormwater is collected via street inlets; there are a total of fifteen existing inlets within the drainage area. No detention ponds exist within the drainage area.

The concern in this area is that the stormwater currently discharges to the Evans Town Ditch. One of the objectives of this alternatives analysis is to minimize the use of the ditch for stormwater routing. The nearest existing major stormwater system to Area #4 is the 37th Street system, described in detail in the description of Area of Concern #9. These pipes are already overwhelmed in large storms and cannot take the additional stormwater without major infrastructure improvements. An alternative is to divert water from Area #4 and surrounding areas south along Carson Ave. Currently, there is no stormwater infrastructure under Carson Avenue, and runoff is conveyed south as street flow. A pipe must be installed along 37th Street from 15th Avenue and extending east regardless of the alternative for Area #9 chosen. This pipe must be 60” in equivalent diameter. The existing 24” pipe under Valmont Street must be removed to prevent further discharge into the Evans Town Ditch. Table 6-7 displays the peak stormwater flowrates to the drainage area outlet.

Table 6-7: Area of Concern #4 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
37th St. and 15th Ave	194.1	168.1	118.1	101.4	77.3

The Evans Town Ditch at Valmont Street is piped under 37th Avenue; the invert of the outlet is at an elevation of 4672; the street surface elevation is 4676. Although the diameter of the pipe or box culvert conveying the ditch was not known for this analysis, it is assumed that installing a 60” pipe under the ditch will likely require a siphon.

Alternative 1

The first alternative supplements the first alternative listed for Area of Concern #9. A new storm sewer under Carson Ave. would collect drainage from the Area #4 basin and from the Area #9 sub-basins located west of St. Vrain and south of 37th Street. At 40th Street, the pipe would turn east and discharge into a new detention pond in the lot where the Family Fun Center currently is located. The required infrastructure includes:

- A 60” pipe to convey the stormwater from the Area #4 drainage basin along 37th Street to Carson Ave. This is approximately 335 feet in length.
- A 30” pipe to collect stormwater generated from the neighborhood immediately north of 37th Street and west of 11th Avenue
- 1,780 feet of new 60” equivalent diameter pipe under Carson Ave.
- A new detention pond south of 40th Street.
- An outlet pipe, increasing gradually between 42” to 72” in equivalent diameter, between the Carson Ave. pond and the floodplain.

The pipe along Carson Ave. would discharge to the proposed regional detention pond. A multiple pipe system will undoubtedly be necessary; the road surface elevation at 37th Street and Carson Ave. is 4673 feet and the proposed detention pond would have a top elevation of 4671 and total depth of 8 feet. Given 1 foot cover at the road, a 60” pipe would require a pond inlet elevation of 4665.5 (the proposed pond invert is 4663). This would yield a pipe slope of 0.084%. A dual 36” pipe system along Carson Ave. would yield a slope of 0.1%. There is no pipe configuration that yields a slope of 0.5% or greater; the surface elevation slope between the two points is 0.11%, and does not account for pipe cover.

A minimum of 15.6 acre-feet of storage is required to detain the flow to historic release rates. A potential configuration, providing this storage, yields a pond depth of 8 feet and surface area of 3.1 acres. On the corner of US Hwy 85 and 42nd Street, there are several lots with no or abandoned development. For the alternative which provides detention, this area was used as a possible pond location. The lot is over 6 acres in total, although constraints to allow for parking and grade-tie-ins decrease the available area to work with. It is recommended that the pond elevation range between 4666 at its surface and 4658 at its invert to ease the grading tie-in and outflow slopes.

The pond outflow would be conveyed south along the W Service Road in a new pipeline until it junctions with an existing pipeline south of 42nd Street. This pipe is currently 34” per the City GIS data (assumed to be an elliptical 34”x53”), but would need to be upsized to accommodate the additional flow.

The additional 350 cfs south of 42nd Street is the estimated outflow from the area west of Carson Ave. and east of 17th Avenue that is not captured by other drainage systems. Approximately 115 acres is included in this area. While rational analysis calculations were not performed in this area, except for that in Area of Concern #12, a reasonable estimate for the major storm flows (in cfs) is 3 times the contributing area (in acres). The stormwater currently is ultimately collected in the previously mentioned 34”x53” pipe. The pond outlet would connect to the pipe in the W. Service Road. However, the 34”x53” pipe would need to be increased to at least a 48” to convey the pond outflow, and needs to have an equivalent diameter of 90" to convey this and the flow from its contributing basin. The proposed flow rates and pipe diameters for these areas are listed in Table 6-8.

Table 6-8: Area #4 Alternative 1 Pipe Requirements

Location	Flow Rate (cfs)	Eq. Pipe Size
Carson Ave. to Pond	222	84"
W Service Rd from Pond	80	48"
W Service Rd south of 42nd St.	430	90"

Alternative 2

Alternative 2 is a modified version of Alternative 1, and routes the stormwater currently discharged from Area #4 to a pipe system along Carson Ave. In this option, however, the pipe continues along Carson Ave. past 40th Street and turns right along 42nd Street before joining with the existing system along US Hwy 85. No detention is provided in this alternative.

The average slope of Carson Ave. between 40th and 42nd Street is 0.9%, and has curb and gutter along its length. The calculated maximum street capacity for the major storm is 25.8 cfs. 42nd Avenue has an average slope of 0.25% between Carson Ave. and US Hwy 85. Its maximum flow capacity during the major storm is 13.8 cfs. The pipe sizes required to convey the flow are:

- 60" equivalent diameter pipe along Carson Ave. between 40th and 42nd Streets
- 66" equivalent diameter pipe along 42nd Street between Carson Ave. and US Hwy 85
- 90" equivalent pipe along W Service Road to discharge into the South Platte

A 0.14 acre pond exists at the southwest corner of 42nd Street and US Hwy 85, which was not designed for the additional flow from Area #4. Therefore, it is recommended that the pond is expanded or bypassed. Downstream, the recommended pipe sizes remain the same as those described in Alternative #1.

The lots adjacent to Carson Ave. and 42nd Street are currently undeveloped, and could accommodate a channel, as an alternative to the extended pipe system. However, the area is in close proximity to US Hwy 85, and is highly valuable land. Should a channel become recognized as a viable option, its required dimensions would be:

- 4 feet deep along Carson Ave. and 4.8 feet deep along 42nd Street; this provides a foot of freeboard during the 100-year storm
- 4:1 H:V side slopes
- 4 foot bottom width

In both Alternatives 1 and 2, the final pipe that discharges to the South Platte also carries the stormwater produced from the area east of 17th Street and west of the W Service Road and north of 43rd Street. The required pipe size is large and may require a dual pipe system. Alternatively, a channel can be constructed to convey these flows to the River. The required channel depth, assuming a bottom width of 4 feet and side slopes of 4:1, is 5.5 feet. The resulting top width of 50 feet would be difficult to implement with the existing land layout, however, such a channel could be included in plans for the area's redevelopment.

Alternative 3

A third alternative may be considered if the 37th Street system is replaced with larger pipe to accommodate all the flow from its drainageway. This alternative involves piping stormwater east to the 37th Street stormwater system, and would require:

- 1,030 feet of new 60" pipe along 37th Street from 15th Avenue to 11th Avenue
- Replacing 1,005 feet of 30" pipe with 60" pipe along 37th Street, between 11th Avenue to the first of the two in-line detention ponds next to US Hwy 85

Given a 1' cover at both junctures, it would have a slope of 0.84%.

A cost estimate was completed for only the first two options due to some site constraints along 37th Street. The total cost for Alternative 1 is **$**7,248,176. Maintenance costs are estimated to be $975,450 per year. This includes the proposed detention pond and all the necessary pipe additions. The total capital cost for Alternative 2 is $4,821,285. The annual maintenance cost is estimated to be $90,600. This assumes that the stormwater is piped along the entire pathway to the South Platte. Using a channel will increase maintenance costs but will lower capital costs.

This system provides resiliency by diverting flows away from Evans Town Ditch. Depending on the option chosen, there may be opportunities for water quality and infiltration in channels. The pipe along the W Service Rd currently discharges into the floodplain of the South Platte. This outfall will be preserved with this report's recommendations. Natural wetlands may already be present between the outlet and the main channel banks of the South Platte. Because of the large flows expected from this system, it is recommended that the wetlands be supplemented or modified so as to permit stormwater treatment without the ecosystem becoming degraded. The recommended treatment area for the contributing watershed is 2.7 acres, assuming the wetlands are in a depression 1.5 feet deep.

RECOMMENDATION: **ALTERNATIVE 2**	✓ **Install 3,860 feet of combined channel and 60" (equivalent) pipe from 15th Avenue to 42nd Street along Carson Street** ✓ **Construct a siphon to transfer stormwater under the ETD, if necessary** ✓ **Install 1,475 feet of combined channel and 90" (equivalent) pipe to along W Service Road to the South Platte**

Alternative 1 Cost Estimate

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern #4
ALTERNATIVE :	1
JURISDICTION :	Evans
SUB-BASIN ID:	37th and Valmont-Area 4 — DATE : 5/2/2016

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	Length (ft)	No. of Barrels				
60-inch	1780	2	3560	L.F.	$308.00	$1,096,480.00
60-inch	335	1	335	L.F.	$308.00	$103,180.00
42-inch	750	1	750	L.F.	$162.00	$121,500.00
48-inch	1500	3	4500	L.F.	$185.00	$832,500.00
30-inch	500	1	500	L.F.	$116.00	$58,000.00
Flare End Sections						
Diameter (in)	Applicable	No. of Barrels				
42-inch	Yes	1	1	EA	$2,184.00	$2,184.00
48-inch	Yes	3	6	EA	$2,646.00	$15,876.00
Headwalls						
Diameter (in)	Applicable	No. of Barrels				
60-inch	Yes	2	2	EA	$3,490.29	$6,981.00
60-inch	Yes	1	2	EA	$2,047.85	$4,096.00
Wingwalls (includes concrete apron)						
Diameter (in)		No. of Barrels				
60-inch		2	2	EA	$13,471.30	$26,943.00
60-inch		1	2	EA	$11,460.50	$22,921.00
Manholes and Inlets						
Manhole, 6' Dia. (Pipe Dia. = 48")			7	EA	$5,524.00	$38,668.00
Type B Manhole (Pipe Dia. 48" and larger, deflection < 10 degrees)			3	EA	$15,416.00	$46,248.00
Type P Manhole (Pipe Dia. 48" and larger, deflection > 10 degrees)			2	EA	$19,271.00	$38,542.00
Detention/Water Quality Facilities						
Detention (Complete-in-Place)						
Detention Facility 1 (Complete-in-Place)			16	AC-FT	$58,582.00	$937,312.00
Detention (User Entered Quantities)						
Excavation, Mid Range			25800	C.Y.	$31.00	$799,800.00
Outlet Works			1	EA	$50,000.00	$50,000.00
Removals						
Removal of culvert pipe (D<48")			300	L.F.	$26.00	$7,800.00
Landscaping and Maintenance Improvements						
Reclamation & seeding (native grasses)			8	ACRE	$1,285.00	$10,280.00

Master Plan Capital Improvement Cost Summary			
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$2,414,119.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$1,787,112.00
Removals			$7,800.00
Landscaping and Maintenance Improvements			$10,280.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$4,219,311.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$210,966.00
Traffic Control	$25,000.00	L.S.	$25,000.00
Utility Coordination/Relocation	$10,000.00	L.S.	$10,000.00
Stormwater Management/Erosion Control	5%		$210,966.00
Subtotal Additional Capital Improvement Costs			**$456,932.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$701,436.00
Legal/Administrative	5%		$233,812.00
Contract Admin/Construction Management	10%		$467,624.00
Contingency	25%		$1,169,061.00
Subtotal Other Costs			**$2,571,933.00**
Total Capital Improvement Costs			**$7,248,176.00**

Master Plan Operation and Maintenance Cost Summary				
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Annual Cost**
Culvert Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	6047	L.F.	$1.00	$1,209.00
Manhole and Inlet Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	17	EA	$64.00	$1,088.00
Hydraulic Structure Maintenance (e.g. debris removal, erosion, structural repairs, etc.)	2	EA	$642.00	$1,284.00
Detention/WQ Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	8	ACRE	$1,927.00	$15,416.00
Mowing (e.g. channels, ponds, etc.)	8	ACRE	$64.00	$512.00
Total Annual Operation and Maintenance Cost				**$19,509.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$975,450.00**

Alternative 2 Cost Estimate

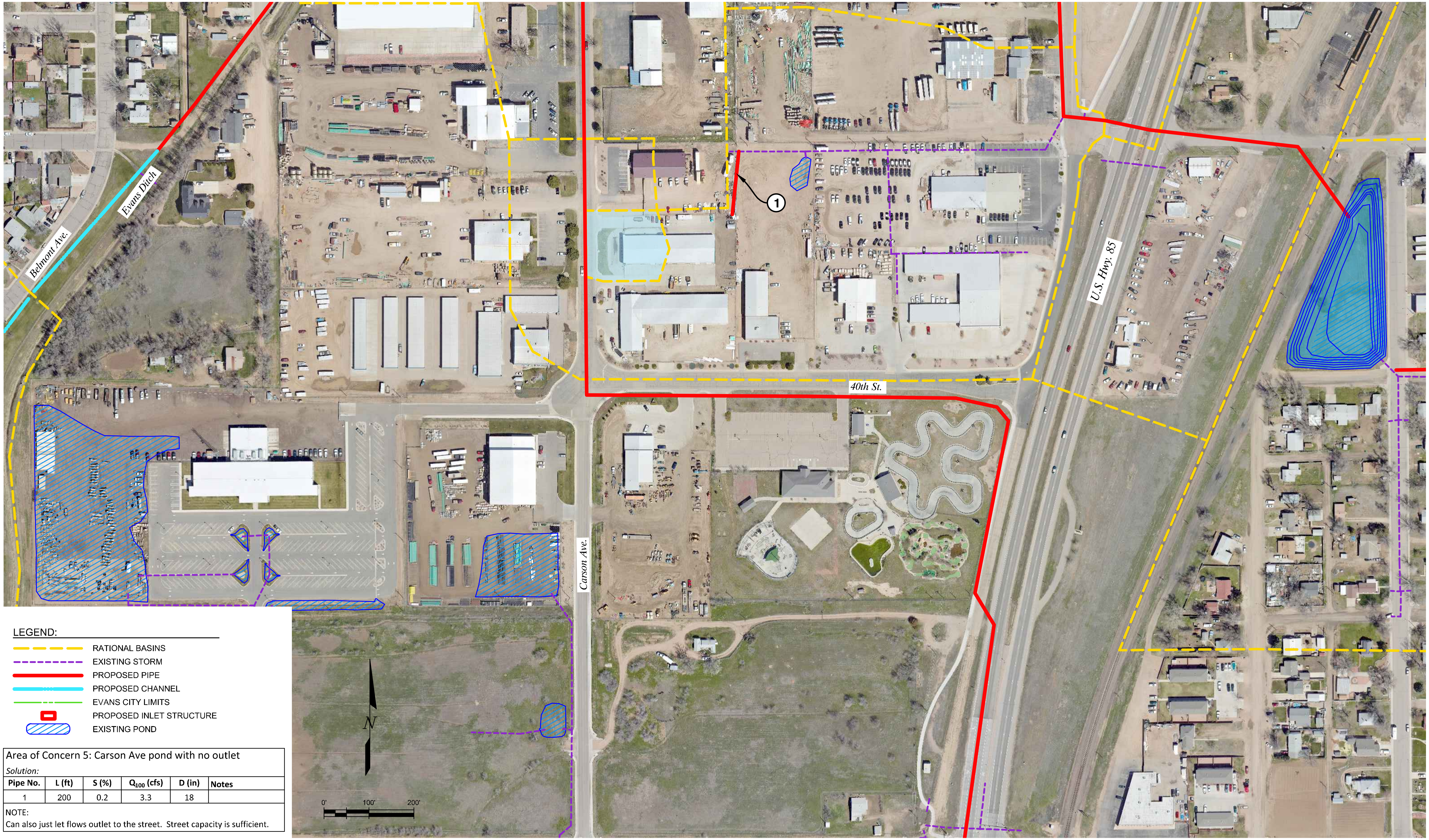
MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 4
ALTERNATIVE :	2
JURISDICTION :	Evans
SUB-BASIN ID:	37th and Valmont-Reach4a
DATE :	5/2/2016

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	Length (ft)	No. of Barrels				
60-inch	335	1	335	L.F.	$308.00	$103,180.00
42-inch	750	1	750	L.F.	$162.00	$121,500.00
60-inch	3422	1	3422	L.F.	$308.00	$1,053,976.00
60-inch	1500	3	4500	L.F.	$308.00	$1,386,000.00
Manholes and Inlets						
Manhole, 6' Dia. (Pipe Dia. = 48")			7	EA	$5,524.00	$38,668.00
Type B Manhole (Pipe Dia. 48" and larger, deflection < 10 degrees)			3	EA	$15,416.00	$46,248.00
Type P Manhole (Pipe Dia. 48" and larger, deflection > 10 degrees)			2	EA	$19,271.00	$38,542.00
Removals						
Removal of culvert pipe (D<48")			300	L.F.	$26.00	$7,800.00

Master Plan Capital Improvement Cost Summary			
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$2,788,114.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$0.00
Removals			$7,800.00
Landscaping and Maintenance Improvements			$0.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$2,795,914.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$139,796.00
Traffic Control	$25,000.00	L.S.	$25,000.00
Utility Coordination/Relocation	$10,000.00	L.S.	$10,000.00
Stormwater Management/Erosion Control	5%		$139,796.00
Subtotal Additional Capital Improvement Costs			**$314,592.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$466,576.00
Legal/Administrative	5%		$155,525.00
Contract Admin/Construction Management	10%		$311,051.00
Contingency	25%		$777,627.00
Subtotal Other Costs			**$1,710,779.00**
Total Capital Improvement Costs			**$4,821,285.00**

Master Plan Operation and Maintenance Cost Summary				
Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, erosion at entrance/exit, structural repairs	5220	L.F.	$1.00	$1,044.00
Manhole and Inlet Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	12	EA	$64.00	$768.00
Total Annual Operation and Maintenance Cost				**$1,812.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$90,600.00**



LEGEND:

- RATIONAL BASINS
- EXISTING STORM
- PROPOSED PIPE
- PROPOSED CHANNEL
- EVANS CITY LIMITS
- PROPOSED INLET STRUCTURE
- EXISTING POND

Area of Concern 5: Carson Ave pond with no outlet

Solution:

Pipe No.	L (ft)	S (%)	Q_{100} (cfs)	D (in)	Notes
1	200	0.2	3.3	18	

NOTE:
Can also just let flows outlet to the street. Street capacity is sufficient.

PREPARED UNDER THE SUPERVISION OF

DESIGNED: SEB

DRAWN: MAB

CHECKED: ALR

PROJECT NO. 15-041.01

SHEET REVISIONS

NO.	DATE	DESCRIPTION	BY

MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

AREA OF CONCERN 5
CARSON AVENUE AND 40TH STREET

DATE: NOV 2016

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6.7 Area of Concern #5 – Carson Avenue and 40th Street

Area of Concern #5 is located near the intersection of Carson Avenue and 40th Street; its entire drainage area is 0.62 acres, and consists of a small privately constructed and maintained detention pond. This basin receives the runoff from 150 feet of the northbound lane of Carson Ave., half the roof and the parking area around the commercial building on whose site the pond is located. Area #5 is located within one of the sub-basins of Area of Concern #11. The majority of the drainage area – 77.9% – is paved; the grassed detention pond comprises 9% of the basin. The rest of the basin, 13.1% is gravel parking lot. The overall imperviousness of the basin is 80%. All of the area is characterized by soil group type B.

The detention pond has a surface area just less than 0.05 acres. A private pipeline, 12” in diameter, conveys the stormwater collected in the pond to the east and ends at the edge of the property without connecting to any of the City’s stormwater systems. The nearest City-maintained stormwater pipe is north and slightly east of the private pipe outlet and is a 12” diameter pipe.

The disconnection of the pond to the City’s system is the source of concern for this area. Only about 140 feet separate the private pipe from the City pipe; however, it is believed that the connection is on private property.

It is recommended that the City install an 18” pipe connecting the private pipe and the existing City-maintained pipe. There is very little slope between the two points. Although the depths to which the pipes are currently buried are unknown, both the private and City pipes connect to nearby ponds and the City pipe discharges to an open channel adjacent to the W Service Road. The invert elevations of the inlet and out points were used estimate the slope of the existing pipes and the elevation at the proposed pipe juncture. A 0.2% slope between the private and City pipe is possible. This provides a cover of 1.7 feet. Flowrates for each of the design storms are presented in Table 6-9.

Table 6-9: Area of Concern #5 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
Carson private detention pond	4.1	3.6	2.6	2.3	1.9

Detention ponds in other areas of concern were not incorporated into the analyses, except in cases where the design pipe was the outlet pipe of a pond. While this is the case in this situation, an exception was made. Thus, in this hydrologic analysis, the detention provided by the pond was not taken into account while calculating the flow rates. Because the flows from the major storm are relatively minor, the capacity of even a small pipe is more than adequate to convey the design storm runoff. More importantly, the pond is privately maintained, and there is no assurance that it will be done so properly or frequently enough so as not to hinder its efficiency. Finally, given the size of the pond, it is unlikely that its detention would reduce the peak flow rates of larger storms, even for the small drainage area.

Following is a cost estimate for the pipe improvements. The 18” pipe size is assumed, to allow for easier maintenance and is the minimum pipe size per the City criteria.

The 18” pipe extension is estimated to cost $56,980. This includes the easement acquisition process. The Weld County Assessors map was used to determine a property valuation for the easement

While the flow from the detention pond is minimal, it still will cause damage since there is not an outlet point. Therefore, the pipe connection will provide some resiliency to the system.

RECOMMENDATIONS	✓ **Install 140 feet of 18” pipe between the pond’s outlet to the existing City stormsewer**

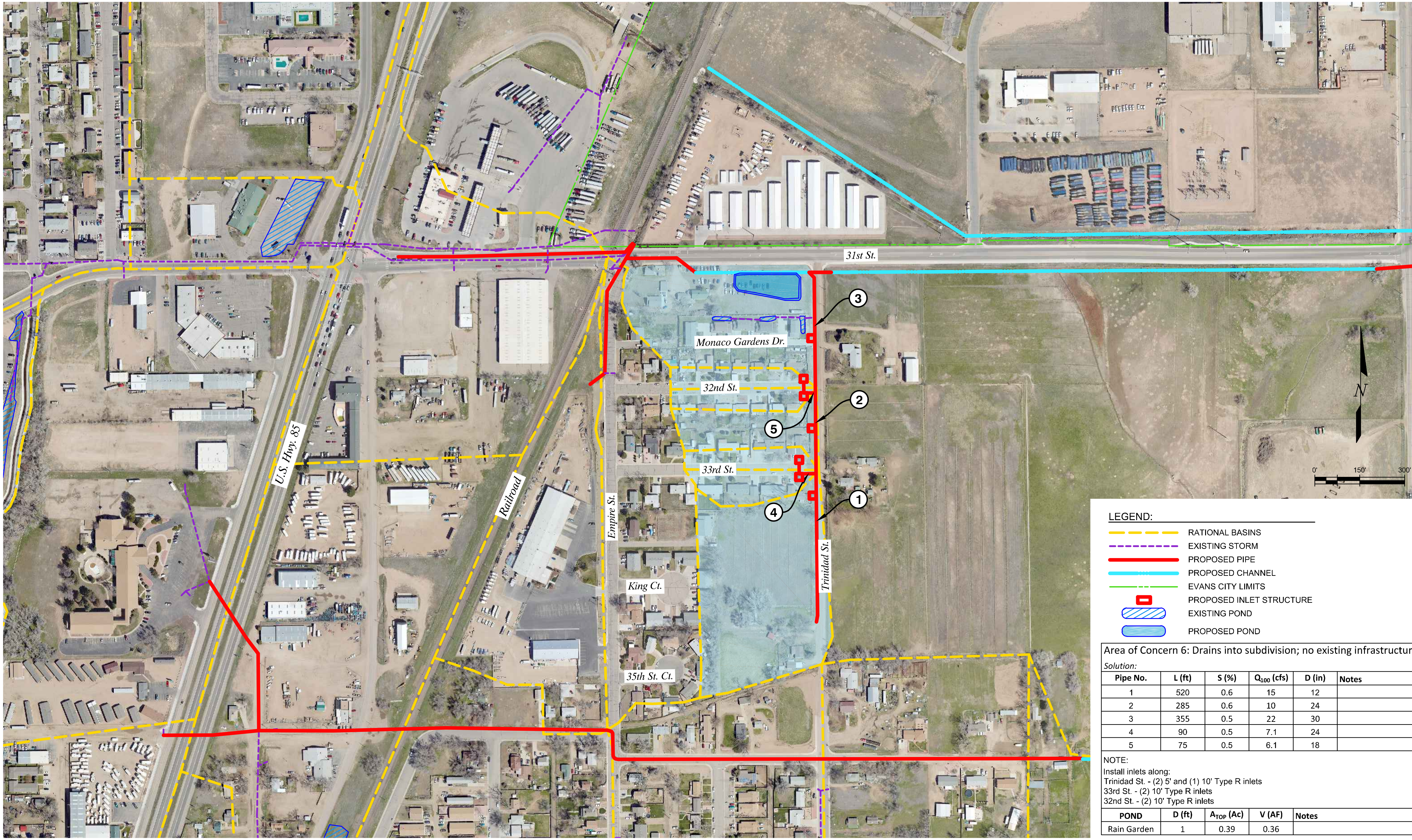
MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern #5
ALTERNATIVE :	1
JURISDICTION :	Evans
SUB-BASIN ID:	Carson St and 40th - Area 5
DATE :	5/2/2016

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	Length (ft)	No. of Barrels				
18-inch	140	1	140	L.F.	$69.00	$9,660.00
Manholes and Inlets						
Manhole, 4' Dia. (Pipe Dia. < 36")			2	EA	$3,726.00	$7,452.00
Land Acquisition						
Easement/ROW Acquisition			0.05	ACRE	$266,000.00	$12,213.00

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Master Plan Operation and Maintenance Cost Summary				
Culvert Maintenance (e.g. sediment & debris removal, erosion at entrance/exit, structural repairs	140	L.F.	$1.00	$28.00
Manhole and Inlet Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	2	EA	$64.00	$128.00
Total Annual Operation and Maintenance Cost				**$156.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$7,800.00**

an Capital Improvement Cost Summary			
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$17,112.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$0.00
Removals			$0.00
Landscaping and Maintenance Improvements			$0.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$17,112.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$856.00
Traffic Control	$5,000.00	L.S.	$5,000.00
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00
Stormwater Management/Erosion Control	5%		$856.00
Subtotal Additional Capital Improvement Costs			**$11,712.00**
Land Acquisition Costs			
ROW/Easements			$12,213.00
Subtotal Land Acquisition Costs			**$12,213.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$4,324.00
Legal/Administrative	5%		$1,441.00
Contract Admin/Construction Management	10%		$2,882.00
Contingency	25%		$7,206.00
Subtotal Other Costs			**$15,853.00**
Total Capital Improvement Costs			**$56,890.00**



LEGEND:

- RATIONAL BASINS
- EXISTING STORM
- PROPOSED PIPE
- PROPOSED CHANNEL
- EVANS CITY LIMITS
- PROPOSED INLET STRUCTURE
- EXISTING POND
- PROPOSED POND

Area of Concern 6: Drains into subdivision; no existing infrastructure

Solution:

Pipe No.	L (ft)	S (%)	Q_{100} (cfs)	D (in)	Notes
1	520	0.6	15	12	
2	285	0.6	10	24	
3	355	0.5	22	30	
4	90	0.5	7.1	24	
5	75	0.5	6.1	18	

NOTE:
Install inlets along:
Trinidad St. - (2) 5' and (1) 10' Type R inlets
33rd St. - (2) 10' Type R inlets
32nd St. - (2) 10' Type R inlets

POND	D (ft)	A_{TOP} (Ac)	V (AF)	Notes
Rain Garden	1	0.39	0.36	

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PREPARED UNDER THE SUPERVISION OF

DESIGNED: SEB
DRAWN: MAB
CHECKED: ALR

PROJECT NO. 15-041.01

SHEET REVISIONS

NO.	DATE	DESCRIPTION	BY

MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

AREA OF CONCERN 6
TRINIDAD STREET

DATE: NOV 2016

DRAWING NO.

PAGE NO. AC6-1

6.8 Area of Concern #6 – North Trinidad Street at Monico Garden Drive

Area of Concern #6 is located in the northeastern section of Evans, south of 31st Avenue and east of Empire Street. Its eastern boundary is Trinidad Street and its southern boundary is the roadside ditch that starts at Empire Street and 35th Street, crosses Trinidad Street, and then continues east towards several undeveloped lots. Seven sub-basins were delineated for this drainage area. The northern-most of these includes residences on Monico Gardens Dr.. Going south, the other sub-basins incorporate the neighborhoods along 32nd Street and 33rd Street. The total drainage basin area is 15.3 acres; the average sub-basin area is 2.2 acres. Just over 50% of the total drainage basin is characterized by single-family residential lots. Another 38% is undeveloped land. The last 12% is pavement area. In the sub-basin adjacent to 31st Street there is approximately an acre of land that is currently used for parking for the local neighborhood businesses, but is unpaved and otherwise unused. The most southern basin of the drainage area is almost completely comprised of undeveloped land. The overall imperviousness of the basin is 43.9%; sub-basin values range from 19% to 77% imperviousness. Most of the drainage area is classified as having type A group soils; only the northernmost basin is predominately soil type B.

Three 0.02 acre detention ponds function in series in the sub-basin just south of 31st Street (north of the houses on Monico Gardens Drive); these are connected by a 12” pipe that discharges to Trinidad Street. No other stormwater infrastructure exists within the drainage area. Although 32nd and 33rd streets are paved and allow for curb-and-gutter flow, Trinidad Street is still unpaved. Plans are in development for the improvement of Trinidad Street; the schedule and design of which is undetermined at the time of writing of this report.

The concern in this area is the lack of stormwater infrastructure to direct the flow out of neighborhoods. Currently, during large storms, stormwater will flow into the Monico Gardens subdivision from the south. The flow rates currently seen during the design storms at several points of interest within the basin are outlined in Table 6-10.

Table 6-10: Area of Concern #6 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
31st St. and Trinidad St.	34.3	29.1	10.5	8.2	5.3
32nd St. and Trinidad St.	24.5	20.9	14.4	11.9	8.3
33rd St. and Trinidad St.	18.7	15.7	19.9	16.4	11.6

The nearest stormwater system to Area #6 is a roadside ditch along 31st Avenue, which also receives the stormwater from Area of Concern #8. It is recommended at the flows from Area #6 be combined with those from #8. Since the City is intending to pave and improve Trinidad Street in the future, a pipeline is recommended to run under Trinidad Street to 31st Street. There, the pipeline would discharge either to the existing or a new system that extends east along 31st Street to the South Platte River. The Evans Urban Growth Area does not extend to the South Platte at this point, so coordination with Greeley and Weld County will be necessary while designing and maintaining the pipe outlet.

Adequate gutter capacity exists for the major storm along all streets (except Trinidad Street, since there is no curb and gutter); however, the allowable street capacity for the minor storms is less and not sufficient to convey the predicted peak flow rates. Inlets were designed to collect the required minor flows; the pipeline was sized for the major storm to allow for future additional flow if required.

A pipeline along Trinidad Street is recommended to collect the stormwater from Area #6 that cannot be conveyed by the street during the minor storm. For all streets, it is assumed that when the road is paved or re-paved, that curb and gutter will be added. The pipe lengths and sizes needed for this system are:

- 500 feet of new 24” pipe along Trinidad Street, in the southern sub-basin
- 90 feet of new 24” pipe along 33rd Street, to connect with the pipe along Trinidad
- 269 feet of new 30” pipe between along Trinidad Street 33rd Street and 31st Street
- 75 feet of new 18” pipe along 32nd Street, to connect with the pipe along Trinidad

The major storm flow rates along 33rd Street and 32nd Street are predicted to be 7.1 cfs and 5.75 cfs, respectively. Two 10-foot type R inlets are proposed for both of these streets to capture the stormwater in a 100-year (major) storm.

To collect the 5-year storm without exceeding allowable street capacity, two 5-foot Type R inlets are needed along Trinidad Street, in addition to the four inlets along 31st Street and 32nd Street. These should be placed south of 33rd Street, between 33rd Street and 32nd Street, and along Trinidad near Monico Gardens Drive.

To collect the 10-year storm without exceeding the allowable street flow capacity, three inlets are required along Trinidad Street, in addition to four inlets along 31st Street and 32nd Street. Two 5-foot Type R inlets are recommended: one adjacent to the agricultural field, and the other near the intersection of Monico Drive and Trinidad Street. A 10-foot Type R inlet is recommended between 33rd and 32nd Streets.

In addition to the pipes and inlets, the lot north of the Monico Gardens Drive subdivision has space for a rain garden to attenuate and improve water quality before stormwater from this area combines with that from Area #8. Its footprint would be 0.4 acres or less, and its depth would be 1 foot.

On the next page is a cost estimate which shows the total cost for all the improvements including the rain garden. The total cost for all the improvements is $526,420. This includes the easement acquisition for the rain garden.

The proposed rain garden provides resiliency as it will allow for infiltration while also providing water quality and slowing down the peak flow. The storm drainage infrastructure will also allow for safe access to and from the residential properties in the vicinity.

RECOMMENDATIONS	✓ **Pave and add curb and gutter to Trinidad Street** ✓ **Add pipe along Trinidad and connecting inlets under 32nd and 33rd Street** ✓ **Construct a rain garden to attenuate and treat the stormwater**

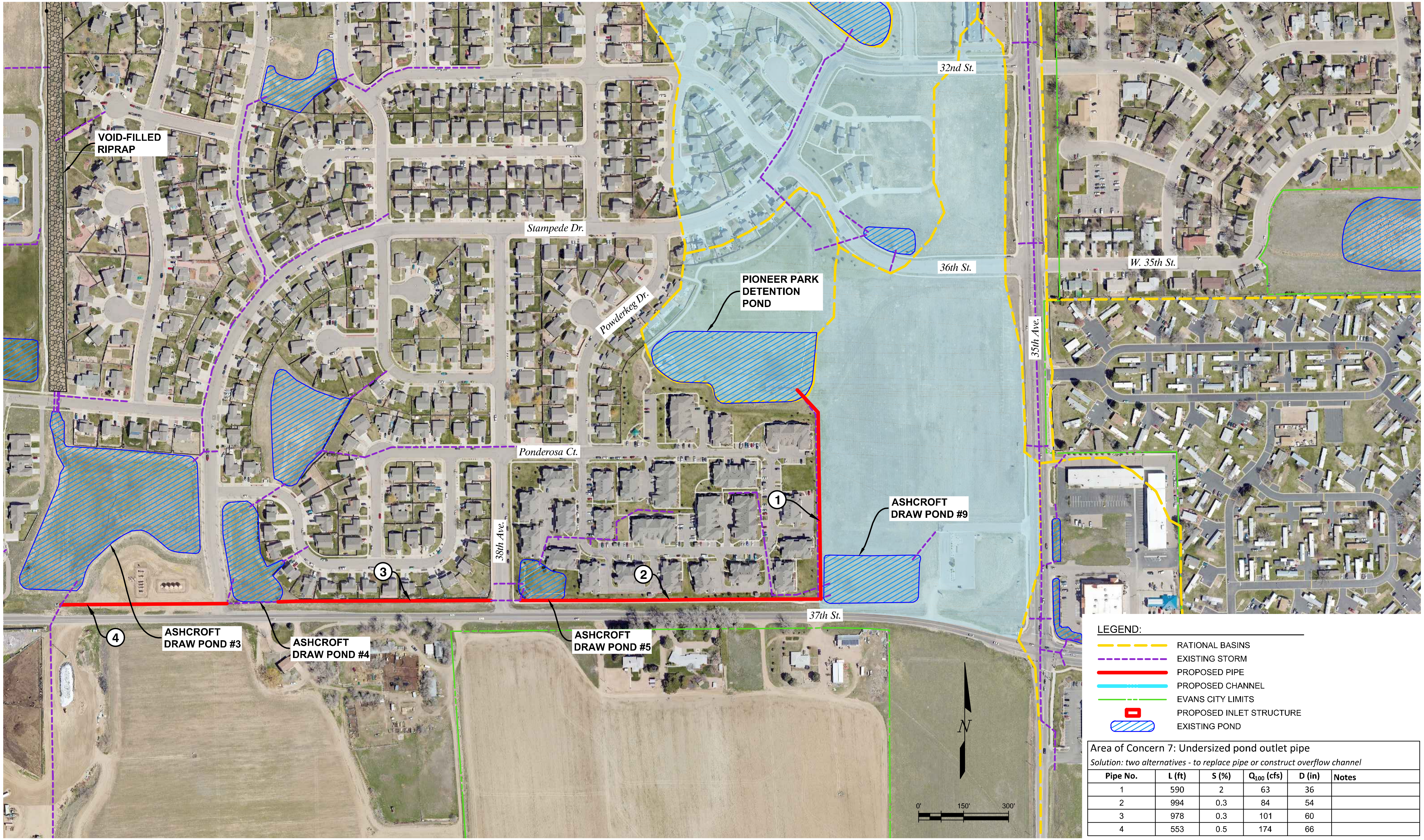
MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 6
ALTERNATIVE :	1
JURISDICTION :	Evans
SUB-BASIN ID:	Trinidad at Monico-Reach6
DATE :	5/2/2016

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	Length (ft)	No. of Barrels				
24-inch	520	1	520	L.F.	$92.00	$47,840.00
30-inch	285	1	285	L.F.	$116.00	$33,060.00
30-inch	355	1	355	L.F.	$116.00	$41,180.00
24-inch	90	1	90	L.F.	$92.00	$8,280.00
18-inch	75	1	75	L.F.	$69.00	$5,175.00
Flare End Sections						
Diameter (in)	Applicable	No. of Barrels				
24-inch	Yes	1	1	EA	$1,246.00	$1,246.00
30-inch	Yes	1	1	EA	$2,017.00	$2,017.00
Manholes and Inlets						
Manhole, 4' Dia. (Pipe Dia. < 36")			5	EA	$3,726.00	$18,630.00
Storm Inlet, Type R/Type 14, 5-foot			12	EA	$5,910.00	$70,920.00
Detention/Water Quality Facilities						
Detention (Complete-in-Place)						
Detention Facility 1 (Complete-in-Place)			0.36	AC-FT	$58,582.00	$21,090.00
Landscaping and Maintenance Improvements						
Reclamation & seeding (native grasses)			0.5	ACRE	$1,285.00	$643.00
Land Acquisition						
Easement/ROW Acquisition			0.50	ACRE	$153,566.00	$76,783.00

Master Plan Capital Improvement Cost Summary			
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$228,348.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$21,090.00
Removals			$0.00
Landscaping and Maintenance Improvements			$643.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$250,081.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$12,504.00
Traffic Control	$10,000.00	L.S.	$10,000.00
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00
Stormwater Management/Erosion Control	5%		$12,504.00
Subtotal Additional Capital Improvement Costs			**$40,008.00**
Land Acquisition Costs			
ROW/Easements			$76,783.00
Subtotal Land Acquisition Costs			**$76,783.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$43,513.00
Legal/Administrative	5%		$14,504.00
Contract Admin/Construction Management	10%		$29,009.00
Contingency	25%		$72,522.00
Subtotal Other Costs			**$159,548.00**
Total Capital Improvement Costs			**$526,420.00**

Master Plan Operation and Maintenance Cost Summary				
Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, erosion at entrance/exit, structural repairs	1325	L.F.	$1.00	$265.00
Manhole and Inlet Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	17	EA	$64.00	$1,088.00
Detention/WQ Maintenance (e.g. sediment & debris removal, mucking out, tree & weed removal,	0.36	ACRE	$1,927.00	$1,387.00
Total Annual Operation and Maintenance Cost				**$2,740.00**
Total Operation and Maintenance Costs Over 50 Years				**$137,000.00**



Area of Concern 7: Undersized pond outlet pipe

Solution: two alternatives - to replace pipe or construct overflow channel

Pipe No.	L (ft)	S (%)	Q_{100} (cfs)	D (in)	Notes
1	590	2	63	36	
2	994	0.3	84	54	
3	978	0.3	101	60	
4	553	0.5	174	66	

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PREPARED UNDER THE SUPERVISION OF

DESIGNED: SEB
DRAWN: MAB
CHECKED: ALR

PROJECT NO. 15-041.01

SHEET REVISIONS

NO.	DATE	DESCRIPTION	BY

MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

AREA OF CONCERN 7
DETENTION POND AT PIONEER PARK/FOX CROSSING

DATE: NOV 2016
DRAWING NO.
PAGE NO. AC7-1

6.9 Area of Concern #7 – Pioneer/Fox Crossing

Area of Concern #7 is the outlet pipe of the detention pond at Pioneer Park, located within the Ashcroft Heights subdivision. Three sub-basins were delineated for this area. The most northern sub-basin and the central sub-basin both have predominantly single-family residential and multi-family residential use with scattered open space. The southern basin, in which Pioneer Park detention pond is located, is an open field used as a neighborhood park. The overall imperviousness of the drainage area is 46.7%; the sub-basin values range from 16% to 55%. In the largest sub-basin, that which includes 34th Avenue and Stampede Drive, just more than 50% of the soil is of Type B; the remaining soil is Type A. The other two sub-basins are characterized exclusively by soil group Type A.

There are three detention ponds in the drainage area, including the Pioneer Park detention pond. Each is an outlet of one of the three sub-basins. The northeastern sub-basin drains to a 0.6 acre pond that discharges to a 15" pipe under Stampede Drive. The central, and largest, sub-basin is collected into a 0.27 acre pond, whose outlet structure is a 33" pipe. Both pipes discharge into an open channel that flows into the Pioneer Park basin. The outlet for this pond currently is a 15" pipe. In the drainage reports, the provided rating curves indicate that the 100-year storm should be detained and released at a peak flow rate of 15.2 cfs. In the supporting documentation, the design inflow rate to the pond was stated to be 132 cfs for this design storm.

The concern for Area #7 is that the existing outlet structure and pipe are undersized which may cause minor flooding in the adjacent neighborhoods. The pipe was calculated to have a maximum capacity of 7.4 cfs. The flow rates predicted by the hydrologic analyses are presented in Table 6-11.

Table 6-11: Area of Concern #7 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
Pioneer Park Outlet	111.1 *179.8 (SWMM)*	94.0	64.8	54.0	38.8

For most of the areas of concern, the flow rates predicted by the rational analysis were used for the alternatives design. In this area, however, the SWMM sub-basin outlet is the same as that used in the rational analysis. The area of the SWMM basin (ASD-275) is 70.1 acres, which is 1.6 times larger than the drainage area delineated for the rational analysis. The area not included in the rational analysis looks to drain in another – albeit smaller – detention pond in the vicinity. The calculated flow rate in SWMM is also approximately 1.6 times that of the rational analysis. In both analyses, the outlet pipe is confirmed to be undersized.

It is recommended that the existing pipe be replaced with a larger pipe with adequate flow capacity. There were two directions taken with the pipe sizing for this analysis. In the first, it was assumed that the pond was indeed sized correctly for the 100-year storm, and that the design inflow rates have not changed since the construction of the pond. The rational analysis results support this assumption. Sizing the pipe for the design release rate of 15.2 cfs, the required pipe would need a 24" diameter. This pipe would have a total capacity of 29 cfs, or 13 cfs greater than required.

The second approach was to make no assumption of pond capacity; that the 100-year storm would not be fully attenuated by the pond. This assumption is the conservative approach and supported by the CUHP/SWMM analysis. Sizing the outlet for the difference between the calculated and design inflow rates in addition to the pond's peak outflow, the required outlet is a 36" pipe. This would provide a total capacity of 85 cfs, or 22 cfs more than required by the current system. While this alternative assumes that Pioneer Park does not currently fully attenuate the 100-year storm, it does still make the assumption that the pond is maintained to adequately detain the design inflow volume.

The pipes downstream increase in diameter from 33" to 42" but receive additional inflow from three downstream detention ponds. These ponds do not function in series, but discharge to the same pipe under 37th Street. Just west of Stampede Drive, the pipe turns south and discharges to Ashcroft Draw. There is a 2,770 foot stretch of pipe between 37th Street and the Draw, from which there is currently no additional inflow to the pipe. The major storm design discharges and the downstream pipe capacities are listed in Table 6-12.

Table 6-12: Area #7 Existing Downstream Infrastructure

Pond ID	Location	Q_{100}	$Q_{SPILLWAY}$	Pipe D	Q_{PIPE}
Pond #9	550 ft west of 37th St. and 35th Ave	21	42	33"	29.0
Pond #5	37th St. and 38th Ave. (NE corner)	17	17	38"	43.4
Pond #4	37th St. and Stampede Dr. (NE corner)	73	188.4	42"	71.1
Pond #3	37th St. and Stampede Dr. (NW corner)	21	64.8	42"	149.2

If the emergency spillways are utilized, or if the discharge from the Pioneer Park detention pond is as assumed in the second approach described, the existing pipe system does not have the capacity to handle the major storm. The third (42") pipe segment is undersized for the Pond #4 outflow by 2 cfs. Flow from the upstream ponds will peak through this section of pipe at approximately 38 minutes into the storm. The peak from Pond #4 does not occur until 50 minutes into the storm. Therefore, there are no critical improvements needed for this pipe. The required flow capacity could also be attained by adding curb and gutter to 37th Street in this location or by constructing an overflow channel along the roadway.

From this point in the system, the pipe diameter remains 42", even though the outflow from the largest Ashcroft Draw detention pond discharges into it as well. After crossing 37th Street, the land use above the pipe is open field, possibly used for agricultural purposes. There is a small, though not well defined, open channel adjacent to the pipe that could potentially carry over flow. The pathway from the Ashcroft Heights ponds and this channel is also not defined.

The pipe capacities listed above assume a pipe slope of 0.3% between Pond #9 and Pond #4, a slope of 0.6% between Pond #4 and Pond #3, and a slope of 2.2% from there to Ashcroft Draw. Given the approximated slope of 2.2%, the 42" pipe from 37th Street to Ashcroft Draw has a potential capacity of 149 cfs. If the spillways are not utilized, the total flow rate through this pipe during a major storm would be 195 cfs, if the peak outflow rates from the ponds are similar. The peak total flow rate if the spillways are used is 375 cfs. The pipes do not necessarily need to be designed for the spillway flowrates, but we recommend that there is a well-defined path to the Draw, possibly using an open channel system. The overflow channel dimensions of this would be a 4-foot bottom, 4:1 side slopes and 3.5-feet deep. All elevations should be verified in the field during improvements to Pioneer Park.

The following is a cost estimate which includes the pipe replacement for Pioneer/Fox Crossing as well as the overflow channel for the Ashcroft Draw Pond #3. The total cost for all the improvements in this option is estimated to be $1,708,434.

The upgrades to this system will provide resiliency by keeping 37th Street from flooding during large storms. Also, by upgrading the outlet pipe on the Pioneer Park detention pond, the pond should not overtop, causing more damage to the surrounding properties.

RECOMMENDATIONS	✓ **Replace the existing Pioneer Park Pond outlet with a 36" pipe** ✓ **Identify and maintain an overflow pathway for spillway flow for all ponds along 37th Street; to achieve adequate pipe capacity the City must replace the existing pipelines with 54" and 60" pipes** ✓ **Construct an overflow channel from 37th Street to Ashcroft Draw as the community develops**

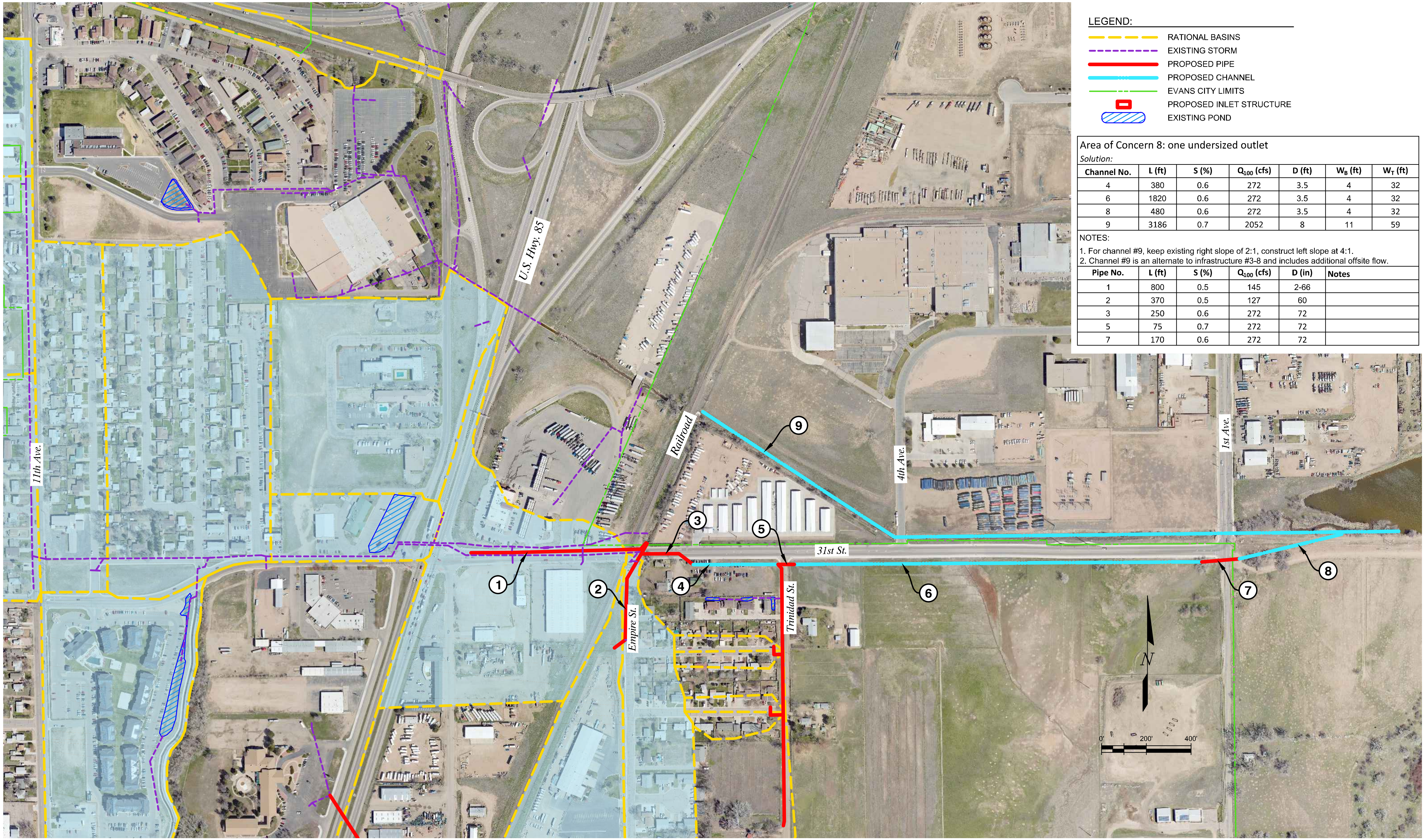
MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 7
ALTERNATIVE :	1
JURISDICTION :	Evans
SUB-BASIN ID:	Pioneer Fox Crossing-Reach7
DATE :	5/2/2016

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	Length (ft)	No. of Barrels				1
36-inch	590	1	590	L.F.	$139.00	$82,010.00
54-inch	994	1	994	L.F.	$277.00	$275,338.00
60-inch	978	1	978	L.F.	$308.00	$301,224.00
66-inch	553	1	553	L.F.	$339.00	$187,467.00
Manholes and Inlets						
Manhole, 5' Dia. (Pipe Dia. 36" - 42")			1	EA	$5,010.00	$5,010.00
Type B Manhole (Pipe Dia. 48" and larger, deflection < 10 degrees)			3	EA	$15,416.00	$46,248.00
Removals						
Removal of culvert pipe (D<48")			3115	L.F.	$26.00	$80,990.00
Special Items (User Defined)						
Removal of Manhole			1	EA	$1,000.00	$1,000.00

Master Plan Capital Improvement Cost Summary			
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$897,297.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$0.00
Removals			$80,990.00
Landscaping and Maintenance Improvements			$0.00
Special Items (User Defined)			$1,000.00
Subtotal Capital Improvement Costs			**$979,287.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$48,964.00
Traffic Control	$20,000.00	L.S.	$20,000.00
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00
Stormwater Management/Erosion Control	5%		$48,964.00
Subtotal Additional Capital Improvement Costs			**$122,928.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$165,332.00
Legal/Administrative	5%		$55,111.00
Contract Admin/Construction Management	10%		$110,222.00
Contingency	25%		$275,554.00
Subtotal Other Costs			**$606,219.00**
Total Capital Improvement Costs			**$1,708,434.00**

Master Plan Operation and Maintenance Cost Summary				
Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	3115	L.F.	$1.00	$623.00
Manhole and Inlet Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	5	EA	$64.00	$320.00
Total Annual Operation and Maintenance Cost				**$943.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$47,150.00**



LEGEND:

- RATIONAL BASINS
- EXISTING STORM
- PROPOSED PIPE
- PROPOSED CHANNEL
- EVANS CITY LIMITS
- PROPOSED INLET STRUCTURE
- EXISTING POND

Area of Concern 8: one undersized outlet

Solution:

Channel No.	L (ft)	S (%)	Q_{100} (cfs)	D (ft)	W_B (ft)	W_T (ft)
4	380	0.6	272	3.5	4	32
6	1820	0.6	272	3.5	4	32
8	480	0.6	272	3.5	4	32
9	3186	0.7	2052	8	11	59

NOTES:

1. For channel #9, keep existing right slope of 2:1, construct left slope at 4:1.
2. Channel #9 is an alternate to infrastructure #3-8 and includes additional offsite flow.

Pipe No.	L (ft)	S (%)	Q_{100} (cfs)	D (in)	Notes
1	800	0.5	145	2-66	
2	370	0.5	127	60	
3	250	0.6	272	72	
5	75	0.7	272	72	
7	170	0.6	272	72	

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PREPARED UNDER THE SUPERVISION OF

DESIGNED: SEB
DRAWN: MAB
CHECKED: ALR

PROJECT NO. 15-041.01

SHEET REVISIONS

NO.	DATE	DESCRIPTION	BY

MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

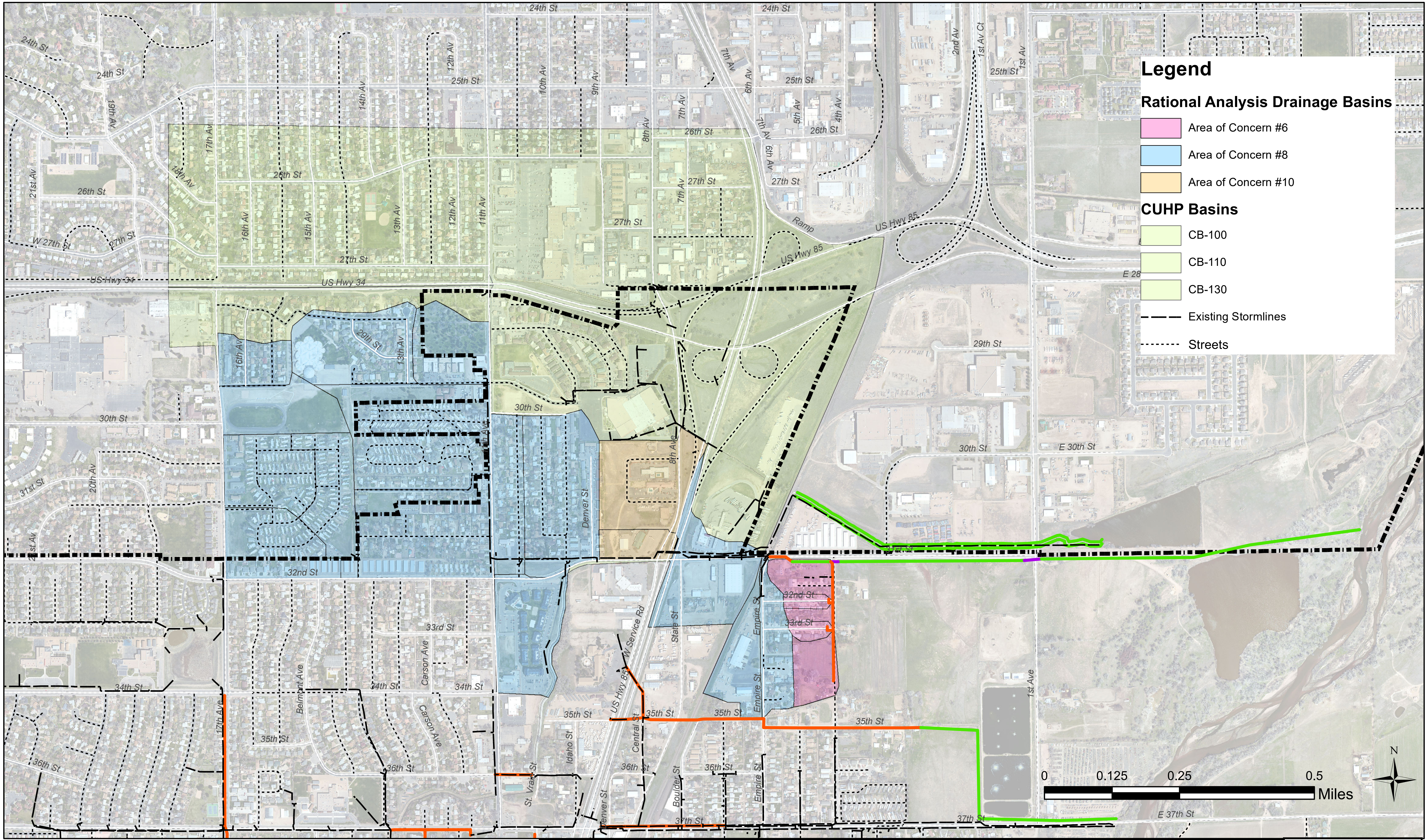
CITY OF EVANS STORMWATER ALTERNATIVES

AREA OF CONCERN 8
31ST STREET BASIN

DATE: NOV 2016

DRAWING NO.

PAGE NO. AC8-1



Evans 2016 Stormwater Master Plan Drainage Study Analysis	31st Street Channel Drainage Basin	October 2016

6.10 Area of Concern #8 – 31st Street East of Trinidad Street

Area of Concern #8 is located where the Union Pacific Railway intersects 31st Street. Immediately to the east of the railway tracks is an open channel that is the discharge point of several stormwater systems in northeastern Evans. The total area draining to this point is 262 acres, including the area draining to Area of Concern #10. An additional 380.6 acres drain to a point along the channel 600 feet downstream of the discharge point of concern. Finally, although the drainage area for Area #6 does not currently discharge into this storm system, all of the alternative improvements would connect it with the Area #8 stormwater infrastructure. Thus, Area #6 was treated as a contributing basin for the alternative analysis for Area #8. Much of the area – 509 acres– from both the Area # 8 drainage basin and the downstream basin is outside of the UGA and is either Greeley or Weld County property.

Seventeen sub-basins, including two for Area #10, were delineated for this area of concern. The area extends west to east from 17th Avenue to Empire Street, and north to south from 28th St Rd (in Greeley) to US Hwy 34th Street. A few areas east of 11th Avenue south of 31st Street are included in the drainage area, including an apartment complex sandwiched between 11th Ave. and the Evans Town Ditch, and a couple commercial areas between US Hwy 85 and Empire Street. The overall imperviousness value of the drainage basin is 58.2; the sub-basin values range from 14% and 81%. The majority of the area is comprised of single family and duplex residential lots and trailer parks. Several large neighborhood parks are located west of 11th Avenue. Twelve of the sub-basins are characterized primarily by soil group type A; the remaining five, all located west of 11th Avenue, have primarily group type B soils.

Three CUHP/SWMM sub-basins contain the area discharging to the downstream channel: CB-100, CB-110, and H-100. A map of the CUHP basins is included in Appendix C. The basins delineated for the rational analysis partially overlap CB-110; the rest of the sub-basin is commercial area, highway (pavement), and large grass buffers. CB-110 is the northern-most sub-basin and is primarily single-family residential and neighborhood commercial. HB-100 is a high-impervious commercial area that is mostly pavement. All three basins are primarily or exclusively comprised of soil group type A.

The area east of 17th Avenue and west of 11th Avenue does not have much stormwater infrastructure. Runoff is conveyed along streets to inlets along 11th Ave., into an 18" pipeline that increases to 27" at 30th Street Road, and to 30" at Pleasant Acres Drive. The 30" pipe continues east under 31st Street and increases to 48" at W Service Road. At this point it also becomes a multiple pipe system, which discharges into the open channel north of Empire Street. Approximately 50 feet before the discharge point, the 48" pipeline decreases to a 24" line. This reduction was likely permitted due to steeper grades in this section of pipe. Two other pipes, one 18" and the other 54" in diameter, convey stormwater from the intersection of 31st Street and US Hwy 85 to the channel. Little neighborhood-level infrastructure exists in the sub-basins; as with the western areas, most stormwater flows along streets into the main storm sewer under 31st Street The only detention ponds within Area #8 are less than an acre, and serve small drainage areas. A 0.43 acre pond exists south of the 31st Street and Lakeside Drive intersection; its drainage area is approximately 16 acres, but its design inflow and outflow rates for the major design storm are unknown. A 24" pipe connects its outlet with the 31st Street storm sewer. In a sub-basin for Area #10, there is a 0.56 acre pond; its design parameters are also unknown. A 48" pipe conveys the outflow under US Hwy 85 and into the 31st Street system.

Because about 80% of the drainage area to Area #8 and the downstream discharge point are outside of the UGA, the Greeley stormwater system is also of importance. An 84" pipe conveys stormwater collected in in the "downstream" drainage area to the channel. It is unclear whether this pipe is maintained by the City of Greeley or by Evans; the pipe appears on both City's master stormwater index (provided in a GIS shapefile). It is recommended that Evans determine whether an inter-governmental agreement is in place and coordinate with Greeley on the pipe's future upkeep. A 42" pipe runs parallel to US Hwy 34, on the north side, and collects stormwater from CUHP/SWMM basin CB-100 and discharges it to an open channel running alongside and south of the highway. This channel is described in more detail under Area of Concern #2. A 30" pipe collects runoff from the US Hwy 34 and US Hwy 85 interchange and into the 84" storm sewer. No information was provided for any neighborhood-level infrastructure north of this interchange; it is possible that stormwater flows along streets into culverts under the highway to the 30" and 84" pipes. Several 15" and 36" culverts are shown in the Evans stormwater infrastructure database that would covey runoff north of the UGA into this system.

The channel into which Area #8 discharges is approximately 560 feet long, before turning east and receiving the additional flow. It is trapezoidal in shape and does not have defined overflow banks to disperse larger flows. Its bottom width is 3.5 feet at the narrowest spot, but is typically about 6 feet. Although well-defined, there are small variances in channel depth along its length. Typically it is 6 feet deep. Its left and right side slopes are 2.4 and 1.9 ft/ft, respectively. At capacity, it can convey 510 cfs; conceding 1-foot to freeboard, it can convey 340 cfs.

The concern for this area is that the outlet to the channel is undersized. This was confirmed in the infrastructure analysis. The predicted flow rates from the rational analysis area listed in Table 6-13.

Table 6-13: Area of Concern #8 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
31st St. and 11th Ave.	302.1	258.3	180.5	152.9	114.2
31st and Empire St.	127.1	110.5	79.8	71.2	55.9
31st St. and Railroad	403.7	346.3	243.3	208.6	157.7

Area #6 is not included in the flow rates listed, but adds approximately 34 cfs to the total for the 100-year storm. CUHP/SWMM estimates the flow rate to the Area #8 outlet (including Area #6 flow) to be 705 cfs. The flow rate predicted at the downstream channel section by SWMM is 2052 cfs, including the flows from the areas included in the rational analysis and from Area of Concern #6 (this is not additional to the flow rates in Table 6-13).

The full-capacity flow rates were calculated for the 30" pipe under 31st Street, the 24" pipe under Empire Street, and the 48" and 18" pipes under 31st Street which discharge directly to the channel. Table 6-14 lists the total capacities.

Table 6-14: Area #8 Existing Infrastructure Capacity

Location	Diameter	Capacity (cfs)
31st and 11th Ave.	30"	71
31st and Empire St.	24"	16
31st St. and Railroad	48"	101.6
31st St. and Railroad	18"	7.4

In the conservative analysis, street capacity along 31st Street was not taken into account. The inverts of the pipes at major junctions were unknown, so with the exception of the 30" pipe, for which the surface slope was 3%, the slopes were assumed to be 0.5%. Comparing tables 13 and 14, it is evident that the existing pipes are considerably undersized. The resulting required system improvements include:

- Replace the pipes at 31st Street (near the railroad) with a dual pipe system consisting of two 66" pipes
- Replace the 24" pipe along Empire St. with a 60" pipe
- Replace the existing pipeline along 31st Street from 11th Avenue to 8th Avenue with a 54" pipe

The latter two pipes tie into the dual pipe system described in the first item.

When street capacities can be relied upon, the pressure on the system is reduced. However, the slopes along vary along 31st Street and the resulting pipe diameters remain unchanged in areas where they are very mild. Table 6-15 shows the expected street capacity along several sections of the road.

Table 6-15: Area #8 Existing Street Capacity

Location	Major Storm Capacity	Minor Storm Capacity
31st Street (Denver St. to 8th Ave.)	319 cfs	15 cfs
31st Street (8th Ave. to Railroad)	128 cfs	6 cfs

The existing system east of the railroad is still undersized. The required pipe sizes are not changed. Assuming that the street capacity of the road can be used, the following improvements west of the railroad are necessary:

- Replace the 18" and 48" pipes in 31st with 66" pipes
- Replace the 24" pipe along Empire St. with a 60" pipe

The inlet capacities along 11th Avenue, Empire Street, and 31st Street were not checked. It is likely that if street capacity is relied upon, the inlets near Hwy 85 and the railroad tracks do not have adequate capacity to convey the stormwater underneath this infrastructure and into the open channel.

These items address the stormwater conveyance prior to discharge to the channel. Analysis of the initial segment of channel verifies adequate capacity exists for the predicted discharge in the major storm. However, the downstream section, after the turn to the east, has a capacity of approximately 1,260 cfs. While sections of the channel have a larger bottom width, the narrowest section of channel was used to calculate the channel capacity. This is about half of the predicted flowrate during the major storm. Two alternatives are proposed as a solution:

- **Improve the channel north of 31st Street** to convey the total flow from Area #8 and the downstream drainage area: this alternative would make the most of existing infrastructure. Since it is on CDOT right-of-way and receives Greeley's as well as Evans' stormwater, it would require coordination but potentially benefit from pooled resources. The only property that would be affected is the electrical substation: the channel needs to be about 25 feet wider and with the location of 31st St. it isn't possible to extend south. The impacts would be mainly to the existing parking/storage lot on the substation. However, there appears (without a preliminary analysis of right-of-way or permitting concerns) to be space to expand the bottom width to 11 feet and introduce 4:1 H:V left side slopes.
- **Construct a new channel south of 31st Street** to convey the stormwater from Area #8: this alternative would allow for the retirement of the initial channel segment and have the benefit of being indisputably in Evans city limits. Relatively little coordination with CDOT and/or Greeley would be required. There is abundant of undeveloped area south of the road to construct a channel to the desired specifications. The recommended channel is 6 feet deep with a 5 foot bottom width and 4:1 side slopes on each side.

Both channel alternatives, but more certainty the first, could potentially discharge to a large (greater than 10 acre) regional pond maintained and owned by Greeley. All of the stormwater theoretically, ignoring potential flooding, is discharged to this point currently. The pond exists within the floodplain and is approximately 2,160 feet west of the South Platte. If the channel discharges into the floodplain its total length may not need to be greater than if discharging to the pond: this is contingent upon discussions with Greeley about flows near their detention pond.

A final alternative would be to pipe the flow from Areas #8 and #6 to the floodplain; however, this would require a 108" equivalent pipe diameter to convey the 428 cfs. If the SWMM flow rate is used to design the pipe system, a 126" equivalent diameter would be required. The slope is very shallow and the cover constraints would necessitate the use of a multiple pipe system.

A cost estimate was prepared for the two channel options. A cost estimate was not prepared for the piped system alternative because of its high relative cost. For cost and channel-sizing analyses, 31st Street was assumed to have surface flow capacity, estimated using the UD-Inlet spreadsheet. The street capacity is 21.4 cfs and 177.4 cfs during the minor and major storms, respectively. It is also assumed that there will not be any property acquisition from CDOT, the property owner between Trinidad and 1st Ave on the south side of the street, Public Service and the City of Greeley. The cost estimates for the two alternatives follow on the next page. As expected, the combined channel on the north side is about half the cost of the channel on the south. There are more property acquisition costs with Alternative 2 but it takes advantage of the existing channel.

By doing the improvements shown, the City of Evans and Greeley are helping to keep this main road that typically has a large volume of traffic open and functioning during large events. Since there is not a lot of residential development in the area it typically would not be as much of a concern. There is a power substation located nearby so it is important to keep the site accessible. With both alternatives, the channel will provide for some infiltration and water quality. It is recommended that wetlands be planted or modified at the channel outlet to treat the stormwater before being discharged to the South Platte. With the contributing area of 650 acres, 7.4 acres is required to adequately treat the water quality capture volume (WQCV), assuming a wetland depth of 1.5 feet. The channel and its discharge location are located north of the Evans' UGA, and will require coordination with Greeley for their design.

RECOMMENDATIONS	
	✓ Replace the 18" and 48" pipes under 31st Street with 66" pipes
	✓ Replace the 24" pipe under Empire Street with a 60" pipe
	✓ Coordinate with Greeley and COT to widen the channel north of 31st St.

Alternative 1 Cost Estimate: Channel South of 31st Street

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 8
ALTERNATIVE :	1
JURISDICTION :	Evans
SUB-BASIN ID:	31st St E of Trinidad-Reach8
DATE :	5/2/2016

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	Length (ft)	No. of Barrels				1
66-inch	800	2	1600	L.F.	$339.00	$542,400.00
60-inch	370	1	370	L.F.	$308.00	$113,960.00
72-inch	250	1	250	L.F.	$462.00	$115,500.00
72-inch	75	1	75	L.F.	$462.00	$34,650.00
72-inch	170	1	170	L.F.	$462.00	$78,540.00
Headwalls						
Diameter (in)	Applicable	No. of Barrels				1
72-inch	Yes	1	1	EA	$2,467.35	$2,467.00
72-inch	Yes	1	2	EA	$2,467.35	$4,935.00
72-inch	Yes	1	2	EA	$2,467.35	$4,935.00
Wingwalls (includes concrete apron)						
Diameter (in)		No. of Barrels				1
72-inch		1	1	EA	$14,907.48	$14,907.00
72-inch		1	2	EA	$14,907.48	$29,815.00
72-inch		1	2	EA	$14,907.48	$29,815.00
Manholes and Inlets						
Type B Manhole (Pipe Dia. 48" and larger, deflection < 10 degrees)			3	EA	$15,416.00	$46,248.00
Type P Manhole (Pipe Dia. 48" and larger, deflection > 10 degrees)			3	EA	$19,271.00	$57,813.00
Detention/Water Quality Facilities						
Detention (User Entered Quantities)						
Excavation, Mid Range			2779	C.Y.	$31.00	$86,157.00
Removals						
Removal of culvert pipe (D<48")			1170	L.F.	$26.00	$30,420.00
Landscaping and Maintenance Improvements						
Reclamation & seeding (native grasses)			2	ACRE	$1,285.00	$2,846.00
Land Acquisition						
Easement/ROW Acquisition			1.00	ACRE	$97,403.00	$97,403.00

Master Plan Capital Improvement Cost Summary

Capital Improvement Costs			
Pipe Culverts and Storm Drains			$1,075,985.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$86,157.00
Removals			$30,420.00
Landscaping and Maintenance Improvements			$2,846.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$1,195,408.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$59,770.00
Traffic Control	$30,000.00	L.S.	$30,000.00
Utility Coordination/Relocation	$30,000.00	L.S.	$30,000.00
Stormwater Management/Erosion Control	5%		$59,770.00
Subtotal Additional Capital Improvement Costs			**$179,540.00**
Land Acquisition Costs			
ROW/Easements			$97,403.00
Subtotal Land Acquisition Costs			**$97,403.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$206,242.00
Legal/Administrative	5%		$68,747.00
Contract Admin/Construction Management	10%		$137,495.00
Contingency	25%		$343,737.00
Subtotal Other Costs			**$756,221.00**
Total Capital Improvement Costs			**$2,228,572.00**

Master Plan Operation and Maintenance Cost Summary

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	1665	L.F.	$1.00	$333.00
Manhole and Inlet Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	6	EA	$64.00	$384.00
Channel Maintenance (e.g. sediment & debris removal, erosion, tree & weed removal, etc.)	2680	L.F.	$3.00	$8,040.00
Mowing (e.g. channels, ponds, etc.)	1.98	ACRE	$64.00	$253.00
Total Annual Operation and Maintenance Cost				**$9,010.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$450,500.00**

Alternative 2 Cost Estimate: Channel on north side of 31st Street

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 8
ALTERNATIVE :	2
JURISDICTION :	Evans
SUB-BASIN ID:	31st St E of Trinidad-Reach8a
DATE :	5/2/2016

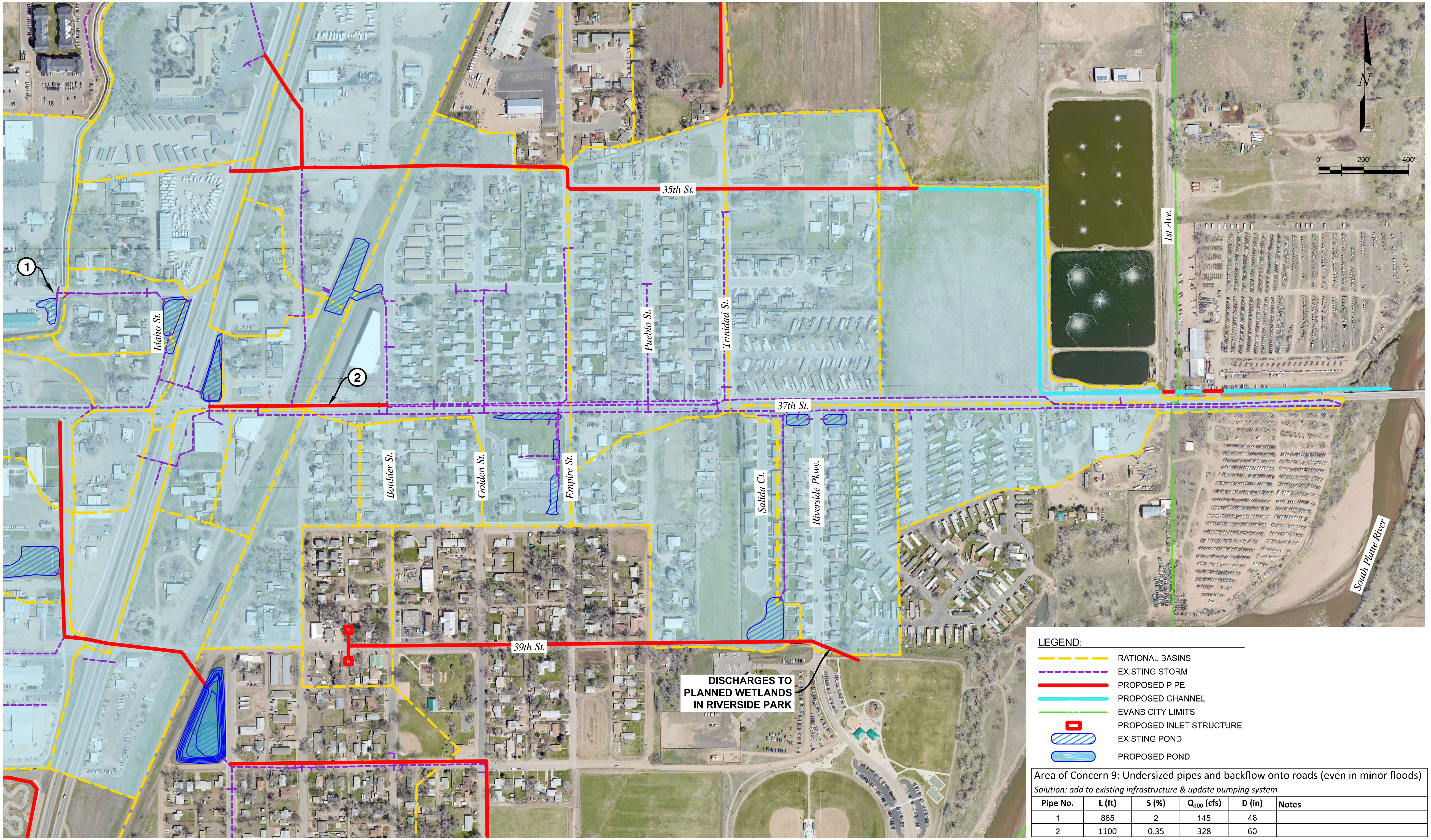
DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	Length (ft)	No. of Barrels				
60-inch	800	1	800	L.F.	$308.00	$246,400.00
60-inch	370	1	370	L.F.	$308.00	$113,960.00
Detention/Water Quality Facilities						
Detention (User Entered Quantities)						
Excavation, Mid Range			3539	C.Y.	$31.00	$109,706.00
Removals						
Removal of culvert pipe (D<48")			1170	L.F.	$26.00	$30,420.00
Landscaping and Maintenance Improvements						
Reclamation & seeding (native grasses)			4.4	ACRE	$1,285.00	$5,637.00
Land Acquisition						
Easement/ROW Acquisition			1.00	ACRE	$48,974.00	$48,974.00

Master Plan Operation and Maintenance Cost Summary

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	1170	L.F.	$1.00	$234.00
Channel Maintenance (e.g. sediment & debris removal, erosion, tree & weed removal, etc.)	3186	L.F.	$3.00	$9,558.00
Mowing (e.g. channels, ponds, etc.)	4.31	ACRE	$64.00	$552.00
Total Annual Operation and Maintenance Cost				**$10,344.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$517,200.00**

Master Plan Capital Improvement Cost Summary

Capital Improvement Costs			
Pipe Culverts and Storm Drains			$360,360.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$109,706.00
Removals			$30,420.00
Landscaping and Maintenance Improvements			$5,637.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$506,123.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$25,306.00
Traffic Control	$20,000.00	L.S.	$20,000.00
Utility Coordination/Relocation	$20,000.00	L.S.	$20,000.00
Stormwater Management/Erosion Control	5%		$25,306.00
Subtotal Additional Capital Improvement Costs			**$90,612.00**
Land Acquisition Costs			
ROW/Easements			$48,974.00
Subtotal Land Acquisition Costs			**$48,974.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$89,510.00
Legal/Administrative	5%		$29,837.00
Contract Admin/Construction Management	10%		$59,674.00
Contingency	25%		$149,184.00
Subtotal Other Costs			**$328,205.00**
Total Capital Improvement Costs			**$973,914.00**



Area of Concern 9: Undersized pipes and backflow onto roads (even in minor floods)

Solution: add to existing infrastructure & update pumping system

Pipe No.	L (ft)	S (%)	Q_{100} (cfs)	D (in)	Notes
1	885	2	145	48	
2	1100	0.35	328	60	

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PREPARED UNDER THE SUPERVISION OF

DESIGNED: SEB
DRAWN: MAB
CHECKED: ALR

PROJECT NO. 15-041.01

SHEET REVISIONS

NO.	DATE	DESCRIPTION	BY

MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

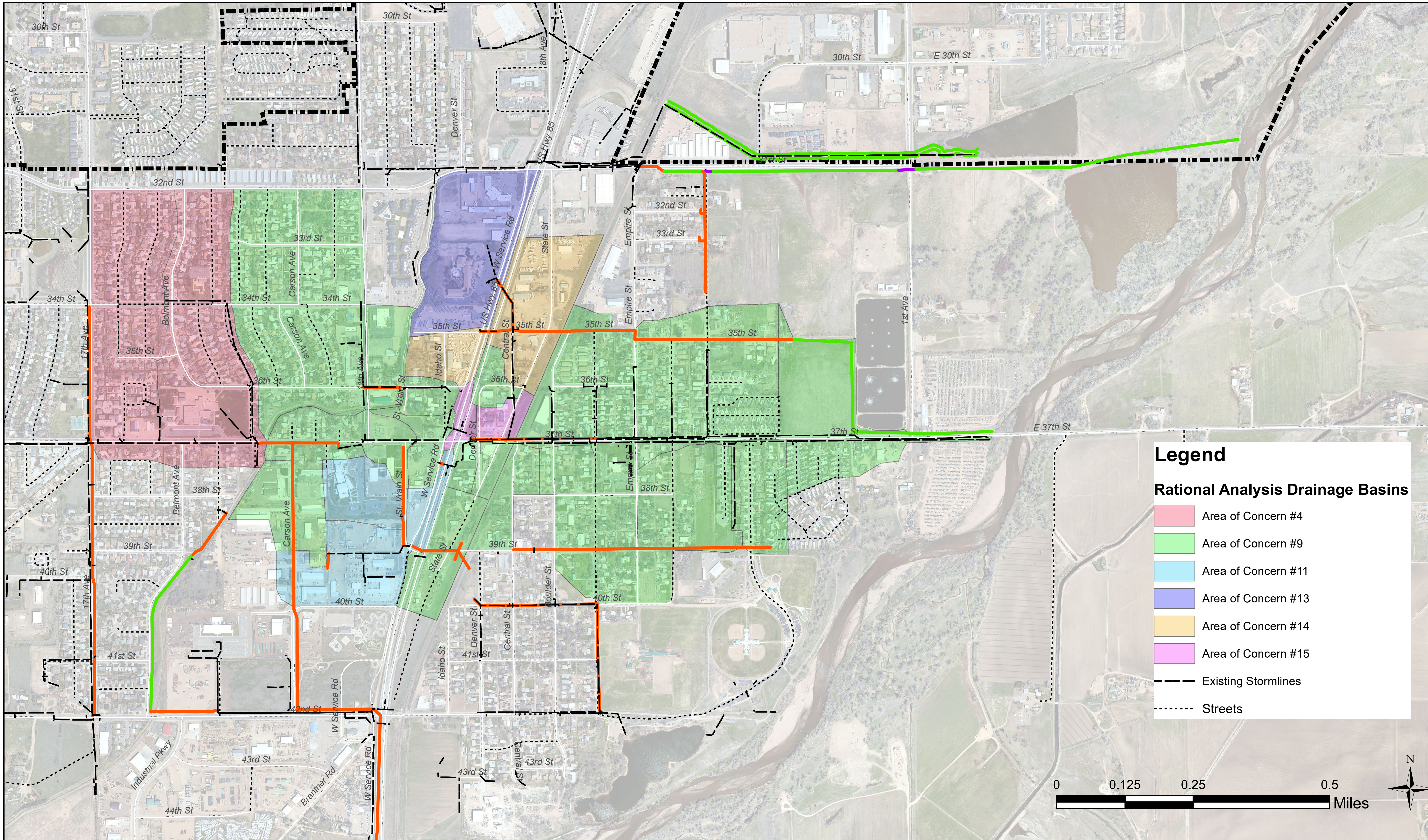
CITY OF EVANS STORMWATER ALTERNATIVES

DATE: NOV 2016

DRAWING NO.

AREA OF CONCERN 9
37TH STREET BASIN

PAGE NO. AC9-1



Evans 2016 Stormwater Master Plan **Drainage Study Analysis**	37st Street Dual Pipe System Drainage Basin	October 2016

6.11 Area of Concern #9 – 37th Street at South Platte River

The point of concern for Area #9 is located at the discharge point of the 37th Street pipe system into the South Platte. However, its drainage area is one of the largest in Evans, and includes Areas #4, #11, #13, #14, and #15. The area extends from 32nd Street to 40th Street at its most southern point, and from 17th Avenue to the South Platte. US Hwy 85 spans the basin north to south; that and 37th Street are the two most major roads in the basin. The basin forms an elongated pole at its very eastern end, where 37th Street approaches the South Platte. Immediately north of this area is a soon to be partially decommissioned wastewater treatment plant and an open field. Both drain directly east and are not collected into the 37th Street storm system. South of 37th Street there is a junkyard; this similarly drains directly east to the river. The floodplain overlies land south of 37th Street and east of Riverside Parkway, and encroaches upon a portion of a neighborhood along Salida Ct.; both of these areas are included in the drainage basin. South of the drainage basin, along Riverside Parkway, is Riverside Park. This park is currently being re-imagined to address damage inflicted by the 2013 floods. The whole of the park is located within the South Platte floodplain. Areas of concern #16 and #17 are positioned directly south of the Area #9 drainage area and adjacent to the Hwy 85-railroad corridor. Although these basins do not currently contribute to the storm systems within Area #9, they and the neighborhoods surrounding 39th Street are incorporated in this analysis, when alternative flow paths are considered.

A total of 468 acres are included in the Area #9 drainage basin; this is divided into 36 sub-basins, including those for the other areas of concern contributing to Area #9. The majority – 72.4% – of the basin is residential area. Along the US Hwy 85 corridor the land use is primarily commercial and light industrial. The block bounded by 37th Street to the north, 40th Street to the south, and to the west and east by Carson Avenue and Hwy 85 is also primarily comprised of commercial and office buildings. The basin has an overall imperviousness value of 59.1%. Of the sub-basins, the highest individual value is 92%; the minimum impervious value is 16%. Twenty-four sub-basins are characterized by soil group Type A. Seven have primarily Type B soils, and five have type D soils. The areas with Type D soils are located in the eastern part of the basin, nearer to the South Platte.

The dual pipes under 37th Street form one of Evans' major storm sewer systems. It starts as a single pipe system at 11th Avenue and has a 30" diameter. When it reaches Idaho Street, the pipe turns north, collects additional water from a 0.44 acre pond, and is piped under US Hwy 85 in a 24" culvert. The pond collects stormwater from 13 acres of commercial area. After being conveyed under the highway, the stormwater collects in a 0.39 acre pond, which has a 24" outlet just west of Denver Street that connects with a 30" pipe under 37th Street. Here it is connected with a parallel 18" pipe, and the dual pipe system begins. Between Boulder Street and Trinidad Street the 18" pipe was recently replaced with a 42" pipe. At Trinidad, this pipe increases again to a 54" pipe; the 30" pipe running parallel to it increases to a 34"x53" squash pipe (42" equivalent). Just before 1st Avenue, the 34"x53" pipe switches to a 42" diameter pipe. These pipe sizes remain unchanged until the final release into the South Platte. Flap gates on the pipe outlets prevent water from the South Platte from back-flowing into the pipe system.

Runoff from the highway both north and south of 37th Street is collected by 18" and 24" pipes which connect to the main system. Neither connecting pipe extends far from 37th Street; for most of the distance, stormwater flows as surface flow along the streets and grass buffers. At 37th Street and Denver Street, the 30" line joins a parallel 18" pipeline, which starts the dual pipeline system. Approximately 275 feet downstream (east), the 12" pipeline conveying flow from Areas #13 and #14 discharges into the 18" pipe. Several 24" neighborhood collector pipes tie into the dual pipe system from the north. These are all located east of the railroad, at Boulder Street, Golden Street, Pueblo Street and Trinidad Street. Only two pipes connect with the 37th Street system from the south: an 8" pipe adjacent Empire Street, and a 17" pipe paralleling Salida Ct.

Area #4 is the most western section of the Area #9 drainage basin. While it does not contain infrastructure to drain to the 37th Street system, any stormwater overflowing from the Evans Town Ditch would enter the system via surface flow. Its neighborhood storm sewer systems are described in more detail in its own section of this report. Currently, this area does not connect with the 37th Street stormline. East of Area #4, sub-basins for Area #9 drain into a 24" pipe under 11th Avenue that discharges into the Evans Town Ditch. The 24" pipe with the collected runoff from Area #11 enters the 37th Street pipe system just north of the intersection with US Hwy 85.

There are two distinct Area #9 concerns. First, the stormwater must be pumped to the South Platte whenever the river elevation rises too high. The eastern areas in the drainageway and pipes have very mild slopes, yielding insufficient hydraulic head to get the stormwater to the River. Therefore, the water will sit stagnant in the pipes. Currently, the City pumps water from a manhole along 37th Street, near the river, to a downstream area along the South Platte as it becomes necessary. This will be discussed in more detail later in the section. The second concern is local flooding that occurs along 39th Street and neighboring properties during large storm events.

The flow rates at design points along 37th Street estimated by the rational analysis are presented in Table 6-16.

Table 6-16: Area of Concern #9 Flow Rates

Location	Flow Rates (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
37th St. and US Hwy 85	363.8	313.9	223.4	194.7	150.2
37th St. at South Platte	486.2	416.7	293.1	249.4	188.3

These flow rates do not include the added flow from Area #4 or the western section of basin that currently drains into Evans Town Ditch. Even so, the system is undersized for the flow currently received in both the major and minor design storms. The existing capacity of the dual pipe system varies as the pipe diameters increase. Table 6-17 summaries the theoretical capacities of the 37th Street storm system at noteworthy juncture points.

Table 6-17: Area #9 Existing Infrastructure Capacities

Location	Diameter(s)	Capacity (cfs)
37th St. and Denver St.	26", 18"	18.5
37th St. and Boulder St.	26", 42"	74.3
37th St. and Trinidad St.	34", 54"	134.3
37th St. and 1st Ave.	42", 54"	259.1

The system is most dramatically undersized along 37th Street between Highway 85 and Boulder Street; the minor (5-year) storm results in a flow rate 6 times that of the existing capacity in this location. In the major storm, the system is undersized by a factor of twelve. Theoretical street flow capacity was calculated for 37th Street, since in some systems the curb-and-gutter flow can be greater than the pipe flow during major storm events. The maximum street capacity predicted for the major storm is 14 cfs; that for the minor storm is just 3 cfs. These small capacities are a product of the flat nature of the area and the resulting slow velocities of flow. The pond which discharges into this section of pipe does not reduce the peak flow of the major storm event by more than 10 cfs.

Together, the 30” pipes along 36th Street and 37th Street which discharge into the first of the two ponds adjacent to Highway 85 are undersized for the minor (5-year) storm by 7 cfs, equivalent to 5% of the expected runoff. In the major storm this section of the 37th Street system is expected to be under-capacity by 210 cfs (130% of the existing system capacity). It is recommended that the City consider increasing the pipe capacity in this area by replacing one of the 30” pipes with a 48” pipe. However, increasing the pipe capacity will overwhelm the existing downstream detention ponds. There is very little room for the pond capacities to be expanded currently; therefore, specific recommendations for this section of 37th Street are not included in the Alternatives below. It is recommended that the City take stormwater drainage at this intersection into consideration when developing the Highway 85 Corridor revitalization plans.

The solution to address the flooding issues along 37th Street and within Area #9 must also address the flow currently discharged into the Evans Town Ditch, since it is the nearest existing system and the shortest path to the river. Two alternatives were examined and deemed feasible.

Alternative 1

One alternative is to split up the drainage area and release stormwater to multiple locations along the South Platte. This would reduce the flow into the 37th Street system, allowing it to function without alteration east of Boulder Street. Alternative 1 for Area #9 is associated with Alternative 1 for areas of concern #4, #16, and #17 as well. The additional improvements required in these areas are summarized here but are described in detail in their respective sections.

Stormwater from Area of Concern #4, as well as several sub-basins of Area #9, would be collected and taken south in a new pipeline along Carson Street to the river. This would relieve the 37th Street system of approximately 250 cfs during the major storm.

The two southernmost sub-basins of Area #11 and the Area #9 sub-basin that is east of the highway and south of the State and Denver Street intersection would be piped east to the Railroad Park detention pond in Area of Concern #17. The pond would be improved as described in its section of this report. The peak flow rate from the pond is estimated to be 13 cfs. While this would not be a significant additional burden to the existing infrastructure, the downstream pipe is undersized for the drainage area it currently services.

All other sub-basins currently captured in the 37th Street storm sewer system would continue to do so. The dual pipe system between US Hwy 85 and Boulder Street would be improved to accommodate the flow. Flow that cannot be handled by the downstream system (290 cfs) would be diverted south in a new pipeline along Boulder Street. At 39th Street, this will turn east and continue until it discharges into the Riverside Park ecological corridor. Peak flow rates and recommended equivalent pipe diameters in the areas concerned are shown in Table 6-18.

Table 6-18: Area #9 Alternative 1 Infrastructure Requirements

Location	Flow Rate (cfs)	Eq. Pipe Size
Hwy 85 to Boulder St.	328	90”
Boulder St. to 39th St.	290	90”
39th St. to Riverside Park	375	120”

Stormwater from several additional neighborhoods, not currently included in the drainage basin for Area #9, would be collected. These include that of Area #16, and the neighborhoods between 38th Street and 40th Street. The pipelines along Boulder Street and 39th will require either a dual pipe system or a box culvert with a 2 to 3 foot rise to maintain the required cover. At Riverside Park, the pipe enters into the floodplain; it is proposed that the stormwater be released into the future wetlands in this area. As the planning of the park moves forward, this should be considered.

Finally, the pipelines along 37th Street east of Boulder Street would remain unaltered, and continue to convey the remaining stormwater to the South Platte.

Although the flow is divided and reduced within this alternative, the addition of three new discharge areas could potentially result in three new areas where pumping would be required when the river is flowing high. Furthermore, infrastructure would be placed in new areas, where easements may be required. Due to the mild slopes in all areas, the required pipe sizes at each location are all relatively large, even though the flow rates are being reduced. The advantage of this alternative is that the several pathways to the river may avert flooding due to pipe blockage; since the flow is not concentrated to one system, a system failure would have a smaller impact on the neighboring areas. Regardless of alternative chosen, it is recommended that the intersections along 37th Street be outfitted with cross-pans, to contain the flow that is carried in the gutter.

Alternative 2

Alternative 2 is a modified version of Alternative 1, and continues to rely on the additional flow paths along Carson and 39th Street. The modifications made to Alternative 1 for this option are:

- Flow from Areas #13 and #14 is diverted east along 35th Street
- The 39th Street system is sized solely for the runoff along 39th Street and the surrounding neighborhoods
- Stormwater from Area #4 is piped south to the river without detention

The infrastructure pertaining to the third modification is described in section 5.6 of this report, along with the alternative that incorporates detention. While the cost estimate for Area #9 Alternative 3 assumes no stormwater detention, both options for Area #4 would be feasible with the other modifications.

No overflow path would be constructed between the 37th Street system and the 39th Street system; therefore the dual pipe system along 37th Street will be over-capacity during major storms.

The slope along 39th Street varies between 0.13% and 1.1%, getting steeper nearer to the River. The average slope is 0.4%; this was the slope assumed for all of the pipe segments listed. Currently, there is no street capacity available during any storm. All of 39th Street and the lateral intersecting streets are unpaved and without curb and gutter. It is recommended that after stormwater infrastructure improvements in the area, that curb and gutter be added and the street paved. This not only would decrease the required capacities of the pipes, but effectively channel the stormwater into the inlets and to the outlet, which is a concern in this area of the City because of the flat grades. The required pipe sizes are:

- 42" equivalent diameter pipe between the Area #16 French drains and Golden Street
- 48" equivalent diameter pipe between Golden Street and Pueblo Street
- 54" equivalent diameter pipe between Pueblo Street and Salida Court
- 60" equivalent diameter pipe between Salida Court and the outlet into the Riverside Park wetlands area

The street flow capacity during the major storms was calculated using the UD-Inlet spreadsheet, which calculates the maximum reasonable street flow given specified gutter depth, street slopes, and behind-the-curb flow area. It was determined that 16 cfs would flow along 37th Street at its most mild section. Curb and gutter is recommended to be included in the improvements to Golden Street, from 37th to 40th Street. This would allow approximately 11 cfs of street flow during the major storm, assuming a slope of 0.1%. No street capacity was calculated or assumed for Pueblo Street or Riverside Parkway. Salida Court dead-ends north of the proposed pipeline. Riverside Parkway has a very mild transverse slope, and 300 feet north of the 39th Street pipe, starts to slope mildly towards 37th Street. The lateral pipes recommended are:

- 30" equivalent diameter pipe between 38th Street and 39th Street along Boulder Street
- 54" equivalent diameter pipe between 38th Street and 39th Street along Pueblo Street
- 54" equivalent diameter pipe between 38th Street and 39th Street along Riverside Parkway

Stormwater that collects along Golden Street would flow in the proposed curb and gutter.

Alternative 3

For the areas currently discharged to the Evans Town Ditch, the shortest path to the South Platte, and the path with the most grade, is 37th Street. The remainder of the drainage area is already connected to the 37th Street dual pipe system through existing infrastructure. Therefore, this alternative consists of connecting Area #4 with Area #9 and replacing the existing pipes all along 37th Street with larger ones that can handle the major storm. Required infrastructure includes:

- Replace the 30" and 18" pipes with 108" equivalent diameter pipe between Denver Street and Trinidad St. (2,205 feet)
- Replace the pipes between Trinidad St. and the 1st Street with 114' equivalent diameter pipe.
- Replace the pipes between 1st Street and the outlet on the South Platte with 96" pipe. This section of road has steeper grades than the sections of 37th St. before it. Consequently, it requires a smaller size pipe to convey the major storm; given the large diameters of the pipes, the decreased size is not a concern.

Because of cover constraints, the replacement pipe along 37th Street would need to be a dual or multiple pipe system. For the length of pipe between Denver Street and Trinidad Street, this would entail two 84" pipes or three 72" pipes. From Trinidad to 1st Street, two 90" pipes or three 78" pipes would be required. These would be extended to the outlet, although the last pipe section would convey the major storm with two 78" pipes.

Alternative 3 replaces considerable pipe, but takes advantage of the existing pipe corridors in place. The main difficulty in this approach is that the corridor is also used by sanitary sewers, water lines, and other utilities. This and the cover constrains the space available for upsizing the existing pipes. In addition, the section of pipe between Boulder and Trinidad Streets was very recently replaced.

Due to concerns about the feasibility of the installation of a large pipe system in 37th Street, a cost estimate was not prepared. For master planning purposes, a cost has only been provided for Alternative 1. The cost for Alternative 2 is the same as presented here, but includes a higher cost in Area of Concern #13 and 14.

Pump Station

Another concern with the storm sewer system on 37th Street occurs when the water level in the South Platte River is high. As mentioned, there is not enough hydraulic head to open the flap gates on the pipes and push the flows out during high river flows. The most cost effective way to generate additional hydraulic head is with gravity. Unfortunately, this is not an option along 37th Street due to its mild grade. It will therefore be necessary to use pumps. The purpose of the pump system is to handle stormwater in the basin that is the result of a small rainstorm, so it is not necessary to pass the large flows. A flow of 30 cfs was assumed, which is significantly less than the 5-year flow rate of 188.3 cfs.

The pump station will be housed in a 20-foot deep and 11'x10' vault. One possible location for the pump station is on land where the wastewater treatment plant currently resides, just west of 1st Avenue. The feasibility of this site and its exact location will need to be coordinated with the WWTP decommissioning plans. A bypass vault can be installed on each storm sewer line in 37th Street to divert some of the flows. Due to the elevations in this area, it is assumed that a splitter wall will be installed in the structure. When the flows back up in the system to a given elevation, they will spill over the wall into the bypass line. The flows will gravity drain to the pump station vault. At least three submersible pumps will be permanently stationed at the base of the station. Each will have a capacity of approximately 10 cfs or 4000 gallons per minute (gpm) each. When the water in the vault reaches a pre-determined elevation, the pumps will turn on and begin releasing the water to a discharge line. Based on the schematic design, this pipeline is expected to be run under 1st Avenue, ultimately discharge into the South Platte River, and have with a check valve on its outlet.

The vault will also have a large opening on the side that will act as a discharge location for flows above the pumping capacity. A dedicated overflow path to the river will need to be determined based on discussions with the adjacent landowners. It should be noted that the land east of the wastewater treatment plan is all within the floodplain.

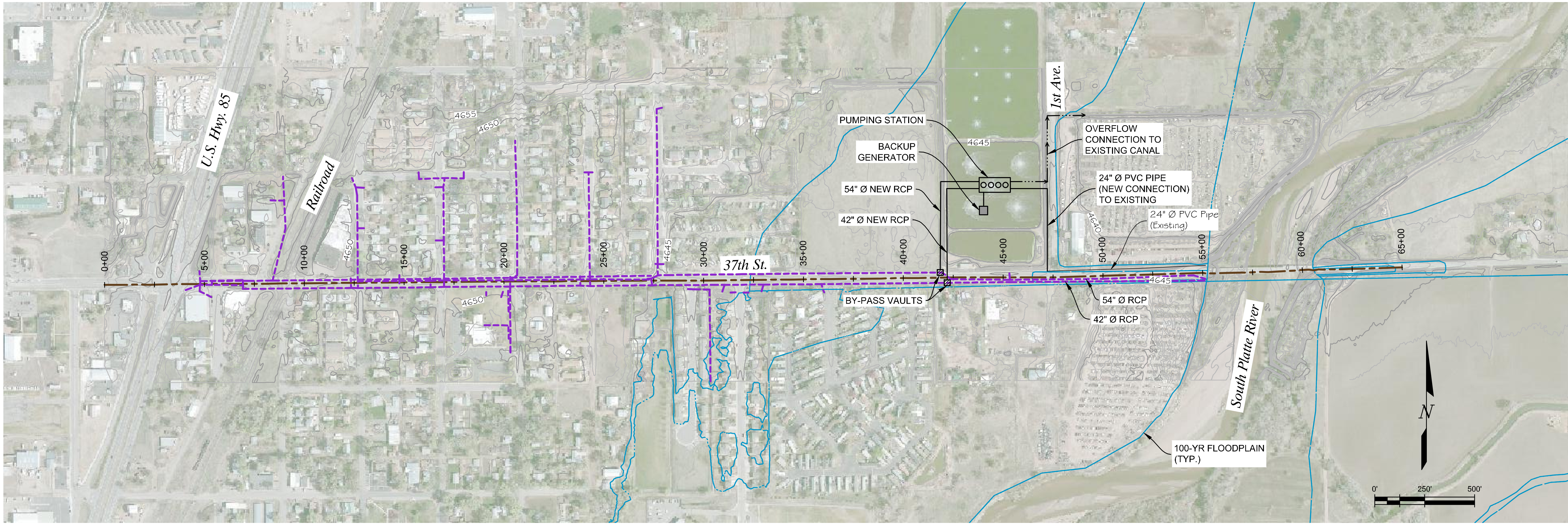
There are some resiliency options that can be explored. One option is a backup pump. When the pumps need to be used, the system will be completely under water and inaccessible. If a pump goes down then a backup pump will keep the system functioning at 30 cfs. Another option that can be considered is a generator. In the event that there is an issue with the power supply to the area, the generator can provide a backup power source to keep the pumps working.

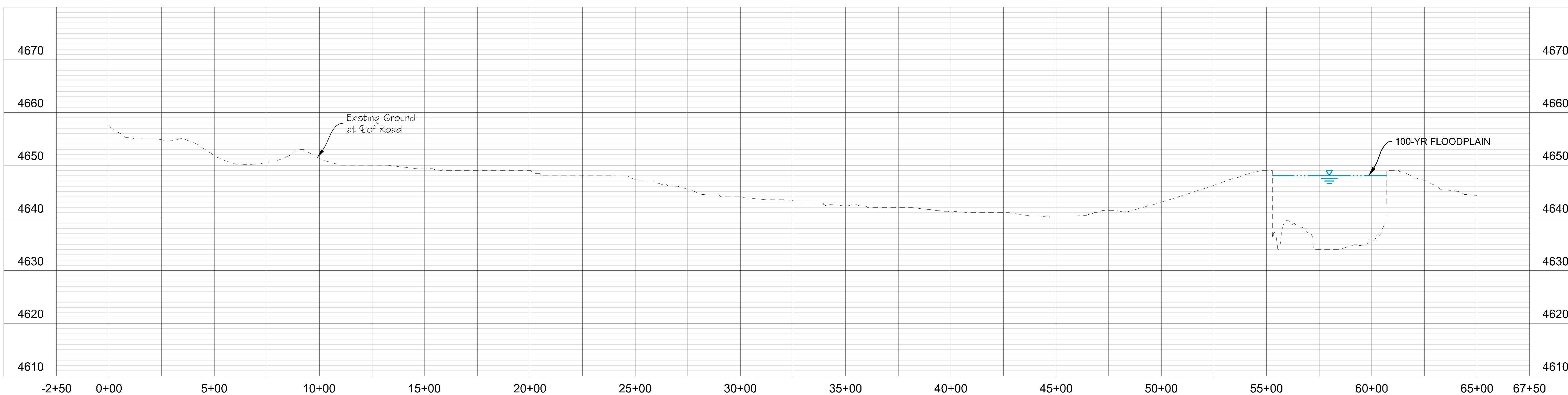
Following is a conceptual schematic that shows a cross-section of the bypass vault. Also shown is a plan and profile sheet illustrating one possible location for the pump station as well as the road profile along 37th Street and the 100-year water surface elevation of the South Platte. A cross-section of the pump station is included to show the approximate depth of the vault, the on and off elevations for the pumps and the overflow. A pump curve has also been generated to illustrate one pump option.

A cost estimate has been prepared to estimate the costs for the full system. This evaluation assumes 4 pumps, all the piping and concrete necessary as well as the earthwork. It does not include a generator. The total cost for all the improvements is $2 Million.

There are many examples of resiliency that are a part of this project. The pump station itself provides resiliency in that it protects the surrounding neighborhoods during times when the water level in the River is high. The City also had to make some hard decisions between the current infrastructure and the cost to get the infrastructure up “to standard”.

RECOMMENDATION:	✓ **Replace both the 26” and 18” pipes under 37th Street with 72” pipe between US Hwy 85 and Boulder Street**
ALTERNATIVE 2	✓ **Construct a 60” pipeline along 39th Street to divert runoff south of 37th Street** ✓ **Build a pump station adjacent to 37th Street and 1st Avenue**





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37TH STREET CENTERLINE PROFILE

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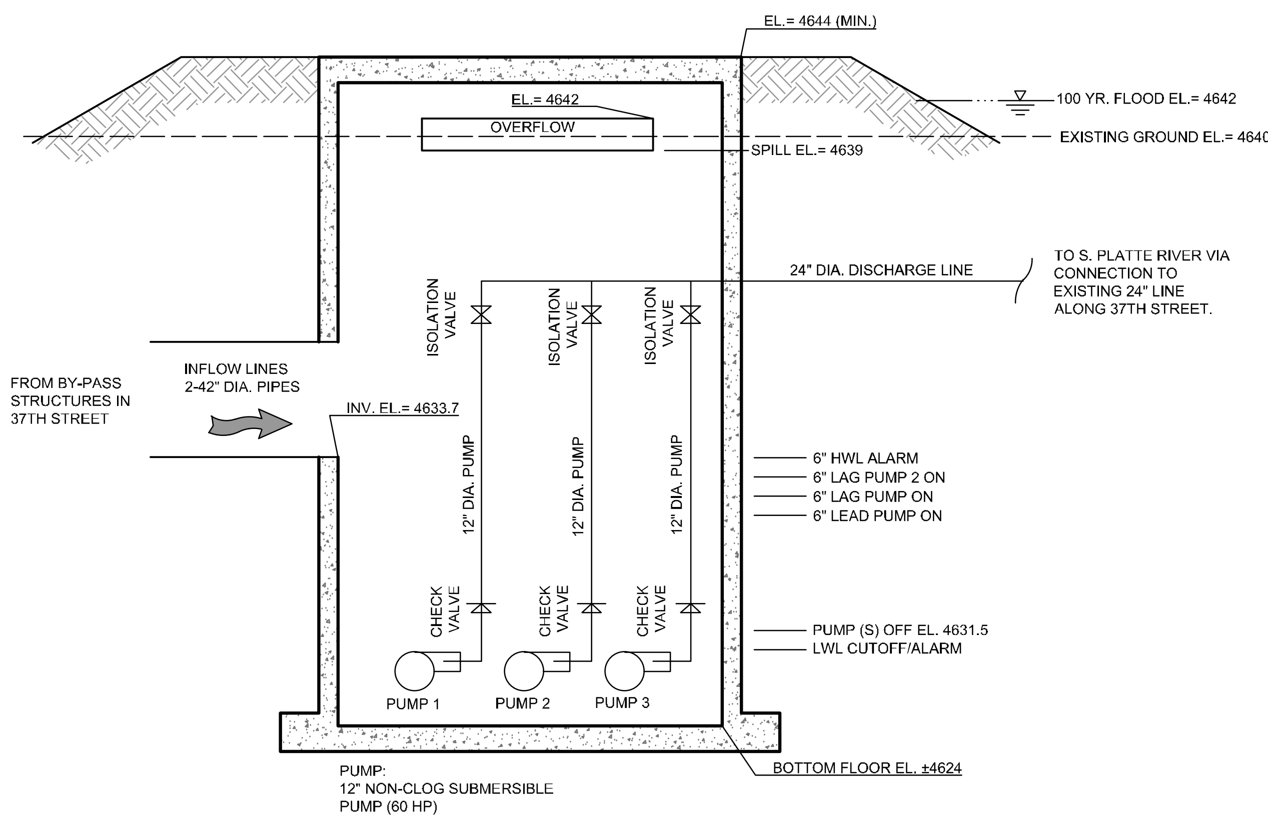

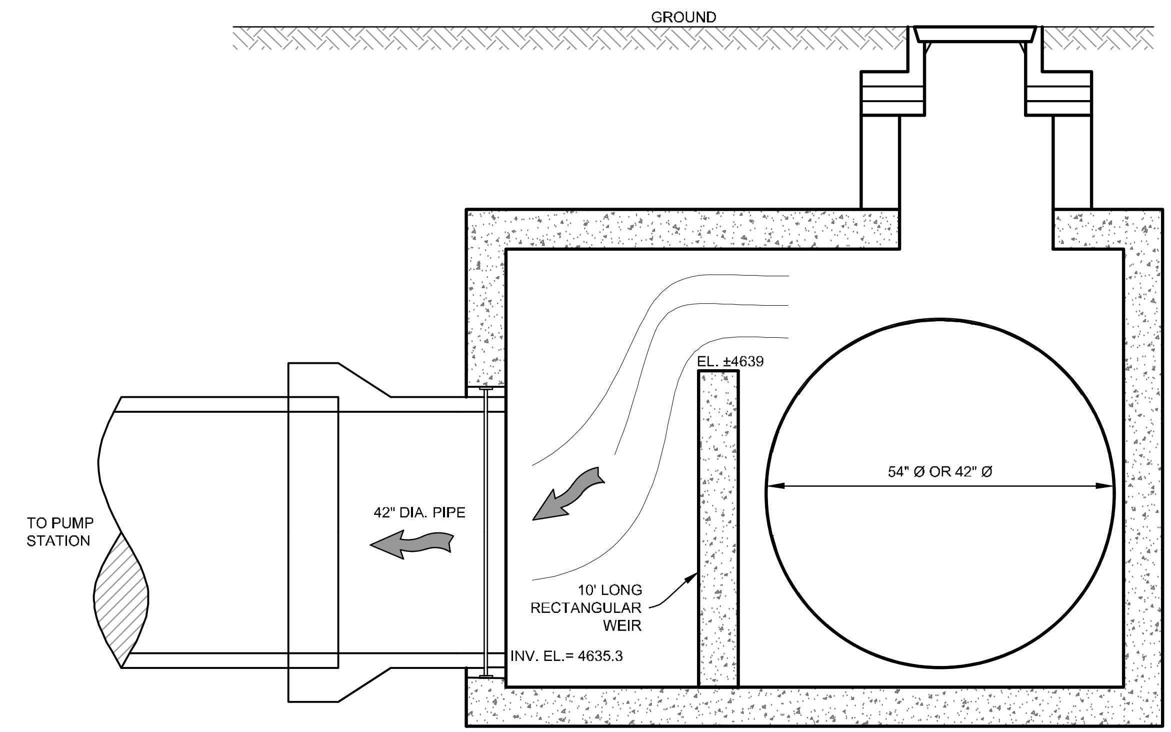

TYPICAL BY-PASS VAULT
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PUMP STATION SCHEMATICS

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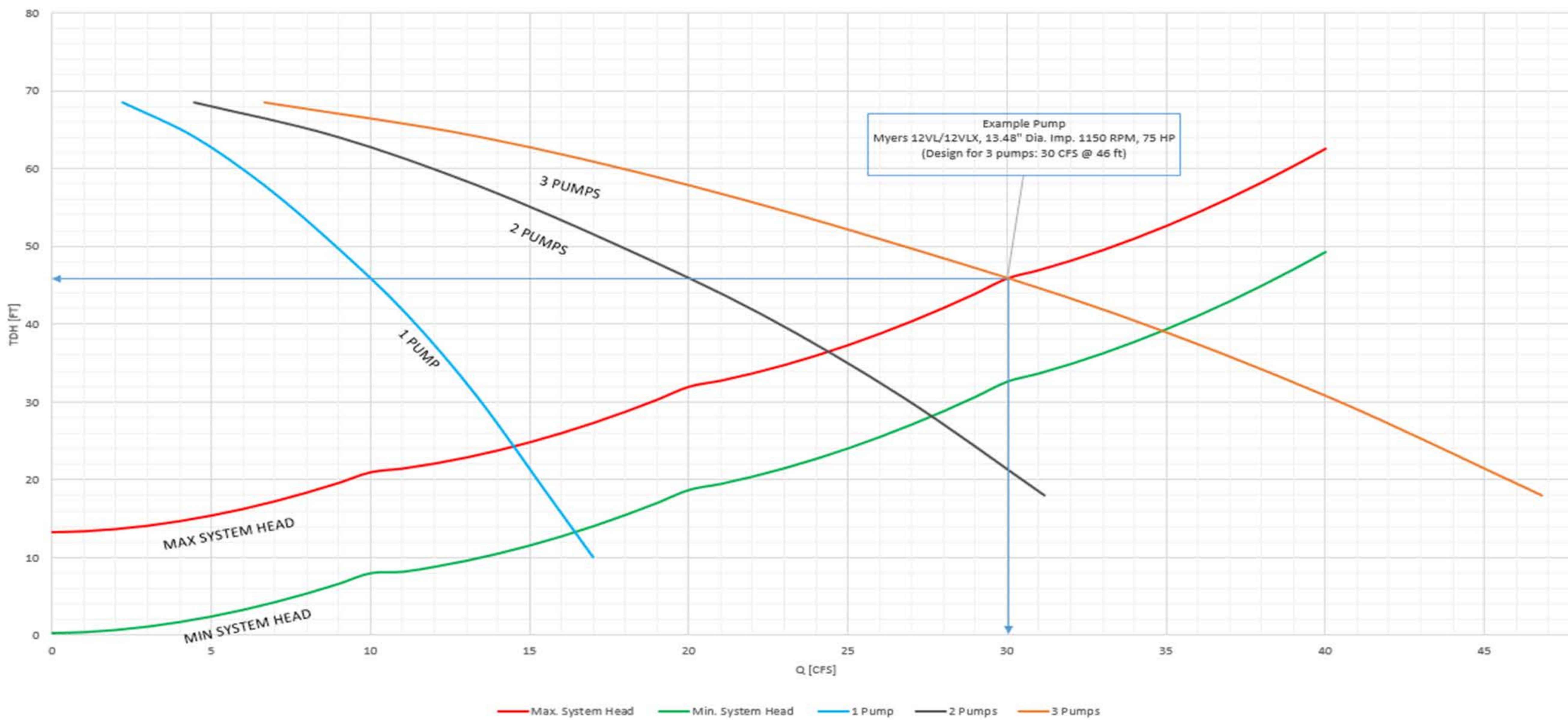


Figure 6-2: 37th Street Stormwater Pump Station Pump Curves (Hazen-Williams)

Alternative 1 Cost Estimate

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 9
ALTERNATIVE :	1
JURISDICTION :	Evans
SUB-BASIN ID:	37th Street at River-Reach9
DATE :	5/2/2016

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	**Length (ft)**	**No. of Barrels**				1
48-inch	885	1	885	L.F.	$185.00	$163,725.00
54-inch	360	1	360	L.F.	$277.00	$99,720.00
72-inch	425	1	425	L.F.	$462.00	$196,350.00
42-inch	830	1	830	L.F.	$162.00	$134,460.00
48-inch	750	1	750	L.F.	$185.00	$138,750.00
54-inch	660	1	660	L.F.	$277.00	$182,820.00
60-inch	390	1	390	L.F.	$308.00	$120,120.00
Flare End Sections						
Diameter (in)	**Applicable**	**No. of Barrels**				1
48-inch	Yes	1	1	EA	$2,646.00	$2,646.00
Manholes and Inlets						
Manhole, 6' Dia. (Pipe Dia. = 48")			5	EA	$5,524.00	$27,620.00
Type B Manhole (Pipe Dia. 48" and larger, deflection < 10 degrees)			33	EA	$15,416.00	$508,728.00
Storm Inlet, Type R/Type 14, 5-foot			12	EA	$5,910.00	$70,920.00
Removals						
Removal of culvert pipe (D<48")			4500	L.F.	$26.00	$117,000.00
Landscaping and Maintenance Improvements						
Reclamation & seeding (native grasses)			4	ACRE	$1,285.00	$5,140.00
Land Acquisition						
Easement/ROW Acquisition			1.00	ACRE	$426,376.00	$426,376.00

Master Plan Capital Improvement Cost Summary

Capital Improvement Costs			
Pipe Culverts and Storm Drains			$1,645,859.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$0.00
Removals			$117,000.00
Landscaping and Maintenance Improvements			$5,140.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$1,767,999.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$88,400.00
Traffic Control	$50,000.00	L.S.	$50,000.00
Utility Coordination/Relocation	$50,000.00	L.S.	$50,000.00
Stormwater Management/Erosion Control	5%		$88,400.00
Subtotal Additional Capital Improvement Costs			**$276,800.00**
Land Acquisition Costs			
ROW/Easements			$426,376.00
Subtotal Land Acquisition Costs			**$426,376.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$306,720.00
Legal/Administrative	5%		$102,240.00
Contract Admin/Construction Management	10%		$204,480.00
Contingency	25%		$511,200.00
Subtotal Other Costs			**$1,124,640.00**
Total Capital Improvement Costs			**$3,595,815.00**

Master Plan Operation and Maintenance Cost Summary

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, erosion at entrance/exit, structural repairs	4300	L.F.	$1.00	$860.00
Manhole and Inlet Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	50	EA	$64.00	$3,200.00
Total Annual Operation and Maintenance Cost				**$4,060.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$203,000.00**

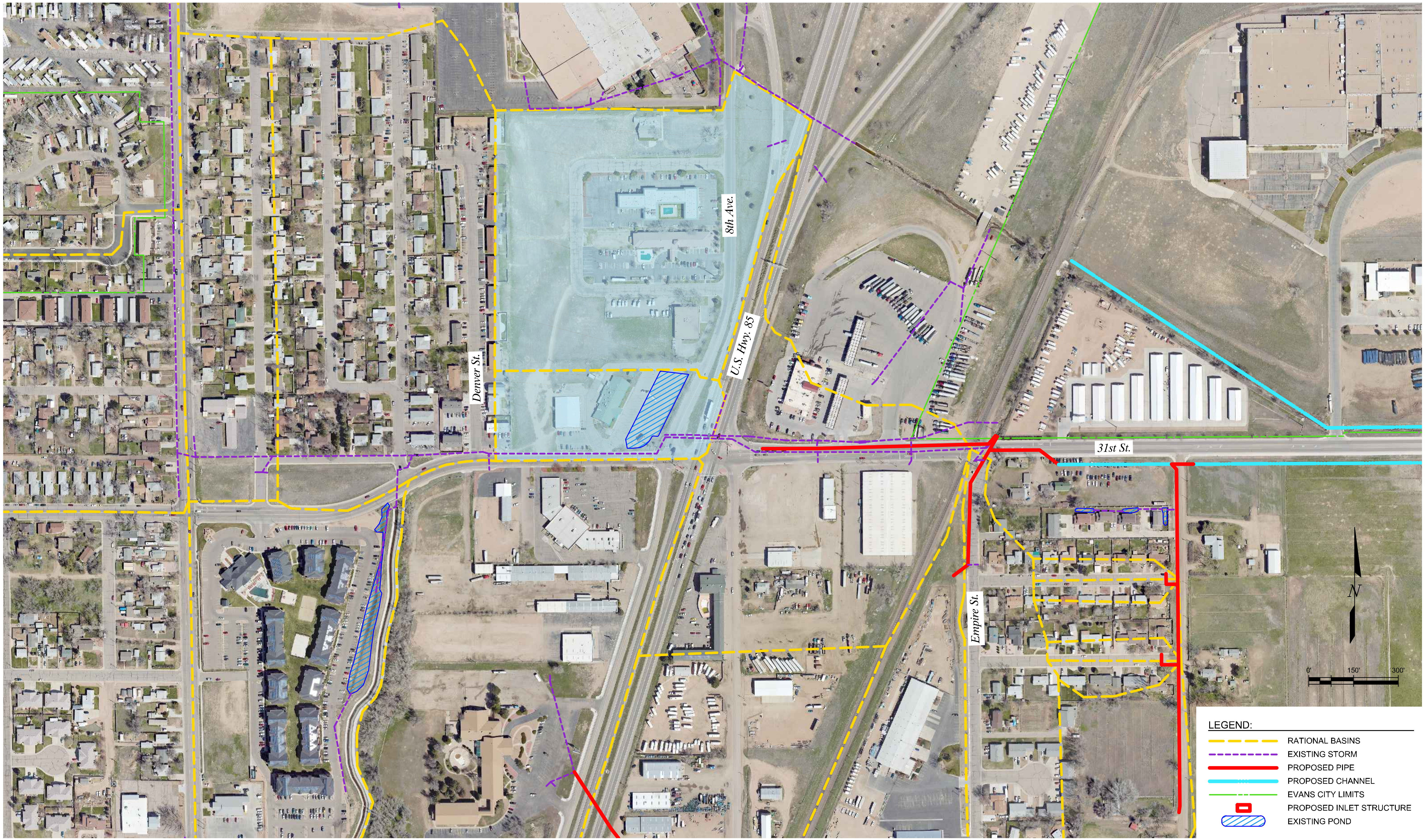
Pump Station Cost Estimate

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	37th and River
ALTERNATIVE :	Pump Station
JURISDICTION :	Evans
SUB-BASIN ID:	Pump Station-Reach1
DATE :	5/2/2016

DESCRIPTION			QUANTITY	UNIT	UNIT COST	COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	**Length (ft)**	**No. of Barrels**				
24-inch	700	1	700	L.F.	$92.00	$64,400.00
42-inch	1400	1	1400	L.F.	$162.00	$226,800.00
Manholes and Inlets						
Type P Manhole (Pipe Dia. 48" and larger, deflection > 10 degrees)			2	EA	$19,271.00	$38,542.00
Special Items (User Defined)						
Pumping Station Wet Well			1	LS	$175,000.00	$175,000.00
Interior Piping			1	LS	$80,000.00	$80,000.00
Pumps			4	EA	$65,000.00	$260,000.00
Electrical System			1	EA	$60,000.00	$60,000.00
180 KW Backup Generator			1	LS	$155,000.00	$155,000.00
Structure Excavation			450	CY	$20.00	$9,000.00
Structure Backfill			300	CY	$30.00	$9,000.00
Overflow Channel			1	LS	$30,000.00	$30,000.00

Master Plan Capital Improvement Cost Summary			
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$329,742.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$0.00
Removals			$0.00
Landscaping and Maintenance Improvements			$0.00
Special Items (User Defined)			$778,000.00
Subtotal Capital Improvement Costs			**$1,107,742.00**
Additional Capital Improvement Costs			
Dewatering	$20,000.00	L.S.	$20,000.00
Mobilization	5%		$55,387.00
Traffic Control	$10,000.00	L.S.	$10,000.00
Utility Coordination/Relocation	$20,000.00	L.S.	$20,000.00
Stormwater Management/Erosion Control	5%		$55,387.00
Subtotal Additional Capital Improvement Costs			**$160,774.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$190,277.00
Legal/Administrative	5%		$63,426.00
Contract Admin/Construction Management	10%		$126,852.00
Contingency	25%		$317,129.00
Subtotal Other Costs			**$697,684.00**
Total Capital Improvement Costs			**$1,966,200.00**



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City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

AREA OF CONCERN 10
HIGHWAY 85 AND 31ST STREET

DATE: NOV 2016

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PAGE NO. AC10-1

6.12 Area of Concern #10 – Highway 85 and 31st Street

Area of Concern #10 is located at the intersection of US Hwy 85 and 31st Street, in the northeastern section of Evans. Its drainage area extends east from Denver Street to the Highway 85, and north from 31st Street to the edge of the parking lot of the shared-space commercial building (3001 8th Ave). Two sub-basins were delineated for the drainage area, which has a total area of 24 acres. Both areas' land use is primarily commercial, with paved parking lots and open, undeveloped lots neighboring the buildings. The overall imperviousness of the basin is 45.5%. Type A soils characterize the entirety of each sub-basin.

Runoff generated in the northern of the two sub-basins flows directly south over the open fields and along 8th Avenue into the southern sub-basin. Here, it collects in the southeastern corner where there is a small and poorly-defined detention basin. The basin is best described as a depression to channel the flow towards the inlet of the 48" pipe that conveys the stormwater across 8th Avenue and US Hwy 85, along 31st Street, and eventually into the open channel that is the main concern of Area #8. A second 48" pipe runs under 31st Avenue across the southern sub-basin of Area #10, but has only one inlet within the basin, in the same vicinity as the pond's outlet. The average slope of the northern sub-basin is 12.7%, yielding fairly fast velocities, considering that the stormwater flows are not controlled by a channel or pipe. However, most of the flow is dispersed over a wide open field, so the depth of flow is shallow in the storms of interest. The flow rates predicted by the rational analysis for the design storms are listed in Table 6-19.

Table 6-19: Area of Concern #10 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
31st St. and 8th Ave.	60.4	50.8	35.0	29.0	20.9

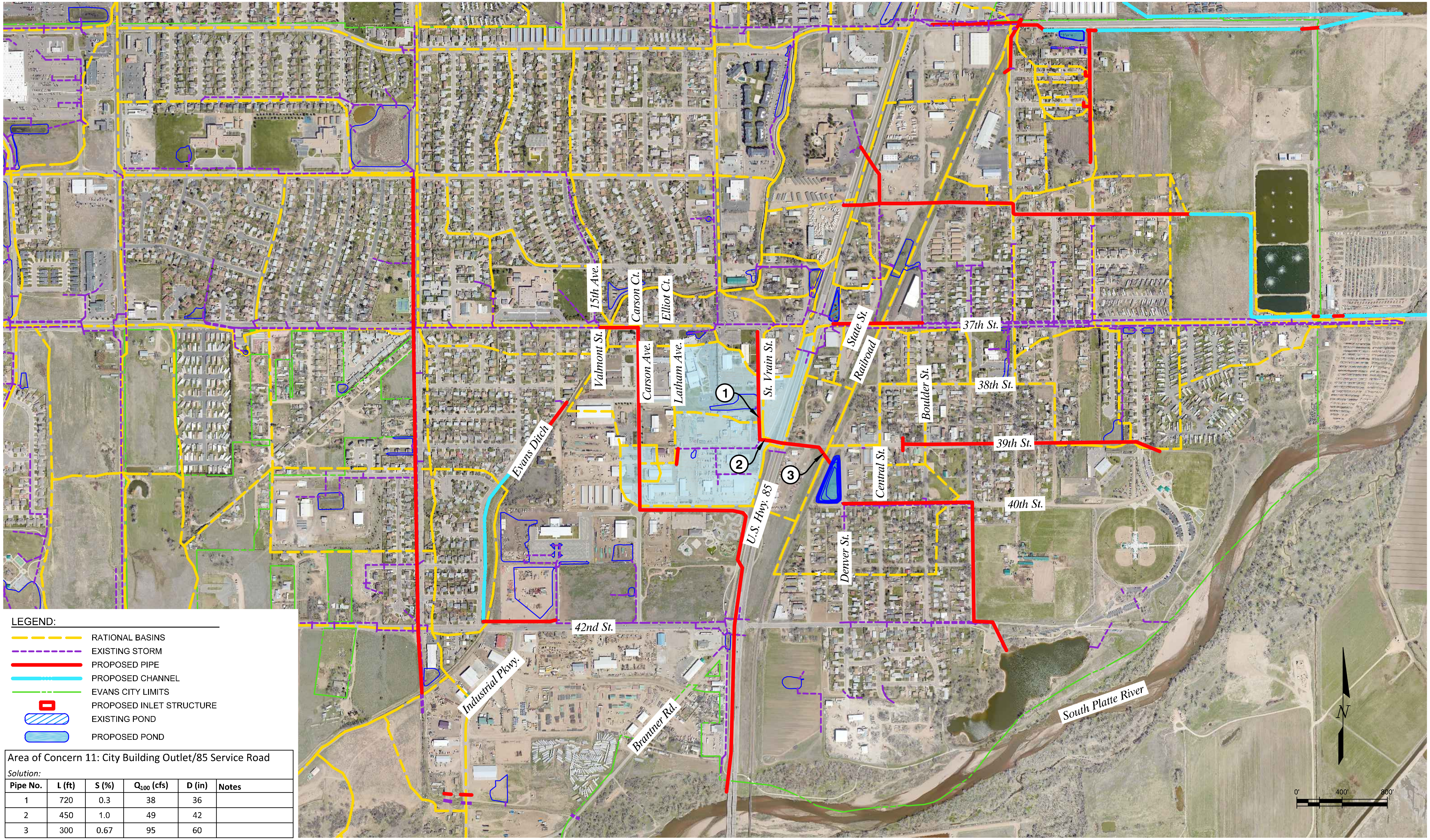
A few years ago the outlet from the pond was replaced with a larger 48" pipe. The City was unsure whether this upgrade was sufficient to fully convey the 100-year storm and mitigate flooding risks. The calculated pipe capacity of the 48" pipe is 101 cfs; therefore, it can be concluded that the upgraded pipe has adequate capacity for the major and minor design stormwater generated by the drainage basin.

Area #10, however, is located within Area #8 and does not function in an isolated system. At the intersection of 31st Street with US Hwy 85/ Union Pacific Railroad, an additional 343.3 cfs flows from the upstream Area #8 sub-basins. The second 48" pipe running parallel to the pond outlet also has a capacity of about 100 cfs, and cannot handle this flow. An 84" equivalent diameter is required to handle the upstream flow. Due to cover constraints, this may not be feasible. The potential street capacity along 31st Street may be considered and would confine infrastructure improvements to Area of Concern #8.

Should street capacity not be considered, infrastructure improvements at the outlet of Area #10 would become necessary. If, however, 31st Street is included in the stormwater management of Area #8, the infrastructure along 8th Avenue and at the pond outlet may remain their current sizes.

At this time, a cost estimate for this individual area has not been prepared since it is encompassed in the larger Area #8.

RECOMMENDATIONS	✓ ***See Area of Concern #8***



Area of Concern 11: City Building Outlet/85 Service Road

Solution:

Pipe No.	L (ft)	S (%)	Q_{100} (cfs)	D (in)	Notes
1	720	0.3	38	36	
2	450	1.0	49	42	
3	300	0.67	95	60	

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City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

AREA OF CONCERN 11
ST. VRAIN AND W. SERVICE ROAD

DATE: NOV 2016

DRAWING NO.

PAGE NO. AC11-1

6.13 Area of Concern #11 – Saint Vrain Street and W. Service Road

Area of Concern #11 is located at two points along US Hwy 85, between 39th Street and 37th Street. The first of the points of concern is at the outlet of a culvert across St. Vrain Street, in a swale adjacent the W Service Road (to the east) and the highway (to the west). The second point is the inlet, in the median of the highway, to the pipe that connects Area #11 to Area #9. The area draining to these points extends from 37th Street to 40th Street and from US Hwy 85 to Latham Avenue. Three sub-basins were delineated for this area of concern; the total area of the drainage basin is 34 acres. Two are comprised of commercial land use, with multiple parking lots and scattered open space for swales or grass buffers. The third contains the segment of US Hwy 85 included in the drainage area, which is fenced by grass strips along each side. In the rational calculations, the commercial areas were designated as residential, since commercial was not a land-use category used in the analysis. Approximately 82% of the drainage basin is residential; 15% is pavement area. The remaining 3% is lawn/open space. This yields an overall impervious value of 64.4%. The three sub-basin impervious values range between 60% and 83%. All of the sub-basins primarily have soil group type A. The southern-most sub-basin has a small percentage of soil group type B in its southwestern corner, but its overall area is still predominantly type A soil.

The southern sub-basin extends from 40th Street, from the south, to approximately 300 feet north of where 39th Street would be if 39th Street crossed US Hwy 85. It is along this line that a 15" pipe extends from St. Vrain Street to 745 feet west. The pipe runs under a parking lot, to an inlet along Saint Vrain Street, and across the W Service Road to the discharge point in a roadside swale. The segment of pipe across W Service Rd. is an 18" pipe; it collects stormwater from one other inlet, at the corner of Saint Vrain Street and W Service Rd. Two 10" pipelines collect stormwater from the north and west of the office building at 3961 W Service Road (at the corner of 40th Street and W Service Rd). These pipes juncture at the northwest corner of the building and a 12" pipeline conveys the stormwater north to the 18" pipeline. At the discharge point of the 18" pipe, the stormwater is channeled north, through a swale that is not well-defined and about 10 feet wide. At a sump, about 220 feet south of 37th Street, the flow is collected into a 24" pipe, which runs under the highway, turns north, and connects with the 37th Street storm sewer just east of the highway. A detention pond is located west of St. Vrain and adjacent to the Evans Community Complex. This is drained by an 18" culvert that discharges onto Saint Vrain Street. Currently, it follows the road south and is either collected into the inlets along St. Vrain (described above) or flows across the street into a sump, from where it is conveyed through a 24" culvert across the highway and into a parking lot on the corner of 39th Street. This area is no longer in the Area #11 drainage area, but still contributes to the Area #9 drainageway.

The concern for this area is that the outlet at the start of the swale and the inlet into the 37th Street system are undersized, and that the outlet from the detention pond is discharged to the street, with no connection to the Area #11 infrastructure. It was confirmed that the pipe and outlet under St. Vrain Street are undersized. The slope of the pipe is 0.7%, or less, and is constructed of CMP. Although its diameter at the outlet is 18", it has a full flow capacity of 4.2 cfs. The 24" pipe has a similarly mild slope, and a maximum capacity of 16 cfs. Flow rates predicted at these locations are listed in Table 6-20 for each of the design storms.

Table 6-20: Area of Concern #11 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
W Service Rd and US Hwy 85	49.1	41.7	29.6	25.4	19.5
Inlet along US Hwy 85	95.1	81.6	58.3	50.8	30.5

The existing channel has a capacity of 16 cfs at its narrowest point. Its bottom width and depth vary along its length, but at the most restrictive point has a bottom width of 4 feet, depth of less than one foot, and top width of 15 feet. The channel top width along its course is constrained by the distance between W Service Road and the highway. To convey the full flow (95.1 cfs), the channel would need to be improved to have a 3.5 foot depth, 4-foot bottom width, and 2:1 side slopes. These would result in a top width of 18 feet across and a freeboard of 0.6 feet during the major storm. These will include disconnecting Idaho Street and W Service road from 37th Street and converting both of these streets to cul-de-sacs. The City is planning to complete street improvements on the W Service Road in the near future. The improvements will not expand or change the centerline of W Service Road, so the available channel width will remain the same.

Alternative 1

This alternative consists of infrastructure replacement but involves no changes to the flow paths. It would be relevant option if all of the Area #9 drainage area continues to drain to the 37th Street stormwater system. The recommended improvements are two-fold: the pipes and outlets must be upsized, and the conveyance along US Hwy 85 must be improved. The pipe diameters required to convey the major storm flows are 36" at the W Service Road and Saint Vrain Street intersection, 27" at the pond outlet to the swale, and 54" at the sump to 37th Street.

Additionally, it is recommended that the existing swale be replaced with a 48" pipe. Currently, the W Service road has a gutter and inlets along the west (southbound) side at its intersection with Saint Vrain and near the sump south of 37th Street. However, the additional capacity added to the street would be 5 cfs during the minor storm and 17 cfs in the major storm. If this street capacity continues to be provided and relied upon after street improvements, the size of the pipe required to replace the swale would be 42".

Alternative 2

The second alternative is to reduce the pressure on the swale and the 37th Street system by routing the two sub-basins east of the highway to the Railroad Park detention pond. This would require a 36" pipe connecting the outlet of the pond at Saint Vrain Street to the inlet at the intersection of Saint Vrain and W Service Road. A 42" pipe is required to convey the flow from the two Area #11 sub-basins along 39th Street to State Street. Here, runoff from the Area #9 sub-basin south of the Denver and State Street intersection is collected and conveyed with the Area #11 sub-basin stormwater to the Railroad pond in a 60" equivalent diameter pipe. The pond size required for this alternative is described in the description for Area of Concern #17.

Alternatives 1 and 2 are expected to cost $560,609 and $478,020, respectively. The maintenance costs for Alternative 1 is $402 per year. That for Alternative 2 is $332 per year. Costs for Alternative 2 do not include the construction or the maintenance of Railroad Pond.

This project is an example of resiliency because of the use of a full-spectrum detention pond just east of the railroad tracks. It also keeps stormwater away from the 37th Street corridor which is undersized and does not have enough capacity.

RECOMMENDATION: ALTERNATIVE 2	✓ **Construct a 36" pipeline along Saint Vrain Street from 37th to 39th Street** ✓ **At W Service Road, increase the pipe size to 42" and continue the pipe east to Railroad pond**

Alternative 1 Cost Estimate

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 11
ALTERNATIVE :	1
JURISDICTION :	Evans
SUB-BASIN ID:	St Vrain Service Rd-Reach11
DATE :	5/2/2016

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	**Length (ft)**	**No. of Barrels**				
36-inch	130	1	130	L.F.	$139.00	$18,070.00
30-inch	250	1	250	L.F.	$116.00	$29,000.00
54-inch	140	1	140	L.F.	$277.00	$38,780.00
48-inch	850	1	850	L.F.	$185.00	$157,250.00
Flare End Sections						
Diameter (in)	**Applicable**	**No. of Barrels**				
36-inch	Yes	1	1	EA	$2,068.00	$2,068.00
30-inch	Yes	1	1	EA	$2,017.00	$2,017.00
48-inch	Yes	1	1	EA	$2,646.00	$2,646.00
Headwalls						
Diameter (in)	**Applicable**	**No. of Barrels**				
54-inch	Yes	1	2	EA	$1,843.52	$3,687.00
Wingwalls (includes concrete apron)						
Diameter (in)		**No. of Barrels**				
54-inch		1	2	EA	$11,271.99	$22,544.00
Manholes and Inlets						
Manhole, 6' Dia. (Pipe Dia. = 48")			1	EA	$5,524.00	$5,524.00
Type B Manhole (Pipe Dia. 48" and larger, deflection < 10 degrees)			1	EA	$15,416.00	$15,416.00
Removals						
Removal of culvert pipe (D<48")			270	L.F.	$26.00	$7,020.00
Land Acquisition						
Easement/ROW Acquisition			0.03	ACRE	$101,709.20	$3,502.00

Master Plan Capital Improvement Cost Summary			
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$297,002.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$0.00
Removals			$7,020.00
Landscaping and Maintenance Improvements			$0.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$304,022.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$15,201.00
Traffic Control	$15,000.00	L.S.	$15,000.00
Utility Coordination/Relocation	$10,000.00	L.S.	$10,000.00
Stormwater Management/Erosion Control	5%		$15,201.00
Subtotal Additional Capital Improvement Costs			**$55,402.00**
Land Acquisition Costs			
ROW/Easements			$3,502.00
Subtotal Land Acquisition Costs			**$3,502.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$53,914.00
Legal/Administrative	5%		$17,971.00
Contract Admin/Construction Management	10%		$35,942.00
Contingency	25%		$89,856.00
Subtotal Other Costs			**$197,683.00**
Total Capital Improvement Costs			**$560,609.00**

Master Plan Operation and Maintenance Cost Summary				
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Annual Cost**
Culvert Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	1370	L.F.	$1.00	$274.00
Manhole and Inlet Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	2	EA	$64.00	$128.00
Total Annual Operation and Maintenance Cost				**$402.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$20,100.00**

Alternative 2 Cost Estimate

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAIANGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 11
ALTERNATIVE :	2
JURISDICTION :	Evans
SUB-BASIN ID:	St Vrain Service Rd-Reach11a — DATE : 5/2/2016

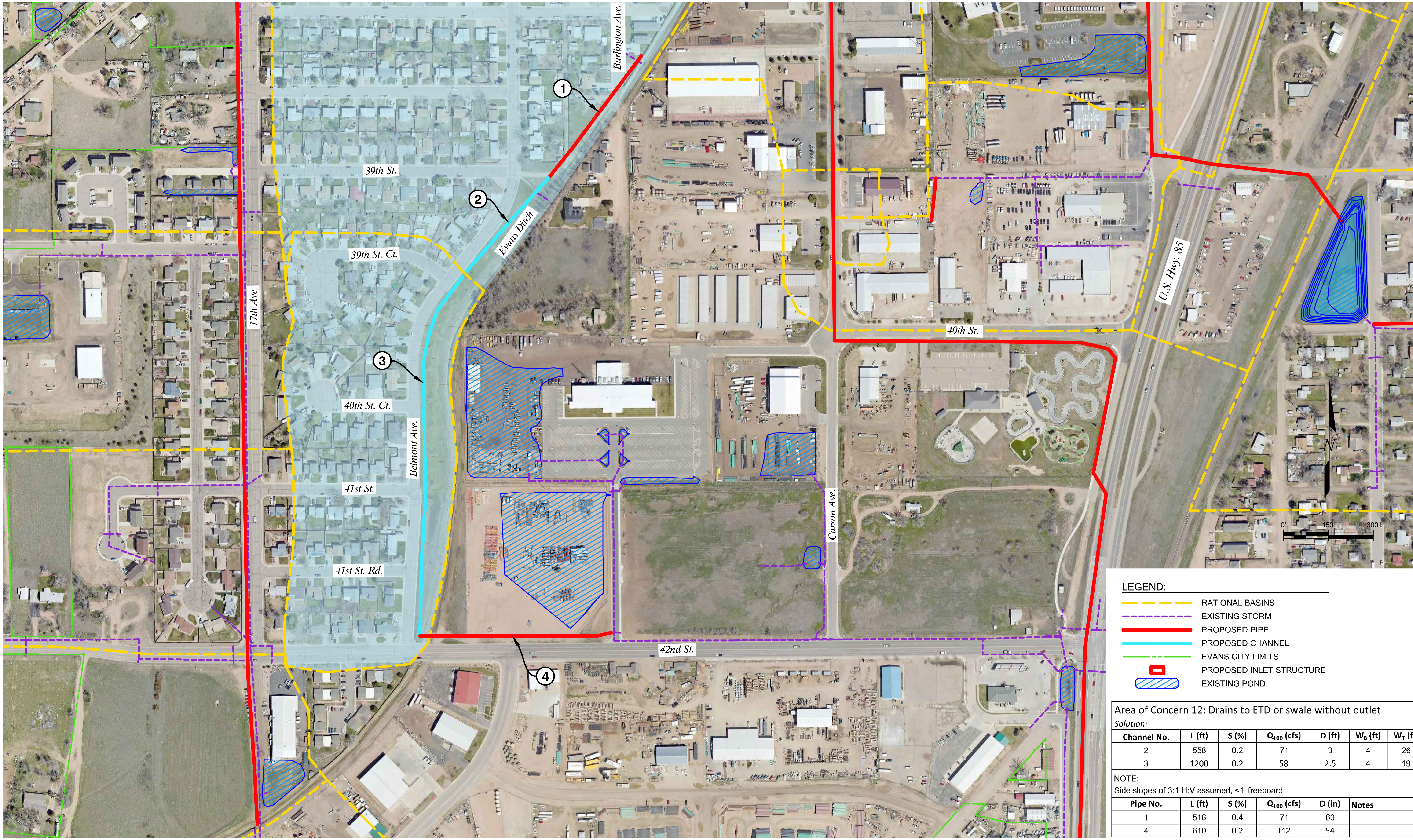
DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	**Length (ft)**	**No. of Barrels**				
36-inch	270	1	270	L.F.	$139.00	$37,530.00
42-inch	450	1	450	L.F.	$162.00	$72,900.00
60-inch	300	1	300	L.F.	$308.00	$92,400.00
Headwalls						
Diameter (in)	**Applicable**	**No. of Barrels**				
60-inch	Yes	1	1	EA	$2,047.85	$2,048.00
Wingwalls (includes concrete apron)						
Diameter (in)		**No. of Barrels**				
60-inch		1	1	EA	$11,460.50	$11,461.00
Manholes and Inlets						
Manhole, 5' Dia. (Pipe Dia. 36" - 42")			1	EA	$5,010.00	$5,010.00
Type P Manhole (Pipe Dia. 48" and larger, deflection > 10 degrees)			1	EA	$19,271.00	$19,271.00
Removals						
Removal of culvert pipe (D<48")			130	L.F.	$26.00	$3,380.00

Master Plan Operation and Maintenance Cost Summary

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	1020	L.F.	$1.00	$204.00
Manhole and Inlet Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	2	EA	$64.00	$128.00
Total Annual Operation and Maintenance Cost				**$332.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$16,600.00**

Master Plan Capital Improvement Cost Summary

Item	Quantity	Unit	Total
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$240,620.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$0.00
Removals			$3,380.00
Landscaping and Maintenance Improvements			$0.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$244,000.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$12,200.00
Traffic Control	$20,000.00	L.S.	$20,000.00
Utility Coordination/Relocation	$20,000.00	L.S.	$20,000.00
Stormwater Management/Erosion Control	5%		$12,200.00
Subtotal Additional Capital Improvement Costs			**$64,400.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$46,260.00
Legal/Administrative	5%		$15,420.00
Contract Admin/Construction Management	10%		$30,840.00
Contingency	25%		$77,100.00
Subtotal Other Costs			**$169,620.00**
Total Capital Improvement Costs			**$478,020.00**



LEGEND:

RATIONAL BASINS
EXISTING STORM
PROPOSED PIPE
PROPOSED CHANNEL
EVANS CITY LIMITS
PROPOSED INLET STRUCTURE
EXISTING POND

Area of Concern 12: Drains to ETD or swale without outlet

Solution:

Channel No.	L (ft)	S (%)	Q_{100} (cfs)	D (ft)	W_B (ft)	W_T (ft)
2	558	0.2	71	3	4	26
3	1200	0.2	58	2.5	4	19

NOTE:
Side slopes of 3:1 H:V assumed, <1' freeboard

Pipe No.	L (ft)	S (%)	Q_{100} (cfs)	D (in)	Notes
1	516	0.4	71	60	
4	610	0.2	112	54	

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PREPARED UNDER THE SUPERVISION OF

DESIGNED: SEB
DRAWN: MAB
CHECKED: ALR

PROJECT NO. 15-041.01

SHEET REVISIONS			
NO.	DATE	DESCRIPTION	BY

MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

DATE
NOV 2016

DRAWING NO.

AREA OF CONCERN 12
BELMONT STREET

PAGE NO.
AC12-1

6.14 Area of Concern #12 – Belmont Street

Area of Concern #12 is located at the corner of 42nd Street and Belmont Street. Its drainage area extends along Belmont Avenue to 39th Street Ct. and to 17th Avenue to the west. Along the eastern boundary, just outside the drainage area runs the Evans Ditch. Two basins, approximately 38 acres total, were delineated for the drainage area. Both are primarily single-family residences, although there is a strip of open space just east of Belmont Avenue that extends the length of the basin and is approximately 100 feet wide at the typical section. The area is not currently being used for recreational or utility purposes; however, there are plans to construct a bike and walking trail in the future. Going south, the open space narrows due to the curving E. The basins have an impervious value of 53% and are characterized as having primarily group Type A soils.

In the northern sub-basin, runoff is conveyed east through street flow to two culverts. Both discharge directly into the Evans Town Ditch. Runoff generated within the southern sub-basin is collected in the gutters of the adjacent streets, flows east at a crosspan, and then flows south along Belmont Avenue. There is currently no stormwater infrastructure, including pipe or open channels, within the drainage area. From Belmont Avenue, it is directed onto 42nd Street and is collected by inlets downstream.

The concern for the area is that the stormwater is uncontrolled, and will cause local flooding during even minor storms. This was confirmed in the hydrologic and hydraulic analyses. Additionally, the Evans Town Ditch will likely be flowing full during any major storms, it is necessary to re-direct the stormwater from the northern sub-basin. It is recommended that it be taken south. Table 6-21 lists the expected flow rates. The flow at 42nd and Belmont includes the flow routed from the northern sub-basin.

Table 6-21: Area of Concern #12 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
Discharge to Evans Town Ditch	71.1	61.5	42.6	36.4	26.8
42nd St. and Belmont Ave.	111.7	96.1	66.8	56.7	41.6

Street capacities for the neighborhood roads were estimated using the UD-Inlet Street Capacity spreadsheet. During the major storm its allowable capacity is 66 cfs and during the minor storm its allowable capacity is 21 cfs. Although the side streets can handle the local runoff, Belmont Avenue does not have the capacity to handle the collected runoff from either the major or minor storms.

Proposed infrastructure includes a channel within the 1,760 foot stretch of open area, extending from just north-east of Burlington Avenue (where the first culvert discharges) to 42nd Street. The required dimensions are:

- 3 foot channel depth
- 3:1 H:V side slopes
- 4 foot bottom width

Given these parameters, the top width of the channel will be 26 feet. The freeboard of the channel during the major storm is less than the typical 1 foot; the calculated normal depth of the channel is 2.67 feet, leaving about four inches of freeboard. The channel side slopes are also steeper than typically preferred in a channel. However, any overflows will continue south along the open space. Moreover, Belmont Ave. would not be flowing at its maximum capacity during either the major or minor storms if the flow is adequately conveying into the channel. The channel was sized for 72 cfs, leaving 40 cfs to be conveyed by the street. The reduced top width of the channel allows approximately 10 feet for the trail and sidewalk at the narrowest point. At most sections, there will be 45 feet or more within which to place the trails. Inlets or possibly curb cuts will need to be installed along Belmont Avenue to convey the street flow into the proposed channel.

At the intersection of 42nd Street and Belmont Avenue, it is recommended that a pipe be installed to collect the channel discharge. The pipe would connect to the existing infrastructure at 42nd Street and Carson Avenue, flow east until US Hwy 85, then flow south to the river in a 48” pipe. Depending on the solution chosen for Area of Concern #9, this pipe may be replaced with a larger pipe. The new section of pipe just downstream of the channel will require a 48” diameter, due to the mild slope. If the pipe can be placed at a 0.5% slope, the required diameter would decrease to 42”.

A cost estimate has been prepared for this area. Since the ultimate configuration of Area of Concern #9 is not known, it is assumed that the channel will be built adjacent to the trail and the pipe will be built to tie into the system in 42nd Street.

By diverting the flows away from Evans Town Ditch this project provides resiliency to the Town’s infrastructure. Also, the use of open channels will provide opportunities for water quality and infiltration.

RECOMMENDATIONS	✓ **Construct a 520 feet of 60” pipeline from the existing pipe across Burlington Avenue to the proposed channel** ✓ **Construct a 1,650 foot channel adjacent to Belmont Avenue to 42nd Street** ✓ **Add a 48” diameter pipeline from the channel outlet to the existing pipeline along 42nd Street**

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASINS

PROJECT :	City of Evans Stormwater Management Plan		
DRAINAGE BASIN :	Area of Concern 12		
ALTERNATIVE :	1		
JURISDICTION :	Evans		
SUB-BASIN ID:	Belmont St-Reach12	DATE :	5/2/2016

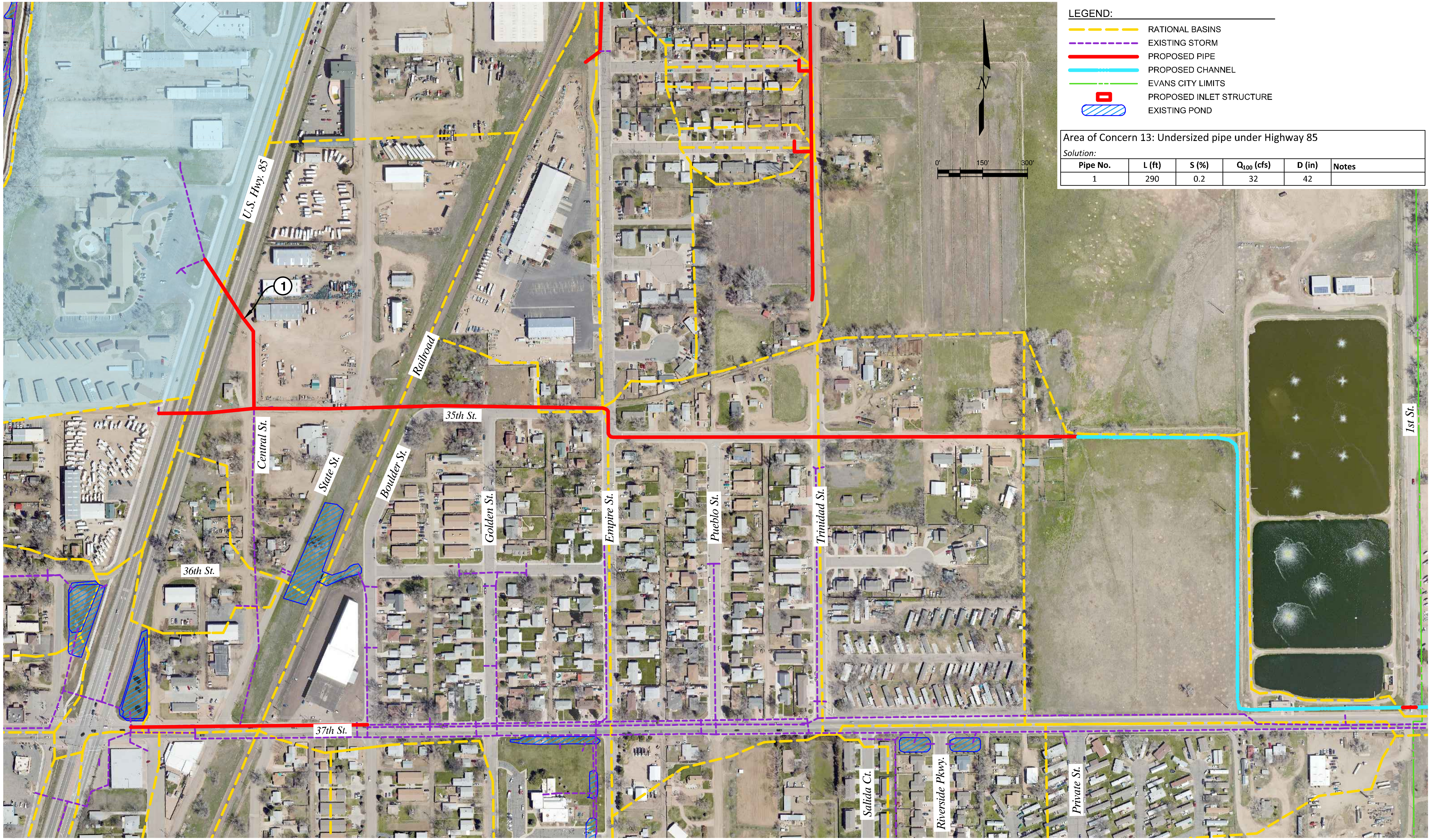
DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	Length (ft)	No. of Barrels				
54-inch	610	1	610	L.F.	$277.00	$168,970.00
Headwalls						
Diameter (in)	Applicable	No. of Barrels				
54-inch	Yes	1	1	EA	$1,843.52	$1,844.00
Wingwalls (includes concrete apron)						
Diameter (in)		No. of Barrels				
54-inch		1	1	EA	$11,271.99	$11,272.00
Manholes and Inlets						
Type B Manhole (Pipe Dia. 48" and larger, deflection < 10 degrees)			1	EA	$15,416.00	$15,416.00
Detention/Water Quality Facilities						
Detention (User Entered Quantities)						
Excavation, Mid Range			778	C.Y.	$31.00	$24,111.00
Landscaping and Maintenance Improvements						
Reclamation & seeding (native grasses)			1	ACRE	$1,285.00	$708.00

Master Plan Operation and Maintenance Cost Summary

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	610	L.F.	$1.00	$122.00
Manhole and Inlet Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	2	EA	$64.00	$128.00
Channel Maintenance (e.g. sediment & debris removal, erosion, tree & weed removal, etc.)	1200	L.F.	$3.00	$3,600.00
Mowing (e.g. channels, ponds, etc.)	0.52	ACRE	$64.00	$67.00
Total Annual Operation and Maintenance Cost				**$3,917.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$195,850.00**

Master Plan Capital Improvement Cost Summary

Description			Cost
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$197,502.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$24,111.00
Removals			$0.00
Landscaping and Maintenance Improvements			$708.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$222,321.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$11,116.00
Traffic Control	$10,000.00	L.S.	$10,000.00
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00
Stormwater Management/Erosion Control	5%		$11,116.00
Subtotal Additional Capital Improvement Costs			**$37,232.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$38,933.00
Legal/Administrative	5%		$12,978.00
Contract Admin/Construction Management	10%		$25,955.00
Contingency	25%		$64,888.00
Subtotal Other Costs			**$142,754.00**
Total Capital Improvement Costs			**$402,307.00**



Area of Concern 13: Undersized pipe under Highway 85

Solution:

Pipe No.	L (ft)	S (%)	Q_{100} (cfs)	D (in)	Notes
1	290	0.2	32	42	

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PREPARED UNDER THE SUPERVISION OF		
DESIGNED:	SEB	
DRAWN:	MAB	
CHECKED:	ALR	PROJECT NO. 15-041.01

SHEET REVISIONS

NO.	DATE	DESCRIPTION	BY

MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

AREA OF CONCERN 13
HERITAGE INN

DATE: NOV 2016

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PAGE NO.: AC13-1

6.15 Area of Concern #13 – Heritage Inn Parking Lot

Area of Concern #13 is located at the eastern corner of the Heritage Inn Parking lot, adjacent to US Hwy 85. Only one basin was delineated for this area of concern, and it extends west from US Hwy 85 to the Evans Town Ditch, and north from 35th Street to 31st Street. The basin is 30.2 acres and is primarily commercial area, with several grassy open spaces between the buildings. About 28% of the basin is paved parking area, while about 11% is lawn or undeveloped land. The overall imperviousness of the basin is 65%. Soils in the area are primarily of group type A.

Two pipes which are assumed to include flared end sections collect stormwater from the Heritage Inn parking lot; both are 12” diameter pipes. The two pipelines join on the eastern end of the lot, from where a 12” pipe conveys the stormwater across the highway and into Area of Concern #14. These pipes are the only stormwater infrastructure in the basin. Runoff flows across the basin into the parking lot, which is located in a sump. The slopes within the basin are relatively mild (0.4%) and little channelization is evident.

The concern for the area is that the pipes are undersized; the pipe under Central Street (within Area #14) is particularly undersized. The flow rates calculated for each of the design storms are listed in Table 6-22.

Table 6-22: Area of Concern #13 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
Heritage Inn Pipe outlet	91.3	79.0	56.2	48.8	37.6

The capacity of the pipe crossing US Hwy 85 is 2.5 cfs, due to the very mild slopes. A 60” pipe is required to convey the full 100-year stormwater flow, both across the highway and south along Central Street, until additional flow is introduced from Area of Concern #14. If a slope of 0.5% can be achieved, then the required pipe diameter would be 54”, and this would allow for 23 cfs additional flow if land use or development changes require it. Currently, Central Street is unpaved and has no capacity for street flow. Should this change, the required pipe size along this road would decrease; however, the inlets and downstream pipes must be sized to convey the full flow under the railroad.

A cost estimate has been completed for only the improvements required to get the flows from this area to Central Street. Please see Area of Concern #14 for the costs to get the flows further south and out to the river. The total cost for the improvements is $413,558. This does not include any CDOT permits and it assumes that no additional ROW will be necessary.

This project provides resiliency by reducing the chance of flooding which may occur along 37th Street. In combination with Area of Concern #14 it provides an additional outlet to the river.

RECOMMENDATIONS	✓ Replace the existing pipeline across US Hwy 85 with a 60” pipe

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 13
ALTERNATIVE :	1
JURISDICTION :	Evans
SUB-BASIN ID:	Heritage Inn-Reach13
DATE :	5/2/2016

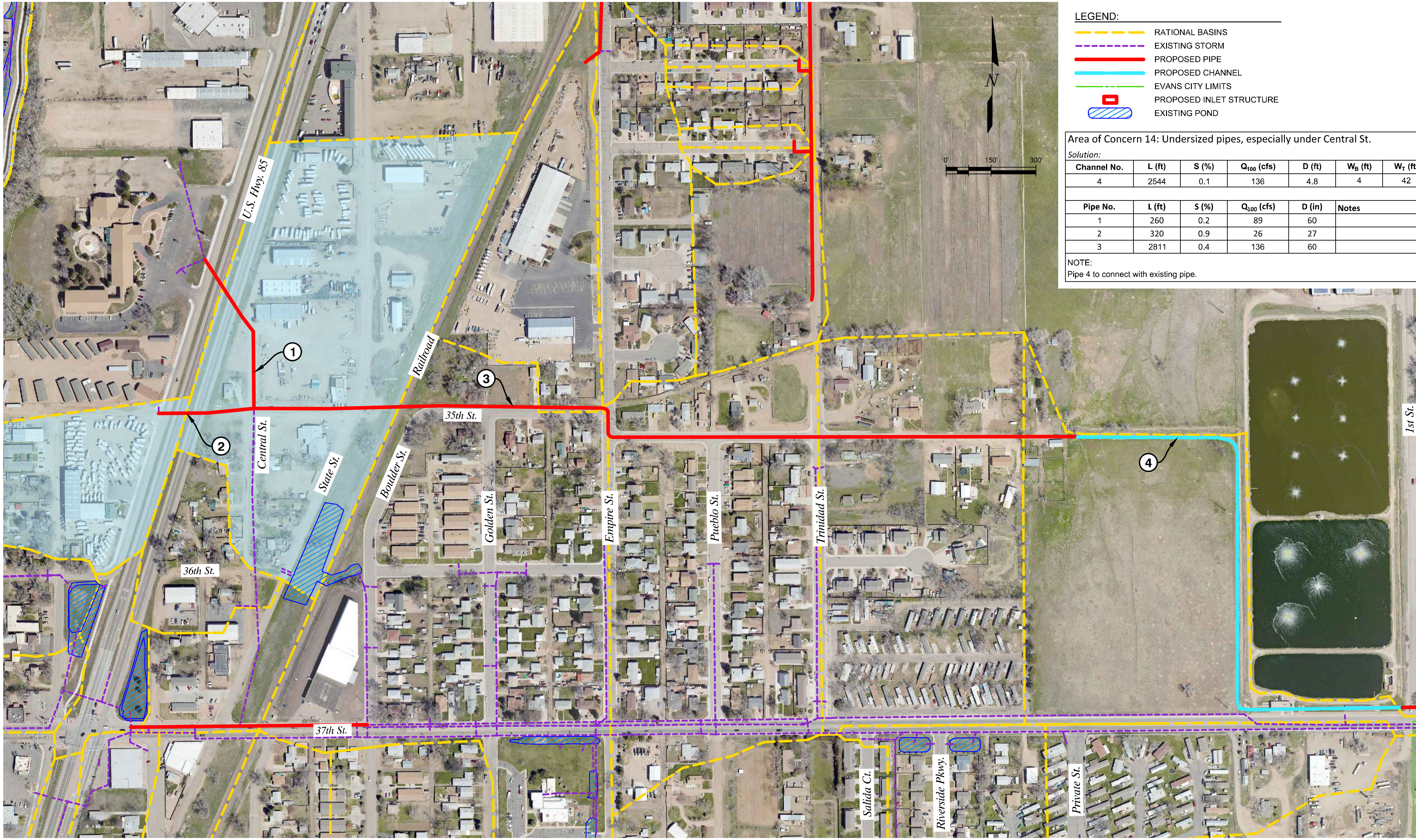
DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	Length (ft)	No. of Barrels				
42-inch	290	1	290	L.F.	$162.00	$46,980.00
60-inch	260	1	260	L.F.	$308.00	$80,080.00
30-inch	320	1	320	L.F.	$116.00	$37,120.00
Flare End Sections						
Diameter (in)	Applicable	No. of Barrels				
30-inch	Yes	1	1	EA	$2,017.00	$2,017.00
Manholes and Inlets						
Type P Manhole (Pipe Dia. 48" and larger, deflection > 10 degrees)			2	EA	$19,271.00	$38,542.00
Removals						
Removal of culvert pipe (D<48")			930	L.F.	$26.00	$24,180.00

Master Plan Capital Improvement Cost Summary

Capital Improvement Costs			
Pipe Culverts and Storm Drains			$204,739.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$0.00
Removals			$24,180.00
Landscaping and Maintenance Improvements			$0.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$228,919.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$11,446.00
Traffic Control	$10,000.00	L.S.	$10,000.00
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00
Stormwater Management/Erosion Control	5%		$11,446.00
Subtotal Additional Capital Improvement Costs			**$37,892.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$40,022.00
Legal/Administrative	5%		$13,341.00
Contract Admin/Construction Management	10%		$26,681.00
Contingency	25%		$66,703.00
Subtotal Other Costs			**$146,747.00**
Total Capital Improvement Costs			**$413,558.00**

Master Plan Operation and Maintenance Cost Summary

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	870	L.F.	$1.00	$174.00
Manhole and Inlet Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	2	EA	$64.00	$128.00
Total Annual Operation and Maintenance Cost				**$302.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$15,100.00**



Area of Concern 14: Undersized pipes, especially under Central St.

Solution:

Channel No.	L (ft)	S (%)	Q_{100} (cfs)	D (ft)	W_B (ft)	W_T (ft)
4	2544	0.1	136	4.8	4	42

Pipe No.	L (ft)	S (%)	Q_{100} (cfs)	D (in)	Notes
1	260	0.2	89	60	
2	320	0.9	26	27	
3	2811	0.4	136	60	

NOTE:
Pipe 4 to connect with existing pipe.

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PREPARED UNDER THE SUPERVISION OF

DESIGNED: SEB
DRAWN: MAB
CHECKED: ALR

PROJECT NO. 15-041.01

SHEET REVISIONS

NO.	DATE	DESCRIPTION	BY

MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

AREA OF CONCERN 14
STATE STREET

DATE: NOV 2016
DRAWING NO.
PAGE NO. AC14-1

6.16 Area of Concern #14 – Highway 85 and 35th Street

Area of Concern #14 is located at the corner of 37th and State Street, 150 feet west of the Union Pacific Railroad. Two sub-basins were delineated for the drainage area; they have a total area of 30 acres. The first extends north to south from the America's Best Value Parking lot to the intersection of Central and State Street, and west to east from US Hwy 85 to the Union Pacific railway. The second, and most western, sub-basin is bounded by 35th Street, 36th Street, the Evans Town Ditch, and US Hwy 85. Area of Concern #13 is immediately north of this sub-basin, and also contributes stormwater to the basin through the pipeline under Central Street. Both sub-basins contain a mix of residential and commercial land use. Most of the parking areas and intervening roads are unpaved. There are grassy lawns adjacent to many of the buildings, but there are no large recreational parks in the area. The overall imperviousness of the drainage basin is 55.7%; the two sub-basin values are 65.4% and 52.3%. Both basins have primarily Type A soils.

Runoff within the western sub-basin flows east; much of the stormwater is collected and conveyed across the highway by a 24" culvert. After crossing the highway, the culvert discharges onto 35th Street. The road is unpaved and the area is very flat, allowing the stormwater to disperse and flow in a generally southern direction onto private properties. No other stormwater infrastructure exists within the sub-basin. In the eastern sub-basin, the stormwater infrastructure consists of a 12" pipe along Central Street. Several inlets are located near 35th Street. Runoff from the northern section of the basin flows, undirected, along State Street and through properties. Neither State Street nor Central Street is paved, and no channelized gutter flow provided. A 160 foot long ditch is located along the north side of 35th Street. This directs flow into one of the inlets into the 12" pipe. It is less than a foot deep and along the 160 feet, the invert elevation changes less than one foot.

The concern for the area is that the culvert from the western sub-basin discharges to the street, without any means to be collected in the main system. On the other side of Central Street, the ditch along 35th Street is routinely plugged by debris. Additionally, the pipe along Central Street has been demonstrated in the hydraulic analysis to be considerably undersized for the design storms. Table 6-23 shows the predicted flow rates in the basin.

Table 6-23: Area of Concern #14 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
36th St. and US Hwy 85	25.5	22.1	15.7	13.7	10.6
State St. and Central St.	117.8	101.4	71.6	61.6	46.7

The flow at State Street and Central Street includes that from Area #14 and Area #13, which discharges into the Central Street pipeline approximately 300 feet upstream. The existing capacities of the culvert and pipe are of 8.7 cfs and 2.5 cfs, respectively. Throughout the basin, the average slope is about 0.2%, resulting in relatively small flows compared to pipe sizes.

Alternative 1

To fully capture the major storm flows, the culvert diameter must be increased to 27" and the main pipe under Central Street must be a 54" pipe. If curb and gutter could be incorporated into future street improvements, the demands on the pipe system would be greatly reduced; however, the pipes would still need to be upsized to handle the minor storms. No alternative major stormwater system changes are proposed in this alternative. The pipe sizes are increased where necessary and curb and gutter is recommended; however the stormwater continues to be discharged into the 37th Street system.

It is also recommended that the culvert under W Service Rd and the Highway be extended and joined to the pipeline under Central Street, at the location of the manhole just north of the road's intersection with 35th Street.

Alternative 2

The stormwater from Areas #13 and #14 cannot be conveyed north due to the surface grades in the drainage basin. However, much of the stormwater flows east before being piped south. It is also feasible to instead pipe the water further east to the field adjacent to the decommissioned wastewater treatment plant, from which it can be conveyed to the South Platte via either a pipe or a channel. The field is currently privately owned and would require an easement through the property. There are currently no alternative routes for an open channel to run south from 35th Street to 37th Street which could be contained within the city right-of-way. If the pipe is extended from 35th Street, then it may be routed under Empire or Trinidad Street; however, it is not recommended to juncture this with the undersized 37th Street system and space is exceedingly limited for either a new channel or pipe adjacent to 37th Street. This alternative is incorporated into Alternative 3 of the Area #9 system improvements.

In this alternative, all of Area #13 would be diverted east. All of the Area #4 sub-basin west of US Hwy 85 and the 16.03 acres in the eastern basin that is north of 35th Street can be routed across the railroad and along 35th Street as well. The average slope of the street is 0.4%. While 35th Street does have curb and gutter, street flow cannot be relied upon because the street slopes of the cross-streets, particularly Empire Street, have much steeper slopes. Water flowing along the 35th Street gutter would continue south along Empire Street, which has a slope of 3.6%, and once again enter the 37th Street system.

A 60" equivalent diameter pipe is required along 35th Street, from Central Street to where the street dead-ends 100 feet east of Trinidad Street. When street capacity is taken into account and assumed to contain the flow, the maximum permissible flow during the major storm is 22 cfs. The resulting required pipe size remains 60" equivalent diameter. Additionally, there are several areas where the full flow must be piped, whether or not street capacity is relied upon in other sections. These include the railroad crossing and the section of 35th Street that becomes unpaved, without curb and gutter, and eventually dead ends. This section starts 180 feet east of Trinidad Street.

After 35th Street dead-ends, the slope decreases to 0.1% and the required channel dimensions are:

- 4.8 feet deep (including 1 foot freeboard during the major storm)
- 4:1 H:V side slopes
- 4 foot bottom width

The resulting velocity of the channel during the major storm is predicted to be 1.9 cfs. The channel could be expanded when it parallels 37th Street and function as an overflow channel for the 37th St. system as well as the main conduit for Area #13 and #14. This would protect neighborhoods south of 37th from street flooding. However, there may be limited space available between the furthest south WWTP pond, which will remain in operation, and 37th Street; if this is the case then the channel may be constructed north of the pond and the abandoned junkyard. Alternatively, the channel could be taken directly east to the South Platte River. This would cross the decommissioned WWTP and would require coordination with those plans, as well as easements along several private properties between 35th Street and the South Platte River.

A cost estimate has been completed for the transport of these flows to 37th Street. They only include the improvements necessary for Area of Concern #14, but the facilities are large enough to convey the flows from Area of Concern #13. The total cost for these improvements is $2,346,813. Since it is a replacement of an existing pipe, it is assumed that no right-of-way is needed. A second cost estimate has been made for Alternative 2, in which the flow is taken east along 34th Street.

This project provides resiliency by reducing the chance of flooding which may occur along 37th Street. In combination with Area of Concern #13 it provides an additional outlet to the river. The swale out to the river also provides additional opportunities for water quality and infiltration. Before the stormwater is discharged into the South Platte, it is recommended that the water first be treated through a wetland channel or pond. Assuming a depth of 1.5 feet, the area required for a wetland pond treating the WQCV is 0.78 acres. Alternatively, wetland vegetation could be planted within the channel recommended in the open area 1st Street and the river. The existing grades along the suggested channel location are ideal for efficient wetland function.

RECOMMENDATION: **ALTERNATIVE 2**	✓ **Construct 2,820 feet of new 60" pipeline to convey stormwater from Area #13 and the northern section of Area #14 along 35th Street between Central Street and where it dead ends** ✓ **Build a channel between the pipe outlet and the South Platte River**

Alternative 1 Cost Estimate

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 14
ALTERNATIVE :	1
JURISDICTION :	Evans
SUB-BASIN ID:	Hwy 85 and 35th-Reach14 — DATE : 5/2/2016

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	Length (ft)	No. of Barrels				
60-inch	2810	1	2810	L.F.	$308.00	$865,480.00
Manholes and Inlets						
Type B Manhole (Pipe Dia. 48" and larger, deflection < 10 degrees)			28	EA	$15,416.00	$431,648.00
Channel Improvements						
Excavation, Mid Range			19220	C.Y.	$31.00	$595,820.00
Landscaping and Maintenance Improvements						
Reclamation & seeding (native grasses)			5	ACRE	$1,285.00	$6,425.00

Master Plan Capital Improvement Cost Summary

Capital Improvement Costs			
Pipe Culverts and Storm Drains			$1,297,128.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$595,820.00
Detention/Water Quality Facilities			$0.00
Removals			$0.00
Landscaping and Maintenance Improvements			$6,425.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$1,899,373.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$94,969.00
Traffic Control	$5,000.00	L.S.	$5,000.00
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00
Stormwater Management/Erosion Control	5%		$94,969.00
Subtotal Additional Capital Improvement Costs			**$199,938.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$314,897.00
Legal/Administrative	5%		$104,966.00
Contract Admin/Construction Management	10%		$209,931.00
Contingency	25%		$524,828.00
Subtotal Other Costs			**$1,154,622.00**
Total Capital Improvement Costs			**$3,253,933.00**

Master Plan Operation and Maintenance Cost Summary

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	2811	L.F.	$1.00	$562.00
Manhole and Inlet Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	6	EA	$64.00	$384.00
Channel Maintenance (e.g. sediment & debris removal, erosion, tree & weed removal, etc.)	2780	L.F.	$3.00	$8,340.00
Total Annual Operation and Maintenance Cost				**$9,286.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$464,300.00**

Alternative 2 Cost Estimate

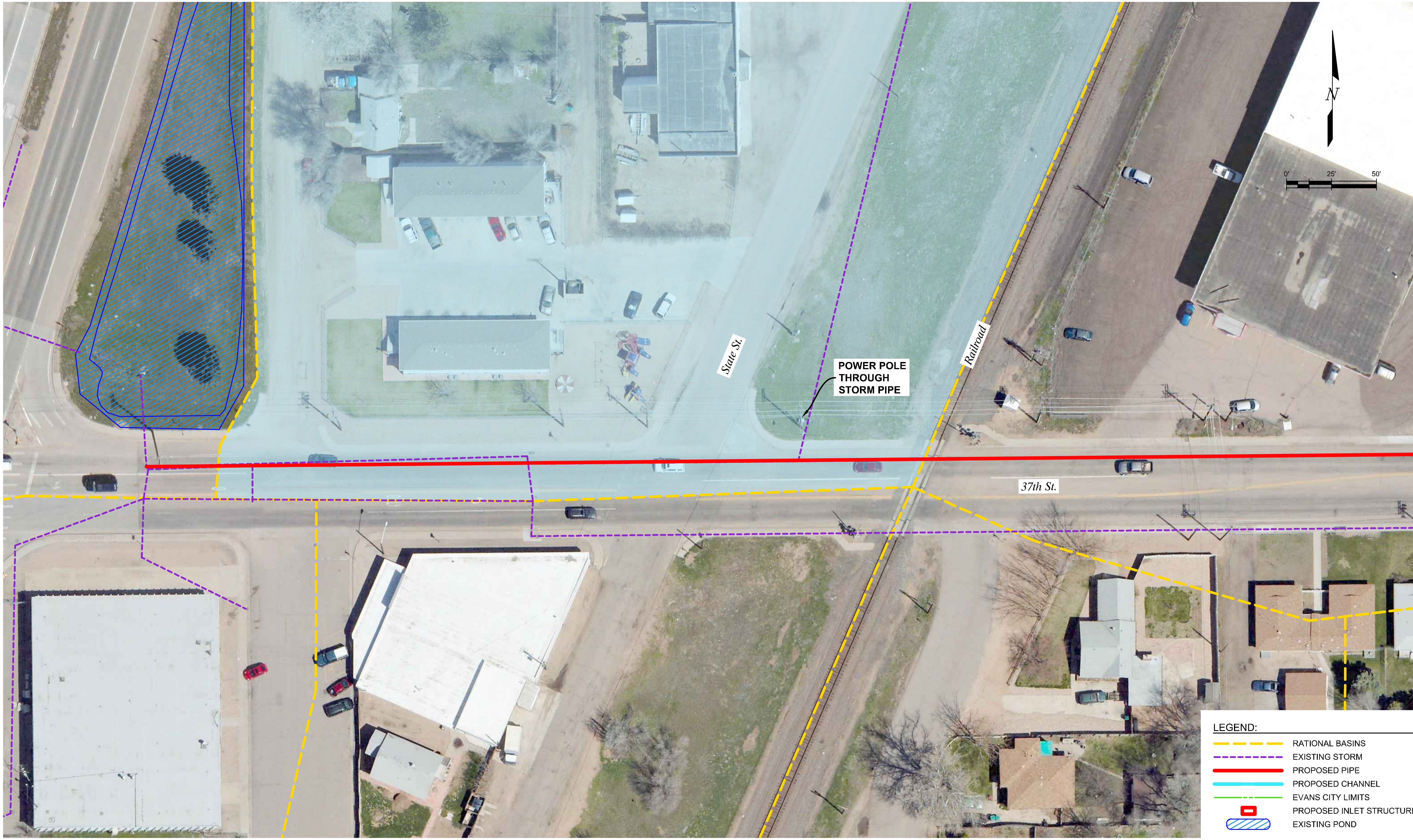
MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 14
ALTERNATIVE :	2
JURISDICTION :	Evans
SUB-BASIN ID:	Hwy 85 and 35th-ReachReach 14a
DATE :	5/2/2016

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	Length (ft)	No. of Barrels				
60-inch	2811	1	2811	L.F.	$308.00	$865,788.00
Manholes and Inlets						
Type P Manhole (Pipe Dia. 48" and larger, deflection > 10 degrees)			6	EA	$19,271.00	$115,626.00
Detention/Water Quality Facilities						
Detention (User Entered Quantities)						
Excavation, Mid Range			11396	C.Y.	$31.00	$353,276.00
Removals						
Removal of culvert pipe (D<48")			1070	L.F.	$26.00	$27,820.00
Land Acquisition						
Easement/ROW Acquisition			3.12	ACRE	$154.60	$482.00

Master Plan Operation and Maintenance Cost Summary				
Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, erosion at entrance/exit, structural repairs	2810	L.F.	$1.00	$562.00
Manhole and Inlet Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	28	EA	$64.00	$1,792.00
Channel Maintenance (e.g. sediment & debris removal, erosion, tree & weed removal, etc.)	2550	L.F.	$3.00	$7,650.00
Total Annual Operation and Maintenance Cost				**$10,004.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$500,200.00**

Master Plan Capital Improvement Cost Summary			
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$981,414.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$353,276.00
Removals			$27,820.00
Landscaping and Maintenance Improvements			$0.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$1,362,510.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$68,126.00
Traffic Control	$10,000.00	L.S.	$10,000.00
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00
Stormwater Management/Erosion Control	5%		$68,126.00
Subtotal Additional Capital Improvement Costs			**$151,252.00**
Land Acquisition Costs			
ROW/Easements			$482.00
Subtotal Land Acquisition Costs			**$482.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$227,064.00
Legal/Administrative	5%		$75,688.00
Contract Admin/Construction Management	10%		$151,376.00
Contingency	25%		$378,441.00
Subtotal Other Costs			**$832,569.00**
Total Capital Improvement Costs			**$2,346,813.00**



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MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

AREA OF CONCERN 15
37TH STREET AND STATE STREET

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6.17 Area of Concern #15 – 37th Street and State Street

Area of Concern #15 is located at the intersection of 37th Street and State Street, about 65 feet west of the Union Pacific railroad crossing at 37th Street. At this location, the 12" pipeline from Area of Concern #14 junctures with the 18" pipeline under 37th Street. This is a major junction within the Area of Concern #9 basin as well; it is the point along the 37th Street system where the dual storm sewer starts. The entirety of the area draining to this point is 230 acres (323 acres if Area of Concern #4 is included, which currently does not reach the 37th Street system). Areas of concern #11, #13, #14, and all of the Area #9 drainage basin west of the railroad tracks are routed to the basin outlet. A total of 27 sub-basins are included in the drainage basin for Area #15; seven of these comprise Area #4. Although Area of Concern #4 does not currently contribute to this basin, it may do so in future improvements. Unless specified otherwise, the predicted flow rates and basin parameters discussed here include Area #4 in the drainage basin. Most of the area between 11th Avenue and State Street is commercial area. East of this, the land use is predominately residential. Together, residential and commercial area comprises approximately 73% of the total drainage basin. East of Evans Town Ditch, all sub-basins are exclusively comprised of soil group Type A. Seven sub-basins in the western area – three of which are within Area of Concern #4 – have soils primarily in soil group Type B.

The existing drainage system is described in detail in the Area of Concern #9 section of this report. It consists of a 24" pipe along 11th Avenue, which collects stormwater from the northwestern sub-basins (expect of that from Area #4). Although currently discharging to Evans Ditch, future improvements are already underway to take the stormwater east along 36th Street and into a detention pond at the corner of Idaho and 37th Street. This detention basin already receives runoff from sub-basins east of 11th Avenue and west of the Evans Town Ditch. The sub-basins west of US Hwy 85 and south of 37th drain into the 37th Street system either via an 18" pipe near 11th Avenue or through the 24" pipe along the highway. The latter pipe is the main outlet of Area of Concern #11. The 18" pipe upsizes to a 24" pipe as it continues under 37th Street. When it reaches the southbound lanes of US Hwy 85, the pipeline turns north (now with an 18" diameter), junctures with the outlet from the detention pond at Idaho Street, crosses the Highway 85, and discharges into a second detention pond adjacent to Denver Street. The outlet from this pond is the inlet to the first of the two pipes under 37th Street. This is a 30" pipe; the other pipe in the system, connected to the southern sub-basins, is an 18" pipe. At State Street the 12" pipe conveying stormwater from Area #11 connects with the 18" pipe.

Currently, the existing pipe capacity of the dual pipe system is 25.7 cfs – 20.5 cfs from the 30" pipeline and 5.2 cfs from the 18" pipe, assuming a 0.25% slope. If the pipes have a slope of 0.5%, which cannot be currently confirmed, the capacity increases to 36 cfs. The initial concern is that a power pole was placed directly into the 18" pipe near State Street. From the hydraulic analysis, it is clear that the pipe is also undersized. The calculated flow rates generated by each of the design storms are listed in Table 6-24. Estimates for both with and without the added flow from Area #4 are included in the table.

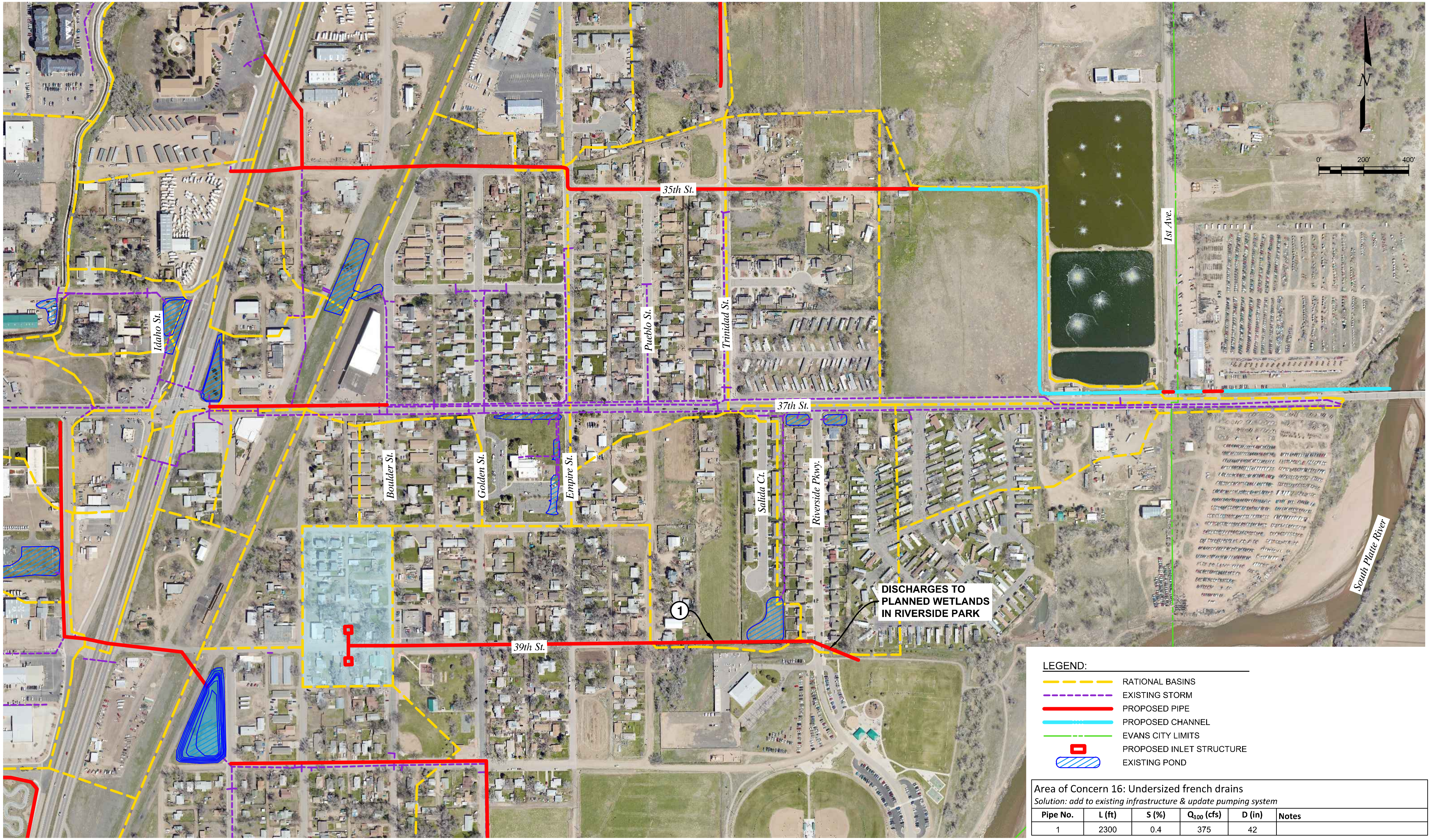
Table 6-24: Area of Concern #15 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
37th St. and State St. *(without AOC #4)*	423.3	366.1	259.9	225.0	173.1
37th St. and State St. *(with AOC #4)*	547.2	473.4	335.4	289.6	222.2

A 108" equivalent diameter pipe is required to convey the full 547 cfs of the major storm. If Area #4 is not included in the flow, a 102" equivalent diameter is required. A dual pipe system requires 84" pipes or 78" pipes, respectively. These pipe diameters assume the surface slope of 0.25%. If a 0.5% can be achieved, then these may be revised to 78" and 72" diameter requirements. Street flow was not considered in this analysis; however, the minor flow allowance on major collector streets is 7.5 cfs for 0.5% sloped roads. In a preliminary analysis of street capacity, it was calculated that even in a major storm just 35 cfs could be conveyed along the gutter. Because this section of 37th Street crosses the railroad, even this flow may not be permitted.

The timing of the improvements for Area #9 is not known. It is recommended that the City contact the electric provider, Xcel Energy, to have the power pole removed and the pipe repaired. It is expected that this will be done at no cost to the city.

RECOMMENDATIONS	✓ **Contact Xcel Energy to remove and relocate the power pole blocking the pipe** ✓ ***See Area #9 recommendations for pipe replacement recommendations***



Area of Concern 16: Undersized french drains

Solution: add to existing infrastructure & update pumping system

Pipe No.	L (ft)	S (%)	Q_{100} (cfs)	D (in)	Notes
1	2300	0.4	375	42	

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	CHECKED: ALR	PROJECT NO. 15-041.01				

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777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

AREA OF CONCERN 16
39TH STREET BASIN

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6.18 Area of Concern #16 – 39th Street between Boulder and Denver Street

Area of Concern #16 is located along 39th Street between Central Street and Boulder Street, in the southeast area of historical Evans. Its drainage area includes just one basin, which is bounded on the north by 38th Street, on the east by Boulder Street, and on the west by Central Street. It extends 170 feet south of 39th Street. The drainage basin has an area of 6.57 acres and is characterized exclusively by residential land use. Sixty percent of the basin is impervious. Almost all of the soil is soil group Type A; a 0.2 acre space in the southeast corner of the basin is soil group Type B.

Currently, the only stormwater infrastructure within the basin is a pair of French drains along 39th Street, approximately equidistant from Central Street and Boulder Street. A 12" pipe connects them, but there is no infrastructure to remove the water from the basin. The runoff from the surrounding neighborhood is collected into the drains, which are in shallow sumps along the road. However, the elevation varies by only 2 feet through the basin, and the average slope is approximately 0.2%.

The concern in this area is that there is always water sitting on the surface of the road. Most likely, the French drains have become plugged over time with sediment and debris and they are no longer functioning. Moreover, the inlets are placed in the gravel so there is material constantly washing down into them. The flow rates predicted for the design storms are listed in Table 6-25.

Table 6-25: Area of Concern #16 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
39th Street French Drains	22.1	18.8	13.3	11.5	8.9

No curb and gutter exist along 39th Street. Therefore, the entirety of the major storm must be captured by the inlets. In order to do so, the existing French drains must be replaced by two Type C area inlets. The closed mesh grate will be necessary due to the pedestrian traffic which could be in the area. It is also beneficial to pave around the inlets so there is a more solid surface around them. During the minor storm, each inlet would have an intercept capacity of 7.3 cfs (83% of the flow). During the major storm, each inlet's capacity would be 12.7 cfs (57% of the total flow). Thus the combined capacity of the two inlets has more than adequate capacity to collect the design storm runoff. A 42" pipe is required to convey the flow, when a slope of 0.1% is assumed. If a 0.3% slope can be achieved, then the required diameter decreases to 36", with 9.5 cfs additional capacity for potential future flow additions. The slope of the surface area, measured with the 1-foot contour dataset, is 0.1%; however, such a mild slope is not generally recommended for pipes. It is difficult to build and as a result the flow may become stagnant. At the initial design slope (0.1%), the predicted velocity of the stormwater during the major and minor (5-year) storms would be 3.2 ft/s and 3.0 ft/s, respectively. Two alternatives were considered for the direction and destination of the pipe; the practical solution will depend largely on the course taken to address the Area #9 concerns.

Alternative 1

Should the first or second alternatives for Area #9 be implemented, 39th Street would become a major avenue of stormwater conveyance. It would not be practical to take stormwater east and west along the same road; therefore, the 39th Street pipe would be extended 200 feet to connect with the inlets. The grades going east are not much steeper than going west; the area is very flat. Both directions would be feasible alternatives. The pipe size required to convey the flow from the French drains to Golden Street is 42". From Golden Street, the pipe increases in diameter several times until ultimately discharging into Riverside Park through a 90" pipe. Since this alternative functions primarily to divert flow from 37th Street, a more detailed discussion of the pipe system after Golden Street is included in the section on Area of Concern #9.

One other item to keep in mind is that based on discussions with the City, it is expected that there will be curb and gutter on 39th in the future. Depending on the timing of the stormwater improvements versus the road improvements, it is recommended that a true curb inlet (such as a Type R) be used.

Alternative 2

Area of Concern #16 is located north and east of Area #17. The Railroad Park pond in that area may be used to detain and release the stormwater from Area #16 if the 42" pipe is taken west along 39th Street and south adjacent to Denver Street. The pond sizing for this alternative is described in the discussion for Area of Concern #17. The pipeline could not extend further east than the inlets due to the flat grades.

For the purpose of providing a construction budget, an estimate has been provided for Alternative 2. Alternative 1 will be included in the improvements for Area of Concern #9. The total cost for the infrastructure to get the 39th Street drainage to the Railroad Pond is $259,332. See area of concern 17 for the cost of the pond revisions. See area of concern 9 for the cost if these inlets are included in that option.

There are options for resiliency based on each option chosen. If the pond is used for detention (Alternative 2), than it will be a full spectrum detention pond which provides resiliency. If the flows from this area are transported along 39th Street to Riverside Park, than they will flow through a series of wetlands which provide water quality and possibly infiltration.

RECOMMENDATION: ALTERNATIVE 1	✓ **Remove the existing French Drain inlets and replace them with Type C inlets** ✓ ***See Area #9 for piping recommendation along 39th Street***

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 16
ALTERNATIVE :	1
JURISDICTION :	Evans
SUB-BASIN ID:	39th St-Reach16
DATE :	5/2/2016

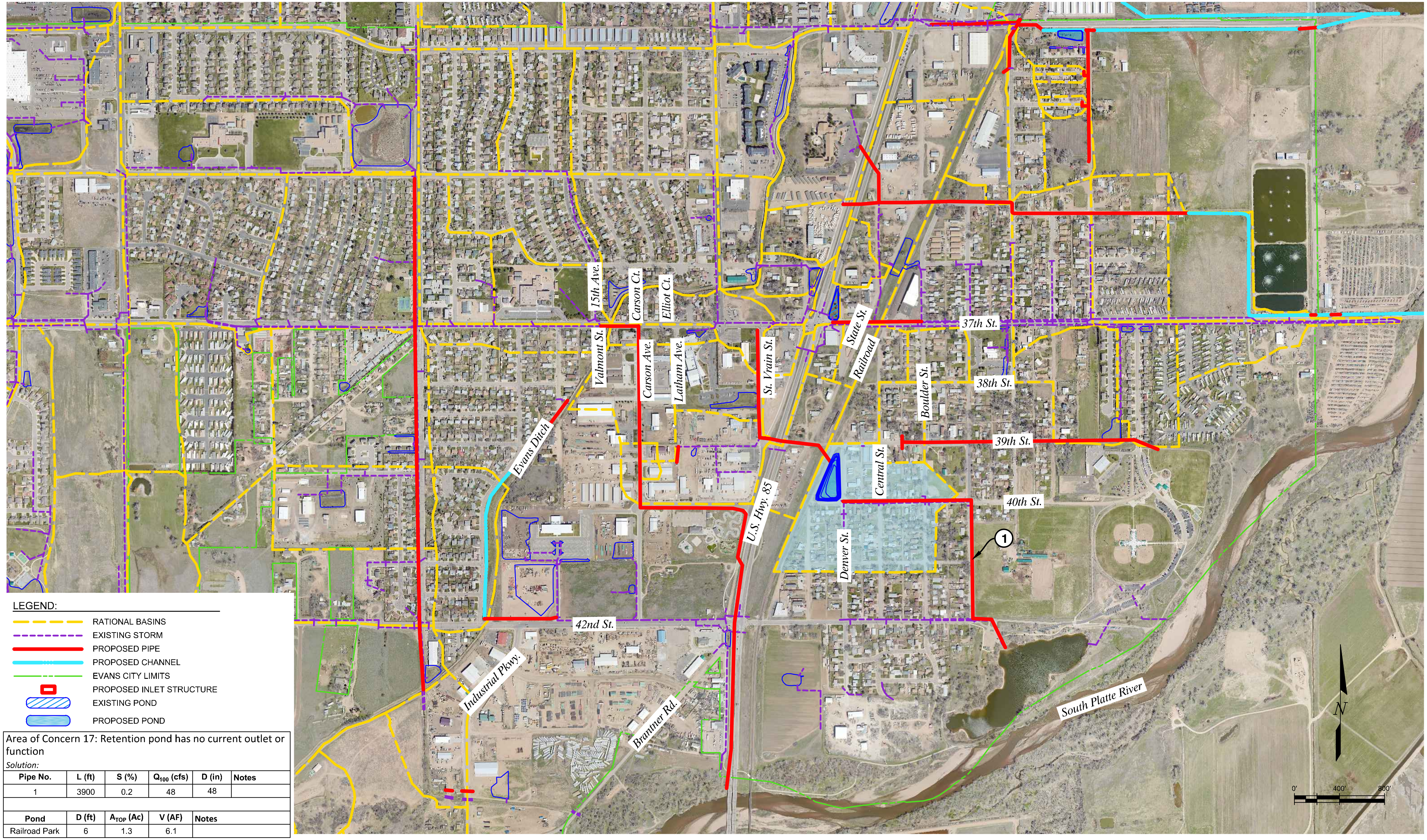
DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	Length (ft)	No. of Barrels				1
42-inch	725	1	725	L.F.	$162.00	$117,450.00
Flare End Sections						
Diameter (in)	Applicable	No. of Barrels				1
42-inch	Yes	1	1	EA	$2,184.00	$2,184.00
Manholes and Inlets						
Manhole, 5' Dia. (Pipe Dia. 36" - 42")			1	EA	$5,010.00	$5,010.00
Storm Inlet, Type R/Type 14, 5-foot			2	EA	$5,910.00	$11,820.00
Special Items (User Defined)						
Removal of Inlet			2	EA	$1,000.00	$2,000.00

Master Plan Capital Improvement Cost Summary

Capital Improvement Costs			
Pipe Culverts and Storm Drains			$136,464.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$0.00
Removals			$0.00
Landscaping and Maintenance Improvements			$0.00
Special Items (User Defined)			$2,000.00
Subtotal Capital Improvement Costs			**$138,464.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$6,923.00
Traffic Control	$10,000.00	L.S.	$10,000.00
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00
Stormwater Management/Erosion Control	5%		$6,923.00
Subtotal Additional Capital Improvement Costs			**$28,846.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$25,097.00
Legal/Administrative	5%		$8,366.00
Contract Admin/Construction Management	10%		$16,731.00
Contingency	25%		$41,828.00
Subtotal Other Costs			**$92,022.00**
Total Capital Improvement Costs			**$259,332.00**

Master Plan Operation and Maintenance Cost Summary

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	725	L.F.	$1.00	$145.00
Manhole and Inlet Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	2	EA	$64.00	$128.00
Total Annual Operation and Maintenance Cost				**$273.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$13,650.00**



Area of Concern 17: Retention pond has no current outlet or function

Solution:

Pipe No.	L (ft)	S (%)	Q_{100} (cfs)	D (in)	Notes
1	3900	0.2	48	48	

Pond	D (ft)	A_{TOP} (Ac)	V (AF)	Notes
Railroad Park	6	1.3	6.1	

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PREPARED UNDER THE SUPERVISION OF

DESIGNED: SEB

DRAWN: MAB

CHECKED: ALR

PROJECT NO. 15-041.01

SHEET REVISIONS

NO.	DATE	DESCRIPTION	BY

MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

DATE: NOV 2016

DRAWING NO.

AREA OF CONCERN 17
RAILROAD PARK

PAGE NO. AC17-1

6.19 Area of Concern #17 – Railroad Park Detention Pond

Area of Concern #17 is located in the southeastern section of the City. Its western boundary is the Union Pacific Railroad, its northern boundary is 39th Street, its eastern boundary lies along Denver Street, and its southern boundary lies along the extension of 41st Street. Its drainage area is comprised of a single 30 acre basin and is characterized by residential and a 1.6 acre grassed area, resulting in an impervious value of 55.0%. The drainage area primarily has type A soils, although a diagonal swath through the basin has type B soils.

Our understanding of the pond is that it was built when the adjacent storm sewer system was built and the roads were being paved. It was used as a location to divert the stormwater. The completed stormwater system bypasses the pond. A 24" pipe collects runoff along Denver Street. At 40th Street it turns east and increases in diameter to 30" after it crosses Central Street. The pipeline again turns south at Golden Street and discharges into the South Platte. At its turn at 40th Street and Golden Street, the diameter of the pipe decreases to 24"; when the pipeline crosses 41st Street it again increases to a 30" pipe.

Currently, the Railroad Park pond is not being utilized and receives no stormwater from the surrounding area. The City would like to consider stormwater improvement that will again make use of the pond, particularly because this area of Evans has little storm sewer infrastructure and frequently experiences flooding.

Both alternatives to use the Railroad Park pond will require pond improvements, such as grading, the installation of a forebay and/or micro-pool, and the addition of an outlet structure. In each case, it is assumed that full spectrum detention will be provided. Due to the flat slopes along the neighborhood streets, the existing full-flow capacity is 30 cfs, assuming a slope of 0.5% was attained. If the more likely condition of a 0.2% slope, the capacity of the existing pipe is 10 cfs. The peak flow rates generated within Area #17 assume a 0.5% slope along the watershed length. Although the flow rate calculated for the intersection of 40th Street and Golden Street is 76 cfs, this is likely an over-estimation due to the mild slope. In either alternative, the peak pond outflow would occur later than the peak from the basin and would be a fraction of what is generated by the basin itself. Therefore, pipe replacement along 40th and Golden Street may be beneficial to the system, but is not considered a priority.

Alternative 1

The first alternative would be considered if the flows from Area of Concern #9 are split and conveyed to several discharge points. In this case, a major pipe will be built under 39th Street and Area of Concern #16 would flow to this system instead of to the Railroad Pond. It may be feasible to further relieve the 37th Street system by redirecting the flow from two sub-basins from Area #11 and a sub-basin of Area #9 to the pond. This scenario requires a minimum of 5.7 acre-feet of storage. A possible configuration yields the following pond dimensions:

- 6.1 acre-foot volume
- 6 feet deep at its deepest point
- 1.3 acre footprint
- Maximum side slopes (no steeper than) of 4:1 (H:V)
- 30" outlet pipe, connecting to the 40th Street storm sewer

The surface area of the pond would not occupy the entire available area in Railroad Park. The smaller area allows for any necessary grading to match surrounding surface elevations. While the 100-year storm is detained in the pond, the freeboard during the 100-year storm would be less than 1 foot. This may be resolved during a more detailed design. The pond would discharge to the 40th Street pipe, and would have a maximum release rate of 13 cfs. The existing system with which the outlet will connect is currently a 24" system. The timing of the peak outflow will be later than the peak flow from the basin, and the peak flow rate may be decreased if the detention pond is designed for a longer detention period. Therefore, no improvements are currently recommended for the existing storm sewer in this area.

Alternative 2

The second alternative would be considered if all of Area of Concern #9 discharges through the 37th Street system. In this case, the stormwater from Area of Concern #16 may be taken west along 39th Street and then south into the detention basin. The slope of the pipe would need to be 0.3%, due to the flatness of the area. For this reason, the pipe cannot be extended past the French drains in Area #16. The required detention basin would have the following configuration:

- 1.7 acre-feet in volume
- 5 feet deep at its deepest point
- Foot print of 0.5 acres
- Maximum side slopes of 4:1 (H:V)
- 18" outlet pipe (provides more capacity than required), connecting to the 40th Street storm sewer.

The pond would discharge to the 24" pipe along 40th Street. Its maximum outflow would be 0.4 cfs, and would not be a burden to the existing storm sewer system. The flow rates in Table 6-26 display those that would be expected in the proposed alternatives.

Table 6-26: Area of Concern #17 Alternative Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
Railroad Park Inlet, *Alternative 1*	36.3	30.6	21.6	17.9	13.0
Railroad Park inlet, *Alternative 2*	123.5	105.2	74.1	60.0	46.7

A cost estimate has been prepared for both alternatives to provide some options for the City. Alternative 1 is more expensive then Alternative 2 which can be expected since the pond has a larger detention volume and more disturbance. While the Railroad Pond is currently owned by the City, the pipe recommended in Alternative 1 would cross the UPRR right-of-way. Therefore, its implementation will require coordination with the Union Pacific Railroad. In either situation, the pond provides water quality and detention which provides resiliency.

RECOMMENDATION: ALTERNATIVE 1	✓ Regrade the railroad pond to provide full-spectrum detention for the stormwater generated between Latham Avenue and State Street. ✓ Replace the 24" pipeline with a 42" pipe between the pond and the River

Alternative 1 Cost Estimate

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan		
DRAINAGE BASIN :	Area of Concern 17		
ALTERNATIVE :	1		
JURISDICTION :	Evans		
SUB-BASIN ID:	Railroad Park-Reach17	DATE :	5/2/2016

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	Length (ft)	No. of Barrels				1
30-inch	100	1	100	L.F.	$116.00	$11,600.00
Detention/Water Quality Facilities						
Detention (Complete-in-Place)						
Detention Facility 1 (Complete-in-Place)			1.7	AC-FT	$58,582.00	$99,589.00
Detention (User Entered Quantities)						
Excavation, Mid Range			4033	C.Y.	$31.00	$125,033.00
Outlet Works			1	EA	$10,000.00	$10,000.00
Landscaping and Maintenance Improvements						
Reclamation & seeding (native grasses)			0.5	ACRE	$1,285.00	$643.00

Master Plan Capital Improvement Cost Summary

Capital Improvement Costs			
Pipe Culverts and Storm Drains			$11,600.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$234,622.00
Removals			$0.00
Landscaping and Maintenance Improvements			$643.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$246,865.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$12,343.00
Traffic Control		L.S.	$0.00
Utility Coordination/Relocation	$1,000.00	L.S.	$1,000.00
Stormwater Management/Erosion Control	5%		$12,343.00
Subtotal Additional Capital Improvement Costs			**$25,686.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$40,883.00
Legal/Administrative	5%		$13,628.00
Contract Admin/Construction Management	10%		$27,255.00
Contingency	25%		$68,138.00
Subtotal Other Costs			**$149,904.00**
Total Capital Improvement Costs			**$422,455.00**

Master Plan Operation and Maintenance Cost Summary

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	100	L.F.	$1.00	$20.00
Detention/WQ Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	1.3	ACRE	$1,927.00	$2,505.00
Mowing (e.g. channels, ponds, etc.)	1.3	ACRE	$64.00	$166.00
Total Annual Operation and Maintenance Cost				**$2,691.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$134,550.00**

Alternative 2 Cost Estimate

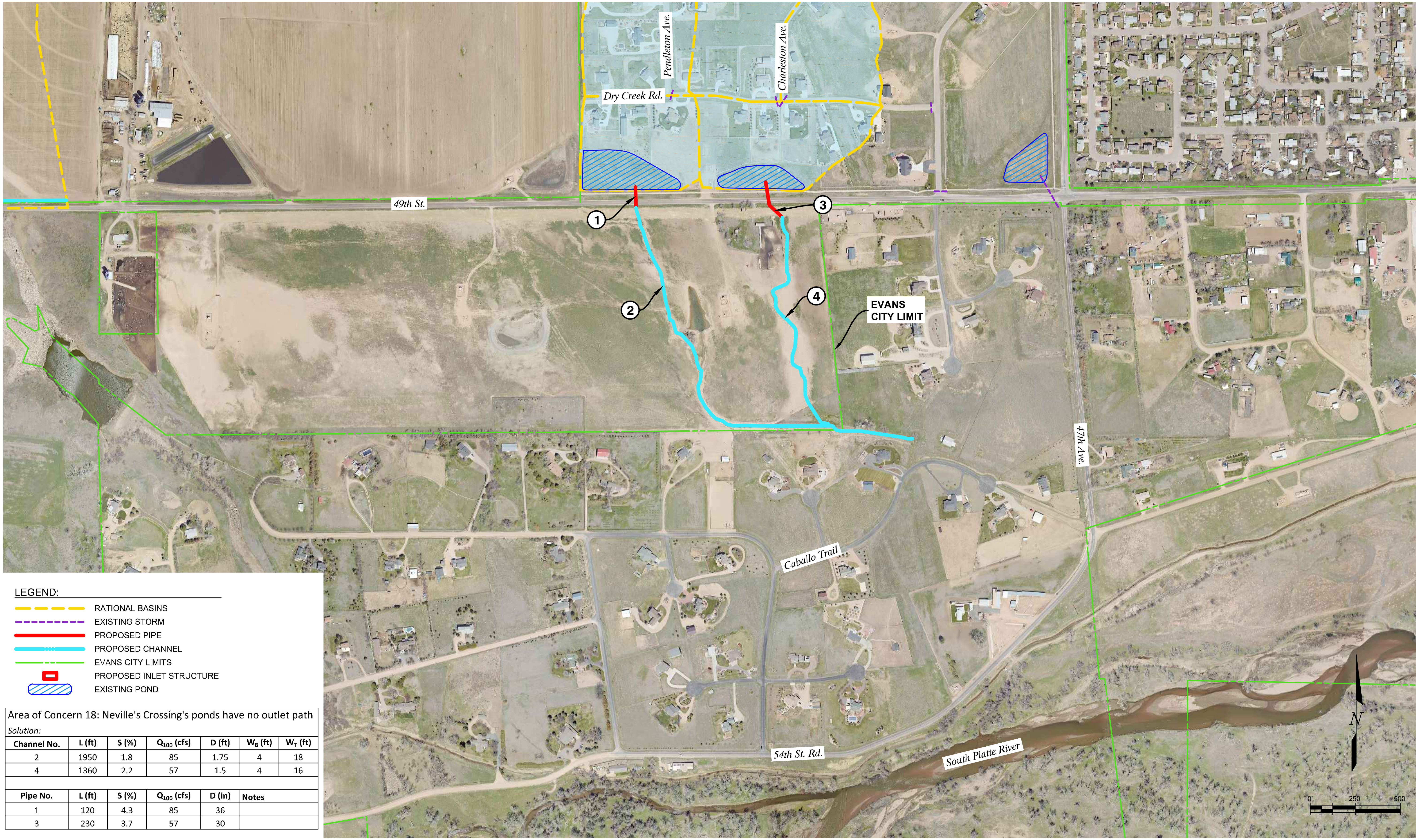
MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 17
ALTERNATIVE :	2
JURISDICTION :	Evans
SUB-BASIN ID:	Railroad Park-Reach17a
DATE :	5/2/2016

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	Length (ft)	No. of Barrels				
18-inch	100	1	100	L.F.	$69.00	$6,900.00
Detention/Water Quality Facilities						
Detention (Complete-in-Place)						
Detention Facility 1 (Complete-in-Place)			6.1	AC-FT	$58,582.00	$357,350.00
Detention (User Entered Quantities)						
Excavation, Mid Range			8389	C.Y.	$31.00	$260,069.00
Outlet Works			1	EA	$10,000.00	$10,000.00
Landscaping and Maintenance Improvements						
Reclamation & seeding (native grasses)			1.3	ACRE	$1,285.00	$1,671.00

Master Plan Capital Improvement Cost Summary			
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$6,900.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$627,419.00
Removals			$0.00
Landscaping and Maintenance Improvements			$1,671.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$635,990.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$31,800.00
Traffic Control		L.S.	$0.00
Utility Coordination/Relocation	$1,000.00	L.S.	$1,000.00
Stormwater Management/Erosion Control	5%		$31,800.00
Subtotal Additional Capital Improvement Costs			**$64,600.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$105,089.00
Legal/Administrative	5%		$35,030.00
Contract Admin/Construction Management	10%		$70,059.00
Contingency	25%		$175,148.00
Subtotal Other Costs			**$385,326.00**
Total Capital Improvement Costs			**$1,085,916.00**

Master Plan Operation and Maintenance Cost Summary				
Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	100	L.F.	$1.00	$20.00
Detention/WQ Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	1.3	ACRE	$1,927.00	$2,505.00
Mowing (e.g. channels, ponds, etc.)	1.3	ACRE	$64.00	$166.00
Total Annual Operation and Maintenance Cost				**$2,691.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$134,550.00**



Area of Concern 18: Neville's Crossing's ponds have no outlet path

Solution:

Channel No.	L (ft)	S (%)	Q_{100} (cfs)	D (ft)	W_B (ft)	W_T (ft)
2	1950	1.8	85	1.75	4	18
4	1360	2.2	57	1.5	4	16

Pipe No.	L (ft)	S (%)	Q_{100} (cfs)	D (in)	Notes
1	120	4.3	85	36	
3	230	3.7	57	30	

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PREPARED UNDER THE SUPERVISION OF

DESIGNED: SEB
DRAWN: MAB
CHECKED: ALR

PROJECT NO. 15-041.01

SHEET REVISIONS

NO.	DATE	DESCRIPTION	BY

MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

DATE: NOV 2016

DRAWING NO.

AREA OF CONCERN 18
NEVILLE'S CROSSING

PAGE NO. AC18-1

6.20 Area of Concern #18 – Neville's Crossing Ponds along 49th Street

Area of Concern #18 is located in the Neville's Crossing subdivision, along 49th Street, 0.38 miles west of 47th Avenue. It extends south from Kanawha Lane to 49th Avenue, and 475 feet east of Pendleton Avenue to Charleston Avenue. The total basin is 74 acres and is comprised of large (approximately 70,000 square feet) residential lots. There are many grassed open areas, and although the area is residential, the imperviousness of the basin is 35.6%. Six sub-basins were delineated for the area, and the maximum impervious value is 63%. The minimum value is 23% imperviousness. The sub-basin areas range between 5.5 acres to 25.6 acres. All of the area is comprised of group type A soils.

The only stormwater infrastructure within Area of Concern #18 are several 18" culverts to convey the runoff across Dry Creek Road, and two detention ponds just north of 49th Street. Runoff flows across open lots and along Pendleton Drive (in the western sub-basins) and Charleston Drive (in the eastern sub-basins). The detention ponds are 2.1 and 1.1 acres and located 777 feet apart, center-to-center. The western pond receives flow from the three western-most sub-basins, or those which surround Pendleton Avenue. Its drainage basin is 23 acres. The eastern sub-basins, totaling 51 acres, contribute to the flow into the east pond. The outlets of the ponds are a 24" and 18" culvert, respectively. These transport the water under 49th Street and discharge into open channels that extend south on private property, then turn east and join into a larger channel, also on private property.

The predicted flow rates to the ponds (or the culverts should the ponds fail) for the design storms are listed in Table 6-27.

Table 6-27: Area of Concern #18 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
49th Street, west culvert	98.5	81.4	54.5	41.2	25.9
49th Street, east culvert	68.5	58.6	40.9	35.0	25.0

The release rates of the west and east detention ponds are 32.0 cfs and 59.5 cfs, respectively. The existing culverts are undersized to convey both the full and attenuated flows of all the design storms. The 18" culvert has a full-flow capacity of 7.4 cfs; the 24" culvert's capacity is 16.0 cfs. No street capacity can be utilized, since the culverts are located in sumps along the road. To convey the maximum release rate from the ponds, the required culvert diameters are 24" and 30", respectively.

If the culverts are to be designed for the peak flow of their respective sub-basins (not assuming any detention), then their diameters must be increased to 36" and 30", respectively. The slopes of the west and east culverts are 4.3% and 3.7%, respectively. In both scenarios, the eastern pipe is close to meeting the full capacity of the proposed pipe. The western culvert would have additional capacity for future basin development (8 cfs in the first scenario and 21 cfs in the second).

It is also recommended that the channels into which the culverts discharge be improved. An overflow path from the pond should be provided so that downstream flows are safely conveyed. The channel dimensions required to convey the stormwater (without freeboard) from the west culvert are:

- 2.75 foot depth; or 2 feet if the pond is functioning as designed
- 4 foot bottom width
- 4:1 (H:V) side slopes

The channel is currently more than 2 feet deep and 4 feet wide in multiple locations, particularly near the outlet. However, as the channel turns east there are sections which have a depth of less than 2 feet. These areas may be able to convey the flow, with minimal freeboard, but the City should be aware that potential flooding may be a concern in larger storms. Should the channel flood, the overflow in this area would flow into an urban-estate residential lot, mainly routed between the lots and onto Caballo Trail (a paved driveway).

The channel into which the eastern culvert discharges requires the following dimensions to convey the major storm:

- 2.5 foot depth, both if the pond is assumed to be functioning or not
- 4 foot bottom width
- 4:1 (H:V) side slopes

Like its western counterpart, this channel is more defined nearer to the culvert outlet. It has a bottom width of greater than 4 feet in most areas; however the basins are not well defined. The east side slope is 4:1 or milder and provides more than 2.5 feet of depth. However, the western bank of the channel allows the flow to be dispersed into a 0.43 acre area with concrete retaining walls on its north and west sides. The flow eventually is directed back to the main channel, but the area does not appear to provide any meaningful detention or quality treatment. Approximately 970 feet downstream of the culvert, the channel becomes undefined and permits the stormwater to diffuse as overland flow into the now east-bound channel conveying the flow from the western culvert. Although all the flow is contained to the grassy area, channel improvements should be considered if the area further develops.

The portion of the channel in Evans that conveys the entirety of flow from Area #18 must have at least a depth of 3 feet, bottom width of 4 feet, and 4:1 (H:V) side slopes. In most areas, this is the case. In the segments at risk of overflowing, the stormwater will be primarily contained in the areas between the residential lots, although the overflow will be spread out. A 36" pipe is required to direct the stormwater across Caballo Trail from the channel and onto a grassy field south of the Evans city limit.

Following is a combined cost estimate for both the east and west culvert. To be conservative, the larger flow rates, assuming the pond is plugged, have been assumed for both of the pipes and channels. The total cost for these improvements is estimated at $237,896. This takes the improvements to approximately the current City limits. The channel is located on private property, and therefore an easement must be obtained to complete any improvements or maintenance.

Resiliency is provided with the open channels on the downstream end that increase the opportunities for water quality and infiltration. They also control the flow and minimize the change of flooding for users along Caballo Trail.

RECOMMENDATIONS	✓ Replace the 24" and 18" culverts across 49th Street with 36" and 30" culverts ✓ Obtain easements for and widen downstream channels to discharge the stormwater South of Caballo Trail

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan		
DRAINAGE BASIN :	Area of Concern 18		
ALTERNATIVE :	1		
JURISDICTION :	Evans		
SUB-BASIN ID :	Nevilles Crossing-Reach18	DATE :	5/2/2016

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT : City of Evans Stormwater Management Plan
DRAINAGE BASIN : Area of Concern 18
ALTERNATIVE : 1
JURISDICTION : Evans
SUB-BASIN ID : Nevilles Crossing-Reach18 DATE : 5/2/2016

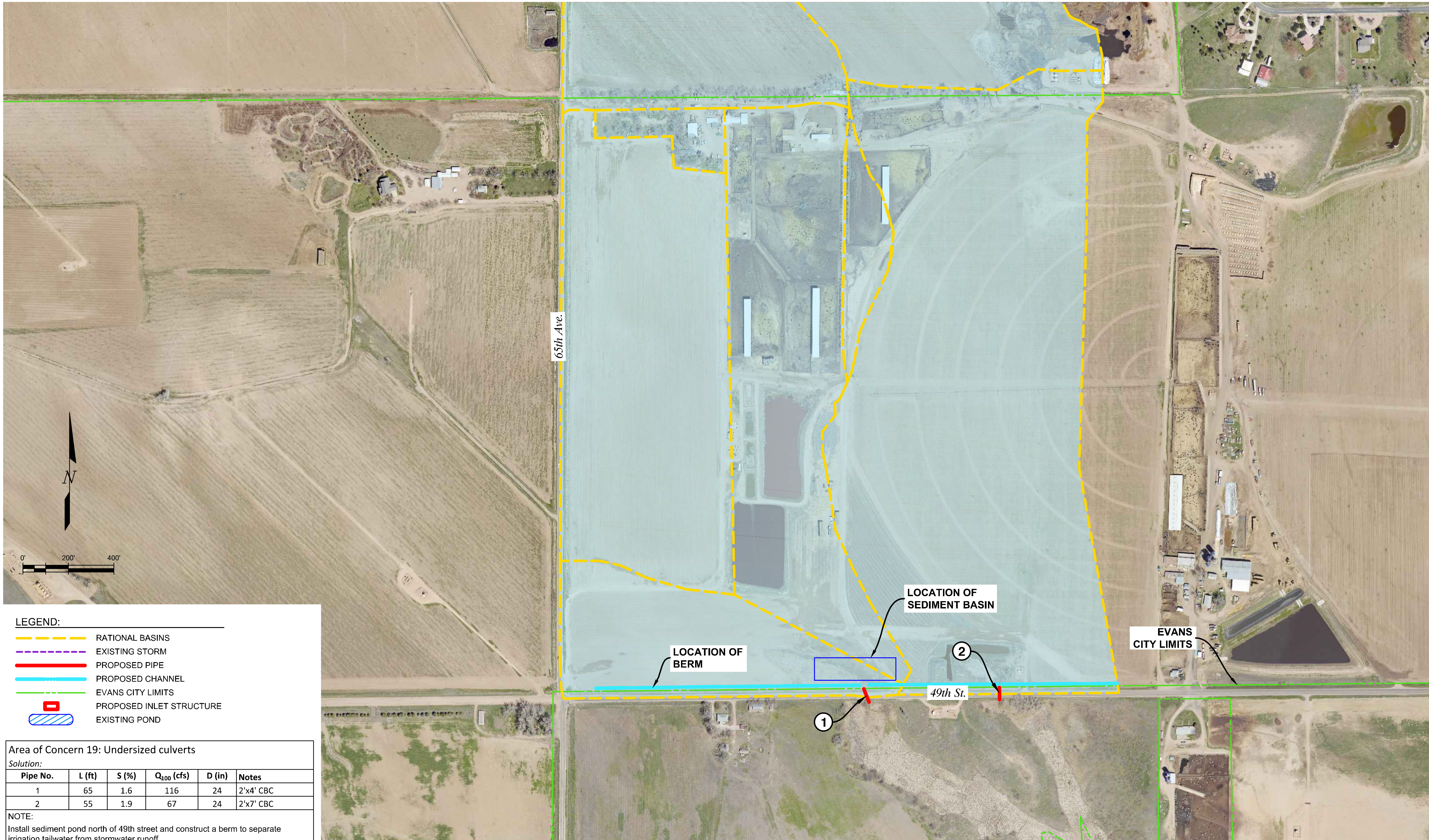
DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	Length (ft)	No. of Barrels				
36-inch	120	1	120	L.F.	$139.00	$16,680.00
30-inch	230	1	230	L.F.	$116.00	$26,680.00
Flare End Sections						
Diameter (in)	Applicable	No. of Barrels				
36-inch	Yes	1	2	EA	$2,068.00	$4,136.00
30-inch	Yes	1	2	EA	$2,017.00	$4,034.00
Detention/Water Quality Facilities						
Detention (User Entered Quantities)						
Excavation, Mid Range			1760	C.Y.	$31.00	$54,560.00
Removals						
Removal of culvert pipe (D<48")			250	L.F.	$26.00	$6,500.00
Landscaping and Maintenance Improvements						
Reclamation & seeding (native grasses)			2	ACRE	$1,285.00	$2,240.00
Land Acquisition						
Easement/ROW Acquisition			3.41	ACRE	$985.00	$3,359.00

Master Plan Capital Improvement Cost Summary

Capital Improvement Costs			
Pipe Culverts and Storm Drains			$51,530.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$54,560.00
Removals			$6,500.00
Landscaping and Maintenance Improvements			$2,240.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$114,830.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$5,742.00
Traffic Control	$20,000.00	L.S.	$20,000.00
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00
Stormwater Management/Erosion Control	5%		$5,742.00
Subtotal Additional Capital Improvement Costs			**$36,484.00**
Land Acquisition Costs			
ROW/Easements			$3,359.00
Subtotal Land Acquisition Costs			**$3,359.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$22,697.00
Legal/Administrative	5%		$7,566.00
Contract Admin/Construction Management	10%		$15,131.00
Contingency	25%		$37,829.00
Subtotal Other Costs			**$83,223.00**
Total Capital Improvement Costs			**$237,896.00**

Master Plan Operation and Maintenance Cost Summary

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, erosion at entrance/exit, structural repairs	350	L.F.	$1.00	$70.00
Total Annual Operation and Maintenance Cost				**$70.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$3,500.00**



LEGEND:

- RATIONAL BASINS
- EXISTING STORM
- PROPOSED PIPE
- PROPOSED CHANNEL
- EVANS CITY LIMITS
- PROPOSED INLET STRUCTURE
- EXISTING POND

Area of Concern 19: Undersized culverts

Solution:

Pipe No.	L (ft)	S (%)	Q_{100} (cfs)	D (in)	Notes
1	65	1.6	116	24	2'x4' CBC
2	55	1.9	67	24	2'x7' CBC

NOTE:
Install sediment pond north of 49th street and construct a berm to separate irrigation tailwater from stormwater runoff.

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PREPARED UNDER THE SUPERVISION OF

DESIGNED: SEB

DRAWN: MAB

CHECKED: ALR

PROJECT NO. 15-041.01

SHEET REVISIONS

NO.	DATE	DESCRIPTION	BY

MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

AREA OF CONCERN 19
CULVERTS UPSTREAM OF REHMER LAKE

DATE: NOV 2016

DRAWING NO.

PAGE NO. AC19-1

6.21 Area of Concern #19 – 65th Avenue Upstream of Rehmer Lake

Area of Concern #19 is located 0.25 miles east of the 49th Street and 65th Ave. intersection. From the intersection, its drainage area extends 0.73 miles north and 0.44 miles east. It has a total area of 190 acres. Eight sub-basins were delineated for the basin, ranging between 2 and 62 acres. Most of the area is agricultural or pastoral, and the overall imperviousness of the basin is 6.6%. The sub-basin impervious values range between 5% and 19.3%. Currently, the Evans city limits does not extend north of 49th Street; thus, all of the basin of Area #19 lies to the north of this and is the property of Weld County. However, drainage from the basin enters into the city when it crosses 49th Street. Most of the area has type A soils. Through the center of the basins are swaths of type C, type B, and type D soils. Type C soil is the second most prominent type, and is the soil type in 12% of the basin.

Runoff in all sub-basins drains south toward 49th Street as sheet flow or dispersed and shallow channelized flow. Two culverts are recommended to convey stormwater under 49th Street. Each receives the stormwater from approximately half of the total basin area. The western culvert's contributing area is comprised of five of the eight sub-basins; the eastern culvert receives flow from the remaining three. Each of the culverts discharges to an open channel that continues south and discharge into Rehmer Lake, which is currently not in the Evans city limits. The current sizes of the culverts are unknown, as they were not included in the stormwater infrastructure GIS information provided by the City; however, it is known that they are not box culverts and that the cover over the roadway restricts the rise to 30" maximum, assuming a minimum cover of 1 foot above the pipe. With this diameter, the combined capacity of the culverts would be 108.4 cfs.

Flooding is common along this segment of 49th Street; the culverts are undersized for the major and minor storms. Additionally, the irrigation tailwater mixes with the stormwater runoff. Stormwater and irrigation tailwater that reach this point carry large concentrations of sediment. It is assumed that after storms, the sediment has deposited within the culvert, on the roadway and within the channel. The calculated flow rates for the design storms are listed in Table 6-28.

Table 6-28: Area of Concern #19 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
49th Street, west culvert	116.2	90.5	55.7	36.3	14.7
49th Street, east culvert	65.6	49.4	29.2	17.3	2.9

Due to cover constraints, box culverts are recommended to replace the existing culverts. The required size in the western location is a 2'x7' CBC. This would result in a cover of about 1.7 feet across the roadway. The required CBC dimensions to the east are 2'x4'. The resulting cover across 49th Street in this location would be about 1.5 feet.

Constructing a berm along 49th Street would help prevent the irrigation tail water from mixing with the stormwater runoff. A sediment basin is recommended in the wetland area north of the western culvert to improve the water quality before it reaches the road crossing. This structure will help minimize the clogging of the culvert and reduce the maintenance requirements of the system. The land north of 49th Street is privately owned, and so an easement will be necessary to construct both the berm and the sediment basin. The area in which the sediment basin is proposed (see the Area #19 basin map on the previous page) is the point in which the natural drainage way collects into the west culvert.

Following is a cost estimate that summarizes the suggested improvements. Resiliency is provided with the sediment basin at the upstream side of the west culvert. It helps keep sediment from being transported into Rehmer Lake and decreasing the storage capacity in the pond.

RECOMMENDATIONS	✓ **Replace the culverts under 49th Street with 24" culverts** ✓ **Obtain easement and construct a sediment basin north of the west culvert** ✓ **Build a berm along the north side of 49th Street**

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 19
ALTERNATIVE :	1
JURISDICTION :	Evans
SUB-BASIN ID:	Rehmer Lake-Reach19
DATE :	5/2/2016

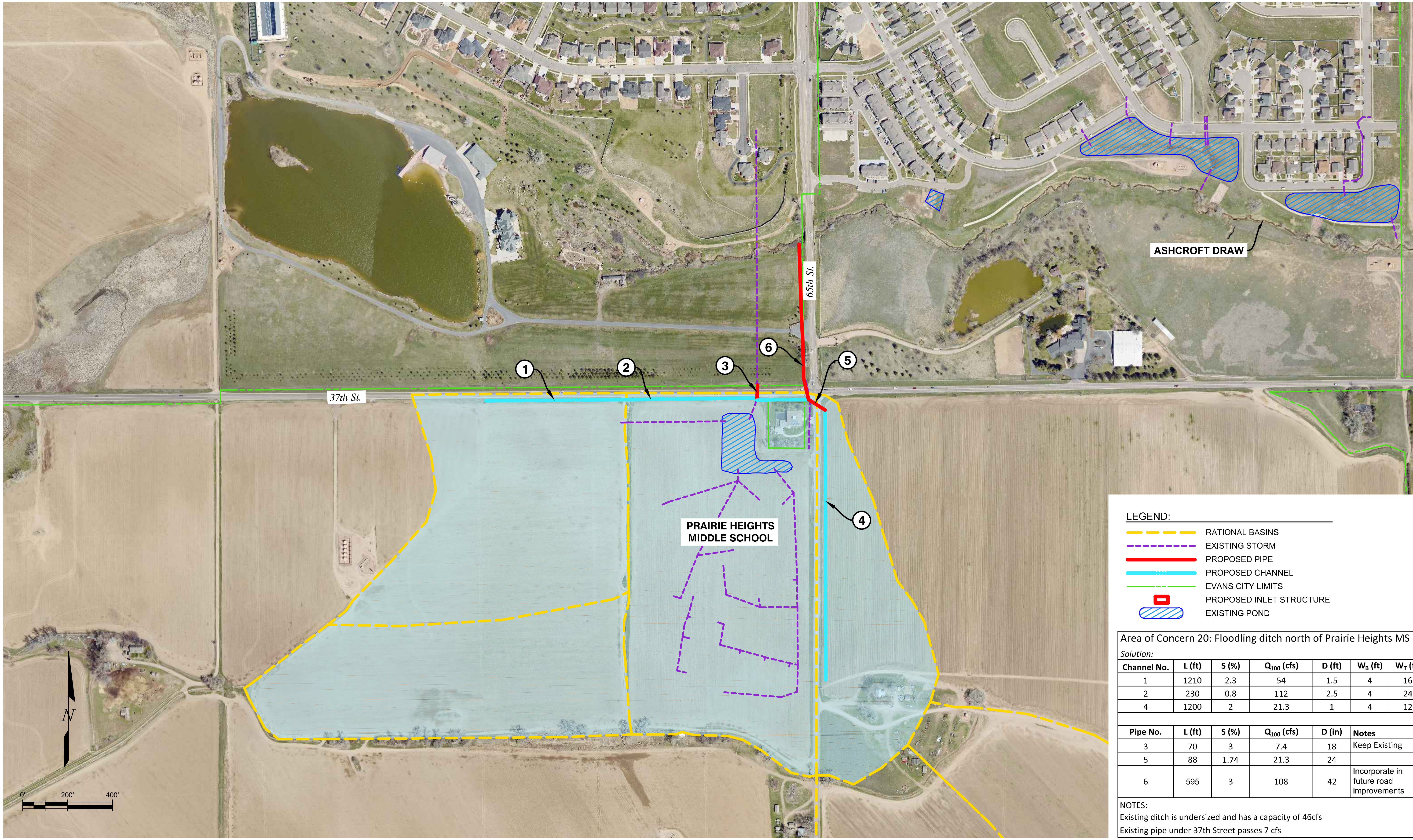
DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Concrete Box Culverts						
Box Culvert Pipe						
Individual Box Span (ft)	Box Height (ft)	No. of Barrels	Length (ft)			
4	2	1	65	L.F.	$459.68	$29,879.00
7	2	1	55	L.F.	$639.32	$35,162.00
Headwall and Toewalls						
Individual Box Span (ft)	No. of Barrels	Total Span (ft)				
4	1	6.00	2	EA	$506.61	$1,013.00
7	1	9.00	2	EA	$788.72	$1,577.00
Wingwalls (includes wingwalls on either side of channel and concrete apron)						
Individual Box Span (ft)	Box Rise (ft)	No. of Barrels				
4	2	1	2	EA	$5,406.29	$10,812.60
7	2	1	2	EA	$6,002.71	$12,005.40
Detention/Water Quality Facilities						
Detention (User Entered Quantities)						
Excavation, Low Range			600	C.Y.	$14.00	$8,400.00
Removals						
Removal of culvert pipe (D<48")			120	L.F.	$26.00	$3,120.00
Land Acquisition						
Easement/ROW Acquisition			1.00	ACRE	$1,000.00	$1,000.00

Master Plan Operation and Maintenance Cost Summary

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	118	L.F.	$1.00	$24.00
Total Annual Operation and Maintenance Cost				**$24.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$1,200.00**

Master Plan Capital Improvement Cost Summary

Capital Improvement Costs			
Pipe Culverts and Storm Drains			$0.00
Concrete Box Culverts			$90,449.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$8,400.00
Removals			$3,120.00
Landscaping and Maintenance Improvements			$0.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$101,969.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$5,098.00
Traffic Control	$20,000.00	L.S.	$20,000.00
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00
Stormwater Management/Erosion Control	5%		$5,098.00
Subtotal Additional Capital Improvement Costs			**$35,196.00**
Land Acquisition Costs			
ROW/Easements			$1,000.00
Subtotal Land Acquisition Costs			**$1,000.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$20,575.00
Legal/Administrative	5%		$6,858.00
Contract Admin/Construction Management	10%		$13,717.00
Contingency	25%		$34,291.00
Subtotal Other Costs			**$75,441.00**
Total Capital Improvement Costs			**$213,606.00**



Area of Concern 20: Floodling ditch north of Prairie Heights MS

Solution:

Channel No.	L (ft)	S (%)	Q_{100} (cfs)	D (ft)	W_B (ft)	W_T (ft)
1	1210	2.3	54	1.5	4	16
2	230	0.8	112	2.5	4	24
4	1200	2	21.3	1	4	12

Pipe No.	L (ft)	S (%)	Q_{100} (cfs)	D (in)	Notes
3	70	3	7.4	18	Keep Existing
5	88	1.74	21.3	24	
6	595	3	108	42	Incorporate in future road improvements

NOTES:

Existing ditch is undersized and has a capacity of 46cfs

Existing pipe under 37th Street passes 7 cfs

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	DRAWN: MAB	
	CHECKED: ALR	PROJECT NO. 15-041.01

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MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

DATE: NOV 2016

DRAWING NO.

AREA OF CONCERN 20
DITCH NEAR 37TH STREET AND 65TH AVENUE

PAGE NO. AC20-1

6.22 Area of Concern #20 – 37th Street and 65th Avenue

Area of Concern #20 is located at the intersection of 37th Street and 65th Street. The drainage area is 85 acres and comprised of four sub-basins. Its area includes the Prairie Heights Middle School and several agricultural or pastoral fields. At its widest point, the drainage basin extends 0.48 miles west and 0.1 miles east of 65th Avenue. The north-south limits are approximately from 37th Avenue to 0.32 miles south. The area is primarily undeveloped, although the school is represented in the hydrologic calculations as a residential area. The overall imperviousness of the basin is 13.1%; sub-basins range between 5% and 23% impervious. Most of the basin is composed of Type A soils; however, an 11 acre area in the northeast section of the basin has Type B soils and an 11 acre section in the central-southern section of the basin has Type C soils.

Several pipes of varying sizes exist around the middle school and discharge to a one acre detention pond in the northeast corner of the property. This pond's outlet conveys the stormwater across 37th Street through a 24" pipe. None of the remaining sub-basins have storm sewers. A channel runs parallel to 37th Street and flows east. A 30" pipe conveys the discharge from this channel across the road and into a grassy field in the northwest corner of the intersection. The existing channel has less than a foot of depth in its most western section. Near the intersection, a 150 foot length of channel has a depth of a little more than one foot, a bottom width of 4-6 feet, and 6:1 side slopes. The predicted flow rates for the design storms are listed in Table 6-29. In addition, there is concern that irrigation tailwater from the field west of the middle school enters into the stormwater system.

Table 6-29: Area of Concern #20 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
37th Street, roadside channel (1)	25.2	22.7	11.2	6.6	1.1
37th Street, roadside channel (2)	92.7	99.6	45.9	31.0	13.0
37th St. and 65th St.	110.3	99.6	54.7	37.0	15.7

The channel section which receives flow from the most western sub-basin requires a minimum depth of 2.0 feet (this includes one foot of freeboard), a bottom width of 4 feet, and 4:1 side slopes. The section collecting flow from the sub-basins west of 65th Avenue requires a channel depth of 2.8 feet, bottom width of 4 feet, and side slopes of 4:1. A roadside channel east of 65th Avenue, along the south side of 37th Street, is recommended to convey the runoff from the eastern-most sub-basin to the road crossing. This channel would need to have a depth of 1.8 feet, bottom width of 4 feet, and 4:1 side slopes. The area is still primarily agricultural land, and finding the 20 to 30 feet to place the channels will likely not be problematic. It may also be necessary to build a berm to try and separate the irrigation tailwater from the stormwater flows.

A 2'x4' box culvert is recommended to collect the discharge of both channels and convey the stormwater under 37th Street. A 36" equivalent diameter pipe is needed, but the cover is limited in that area. The recommended box culvert would result in a cover of approximately 1 foot. Either a channel or pipe could be practical to convey the stormwater from the north side of 37th Street to Ashcroft Draw, which is 660 feet north of the intersection. Evans plans to implement street improvements to this section of 65th Avenue in the near future, so a pipe may be especially convenient. A 42" pipe is required to convey the flow, but would have 40 cfs of additional capacity for future flow or for stormwater collection north of 37th Street.

An improvement cost estimate has been completed for Area of Concern #20. See the following table for additional details. The total cost for these improvements is $254,993. The existing pipe under 37th Street will remain in use.

Resiliency is provided with the use of surface channels to promote infiltration and water quality. In addition, since the intersection of 37th Street and 65th Street is expected to be a major intersection in the future, the planning prior to development can allow for the ultimate infrastructure to be installed ahead of time. The proposed pipe adjacent to 65th Street discharges to Ashcroft Draw. To comply with the spirit of the MS4 permit, the stormwater may be treated via constructed wetland or channel before ultimately discharging to the Draw. If a wetland pond is preferred, its recommended area (assuming a 1.5' depth) is 0.354 acres.

RECOMMENDATIONS	✓ **Widen the channel along the southern edge of 37th Street** ✓ **Construct a 42" culvert across 37th Street to a new channel or pipeline to Ashcroft Draw** ✓ **Construct a channel south of 37th Street along 65th Avenue to discharge into the culvert under 37th Street**

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan		
DRAINAGE BASIN :	Area of Concern 20		
ALTERNATIVE :	1		
JURISDICTION :	Evans		
SUB-BASIN ID:	37th at Prairie Hts MS-Reach20	DATE :	5/2/2016

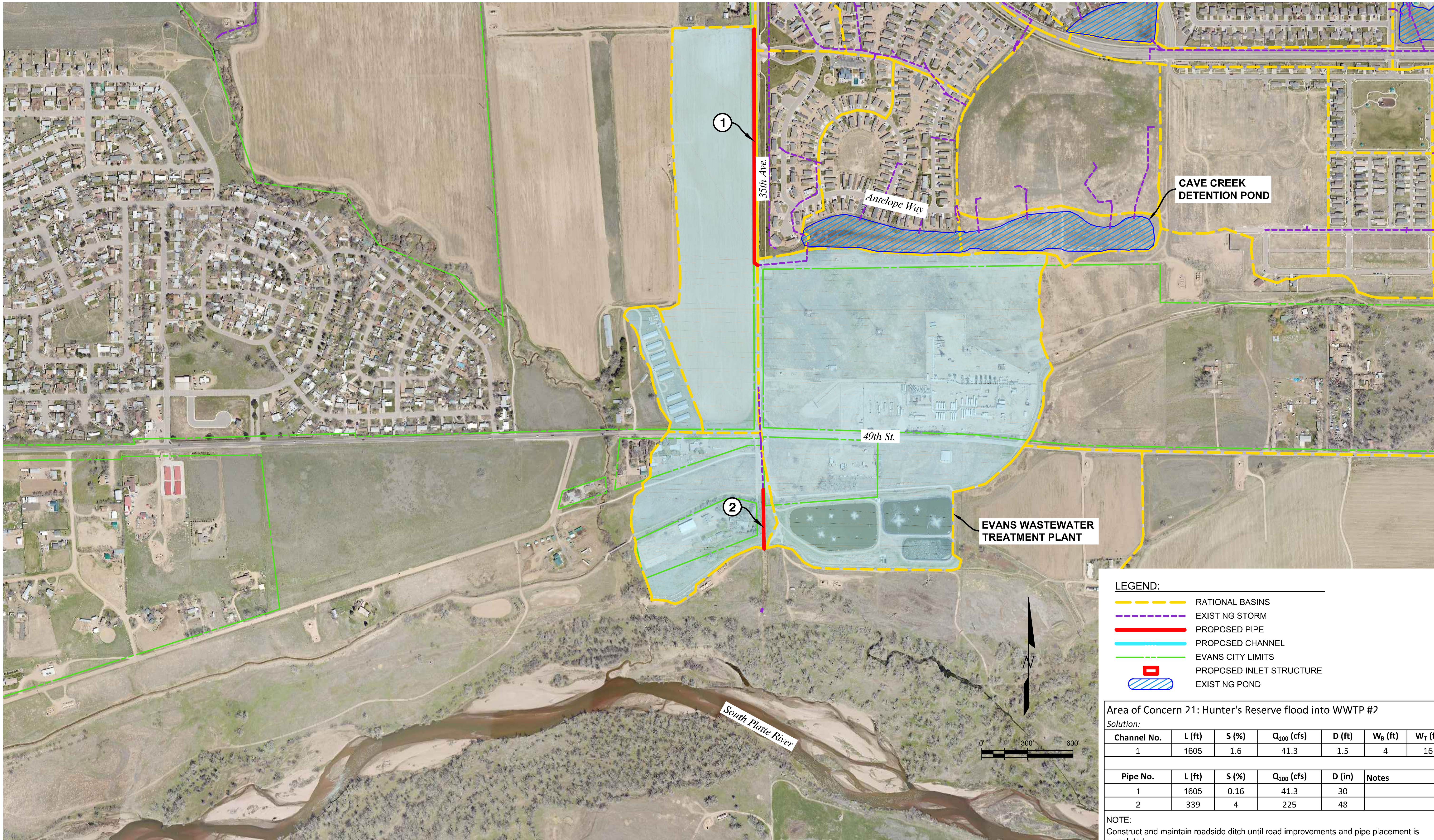
DESCRIPTION			QUANTITY	UNIT	UNIT COST	COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	Length (ft)	No. of Barrels				
18-inch	70	1	70	L.F.	$69.00	$4,830.00
24-inch	88	1	88	L.F.	$92.00	$8,096.00
42-inch	595	1	595	L.F.	$162.00	$96,390.00
Flare End Sections						
Diameter (in)	Applicable	No. of Barrels				
18-inch	Yes	1	2	EA	$1,182.00	$2,364.00
24-inch	Yes	1	1	EA	$1,246.00	$1,246.00
42-inch	Yes	1	1	EA	$2,184.00	$2,184.00
Detention/Water Quality Facilities						
Detention (User Entered Quantities)						
Excavation, Mid Range			1064	C.Y.	$31.00	$32,975.00
Landscaping and Maintenance Improvements						
Reclamation & seeding (native grasses)			1.1	ACRE	$1,285.00	$1,470.00

Master Plan Capital Improvement Cost Summary

Item	Quantity	Unit	Cost
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$115,110.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$32,975.00
Removals			$0.00
Landscaping and Maintenance Improvements			$1,470.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$149,555.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$7,478.00
Traffic Control		L.S.	$0.00
Utility Coordination/Relocation		L.S.	$0.00
Stormwater Management/Erosion Control	5%		$7,478.00
Subtotal Additional Capital Improvement Costs			**$14,956.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$24,677.00
Legal/Administrative	5%		$8,226.00
Contract Admin/Construction Management	10%		$16,451.00
Contingency	25%		$41,128.00
Subtotal Other Costs			**$90,482.00**
Total Capital Improvement Costs			**$254,993.00**

Master Plan Operation and Maintenance Cost Summary

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	753	L.F.	$1.00	$151.00
Total Annual Operation and Maintenance Cost				**$151.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$7,550.00**



Area of Concern 21: Hunter's Reserve flood into WWTP #2

Solution:

Channel No.	L (ft)	S (%)	Q_{100} (cfs)	D (ft)	W_B (ft)	W_T (ft)
1	1605	1.6	41.3	1.5	4	16

Pipe No.	L (ft)	S (%)	Q_{100} (cfs)	D (in)	Notes
1	1605	0.16	41.3	30	
2	339	4	225	48	

NOTE:
Construct and maintain roadside ditch until road improvements and pipe placement is completed.

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DESIGNED:	SEB
DRAWN:	MAB
CHECKED:	ALR

PROJECT NO. 15-041.01

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MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

DATE: NOV 2016

DRAWING NO.

AREA OF CONCERN 21
35TH AVENUE AND 49TH STREET

PAGE NO. AC21-1

6.23 Area of Concern #21 – 35th Avenue and 49th Street

Area of Concern #21 is located at the intersection of 35th Avenue and 49th Street. The basin discharge point is 0.14 miles south of 49th Street. Its basin extends from there to 0.5 miles north of 49th Street, and from 35th Avenue to 0.16 miles west and 0.36 miles east at its widest point. Four sub-basins were delineated for the basin; all are characterized by undeveloped and light industrial land use. Just east of the point of concern, within the most southern portion of the basin, the Evans Wastewater Treatment Plant #2 (WWTP) exists. Impervious values for the sub-basins range from 9% to 26%; the overall impervious value is 16.8% for the basin. The total basin area is 133 acres. The entirety of the basin has Type A soils.

A 42" pipe extends along 35th Avenue from Antelope Way (approximately) to the basin outlet, which exists within the floodplain and adjacent to the WWTP. This pipe conveys the discharge from the Cave Creek detention pond in Area of Concern #22, and has no inlets along 35th Avenue to collect the stormwater generated by Area #21. Therefore, all of the stormwater flows as sheet flow along grassed fields or the roadway (35th Avenue has no curb and gutter) south to the floodplain.

The concern in this area is that the overland and dispersed channelized flow will frequently flood the outlot of the wastewater treatment plant. Stormwater infrastructure and BMPs are required to prevent the inundation of this and any future development. The predicted flow rates for the design storms are listed in Table 6-30.

Table 6-30: Area of Concern #21 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
35th Avenue, north of 49th St.	41.3	31.7	19.3	12.3	3.7
35th Avenue, south of 49th St.	197.6	159.6	101.7	71.8	35.9

Since 35th Avenue is scheduled for improvements in the near future, a pipe system is recommended for the system. A 30" pipe would be required in the northern section of basin, which consists of only one relatively narrow sub-basin. This pipe could tie into the existing 42" pipe along 35th Avenue, which is calculated to have adequate capacity for the additional flow until the final 390 feet. At the basin outlet, this section of pipe would need to be increased to a 48" pipe. Prior to construction, it is recommended that the runoff from the northern sub-basin be collected in a channel, whose dimensions are:

- 1.5 foot depth
- 4 foot bottom width
- 4:1 (H:V) side slopes

This channel may be extended south to the outlet or tied into the 42" pipeline. To prevent further infiltration into the WWTP, a berm, and possibly an inlet and connector pipe, is recommended along the WWTP access road, 400 feet south of 49th Street.

For cost estimating purposes, since the pipe will be more expensive than a channel, this will be included in the cost estimate. The total cost for these improvements is estimated at $504,115. It should be noted that since the existing pipe near Evans Town Ditch is being removed and replaced, no additional property acquisitions are believed to be necessary. This project provides resiliency by safely conveying the flow to keep it out of the Evans Town Ditch as well as the WWTP.

Since the pipe discharges into the floodplain of the South Platte, it would be good practice to construct a wetland to treat the stormwater before it reaches the river. With the combined flows from areas #21 and #22, the recommended area for efficient treatment is 2.8 acres, assuming a wetland depth of 1.5 feet. There is an existing channel into which the existing pipe discharges. This can be retrofitted into a wetland channel to provide the same treatment.

RECOMMENDATIONS	✓ **Construct a 30" pipeline and/or channel along 35th Avenue to discharge into the existing 42" pipeline** ✓ **Replace the last 400 feet of pipeline with 48" pipe**

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 21
ALTERNATIVE :	1
JURISDICTION :	Evans
SUB-BASIN ID:	35th Ave and 49th St-Reach21 — DATE : 5/2/2016

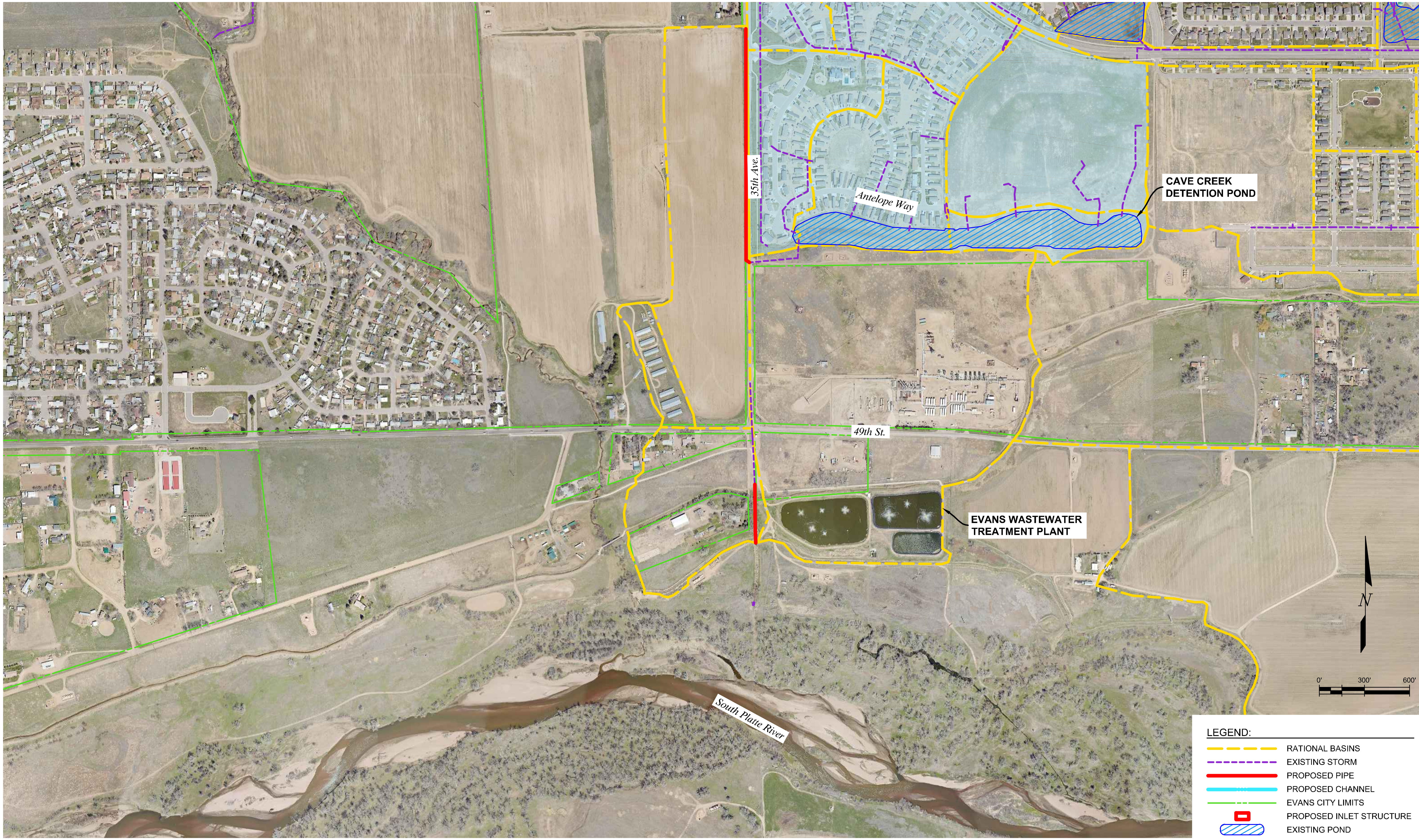
DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	Length (ft)	No. of Barrels				
30-inch	1605	1	1605	L.F.	$116.00	$186,180.00
48-inch	340	1	340	L.F.	$185.00	$62,900.00
Flare End Sections						
Diameter (in)	Applicable	No. of Barrels				
30-inch	Yes	1	1	EA	$2,017.00	$2,017.00
48-inch	Yes	1	1	EA	$2,646.00	$2,646.00
Manholes and Inlets						
Manhole, 4' Dia. (Pipe Dia. < 36")			4	EA	$3,726.00	$14,904.00
Removals						
Removal of culvert pipe (D<48")			340	L.F.	$26.00	$8,840.00

Master Plan Operation and Maintenance Cost Summary

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	1945	L.F.	$1.00	$389.00
Manhole and Inlet Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	4	EA	$64.00	$256.00
Total Annual Operation and Maintenance Cost				**$645.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$32,250.00**

Master Plan Capital Improvement Cost Summary

Capital Improvement Costs			
Pipe Culverts and Storm Drains			$268,647.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$0.00
Removals			$8,840.00
Landscaping and Maintenance Improvements			$0.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$277,487.00**
Additional Capital Improvement Costs			
Dewatering		L.S.	$0.00
Mobilization	5%		$13,874.00
Traffic Control	$15,000.00	L.S.	$15,000.00
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00
Stormwater Management/Erosion Control	5%		$13,874.00
Subtotal Additional Capital Improvement Costs			**$47,748.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$48,785.00
Legal/Administrative	5%		$16,262.00
Contract Admin/Construction Management	10%		$32,524.00
Contingency	25%		$81,309.00
Subtotal Other Costs			**$178,880.00**
Total Capital Improvement Costs			**$504,115.00**



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SHEET REVISIONS

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MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

DATE: NOV 2016

DRAWING NO.

AREA OF CONCERN 22
CAVE CREEK

PAGE NO. AC22-1

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6.24 Area of Concern #22 – Cave Creek Detention Pond

Area of Concern #22 is located at the Cave Creek detention pond, south of Antelope Way. The drainage basin extends from 35th Avenue to Buffalo Trail at its southern section, and from 35th Avenue to Eagles Nest Drive in its central section. From the Cave Creek detention pond, the basin extends north to 37th Avenue. A narrow sub-basin extends further north to 29th Street. This sub-basin encompasses 35th Avenue and little else around it, except a commercial lot which currently houses RCC Medical Supply and DVM Systems. About eight acres of this basin's existing 10 sub-basins were delineated for Area of Concern #22. The total basin area is 193 acres; the sub-basin areas range between 8 and 31.1 acres. Most of the basin contains single-family residential lots. A sub-basin in the southeast corner of the basin, however, is a currently undeveloped lot. Although completely grassed open field at the taking of the aerial photograph, it will likely be developed into a subdivision in the near future. The northernmost basin is primarily pavement and commercial area. Sub-basin impervious values range between 5% and 76%. The overall imperviousness of the basin is 52.3%. The entire basin is comprised of type A soils.

In the northern sub-basin, runoff from the intersection of 29th Street and 35th Ave. is collected by an 8" pipe maintained and owned by Greeley. Approximately 800 feet south of the intersection, Greeley has a 12" pipe in place along 35th Ave., and a 24" pipe exists 100 feet south of that. These pipelines are discontinuous, however, and their purpose appears to be to prevent runoff from flowing through commercial driveways. Where the 8" pipeline ends, Evans has an 18" storm sewer in place that extends from there to 425 feet south of the 35th Ave. and 37th Street intersection. Here, it discharges into a roadside swale. At the corner of Prairie View Drive and 35th Ave., the swale discharges into a 25" pipe; this extends south for 2,530 feet and discharges into the west side of the Cave Creek detention pond. In addition to Cave Creek, one other detention pond exists within the drainage area. It is smaller, but has a footprint of 1.6 acres. It is located in the open lot north of Pheasant Drive and 35th Avenue. This pond also discharges into the swale.

Runoff generated by the residential sub-basins south of 37th Street flows south along the neighborhood collector streets – which allow for curb-and-gutter flow – and into local stormsewers. Part the of drainage area (that west of Falcon Lane) is collected into the channel and 25" pipe. The sub-basin to the east drains to a 27" pipe along Prairie View Drive, which turns south and discharges into an open channel parallel to Mesquite Lane and located adjacent to an undeveloped lot to the east. The two sub-basins south of Prairie View Drive and north of Sagebrush Blvd also drain to this channel after first being collected by a 24" pipeline along Sagebrush Drive. The two southern sub-basins drain directly to Cave Creek detention pond through multiple 30" to 36" pipes; these connect to curb inlets along Antelope Way and connecting side streets.

The Cave Creek detention pond is currently owned by the developer of the subdivision. It is a 21.8 acre-foot pond and has a foot print of 9.5 acres. The detention pond has a length of 2,240 feet in the east-west direction. In the north-south direction, Cave Creek is 260 feet wide at its widest point. The detention pond has one outlet, located on its western side; the pipe is 42" and runs west then south along 35th Avenue. It extends past the wastewater treatment plant and discharges into the South Platte floodplain.

The concern for the area is that the Cave Creek detention pond is not well maintained. The City is wondering whether they need to take ownership and responsibility for the pond, since it is an essential stormwater management feature in this basin. Predicted flow rates to the detention pond for the design storms are listed in Table 6-31.

Table 6-31: Area of Concern #22 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
Cave Creek Detention pond	325.8	278.3	195.1	166.2	123.5

Relevant drainage reports show that the design outflow of the pond during the major storm is 82.6 cfs. If improperly maintained, however, the pond is likely to clog and overflow, releasing stormwater at rates and in locations unplanned for.

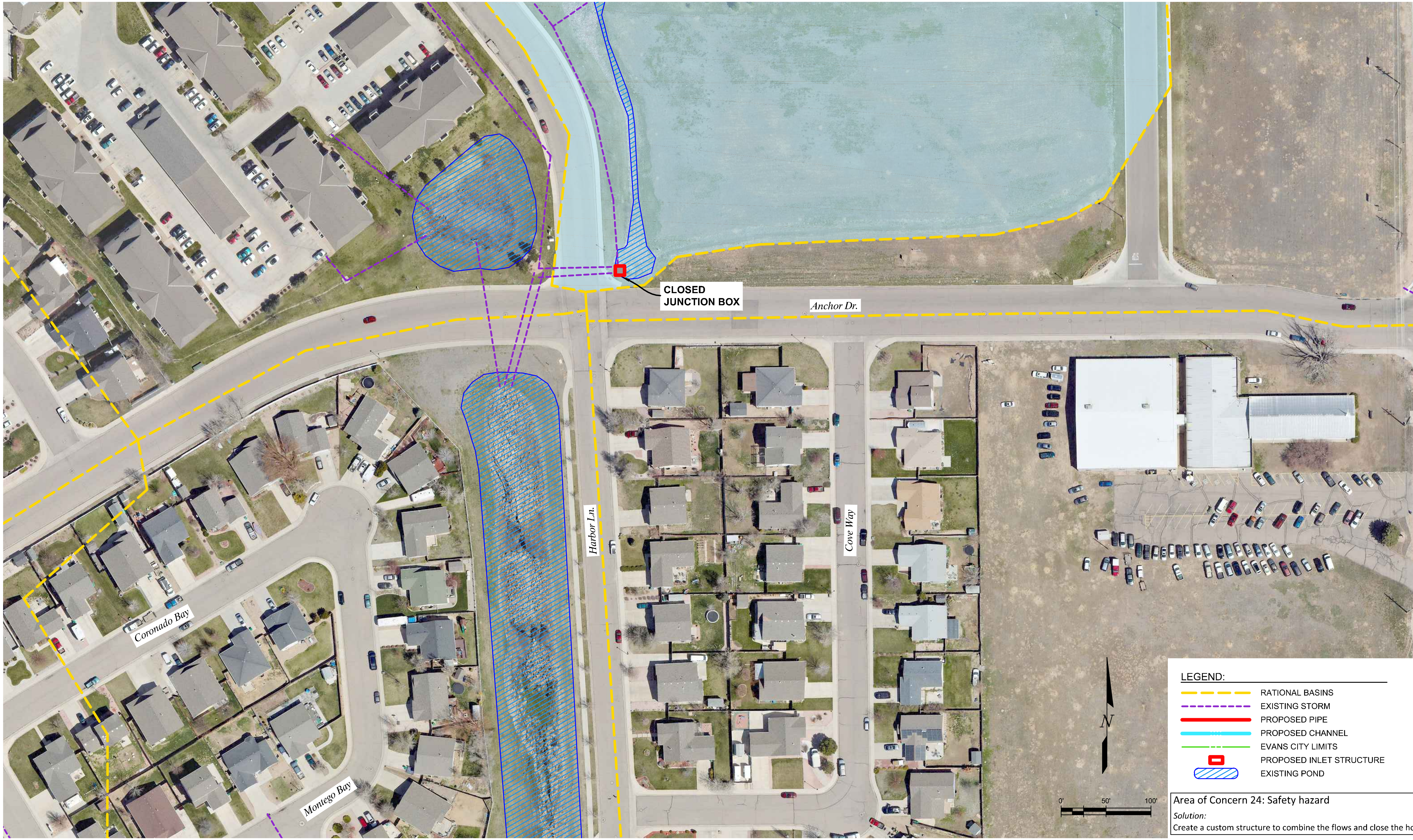
It is recommended that the City of Evans either take ownership and responsibility of the Cave Creek detention pond, or stipulate to its current owners the seasonal and annual maintenance measures that must be taken. Should the City choose to not directly maintain the pond themselves, then annual inspections to verify its condition are recommended.

Maintenance requirements include (but may not be limited to):

- Seasonal mowing, and trash and debris removal from the outlet structure, inlets, and pond
- Sediment removal at the outlet structure, to be performed on an as-needed basis
- Annual noxious weed control, to be completed in the spring
- Revegetation, removal of unwanted trees, and mitigation of scour, to occur annually or as-needed

Additional maintenance activities may be required, especially in the first few years of care. These should be identified during on-site annual inspections. Maintenance is an important form of resiliency. When this pond is properly maintained, it does not flood facilities causing damage.

RECOMMENDATIONS SUMMARY	✓ **Ensure the Cave Creek detention pond is properly maintained through frequent inspections, seasonal mowing, and cleaning of the inlet and outlet structures**



Area of Concern 24: Safety hazard

Solution:

Create a custom structure to combine the flows and close the hole

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LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

DATE: NOV 2016

DRAWING NO.:

AREA OF CONCERN 24
HARBOR LANE AND ANCHOR DRIVE

PAGE NO.: AC24-1

6.25 Area of Concern #24 – Harbor Lane and Anchor Drive

Area of Concern #24 is located at the northeast corner Harbor Lane and Anchor Drive. Its drainage area is 115 acres, 88 of which are outside of the Evans UGA. Six sub-basins were delineated for the area, ranging in area between 8.7 acres to 30.9 acres. Its southern sub-basin, the only one within the UGA, encompasses the Sam's Club facility, parking area, and the open field south of the lot. The northern sub-basins extend west from 29th Avenue to 23rd Avenue and from 32nd Street to S 27th Avenue. Two of the sub-basins have primarily agricultural or pastoral fields. The three adjacent to the east are commercial lots (they currently contain Walmart, Hobby Lobby, and the Habitat for Humanity ReStore). Overall, the basin imperviousness is 60%; the sub-basins' values range between 13.4% and 82.6%. Except for a three acre area with soil group Type B, the entire drainage basin is composed of soil group Type A.

North of the UGA, Greeley owns and maintains several pipelines that collect runoff from the parking lots. All the stormwater is taken south through a 24" pipeline under Harbor Lane, which discharges into the point of concern. The runoff from Sam's Club property is similarly collected into storm lines under the parking lot, but is discharge to a 0.6 acre detention pond and 310 foot open channel which terminates at the point of concern. At this point, there is a four foot deep depression; its bottom area is 245 square feet and its side slopes are between 2:1 and 3:1 (H:V) throughout its perimeter. At the point of discharge from the channel into the depression, the elevation drops 6 feet over a horizontal length of 17 feet (the channel invert is greater than elevation of Anchor Drive, to the south). The area discharges to a 48" pipe that conveys the stormwater west and south to the Landings detention pond.

The concern for this area is the safety hazard the depression creates. It is located 7 feet from the edge of sidewalk at the Harbor Lane and Anchor Drive intersection and there is no fence or guardrail to mitigate fall risk. Additionally, the area collects trash and litter (at the time of the site visit a shopping cart had been deserted in the depression). The steep slopes make it difficult to climb out of after a fall. Predicted flow rates to the site are listed in Table 6-32; these do not include the attenuation of flow from the detention pond near Sam's Club.

Table 6-32: Area of Concern #24 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
Harbor Ln. and Anchor Dr.	325.8	278.3	195.1	166.2	123.5

To mitigate the safety risk, a customized structure is recommended to replace the existing open depression. The structure would act as a manhole or junction, receiving inflow from the 24" pipe and the channel (via a pipe inlet), being the entrance to the 48" outlet pipe, and providing access through the top for maintenance. After placement, fill should be placed around the structure to bring the surface elevation up to that of the adjacent sidewalk. The city should also evaluate whether a guardrail is necessary for public safety.

The approximate total cost for the safety improvements at this intersection is $100,419. It is expected that this will need a structural design due to the complexity of the existing pipes. This project is a safety concern for the surrounding residents. While it does not specifically promote resiliency, by making this a closed structure it makes it less accessible which should reduce the buildup of debris in the system.

RECOMMENDATIONS SUMMARY	✓ **Install a customized structure that is closed and removes the fall hazard and functions as a juncture between stormwater lines**

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 24
ALTERNATIVE :	1
JURISDICTION :	Evans
SUB-BASIN ID:	Harbor Ln Anchor Dr-Reach24
DATE :	5/2/2016

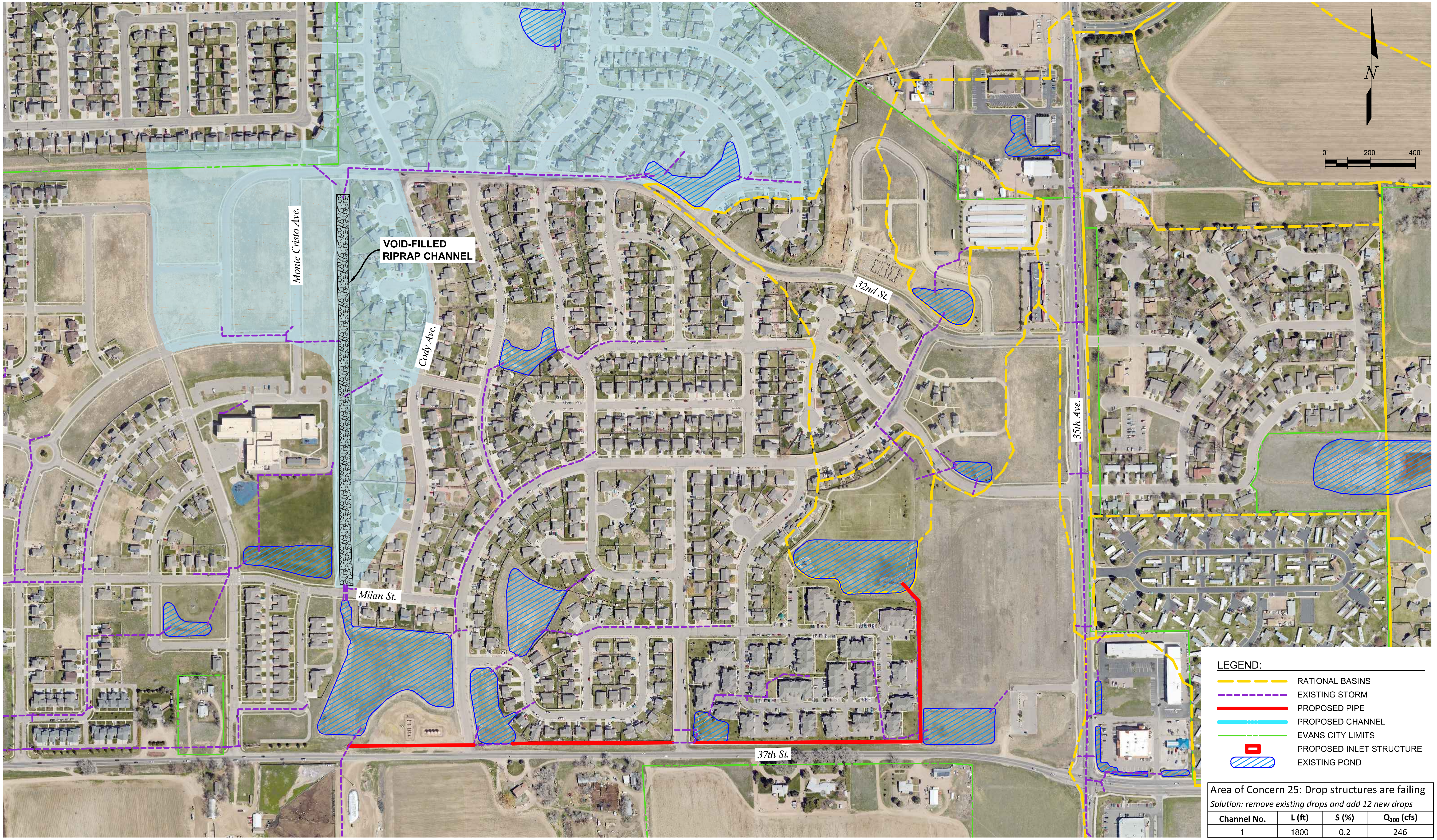
DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Removals						
Removal of culvert pipe (D<48")			10	L.F.	$26.00	$260.00
Special Items (User Defined)						
Custom Structure			1	EA	$45,000.00	$45,000.00

Master Plan Capital Improvement Cost Summary

Capital Improvement Costs			
Pipe Culverts and Storm Drains			$0.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$0.00
Removals			$260.00
Landscaping and Maintenance Improvements			$0.00
Special Items (User Defined)			$45,000.00
Subtotal Capital Improvement Costs			**$45,260.00**
Additional Capital Improvement Costs			
Dewatering	$5,000.00	L.S.	$5,000.00
Mobilization	5%		$2,263.00
Traffic Control	$5,000.00	L.S.	$5,000.00
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00
Stormwater Management/Erosion Control	5%		$2,263.00
Subtotal Additional Capital Improvement Costs			**$19,526.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$9,718.00
Legal/Administrative	5%		$3,239.00
Contract Admin/Construction Management	10%		$6,479.00
Contingency	25%		$16,197.00
Subtotal Other Costs			**$35,633.00**
Total Capital Improvement Costs			**$100,419.00**

Master Plan Operation and Maintenance Cost Summary

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Hydraulic Structure Maintenance (e.g. debris removal, erosion, structural repairs, etc.)	1	EA	$642.00	$1,284.00
Total Annual Operation and Maintenance Cost				**$1,284.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$64,200.00**



Area of Concern 25: Drop structures are failing

Solution: remove existing drops and add 12 new drops

Channel No.	L (ft)	S (%)	Q_{100} (cfs)
1	1800	0.2	246

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LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

AREA OF CONCERN 25
CHANNEL BETWEEN 32ND STREET AND MILAN STREET

DATE: NOV 2016

DRAWING NO.

PAGE NO. AC25-1

6.26 Area of Concern #25 – Channel between 32nd Street and Milan Street

Area of Concern #25 is located immediately south of 32nd Avenue, along the channel that is 260 feet west of Cody Avenue. The drainage area to the channel is 81.5 acres, all of which is single-family residential, with parks and undeveloped lots dispersed throughout. The northern sub-basin area extends from the UGA to 32nd Avenue. To the south, the drainage basin extends from Cody Avenue to the social trail west of the channel. A portion of the undeveloped area between 32nd Avenue and Florence Avenue is included in the drainageway as well. The overall imperviousness of the basin and four sub-basins is 60%. All of the sub-basins primarily have soils in group type A.

The channel extends from 32nd Avenue to Milan Street, where the flow is conveyed through box culverts into the Ashcroft Heights detention basin #8. It is 5 feet wide and 5 feet deep in the typical section. Its side slopes vary between 3:1 and 6:1 (H:V). Six drop structures exist along its length. Three of these are 2 foot drops, two are 1 foot drops, and one is a 3 foot drop. All are concrete vertical drop structures. Several 18" to 24" storm lines contribute flow from the neighborhoods west and east of the channel. Stormwater from the northern sub-basin is collected into a 30" pipe under 32nd Avenue and is discharged into the channel.

Alternative 1

At several drop structures, scouring has occurred around the vertical drops such that the flow is by-passing the drop structure. UDFCD recommends a maximum channel slope of 0.6%; the measured slope for the non-drop sections of this channel is 1.6%. To achieve the slope recommended by UDFCD, an additional 16 feet of drop is required. A series of 5 additional (11 total) 2-foot drops is recommended. In addition, a larger 5' drop will be added at the CBC to the south.

The expected 100-year flow rate is 246 cfs. The channel as it exists has a full flow capacity of 547 cfs. This allows for a freeboard depth of 1 foot, and a conservative value of 3:1 (H:V) for the right and left side slopes. If the channel is improved such that the non-drop sections have a slope of 0.6%, the maximum flow capacity is 335 cfs, assuming still the 3:1 (H:V) side slopes and 1 foot freeboard.

Alternative 2

Alternatively, the channel can be lined with concrete. This would allow for simpler maintenance, regarding both the access and ease of debris removal. A concrete lined channel would still utilize the existing drop structures to maintain safe velocities.

Alternative 3

The channel may be protected by a rock-based lining as well. Based on the flow rate and slope of the channel, the required size of riprap varies between Type L and Type M. At a 6% slope the initial 100 feet of channel needs Type M riprap, which has a D_{50} of 12 inches. The remainder of the channel has a slope of about 2%, and will require Type L riprap, which has a D_{50} of 6 inches. All existing drops will remain. Void-fill riprap material is more difficult to place than concrete. The rock with the specified D50 is mixed with a variety of rock sizes in pre-specified ratios in order to get a more dense mixture. This material most closely matches the natural streambed in mountain systems.

The channel improvements described in Alternative 3 are estimated to cost $862,330. There will need to be a detailed analysis of the channel hydraulics during final design to make sure that the suggested design will result in an acceptable velocity and flow depth.

Resiliency is an important piece of this project. Since the structures are starting to fail, this system is providing an additional sediment supply, causing the need for more maintenance downstream of the channel. This may also impact water quality for the downstream facilities.

RECOMMENDATION:	✓ **Reline the channel with Type L void-fill rip rap**
ALTERNATIVE 3	✓ **Regularly inspect the channel for signs of erosion or sedimentation**

Alternative 1 Cost Estimate

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 25
ALTERNATIVE :	1
JURISDICTION :	Evans
SUB-BASIN ID:	Channel 32nd-Reach25
DATE :	5/2/2016

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Hydraulic Structures						
Sloping Drop Structures						
Height (ft)	Bottom Width (ft)	Yn (ft)				
2	5	5	11	EA	$67,636.51	$744,002.00
5	2	5	1	EA	$77,512.34	$77,512.00
Detention/Water Quality Facilities						
Detention (User Entered Quantities)						
Excavation, High Range			200	C.Y.	$40.00	$8,000.00

Master Plan Capital Improvement Cost Summary			
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$0.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$821,514.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$8,000.00
Removals			$0.00
Landscaping and Maintenance Improvements			$0.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$829,514.00**
Additional Capital Improvement Costs			
Dewatering	$10,000.00	L.S.	$10,000.00
Mobilization	5%		$41,476.00
Traffic Control	$2,000.00	L.S.	$2,000.00
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00
Stormwater Management/Erosion Control	5%		$41,476.00
Subtotal Additional Capital Improvement Costs			**$99,952.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$139,420.00
Legal/Administrative	5%		$46,473.00
Contract Admin/Construction Management	10%		$92,947.00
Contingency	25%		$232,367.00
Subtotal Other Costs			**$511,207.00**
Total Capital Improvement Costs			**$1,440,673.00**

Master Plan Operation and Maintenance Cost Summary				
Description	Quantity	Unit	Unit Cost	Total Annual Cost
Hydraulic Structure Maintenance (e.g. debris removal, erosion, structural repairs, etc.)	12	EA	$642.00	$7,704.00
Channel Maintenance (e.g. sediment & debris removal, erosion, tree & weed removal, etc.)	1066	L.F.	$3.00	$3,198.00
Mowing (e.g. channels, ponds, etc.)	1	ACRE	$64.00	$128.00
Total Annual Operation and Maintenance Cost				**$11,030.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$551,500.00**

Alternative 2 Cost Estimate

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 25
ALTERNATIVE :	2
JURISDICTION :	Evans
SUB-BASIN ID:	Channel 32nd-Reach25b
DATE :	5/2/2016

DESCRIPTION		QUANTITY	UNIT	UNIT COST	TOTAL COST
Detention/Water Quality Facilities					
Detention (User Entered Quantities)					
Excavation, Low Range		920	C.Y.	$14.00	$12,880.00
Special Items (User Defined)					
Concrete		920	C.Y.	$600.00	$552,000.00

Master Plan Capital Improvement Cost Summary

Description	Quantity	Unit	Total Cost
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$0.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$0.00
Detention/Water Quality Facilities			$12,880.00
Removals			$0.00
Landscaping and Maintenance Improvements			$0.00
Special Items (User Defined)			$552,000.00
Subtotal Capital Improvement Costs			**$564,880.00**
Additional Capital Improvement Costs			
Dewatering	$10,000.00	L.S.	$10,000.00
Mobilization	5%		$28,244.00
Traffic Control	$2,000.00	L.S.	$2,000.00
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00
Stormwater Management/Erosion Control	5%		$28,244.00
Subtotal Additional Capital Improvement Costs			**$73,488.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$95,755.00
Legal/Administrative	5%		$31,918.00
Contract Admin/Construction Management	10%		$63,837.00
Contingency	25%		$159,592.00
Subtotal Other Costs			**$351,102.00**
Total Capital Improvement Costs			**$989,470.00**

Master Plan Operation and Maintenance Cost Summary

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Channel Maintenance (e.g. sediment & debris removal, erosion, tree & weed removal, etc.)	1066	L.F.	$3.00	$3,198.00
Mowing (e.g. channels, ponds, etc.)	0.5	ACRE	$64.00	$64.00
Total Annual Operation and Maintenance Cost				**$3,262.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$163,100.00**

Alternative 3 Cost Estimate

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGEWAY :	Area of Concern 25
ALTERNATIVE :	3
JURISDICTION :	Evans
SUB BASIN ID:	Channel 32nd-Reach25a
DATE :	5/2/2016

DESCRIPTION		QUANTITY	UNIT	UNIT COST	TOTAL COST
Channel Improvements					
Excavation, High Range		370	C.Y.	$40.00	$14,800.00
Detention/Water Quality Facilities					
Detention (User Entered Quantities)					
Excavation, Low Range		5690	C.Y.	$14.00	$79,660.00
Special Items (User Defined)					
Void-fill Riprap (Type M)	<---User Defined Items	490	CY	$65.00	$31,850.00
Void-fill Riprap (Type L)	<---User Defined Items	5200	CY	$70.00	$364,000.00

Master Plan Capital Improvement Cost Summary

Capital Improvement Costs			
Pipe Culverts and Storm Drains			$0.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$14,800.00
Detention/Water Quality Facilities			$79,660.00
Removals			$0.00
Landscaping and Maintenance Improvements			$0.00
Special Items (User Defined)			$395,850.00
Subtotal Capital Improvement Costs			**$490,310.00**
Additional Capital Improvement Costs			
Dewatering	$10,000.00	L.S.	$10,000.00
Mobilization	5%		$24,516.00
Traffic Control	$2,000.00	L.S.	$2,000.00
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00
Stormwater Management/Erosion Control	5%		$24,516.00
Subtotal Additional Capital Improvement Costs			**$66,032.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$83,451.00
Legal/Administrative	5%		$27,817.00
Contract Admin/Construction Management	10%		$55,634.00
Contingency	25%		$139,086.00
Subtotal Other Costs			**$305,988.00**
Total Capital Improvement Costs			**$862,330.00**

Master Plan Operation and Maintenance Cost Summary

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Hydraulic Structure Maintenance (e.g. debris removal, erosion, structural repairs, etc.)	6	EA	$642.00	$3,852.00
Channel Maintenance (e.g. sediment & debris removal, erosion, tree & weed removal, etc.)	1066	L.F.	$3.00	$3,198.00
Mowing (e.g. channels, ponds, etc.)	1	ACRE	$64.00	$128.00
Total Annual Operation and Maintenance Cost				**$7,178.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$358,900.00**

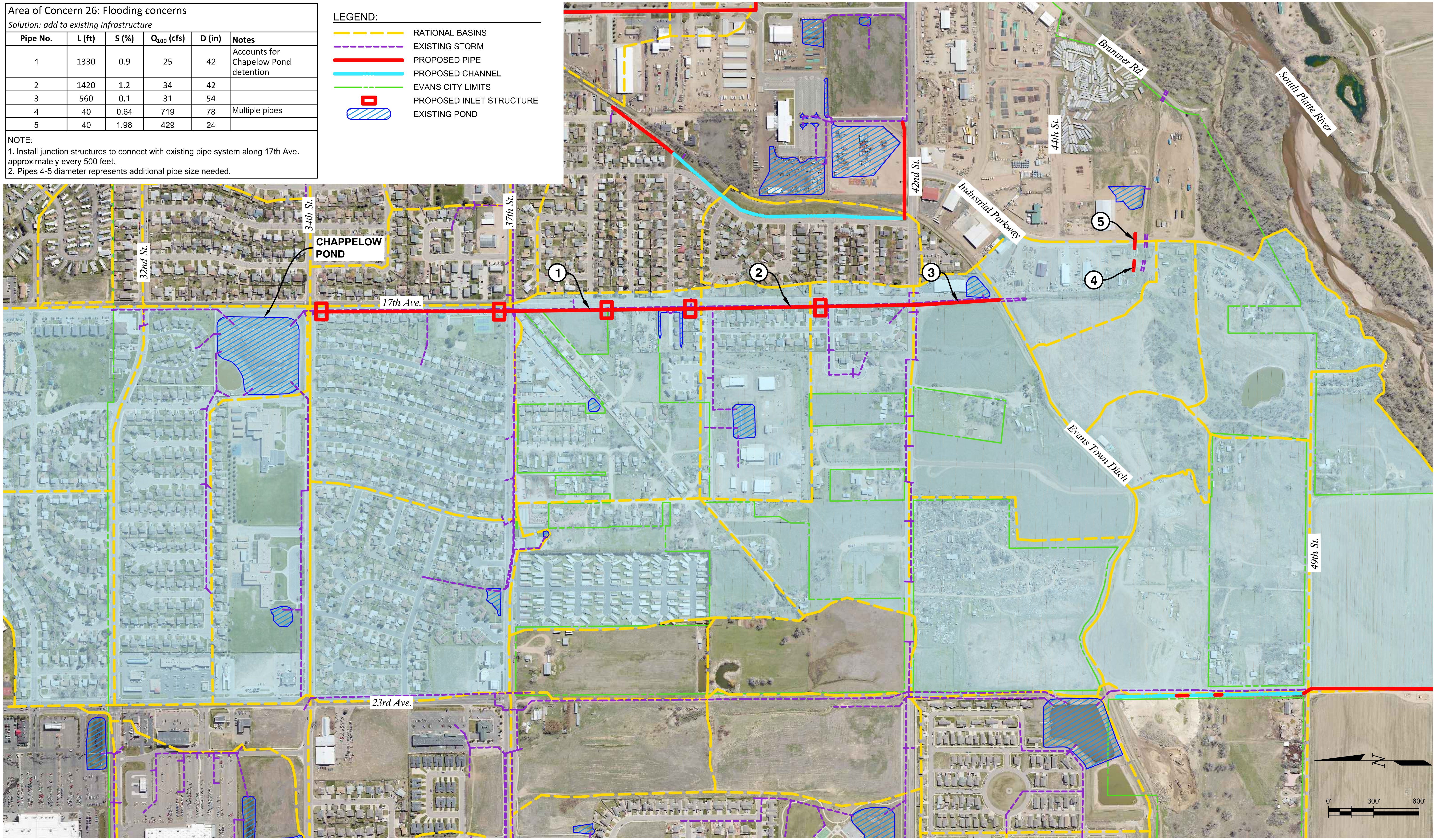
Area of Concern 26: Flooding concerns

Solution: add to existing infrastructure

Pipe No.	L (ft)	S (%)	Q_{100} (cfs)	D (in)	Notes
1	1330	0.9	25	42	Accounts for Chapelow Pond detention
2	1420	1.2	34	42	
3	560	0.1	31	54	
4	40	0.64	719	78	Multiple pipes
5	40	1.98	429	24	

NOTE:
1. Install junction structures to connect with existing pipe system along 17th Ave. approximately every 500 feet.
2. Pipes 4-5 diameter represents additional pipe size needed.

LEGEND:
- RATIONAL BASINS
- EXISTING STORM
- PROPOSED PIPE
- PROPOSED CHANNEL
- EVANS CITY LIMITS
- PROPOSED INLET STRUCTURE
- EXISTING POND



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NO.	DATE	DESCRIPTION	BY

MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

City of Evans, Colorado

CITY OF EVANS STORMWATER ALTERNATIVES

AREA OF CONCERN 26
INDUSTRIAL PARKWAY

DATE: NOV 2016

DRAWING NO.

PAGE NO. AC26-1

6.27 Area of Concern #26 – 17th Avenue to Industrial Parkway

This point of concern is located along Industrial Parkway 656 feet south of 44th Street. Here, an open channel crosses the road through a culvert. The area draining to this point, via the channel and overland flow from the south, is 764 acres and is comprised of 20 sub-basins. The northern boundary of the Industrial Parkway drainage basin cuts through the building and parking lots of the Greeley Mall, between US Hwy 34 and 30th Street. It is bounded to the west by 23rd Avenue and to the east by 17th Avenue until the basin crosses Evans Town Ditch. South of the ditch, the basin is bounded to the east by Industrial Parkway. At 49th Street, the basin extends further west, to the edge of agricultural and pastoral fields (0.57 miles west of 23rd Avenue at its widest point). The southern-most 207 acres lie within the South Platte floodplain. South of 42nd Street, the basin's land use is primarily vegetated open space; about 18 acres of light commercial area exist in the east, next to Industrial Parkway. The section of basin between 30th Street and 42nd Street is mostly single-family residential lots, with several large parks interspersed. The northernmost sub-basin is commercial land, and overlies the Greeley Mall. The sub-basins' impervious values range between 5.7% and 80.3%; the drainage area has an overall 38.1% imperviousness. All of the sub-basins have primarily group Type A soils, though there are several small areas containing Type B or Type D soils.

At 29th Street Road, the 17th Avenue storm sewer starts with a 24" diameter. This increases to 36" at 30th Street, when a 27" pipeline, conveying the runoff from the Greeley Mall, discharges into the system. Several neighborhood collector pipes also discharge to the 17th Street sewer, which increases to 48" by the time it reaches the north border of the UGA. After crossing this border, the pipeline increases to a 60" diameter and continues south for 0.15 miles until it discharges into the Chappelow detention pond. The outlet to the pond, which receives flow from the neighborhoods east of it and west of 23rd Avenue as well, has a 36" outlet pipe. The pipe decreases in diameter to a 24" pipe until the intersection of 17th Avenue and 37th Street. Here, a 24" pipe, with collected stormwater from the sub-basins bounded by 24th Avenue and 30th Street, discharges in the 17th Street storm sewer. The storm sewer has an increased diameter of 30" for 400 feet and then increases to a 36" diameter. After crossing 40th Street, the diameter of the pipe increases again to 48", and at 41st Street it becomes a 60" pipe. It remains a 60" pipe until it crosses the Evans Town Ditch and discharges into the open channel 375 feet west of Industrial Parkway. The channel has a bottom width ranging between 3 and 4 feet, a depth of 4 feet, and side slopes varying from 2.3:1 (H:V) and 6.9:1 (H:V). It continues south from 17th Avenue for 675 feet until turning east through a curve with a radius of approximately 200 feet.

A series of culverts take it under an unpaved access road, under Industrial Parkway, and under Brantner Road. The culvert under the access road has a diameter of 36" and a capacity of 53.4 cfs. Two culverts convey the flow under Industrial Parkway; these have diameters of 48" and 42" and full-flow capacities of 202 cfs and 142 cfs, respectively. Finally, the two culverts under Brantner Road have diameters of 48" and 60", and capacities of 157 cfs and 285 cfs, respectively.

The concern for the area is two-fold. First, the culverts under the access road, Industrial Parkway, and Brantner Road are undersized. As it backs up, the channel overflows into the commercial lot and onto Industrial Parkway. Secondly, the SWMM analysis indicated that the storm sewer system along 17th Avenue is undersized, particularly because not all sections of the roadway provide good street capacity. Predicted flow rates within the drainage basin, when detention is not included in the analysis, are listed in Table 6-33.

Table 6-33: Area of Concern #26 Flow Rates

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
34th Street and 17th Avenue	351.8	303.6	216.0	189.0	144.8
37th Street and 17th Avenue	421.8	362.5	257.6	224.4	171.7
42nd Street and 17th Avenue	586.2	502.3	354.3	305.3	229.9
Industrial Parkway	722.0	613.4	426.7	358.2	260.3

While drainage report data is not available for the Chappelow detention pond, the size and slope of the outlet structure is known, and it is estimated that a peak flow rate of 50 cfs is possible from the pond. Using that rate for each of the design storms at the pond outlet, the downstream flow rates were re-evaluated assuming proper functioning of the Chappelow detention pond. The resulting flow rates are listed in Table 6-34.

Table 6-34: Area of Concern #26 Flow Rates (with detention)

Location	Flow Rate (cfs)				
	100-Year	50-Year	25-Year	10-Year	5-Year
34th Street and 17th Avenue	351.8	303.6	216.0	189.0	144.8
37th Street and 17th Avenue	50.0	50.0	50.0	50.0	50.0
42nd Street and 17th Avenue	214.5	189.8	146.8	130.9	108.2
Industrial Parkway	350.2	300.9	219.2	183.7	138.7

Instead of replacing the existing pipeline under 17th Avenue, a second system is recommended to carry the additional flow predicted from the hydrologic analysis. To connect it with the existing system, junction boxes are recommended every 500 to 1000 feet along its length. Between 32nd and 42nd Avenue, five to 10 junction boxes would be required. The required pipe sizes vary along 17th Avenue and depend on whether the Chappelow detention pond can be relied upon to attenuate the design flows. Table 6-35 shows the required pipe sizes for each case. These take into account street capacities for the major and minor storm where it is permitted by curb-and-gutter and back slopes.

Table 6-35: Area #26 Required Infrastructure

Location (along 17th Ave.)	Required (Additional) Pipe Diameter	
	Without Detention	With Detention
30th St. to 34th St.	48”	n/a
34th St. to 37th St.	72”	42”
37th St. to 42nd St.	78”	42”
42nd St. to Outlet	108”	54”

The required pipe decreases south of 34th St. in the case of the functioning detention pond because of the reduced flow rate from the Chappelow pond. Whether the Chappelow detention pond is working as designed should be verified by the City prior to implementing the proposed changes. If it is to be relied upon in the stormwater master plan, the City should develop a maintenance plan and verify through annual inspections that the pond continues to function correctly, if these steps have not already been taken. The City should also consider that it is important to have an overflow path for the stormwater in the event the outlet structure is not function. While 17th Avenue does provide this route, it can be helpful to have a more defined conveyance in place.

Along the channel, the culverts under the access road for the property located just west of Industrial Parkway, south of Evans Town Ditch, are undersized whether Chappelow detention is included in the flow routing or not. If upstream detention is considered, the culvert must have an equivalent additional diameter of 78”. If not, the pipe must have a 102” equivalent diameter. As an alternative, this crossing could be sized for the 10-year storm with overtopping protection during larger events.

The additional equivalent diameter required at the Industrial Parkway crossing is 24” when the Chappelow detention pond is considered and 72” when it is not.

Finally, the existing diameter of the Brantner Road crossing is adequate to convey the major storm only if the Chappelow detention pond functions as modeled. Otherwise, an additional culvert of 72” equivalent diameter is required to pass the stormwater under the roadway. In some of these locations the City may be willing to protect the road and let the flows pond and spill over

Improvements to the channel itself include placing riprap protection at the curve along its outside bend. The riprap should have a D50 of 12 inches. Prior to the bend, the channel has adequate capacity to convey the 100-year flow for both detention scenarios. Immediately after crossing Industrial Parkway, however, the channel has a reduced depth of 4 feet and a reduced capacity of 233 cfs. The required channel improvements include:

- Ensuring the channel has a minimum bottom width of 6 feet
- Lowering the invert by 2.0 feet to ensure a channel depth of 6 feet, which allows for 1.2 feet of freeboard during the major storm
- Restoration of the side slopes such that they have 4:1 (H:V) slope on either side of the channel

Due to the amount of development in the upper part of the basin, an open channel option has not been included.

A cost estimate has been prepared for the suggested improvements for Industrial Parkway. It is assumed that the Chappelow detention pond is working as designed, and it is therefore recommended that this pond is inspected and its function is verified or improved upon in conjunction with these improvement recommendations. The estimated capital is $2,088,771. Maintenance costs are estimated to be $1,544 per year, not including any necessary pond maintenance necessary within the basin.

Resiliency for the Industrial Parkway project is important due to its proximity to the River as well as Evans Town Ditch. By safely transporting the flows across Evans Town Ditch we are keeping downstream facilities from flooding. In addition, by upsizing the pipes and providing conveyance under the roads we are protecting the roadway infrastructure.

RECOMMENDATIONS SUMMARY	✓ **Add a second stormsewer line under 17th Avenue that is 42” between 34th Street and 42nd Street and 58” between 42nd Street and the outlet** ✓ **Add culverts under the Evans Town Ditch access road (78” equivalent) and Industrial Parkway (24” equivalent)** ✓ **Ensure that Chappelow Detention Pond is properly maintained, including frequent mowing, and functions efficiently to detain the 100-year design storm**

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL DRAINAGE BASIN

PROJECT :	City of Evans Stormwater Management Plan
DRAINAGE BASIN :	Area of Concern 26
ALTERNATIVE :	1
JURISDICTION :	Evans
SUB-BASIN ID:	Industrial Parkway-Reach26
DATE :	5/2/2016

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	**Length (ft)**	**No. of Barrels**				
48-inch	2330	1	2330	L.F.	$185.00	$431,050.00
30-inch	1330	1	1330	L.F.	$116.00	$154,280.00
30-inch	1420	1	1420	L.F.	$116.00	$164,720.00
48-inch	560	1	560	L.F.	$185.00	$103,600.00
48-inch	40	1	40	L.F.	$185.00	$7,400.00
54-inch	40	1	40	L.F.	$277.00	$11,080.00
72-inch	40	1	40	L.F.	$462.00	$18,480.00
72-inch	40	1	40	L.F.	$462.00	$18,480.00
Flare End Sections						
Diameter (in)	**Applicable**	**No. of Barrels**				
48-inch	Yes	1	1	EA	$2,646.00	$2,646.00
48-inch	Yes	1	1	EA	$2,646.00	$2,646.00
48-inch	Yes	1	1	EA	$2,646.00	$2,646.00
Headwalls						
Diameter (in)	**Applicable**	**No. of Barrels**				
54-inch	Yes	1	2	EA	$1,843.52	$3,687.00
72-inch	Yes	1	2	EA	$2,467.35	$4,935.00
72-inch	Yes	1	2	EA	$2,467.35	$4,935.00
Wingwalls (includes concrete apron)						
Diameter (in)		**No. of Barrels**				
54-inch		1	2	EA	$11,271.99	$22,544.00
72-inch		1	2	EA	$14,907.48	$29,815.00
72-inch		1	2	EA	$14,907.48	$29,815.00
Manholes and Inlets						
Type P Manhole (Pipe Dia. 48" and larger, deflection > 10 degrees)			6	EA	$19,271.00	$115,626.00
Channel Improvements						
12-inch Riprap, Type M			370	C.Y.	$77.00	$28,519.00

Master Plan Capital Improvement Cost Summary

Capital Improvement Costs			
Pipe Culverts and Storm Drains			$1,128,385.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$28,519.00
Detention/Water Quality Facilities			$0.00
Removals			$0.00
Landscaping and Maintenance Improvements			$0.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$1,156,904.00**
Additional Capital Improvement Costs			
Dewatering	$20,000.00	L.S.	$20,000.00
Mobilization	5%		$57,845.00
Traffic Control	$30,000.00	L.S.	$30,000.00
Utility Coordination/Relocation	$25,000.00	L.S.	$25,000.00
Stormwater Management/Erosion Control	5%		$57,845.00
Subtotal Additional Capital Improvement Costs			**$190,690.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$202,139.00
Legal/Administrative	5%		$67,380.00
Contract Admin/Construction Management	10%		$134,759.00
Contingency	25%		$336,899.00
Subtotal Other Costs			**$741,177.00**
Total Capital Improvement Costs			**$2,088,771.00**

Master Plan Operation and Maintenance Cost Summary

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Culvert Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	5800	L.F.	$1.00	$1,160.00
Manhole and Inlet Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	6	EA	$64.00	$384.00
Total Annual Operation and Maintenance Cost				**$1,544.00**
Effective Interest Rate				0.00%
Total Operation and Maintenance Costs Over 50 Years				**$77,200.00**

6.28 CUHP/SWMM Proposed Infrastructure Results

The proposed changes for the areas of concern were incorporated into a new CUHP/SWMM model to analyze the effects of the improvements on the overall City infrastructure. Many of the proposed changes are on too small of a scale to affect the SWMM model. Therefore, only those changes that affect Evans' major infrastructure were included in the updated model. Figure C-3, in Appendix C, shows the SWMM schematic for the current infrastructure in Evans. This model was used for the proposed infrastructure layout as well, with several changes to conduit connections and contributing basins. In several cases, including the east 37th Street drainage area, drainage basins were split. All basin properties were updated in CUHP. The model changes include:

- Area #9 pipe replacement under 37th Street and pipe installment under 34th and 39th Streets
- Channel improvements along 31st Street and pipe replacement at the intersection of 31st Street and the railroad
- The re-grading of Railroad Pond and rerouting stormwater from the Hwy 85 corridor into the pond
- Area #4 pipe addition to re-route stormwater south
- Adding pipe along 17th Avenue

The model was then run for all design storms. More detailed results are included in Appendix D of this report. Flooding was reduced in the 100-year model. Many of the same conduits are surcharged within the model. Of those, most are within systems that have been designed with street capacities in mind. Those that do not rely on street capacity or that exceed the street capacity are:

- The system along 37th Street continues to flood in the 100-year model. However, even with the improvements listed in this report it is not expected to be a 100-year system.
- The roadside ditch just upstream of the 31st Street channel, along the border of the Evans UGA and Greeley still floods. This area is Area of Concern #2, and should be addressed in collaboration with Greeley and CDOT during the re-design of the US Hwy 34 and US Hwy 85 intersection.

In addition to the street flow, several areas in the CUHP/SWMM model produced more runoff than expected through Rational calculation results. This is primarily due to the larger basin sizes and coarser resolution of the stormwater infrastructure. When the proposed improvements shown with this Management Plan are installed, the City will have a system which functions more efficiently. It also provides a safer system for the residents with less of a risk of flooding. The plan also helps the City identify areas that may need attention after major storm events.

7 OPERATIONS AND MAINTENANCE

Ongoing operations and maintenance are two critical aspects of the recommended management plan. Adequate and regular maintenance will reduce costs of the stormwater system in the long term by extending the life of the infrastructure, maintain water quality treatment integrity, and prevent infrastructure failure and flooding. All aspects of the Evans Stormwater System, including the improvements recommended in this report, the existing infrastructure, and systems that will be installed to convey stormwater from future developments should be included in Evans' stormwater maintenance plan. As part of this plan, infrastructure should be inspected regularly and repaired as-necessary to ensure that the systems remain functional.

Maintenance responsibilities and access should be considered with the design of all stormwater infrastructure. Effective maintenance allows stormwater infrastructure to function as designed; neglecting maintenance may cause localized flooding, unsightly and pest-infested ponding, and more costly repairs to existing infrastructure. Activities include both routine, preventative measures and as-needed repairs. Specific maintenance considerations depend on the type of infrastructure, its location, and surrounding development. General recommendations are outlined here and are in the updated Evans Stormwater Criteria Manual.

During inspections of detention ponds and swales, the city should verify the entrances and outlets are functioning properly and remain unclogged, that scouring has not occurred at or near the site, and that the healthy vegetation covers the intended limits. Debris removal and mowing should be performed at least three times per year or as-needed. Additional inspections should be performed after significant storm events.

Storm sewers, manholes, and other junction structures should be inspected annually and after major storm events for debris and signs of failure. Repairs and debris removal should be performed on an as-needed basis. More frequent inspections should be completed in the area(s) involving a pump station or siphon.

Green infrastructure should be inspected for the items listed for detention ponds and swales, but also for effective infiltration. Porous media, like sand or permeable pavers, and vegetation will require periodic replacement to remove pollutants and debris, and to ensure continued efficient infiltration. They should be observed annually and after storm events to unsure they are draining and/or infiltrating within the designed time.

7.1 Maintenance Costs and Assumptions

The items considered in the detailed maintenance cost analyses in this report include only the infrastructure that is new or replaced. The existing inlets – for example – along a pipeline, to which a new pipeline is connected, are therefore not included in the costs for each area of concern. Nor is connected infrastructure upstream or downstream of the improvements included in these costs. The Urban Drainage Cost Estimator for Master Planning (UD-MP Cost) spreadsheet (version 2.2) was used to estimate the maintenance costs of the alternatives.

- Maintenance costs for the alternatives presented in this report assume an annual cleaning and inspection, although additional inspections and cleanings may become necessary after large storms.
- Mowing was included for alternatives with channels and ponds; the mowed area is assumed to be the top width of the channel area multiplied by the length of channel, or the area of the pond. Additional or alternative techniques, such as weed whacking, may be required to trim back vegetation in some areas, particularly those on steep slopes.
- Pipe maintenance was accounted for in the spreadsheet under the category of "Culvert Maintenance", which involves sediment and debris removal, correcting erosion at entrance and exit points, and structural repairs. It was assumed that pipe maintenance would be necessary every three years.
- Maintenance of inlets and manholes was assumed to be necessary once every year and includes sediment and debris removal and structural repairs.
- Channel maintenance includes sediment and debris removal, repairing erosion, and tree and weed removal. It was assumed that these and at least one regular inspection to determine necessary actions be performed per year. Additional inspections should be made after large storm events to determine if and when additional maintenance is required.

A general maintenance cost estimate is provided for the existing infrastructure. This was determined by summing the infrastructure lengths within the provided GIS shapefiles at the time of this plan and assuming maintenance frequencies consistent with those in the proposed infrastructure cost analyses.

7.2 July 2016 MS4 Compliance Requirements

The purpose of the municipal separate storm sewer system (MS4) permit is to protect receiving waters from pollutants that collect in urban environments, and thus preserve them for recreational activities, wildlife habitat, and as a drinking water source. It is just a part of the Colorado Stormwater Program established to address water quality impairments identified through the National Pollution Discharge Program (NPDES).

Between the St. Vrain Creek confluence with the South Platte to the Weld and Morgan County line boundary, the South Platte River is impaired by *E. coli*, dissolved manganese, and total arsenic. This section of the river is designated for agricultural use, aquatic habitat, recreation and water supply; however, the water quality impedes its use for recreation and water supply. Of the contaminants, *E. coli* has the highest priority for removal. *E. coli* is an indicator organism that indicates the presence of other pathogens in the water. It is introduced into the water system through livestock, pet, and wildlife waste, usually as non-point source pollution. Good management practices for agricultural waste storage and treatment and the method and timing of manure application will reduce the concentrations of *E. coli* reaching the river.

The current MS4 permit requires the development of a city-wide stormwater plan, referred to in the document as a Project Description Document (PDD). This document is meant to outline measurable goals and plans to implement BMPs or other stormwater management controls. The document should include a strategy for operations and maintenance.

In addition to the document, the Phase II MS4 permit requires adherence to six minimum control measures (MCMs):

- Public education and outreach on stormwater impacts
- Public involvement and participation
- Detection and elimination of illicit connections and discharge
- Construction site stormwater management
- Post-construction stormwater management in new development and redevelopment
- Pollution prevention and good housekeeping

Good housekeeping can include the development and execution of a general O&M manual that incorporates street sweeping and regular repair, storm drain maintenance, and park maintenance. Specific targeted activities that reduce pollutant loads into the stormwater system may also be included. A key component is the management of pollutant point sources such as large truck or bus lots, waste management facilities, golf courses, and areas where herbicides or insecticides are used. Actions such as pet waste pick up stations in parks, employee training, and public outreach are all common items added to a good housekeeping plan.

In recent years, the EPA has increased their emphasis on reducing stormwater runoff volumes as well as improving water quality. While it is currently only afforded a brief mention within Phase 1 MS4 permits and not applicable to Evans, it would be prudent to incorporate stormwater attenuation BMPs proactively, particularly since they have so many additional benefits in addition to providing permit compliance.

7.3 Operations and Maintenance Prioritization

Maintenance activities are listed and described for each major type of stormwater infrastructure: pipes, channels, and detention facilities. Table 7-1 summarizes the maintenance recommendations and provides suggested prioritizations, both for specific actions and attention to major infrastructure categories.

Table 7-1: Maintenance Itemization and Prioritization Recommendations

PIPE			CHANNEL			DETENTION FACILITIES		
Overall Ranking:		*3*	*Overall Ranking:*		*1*	*Overall Ranking:*		*5*
DESCRIPTION	FREQ.	RANK	DESCRIPTION	FREQ.	RANK	DESCRIPTION	FREQ.	RANK
Inspection of manholes, inlets, and outlets	1 p year	5	Site inspection	1 p year	5	Site inspection	3 p year	5
			Mowing/ Weed Wacker	3 p year	4	Mowing	3 p year	4
Sediment and debris removal of inlets & outlets	1 p year	4	Noxious weed control	1 p year	1	Noxious weed control	1 p year	1
			Debris and trash removal	3 p year	2	Debris and trash removal	2 p year	3
			Sediment removal	0.3 p year	3	Sediment removal	0.3 p year	3
Sediment and debris removal of pipe (Jet Vac)	0.2 p year	1	Vegetation	AN		Vegetation	AN	
			Tree removal	AN		Outlet structure (including weir) maintenance	AN	
Inspection of pipe	AN		Pest control	AN				
						Clean up of forebays and other facilities	AN	
Removal of tree roots	AN							
						Tree removal	AN	
Street sweeping	AN					Pest control	AN	

p = per; AN = As Needed

Recognizing that resources are limited and that stormwater is only one aspect of City Staff responsibilities, many of the activities are recommended to be performed as needed, determined during the inspections of infrastructure. One consequence of this is that much of the maintenance will be completed in a reactionary manner. Ideally, inspections will reveal when issues are developing such that the City may prepare in advance for the upcoming maintenance needs.

Pipes should be inspected for dents, blockage, and rust. CMP pipes should be inspected more frequently than shown in the table as they are more prone to these issues. Additionally, pipes should be cleaned out when sediment and debris reaches or exceeds 25% of the pipe volume. Site inspections of channels and detention facilities should include attention to erosion and sediment at the outlets, vegetation, erosion and scouring, access routes, and pond of water for greater than 72 hours.

Rankings of the individual maintenance activities were determined such that items of higher priority, if performed successfully, should minimize the need for other maintenance actions in this table. The recommended attention to be given to each individual maintenance activity, both in time and in budget, is reflected in their rankings. The priorities designated to each of the individual maintenance items should be interpreted as the shown in Table 7-2:

Table 7-2: M&O Priority Scale Definition

RANK	DEFINITION
5	Has a designated budget, is completed regularly and on a fixed schedule
4	Has a designated budget, is completed semi-regularly as feasible
3	Has a designated budget, is completed when inspection deems necessary
2	Budget actively procured when inspection deems it necessary
1	Completed when budget is available and when inspection deems it necessary

Detention facilities are given a higher overall priority than channels and pipes due to their impact on these latter structures: when the detention is functioning as designed, the pipes and channels downstream are more likely to be able to function properly if they are properly designed. Pipes are given a higher priority than channels because they can have larger impacts to infrastructure upstream and downstream. In addition, most of the City's main conveyances are pipes; therefore, they have a disproportionate importance to the City's infrastructure.

7.4 Estimated Work Hours and Budget

A formal maintenance plan that includes the recommendations listed in Section 8.3 will require a dedicated budget and employee base. For this report, both the budget and work hour estimates were generated using the GIS dataset of stormwater infrastructure provided by the City. The budget required was estimated by using the UD-Cost estimating spreadsheet used to for the areas of concern. A total of $305,000 is expected to be incurred on a yearly basis to perform basic maintenance on current infrastructure.

To estimate the work hours, the time required to perform each task was estimated and multiplied by its frequency and the amount of corresponding infrastructure in Evans. It was assumed that each employee works a 40 hour week. Four full-time employees are expected to be necessary to achieve the maintenance work each year. However, because most of the maintenance activities are relevant only during the summer, it is likely that more employees will need to be utilized between May and September, while fewer will be necessary in other months.

7.5 City Accountability Measures

In addition to identifying the maintenance requirements, the City should identify the responsible party, especially in new developments, which will be required to release stormwater at the historic release rate. Even when the City is not directly responsible for the infrastructure, annual or seasonal inspections should be arranged. Per the MS4 criteria, Evans is ultimately responsible since they hold the permit.

For this reason, it is recommended that Evans develop a city-wide and consistent operations and maintenance policy. The EPA has identified from a series of case studies six elements that make such policies successful (EPA 2013):

- Accountability mechanisms such as an O&M plan or manual
- Documentation and tracking systems
- Vehicles for compliance assurance (maintenance agreements or local ordinances)
- Training and education
- Partnerships (with contractors, private landowners, etc.)
- Dedicated funding source(s) (including municipal or district general funds and stormwater utility fees)

The first of these can be informed by a City document with maintenance guidelines, but each development should include its own manual for stormwater infrastructure maintenance. The City should review and provide any necessary comments prior to approval. At a minimum, the document should include clear identification of the responsible party, all general and structure-specific maintenance activities, and a schedule that identifies the frequencies at which they will occur.

Documenting the execution of the maintenance assures the City that the stormwater infrastructure is functioning properly or receiving attention before becoming unproductive. The maintenance of developer-maintained infrastructure should be documented by the responsible parties and made available to the City when requested or immediately, as the City prefers. It is an MS4 permit requirement that the City track and keep records of maintenance. In addition, compliance measures should be outlined in the agreements made with private entities. Such language should describe the policies for inspection of the infrastructure, the measures to be taken if the structure is not operating to specified standards, and reporting.

It is important that the facilitators are aware of the best maintenance practices and the design of the system to keep them in working order. Additionally, if Evans wishes to incorporate green infrastructure and other BMPs into their stormwater management planning, it is important to train developers in green infrastructure options, limitations, and maintenance requirements. This will encourage developers to use green infrastructure where it may be beneficial and to use alternative management methods in areas where the former would not be effective. Stormwater quality can be improved by providing educational resources to residents about the gutter function and the importance of not disposing litter, soaps, and fertilizers into sewers. This could be especially beneficial to Evans, since a large number of residences farm on their property and in many older areas these properties drain directly to the street. If fertilizers are used, these could be an avoidable source of nonpoint source stormwater pollution.

Establishing partnerships with contractors that can assist with maintenance activities can benefit Evans, whose maintenance team may not have the equipment or resources necessary to perform all the recommended maintenance activities on City-owned infrastructure. Funding sources are addressed in section 10 of this report.

In its 2013 document, *The Importance of Operation and Maintenance for the Long-Term Success of Green Infrastructure*, the EPA identifies cities or organizations that have implemented one or more of these policy elements. For example, Spokane, WA has implemented an electronic record-keeping system that allows for all maintenance activities to be recorded in a GIS-based platform from the field (via laptops). This lets the City monitor maintenance frequencies, costs, staff time, and the effectiveness of green infrastructure. The EcoCenter at Heron's Head Park in San Francisco, CA has an effective operations and maintenance plan that includes proper procedures and schedule as well as log sheets for record-keeping. The plans in the two examples here are for very different management areas and are therefore organized in different ways. However, both incorporate at least some of the six elements previously listed and are used to actively evaluate and respond quickly to stormwater management needs.

In addition to the plans referenced in the EPA report, the City of Evans may also reference the City of Golden's *Stormwater Drainage Maintenance Plan*, which was last revised in August 2015. This plan specifies the number of inlets, outlets, and manholes within Golden, the total lengths of pipe and channel within the city, and the required maintenance tasks and frequencies. It also states that privately owned infrastructure which receives city stormwater must be maintained and be subjected to inspection by the city. The document itself is an accountability mechanism (the first of the six elements) and the inspections are a vehicle for compliance. It does not detail how maintenance activities will be tracked.

7.6 The Importance of Maintenance

It is critical that stormwater infrastructure is maintained and functions as designed. Any structure will only function efficiently to convey or detain stormwater when it is clear of debris and blockages. Additionally, BMPs which function to improve water quality will only do so if they are frequently cleaned and removed of accumulated pollutants. An unmaintained BMP structure may cause the water quality to further deteriorate, as it may potentially become a source of collected pollutants. Proper and frequent maintenance to even non-BMP infrastructure helps to ensure that their capacities do not decrease, which could cause both flooding and deteriorated water quality.

As a storm progresses, the early rainfall becomes runoff and collects the pollutants sitting in gutters and on surfaces during the time since the previous runoff-producing storm. This first wave of runoff develops particularly high concentrations of pollutants compared with flow from the remainder of the storm. It is for this reason that there is an emphasis on treating the water quality capture volume (WQCV) when designing BMPs. When infrastructure for stormwater conveyance or detention is undersized due to land development or improper maintenance, stormwater will overflow from these structures. Higher concentrations of pollutants are introduced into the system in several ways, including:

- Since the runoff is now flowing over adjacent areas at higher flowrates, there is an additional pollutant load introduced into the stormwater system and the natural water body at the discharge point, as debris that would have remained within residential or commercial lots is swept up into the channelized flow.
- If there is detention downstream of the flooding, the pollutants from stormwater that by-pass the undersized system will not settle and be removed as designed. If the system is very undersized, there could be treatment from infiltration BMPs that are bypassed as well.
- Uncontrolled flow may also cause erosion in areas that were not meant to be conveyance structures. This would increase concentrations of TSS and of any pollutants adsorbed to the soil into the waterways.

Undersized or unmaintained infrastructure can become a public health hazard as well. Stormwater overflow may also collect in sumps within developed areas, creating islands of still water that attract mosquitos and pathogens. Erosion and street or sidewalk damage may be a safety risk to residents.

8 PROJECT PRIORITIZATION

The improvements recommended for the Evans stormwater system address many concerns and cover multiple acres. Changes in the stormwater infrastructure and management policy will occur amidst other City projects and its usual operations. Therefore, there is neither the budget nor the time to address all recommendations at once. Project priorities are established in this report for Evans' consideration. They were determined using a Weighted Sum Model (WSM), which is the most common approach to Multi-Criterion Decision Analysis (MCDA).

8.1 Criteria Selection and Weighting

In this type of analysis, the alternatives are evaluated on the basis of a common set of pre-determined criteria. Any number of criteria can be used, and the analysis is most beneficial when the chosen criteria represent a variety of stakeholders. Table E-1 (in Appendix E) lists the criteria chosen for the analysis of the improvements recommended. The stakeholders and interests taken into account by these criteria include:

- **City residents**, via the flooding risk posed by the currently undersized or ill-functioning infrastructure
- **City taxpayers** and other financiers, via the cost of the project and alternative payment options
- **City planners**, via the consideration of easements required
- **Motorists** and commuters, via the construction impact of the alternatives to roads
- **Environmentalists**, via the potential improvement to water quality (this criteria also represents the City, which is obligated by its MS4 permit to make water quality improvements, and to City residents who benefit from improved water quality)

Several of the criteria take related factors into account but have conflicting ranking scales. For instance, high-cost projects are given low priority ranking while severely undersized systems are given a high priority ranking. Although the two are correlated – generally, a more undersized system will cost more to renovate – the criteria represent two real competing interests: to fix the most unreliable systems and to delay costs to a future date. Similarly, several criteria that are based on related factors are ranked with similar scales, and may therefore seem to double-count a feature of an area in the rankings. For instance, the more developed an area is, the higher the risk to existing structures *and* the less likely it is to be included in future development plans. Both of these are criteria are included in the analysis. These criteria, which rely on the same input feature, are weighted differently in several iterations of the analysis. Therefore, they truly represent two (or more) different attributes of the area of concern.

In MCDA analyses, criteria can be assigned different weights to show that different decision factors are more important to stakeholders than others. In this analysis, three different sets of criteria weighting were applied, corresponding to three main groupings of stakeholders. Thus, three separate analyses were performed. The criteria weighting groups are:

- **Weighting Group 1**: in this analysis, all criteria are given a weight of one, such that all factors contribute to the decision equally
- **Weighting Group 2**: in this cost-based analysis, the cost and payment options of the projects, the easements required, and the impact to other structures are given heavier weights than those for other criteria
- **Weighting Group 3**: this analysis is risk-based, and places higher weights on the impact to other structures and the flooding risks

8.2 Descriptions and Assignment of Individual Rankings

In determining the qualitative and quantitative descriptions of each area of concern, information represented in GIS was used, including 1-foot contours, existing stormwater infrastructure, street locations and types, and zoning information. In Areas of Concern where two alternatives are presented, the higher cost option is chosen as that for the MCDA analysis.

The area affected by conduit overflows that are listed in the table used to quantify the prioritization of concerns was determined using the 1-foot contours. The most likely flow path after over-flowing from the existing infrastructure was identified. In several cases, this was a relatively narrow channelized path; for other areas it was a wide path that did not have a definite outlet point. The area was extended until the contours began increasing again or until a natural barrier (such as a large structure) blocked the flow path. The depth of water along the flow path was not calculated; in nearly all cases, the flow disperses and both the depth and velocity will continue to decrease with increased distance from the overflow point. The area is approximate only, and does not assure that the overflow stormwater would not extend further or completely inundate the estimated area.

Area of Concern #9 is a unique case that does not fit into the structure of the prioritization analysis well. Due to physical constraints within the system, the full 100-year runoff is not contained in the primary alternative. Attempts are made to mitigate flooding by the diversion of runoff within the basin to secondary systems. The improvements to Area #9 therefore are interdependent on the solutions chosen for contributing basins (including Areas #4, #11, #13, #14, and #15). These smaller areas are included in the prioritization analysis as separate entities, but will realistically be part of a phased approach to reducing flooding on 37th Street.

8.3 Analysis Results

Table D-2 shows the qualitative descriptions and rankings for each criterion for all areas of concern. Table D-3 describes the scales used to assign the rankings; for the quantitative criteria, these are straightforward scales. For the more qualitative criteria, descriptions are provided and assignment of rankings requires somewhat more engineering judgement.

The rankings for each alternative-criteria pairing were multiplied by the criteria weight. All such products for each alternative were summed to obtain its overall score. The average score, which adjusts the overall score to a 1 -5 scale (except when criteria weighting was applied), was found by dividing the overall score by the number of criteria included in the analysis. A full listing of the scores is presented in Table D-4 and includes the results for each of the three criteria weighting sets. The scores were sorted in numerical order, and then assigned priority rankings. Many alternatives received the same score and therefore were assigned the same priority ranking. Priority rankings are included in Table 8-1.

Table 8-1: Summary of Priority Rankings

AREA	CONCERN	PRIORITY RANKINGS			
		Equal	Cost	Risk	Avg.
9	Undersized pipe at 37th and UPR	2	3	1	1
26	Undersized culverts south of ETD	1	1	3	2
16	Undersized inlets	6	5	3	3
15	Undersized pipe at 37th and Hwy 85	7	19	7	4
1	Undersized inlets	5	2	4	5
11	Outlet across Hwy 85 to 37th St.	3	2	6	6
3	No conveyance south of 49th St.	3	4	5	7
26	Undersized pipe along 23rd Ave.	5	8	2	8
22	No maintenance given to Cave Creek	3	3	14	9
19	Undersized culverts and sedimentation	3	5	13	10
24	Safety concern	6	6	9	10
18	Undersized culverts	4	7	11	11
17	Abandoned pond	5	12	6	12
6	Lack of infrastructure	6	9	10	13
8	Undersized pipe along 31st St.	7	14	6	14
7	Undersized pond outlet	6	10	12	15
8	Downstream channel sizing	7	11	9	15
4	Discharging to ETD	8	17	4	16
13	Undersized pipe across US Hwy 85	9	13	11	17
20	Undersized channel	9	9	16	18
21	No infrastructure to discharge point	9	11	15	19
5	Lack of pipe connection	10	10	18	20
9	Undersized pipe at 37th and 1st St	7	16	12	20
3	Undersized pipe north of 49th St.	6	15	15	21
25	Scouring channel	7	12	19	21
14	Undersized pipe along Center Ave	10	18	8	21
12	Lack of infrastructure	10	14	20	22
4	Undersized pipe along 15th Ave.	11	20	17	23

The table lists the results from each of the three sets of criteria weighting and the average ranking, as determined from averaging each area's three resultant scores (not shown). Using the average rankings, the areas of concern are listed in from highest priority, with a priority ranking of 1, to the lowest priority, with a priority ranking of 23. Two areas were given the same ranking if their scores were identical.

The top 5 priority areas are:

1. Area of Concern #9
2. Area of Concern #26
3. Area of Concern #16
4. Area of Concern #15
5. Area of Concern #1

As stated previously in the report, the area contributing flow to the dual pipe system along 37th Street forms one of the largest drainage basins in Evans. It is also one of the most developed and oldest drainage basins, and is very undersized. It is no surprise, therefore, that it is listed as the first priority for stormwater improvements. Moreover, Areas #15 and #16 are within or are associated with the contributing area of Area #9.

8.4 Implementation Timeframe

There were three different timeframes considered for this analysis:

- Near-Term : 0-3 years
- Medium-Term: 4-7 years
- Long-Term: 7+ years

The prioritization results were used to determine the recommended schedule of projects; however, several areas are listed as being a near or long term project based upon its reliance on stormwater improvements in another area of concern. In actuality, the phasing of the projects will also depend on funding opportunities and on the timing of land-use development in each area.

We recommend the following areas be included near-term projects:

- Pump station along 37th Street near the South Platte
- Area #9 (and #15) at 37th and UPRR: remove power pole and replace pipes
- Area #16: replace inlets and construct 34th Street pipe system
- Area #1: Increase the inlet sizes along Montego Bay

Medium term-projects are recommended to include the following areas:

- Area #26: add culverts or overflow pathway to the channel under Industrial Parkway
- Area #11 and #17: re-grade Railroad Pond and re-route the stormwater from the City building and surrounding area to the pond
- Area #3: extend the pipeline or construct a channel south of 49th Street to the South Platte River
- Area #24: replace the open structure to remove the falling hazard
- Area #8: initiate coordination with Greeley about the roadside ditch if not already done so
- Area #4: re-route stormwater from the ETD to a new pipeline along Carson Street

These lists embody the both the risk and relative ease associated with performing the improvements. Area #1 is included as a short-term project because the City had already acquired funding for improvements in this area. Other areas are listed to circumvent potential flooding in the most vulnerable areas. The remaining areas can be performed at a later date as funding becomes available.

9 FUNDING OPPORTUNITIES

Having funds dedicated to the upkeep of the stormwater system is critical to the flow of the maintenance framework. A city-wide stormwater fund is recommended to at least partially fulfill the budget requirements. Evans currently charges a flat residential stormwater utility rate of $4.30 per dwelling unit, and a commercial utility rate of $6.65 per 20,000 square feet. Figure 9-1 displays the residential monthly billing rates of several Colorado cities as compared to the current stormwater fee in Evans. When the rate was based upon area, an 8,600 square foot residential area (60% impervious) was assumed as this is was the 2015 average single-family residential lot size as reported by the US Census Bureau. Most cities use a rate system that is a function of the impervious land area of the lot. It is recommended that Evans evaluate and update their stormwater fee structure periodically to fund stormwater system improvement projects as they are addressed.

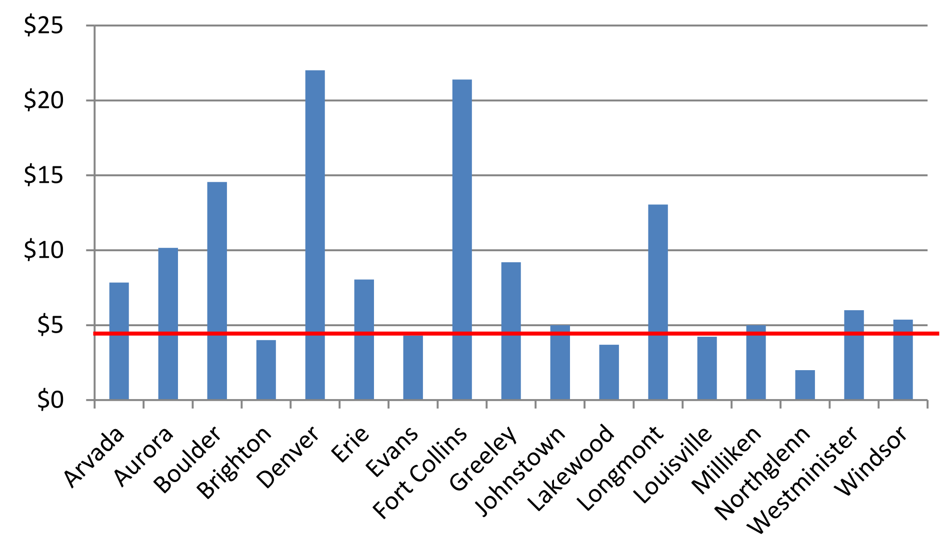


Figure 9-1: Single-Payer Monthly Stormwater Utility Rates in Colorado

There are other funding opportunities that can be explored by the City in addition to the stormwater utility rate. This report provides a summary of some of these potential sources. In general, most of these grants have a match requirement from the City, however each grant is slightly different. Unfortunately, the population of Evans has grown enough that they are no longer eligible for grants from the United States Department of Agriculture (USDA) Rural Development division. Additional information is available on the internet for each of these grants with requirements, deadlines and applications.

Community Development Block Grant – Disaster Recovery (CDBG-DR) from the Colorado Department of Local Affairs (DOLA)

The master planning project was partially funded with a CDBG-DR grant. The grant money was received from the US Department of Housing and Urban Development (HUD) for flood and fire recovery programs. There are three funding allocations planned. The third funding request allocation is expected to come out towards the end of 2016. The grant is specifically for Low to Moderate Income areas and there is a focus on providing resilient improvements. Examples of projects that might qualify for the grant would be the pump station along 37th Street and some of the infrastructure upgrades in the immediate vicinity (area of concern 9).

Colorado Department of Transportation Permanent Water Quality projects

The Colorado Department of Transportation (CDOT) contributes $6.5 million annually to a Permanent Water Quality (PWQ) Mitigation Pool to meet the requirements of their MS4 permit. The funds are used to construct PWQ control measures and BMPs that meet the design standards for stormwater treatment and mitigation for the area. The funds must be used to treat a portion of runoff from CDOT's MS4 area, defined as CDOT right-of-way within the MS4 boundary. They will request projects two times per year. Both US 34 and SH 85 are within the drainage areas for the master plan so any water quality projects which receive stormwater from these two roads are eligible. There are a few projects mentioned in this document that may be eligible for funding from CDOT, including the Railroad Pond (Area of Concern 16) and 31st Street (Area of Concern 8).

Colorado Department of Transportation Local Agency projects

CDOT provides federal funds to help with the construction of transportation facilities on major roads. At a minimum, we know that 37th Street and 1st Street are eligible for federal funds. While the funds are typically for road improvements, it also can include the infrastructure under the road. For 37th Street specifically, we know that the pipes are undersized which is causing more stormwater to run down the road. The flooded roads cause a safety hazard to the traveling public as well as emergency vehicles. The stormwater can also damage the roads and cause stormwater to spill to undesirable locations such as the residential neighborhoods south of 37th Street. Figure 9-2 shows the roads that qualify for FHWA funding (in red) and the roads that potentially qualify for FEMA funding (in blue). The map was obtained from CDOT's collection of online maps (C-Plan). Many of the major roads in Evans are eligible, including several listed as areas of concerns in this report.

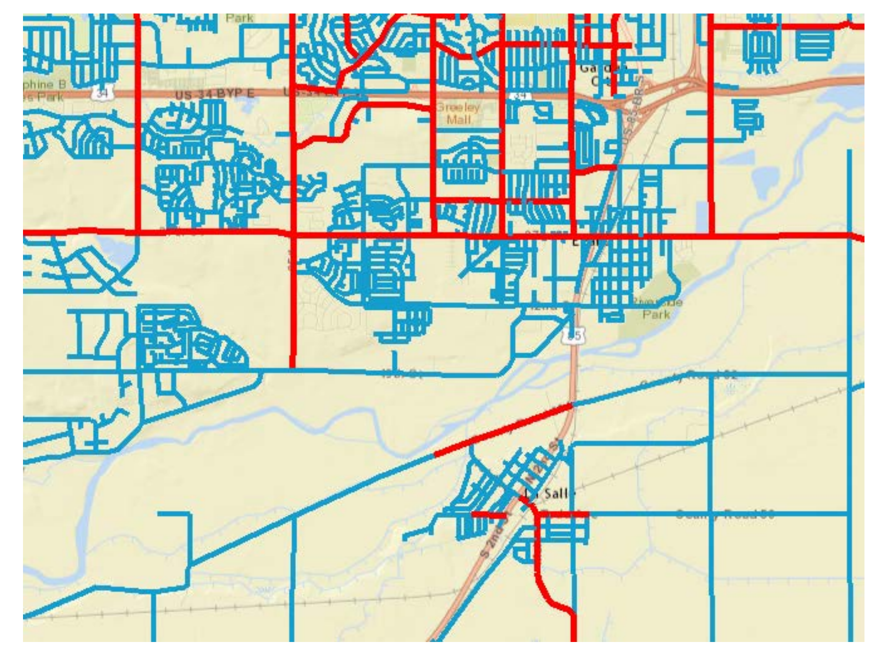


Figure 9-2: Flood Federal Aid and Functional Class Map (from CDOT)

Additional funding opportunities from DOLA and the Colorado Department of Public Health and Environment (CDPHE)

There are some additional funding opportunities from both DOLA and CDPHE that may work for the City. For example, CDPHE has a Water Quality Improvement Fund (WQIF) grant for stormwater. The funds can be used for stormwater management training and BMP training, as well as planning, design, construction or repairs of stormwater projects. It is recommended that once the Master Plan has been approved, the City meet with representatives from both of these agencies to discuss other possible funding opportunities.

10 FUTURE CITY PLANNING

Approximately 25 square miles (70%) of the UGA lies outside of the current city limits. Most of this area is undeveloped, or exists primarily as agricultural zones. As Evans expands, additional stormwater infrastructure will need to be constructed to adequately convey runoff away from new developments. Much of the infrastructure can be implemented through individual developers as subdivisions or commercial development occurs. However, Evans should develop a plan for managing discharging points along the South Platte or its tributaries.

The southwestern UGA zone is very flat, having an average slope from the southern UGA border to the South Platte floodplain boundary of 0.1%. This will make achieving ideal grades of pipelines and channels difficult. Areas northwest of the current city limits will pose different concerns than those presented in the southwestern UGA and historical Evans; the slopes are generally steeper, whereas areas east are mild. A number of tributaries extend from the northern UGA border to the South Platte, providing more potential discharge areas. Both areas will benefit greatly from flow attenuation by numerous local and regional detention ponds. In the southern area, the attenuation will reduce the pipe sizes required, helping the City to achieve the required cover along a pipeline. In the northern area, the benefit will be the reduced velocities to the natural channels, consequently creating safer conduits and reducing the risk of erosion.

In addition, portions of the city are planned for redevelopment; in particular, the Highway 85 corridor is targeted for revitalization. The current industrial centers will be replaced with high-density commercial venues and vertically developed residential units. While the major outlets to the South Platte will not likely be modified beyond what's recommended in this report, source-control measures can be implemented as individual developments are constructed. In addition, all new developments can be required to implement a green infrastructure technique. For example, a new commercial development could put a small bioretention cell in one of their parking lot medians. For any new large residential developments, the developer should be required to put in a detention pond with water quality.

10.1 Sustainable (Green) Infrastructure

Urban Drainage and Flood Control District lists four main principles of sustainable stormwater management. These goals will not only benefit the receiving waters, but reduce stress on major pipelines, channels, and detention ponds, and reduce the risk of flooding where they are implemented.

- Reduce the peak flowrate and volume: this can be achieved through stormwater attenuation or by providing infiltration opportunities
- Implement Best Management Practices (BMPs): this type of infrastructure improves water quality and will help accomplish the goals listed in the first point
- Stabilize streams to reduce erosion: this will improve water quality and reduce sedimentation in critical infrastructure downstream
- Implement source-control BMPs: this will reduce non-point source pollution and reduce the volume of runoff from the start

All of these principles can be addressed through the use of green infrastructure, as part of the approach to urban planning. This minimizes the impact of development on natural processes. Specifically for stormwater, the goal of green infrastructure is to provide water quality treatment and also allow the stormwater to infiltrate into the ground and recharge groundwater.

One of the fundamental features of green infrastructure is the preservation of existing drainage features such as wetlands. Wetlands not only help treat the water, but can also slow it down to promote infiltration. A grass swale or vegetated lot will provide the same benefit.

As the name suggests, one of the important factors in green infrastructure is vegetation. Vegetation and other pervious surfaces allow for infiltration. Infiltration reduces the peak flow rate and volume of runoff and provides water quality treatment. Impervious areas can be implemented in a variety of ways and allow for flexibility in design. An advantage of green infrastructure is that many of the techniques do not require copious amounts of space. In many already developed areas, green infrastructure or other BMPs can be implemented without impacting the area's original function.

Future and renovated development can reduce the time and magnitude of peak runoff rate by separating impervious areas with vegetated areas. These areas allow for infiltration, reduce the velocity of the stormwater, and provide water quality treatment through the biological uptake of pollutants. If they are to be effective in stormwater management, it is important that the pervious area not be elevated. Stormwater must be able to flow from the impervious to the pervious area. This practice may be implemented with locally-sourced, readily-available materials.

10.1.1 Best Management Practice Descriptions

There are a wide variety of BMPs that use green infrastructure principles to provide water quality improvements to stormwater. They typically target the water quality capture volume (WQCV), a volume of water based on the runoff from the first 0.6 inches of precipitation. The size of a BMP will vary, and depends on the requirements inherent in the treatment process and on the volume of water it must manage. Numerous smaller BMPs designed to treat the runoff from a single development can be incorporated into city planning as an alternative to several large regional BMPs. Such a strategy reduces the stress on downstream infrastructure and is more efficient at removing pollutants at their source, but may require more maintenance and accountability measures. The following sections give brief descriptions of several common BMP types. It is not a complete list of BMP structures, nor is it comprehensive in the descriptions. For additional and more detailed information on BMP selection and WQCV calculations, see Volume 3 of the UDFCD Urban Strom Drainage Criteria Manual Volume 3: Stormwater Best Management Practices. The most recent version of this manual is November 2010; the UDFCD website should be revisited periodically to check for updates of this and the other volumes of the manual, upon which Evans' updated stormwater management criteria and resiliency recommendations are based.

<u>Extended Detention Basins</u>

Extended detention basins (EDBs) are detention ponds constructed to detain stormwater runoff. They have individually designed outlet structures that release the stored water slowly, allowing for water treatment. The primary method of water treatment is sedimentation. Limited infiltration and evaporation also occur, reducing the volume of stormwater by small amounts. Thus, in addition to improving water quality, extended detention basins reduce the peak runoff rates.

The main pollutant category treated by extended detention basins is total suspended solids (TSS), which can be reduced by 40% to 60%. Pollutants that attach to particulate sediment (and that do not dissolve in water) are also removed. These include phosphorus, nitrogen, nitrate, metals, and bacteria.

The required area of the basin will depend on the contributing area; it can be designed as anything from a neighborhood to a regional EDB. Usually they are between 3 and 12 feet deep (NJ Stormwater Technical Manual Chapter 6.4, 2011). The Stormwater Manager's Resource Center (SMRC) estimates the typical construction cost of a 1 acre-foot EDB to be $41,600 and the average annual maintenance cost to be about 5% of the construction cost.

Extended detention basins require regular maintenance and are similar to the requirements of regular pond maintenance. Special attention should be given to the outlet structure and sedimentation within the basin. Regular clean out will be necessary, due to the sedimentation of particulates which occurs during normal operation.

<u>Bioswales and Constructed Wetland Channels</u>

Bioswales are vegetated channels that are typically trapezoidal in shape. They can be used in place of concrete or grass lined channels and are constructed similarly, but incorporate native wetland vegetation – such as willows, reeds, and cattails – along the channel bottom. Wetland channels specifically utilize species of vegetation found in wetlands. The increased roughness of the flow path slows down the flow, reducing peak discharge and providing time needed for particulates to settle out. They are best used along milder slopes and typically need a wider bottom width than other types of constructed channels.

Both Bioswales and constructed wetland channels employ sedimentation, nutrient cycling and infiltration to remove pollutants. Pollutant removal rates will vary depending on the type of vegetation employed and how the channel is maintained. Bioswales mostly remove pollutants adsorbed to particulate particles and are not as effective as removing dissolved contaminants. TSS has been demonstrated to be removed by between 30% and 65%. Constructed wetland channels can remove both phosphorus and nitrogen by approximately 20%, although phosphorus can be removed by as much as 68%. However, nutrients may actually be introduced into the system if the system in unmaintained. Fecal coliform concentrations can be reduced by 75%. The concentration of metals and chemical oxygen demand (COD) are also both reduced after treatment from the wetlands. For instance, in one study of four different channels, zinc was removed by between 29% and 62% (Yu, et al.).

A continuous flow is required to maintain the wetland vegetation and prevent algal growth, which can impede its function. In addition, dead plants and sediment must be periodically removed from the wetlands to prevent the re-introduction of nutrients into the stormwater system.

<u>Permeable Interlocking Concrete Pavers</u>

Parking lots, driveways, and other normally impervious surfaces can be made permeable via the application of either porous concrete or interlocking concrete pavers that allow for the infiltration of runoff through the spaces between the pavers. Runoff volumes flowing over these areas are reduced and pollutants are removed through the filtration process which occurs after infiltration. The infiltrated water can drain into sub-soil and become groundwater recharge or be collected via sub-drains. Permeable concrete and interlocking pavers are particularly space-efficient BMPs since much of an urbanized environment is paved – providing ample opportunity for their application – and because the use of the permeable paving alternatives do not impact the original function of the space (for example, parking, driving, or walking). Discretion should be used in identifying the appropriate techniques for each area, however; high traffic volume and weight can damage the pavers.

The primary function of permeable concrete is the reduction of flow volume, which it achieves through infiltration. Thus, the pollutants removed are those that are dissolved within the runoff. Infiltration rates will vary with the technique used, but can be as much as 270 to 450 inches per hour per square foot. Similarly, the costs of installation will vary depending on the type of material used. A general estimate is between $4 and $6 per square foot (improve.net).

Periodic vacuuming is required to unclog the pores and sub-bed material. Occasional paver replacement may be necessary if damage occurs or if they are uncleanable. In addition to these active maintenance items, considerations should be taken when performing regular street maintenance. Permeable concrete and pavers should not be applied with sand or some other types of deicers during the winter.

<u>Bioretention</u>

Bioretention basins are vegetated shallow-storage BMPs that collect runoff and release it at much lesser rates. They tend to be large enough to capture runoff from a neighborhood-sized subcatchment, are held to a similar design standard as a typical detention basin, and treat concentrated runoff. In many applications, specialized bed material and underdrain systems are installed underneath bioretention ponds. Bioretention outlets usually contain an underdrain outlet, a low-flow outlet, and an overflow weir. Shallow ponding depths are ideal to allow for more efficient infiltration and sedimentation. The vegetation used can include grasses, shrubs, and trees and can be selected for native species, flood-adaptable species, or salt-tolerant species according with the watershed demands.

Bioretention uses sedimentation, filtration, biological uptake, and filter media adsorption to remove pollutants from the stormwater. TSS can be removed by as much as 90%. Total phosphorus can be removed by between 70% and 83%, and total nitrogen can be replaced by between 68% and 80%. About 95% of metals, for instance lead and zinc, can be removed by a properly functioning bioretention basin. Hydrocarbons (oil and grease) are also efficiently removed by these BMPs, and can be reduced by 90%.

The costs of bioretention construction will vary depending on the size of the ponds and the contributing area. Regular maintenance includes routine inspections, weeding and culling, and sediment and trash removal. All of these are listed in the general maintenance guide for detention ponds provided in this report. It is important for bioretention ponds that any dead or diseased plant material be removed and replaced promptly. Filter clean-outs will occasionally be necessary for bioretention basins; it is important to take note of infiltration times during and after storm events to determine when such maintenance is needed.

<u>Wetlands</u>

Natural wetlands should be preserved and are exceptionally beneficial for stormwater control. Wetlands slow the flow of runoff, reduce the volume of stormwater discharged to downstream infrastructure, and treat the water through a plethora of means. Nevertheless, it is good practice to treat stormwater before it enters into natural wetlands, so as not to disrupt the ecology. Constructed wetlands are designed specifically to enhance treatment efficiencies. Among the design considerations are area, WQCV pool volume, trash rack and outlet sizing, and maintenance access.

Pollutant removal pathways include infiltration, sedimentation and biological uptake. As with other BMPs, particularly those that rely on biological components, the efficiency of treatment will vary widely with each application. There are many design models for wetlands, particularly; these include wetland-pond systems, shallow marsh wetlands, and submerged wetlands. Each will have a different effect on pollutant removal. However, typical values are available from several sources both in-state, out-of-state and from varying organizational levels (local to national). TSS removed from constructed wetlands vary between 69% and 83%. Total phosphorus and total nitrogen are removed by approximately 45% and 25%, respectively. In shallow and submerged wetlands, bacteria are removed by 75%.

Due to the elevated pollutant loads to constructed wetlands, they will periodically need to be drained for removal of sediment and debris. The health of the vegetation should be monitored and dead or diseased plants should be removed. Other maintenance activities are the same as those outlined for detention ponds: regular inspections, outlet maintenance, and trash removal are essential for the proper functioning of constructed wetlands and all other storage BMPs.

Rain Barrels

Until recently, the collection of precipitation in rain barrels was not a permitted stormwater management technique in Colorado. However, House Bill 1005 was passed on August 5, 2016 and legalized rain barrels. Simple rain barrels capture runoff from roofs and gutters, typically in residential areas, and store the rain before the runoff can reach the ground. Thus, the runoff volume is reduced immediately by a slight amount. When used consistently throughout a watershed, the peak runoff can be reduced by a marginal degree. The only pollutants which enter the rain barrel are those that were present on the roof. Rain barrels may not be advisable where roofs are made of reactive material such as plastic or steel. Rainwater collected by the barrels can be reused for irrigation water, and reduces the demands on both the stormwater system and the potable water system. Rain barrels do not remove pollutants from stormwater they collect. Rain barrels should be covered when not collecting runoff so that the standing water does not attract pests. Rain barrels and the gutters draining to them should be inspected at the start and at the end of the wet season. Any debris that has accumulated in either the barrel or gutter should be removed and disposed of.

Green Roofs

Green roofs, as with rain barrels, intercept precipitation before it reaches the ground and becomes runoff. Although each green roof will have a unique appearance, they are by definition planted roof tops. There are two main types of design: extensive and intensive. The first of these are shallow (approximately 4” soil depth) and have limited root space. Intensive green roofs incorporate deeper substrate and can thus support larger root systems and a greater biodiversity. This BMP reduces runoff volume and peak rate, and can be used to help qualify the building for Leadership in Energy and Environmental Design (LEED) certification. In Colorado, the application of green roofs has been sporadic and relatively little research attention has been afforded to this BMP as of yet. Furthermore, not all roofs can support the weight of soil and vegetation. Green roofs capture runoff at the source and therefore do not directly remove any pollutants from the stormwater system.

The cost of installing green roofs has been estimated to be between $15 and $20 per square foot. Maintenance costs may be at least partially offset by the building’s energy savings, due to the insulating effect of the vegetated roof. Low-maintenance plants can be selected, although any plants will still need monitoring and at least occasional care, as is the case with any garden.

BMP Summary

These BMPs, and the green infrastructure approach, are techniques that need to be incorporated into an effective stormwater management plan. Many of the BMPs work best when pre-treatment is provided. Treatment trains can be constructed by implementing several types of BMPs in series. This approach is especially beneficial if the water is to be considered for re-use, for example as irrigation water. For the City, we recommend the use of bioretention within the older sections of the City, east of Highway 85 and south of 31st Street. These systems can be implemented by the City in locations where there is flooding. With minimal upkeep, ideally by the residents, they provide an amenity to everybody but also help beautify the City.

10.2 Stormwater System Resiliency

In the development of a stormwater master plan, having a system that can recover quickly from major flooding events is a necessity. For the City of Evans, this encompasses many items. There are infrastructure impacts, such as damage to roads, trails and pipelines, but there are also impacts to buildings, parks and other City facilities. There are traditional methods that the City can employ to become more resilient, such as making sure the infrastructure can safely handle storms of a large magnitude.

As part of the stormwater master plan, a map showing the capacity of the critical infrastructure in the main roads has been prepared and is included as Figure 5-1 in this report. The color-coded map highlights the design storm where capacity is exceeded and flooding beyond the allowable capacity in the road can be expected. Once the magnitude of a given storm event is known, it provides a roadmap for critical inspections and damage investigations. It can also assist emergency responders with areas that may need to be avoided due to flooding concerns or damage.

Redundancy is another piece of resiliency that is probably more important for stormwater than it is for water and wastewater applications. This is partially because the water and wastewater systems are constantly flowing compared to the stormwater systems that only flow after storm events. It can also be important to have redundancy in the system due to clogging. If a pipe is clogged, it will push more stormwater onto the road which can impact traffic patterns. Having extra capacity in the major pipe systems, or in pipe systems under major roadways, is beneficial. Similarly, the City should focus on having the combined storm sewer and street capacity in major roads at closer to 100-year systems so they flood less frequently.

Prioritization is also a form of resiliency. In this master plan, a prioritization for the proposed infrastructure based on three different scales (even weight, risk based and cost based) has been included. The criteria and the scales are a guideline to the City of which projects provide the most benefit to the overall stormwater system, while taking into account the overall cost of the improvements.

There are additional measures that can be taken to reduce the amount of flooding, direct it away from structures or enable the City to respond quicker. These include:

- Having multiple outlets to the South Platte River
- Installing a pump station at areas at risk of back-flow, including the 37th Street outfall
- Construct local and regional full-spectrum detention basins within new and existing developments
- Provide safe egress and ingress to residential properties
- Use channels and green space to provide additional infiltration opportunities and reduce peak flow. In addition, it provides a water quality benefit as well.
- Ensure inlets are frequent and numerous so that in case of clogged inlets the flow is not transferring to another basin

- Diverting flows away from Evans Town Ditch will minimize the flooding chance downstream.

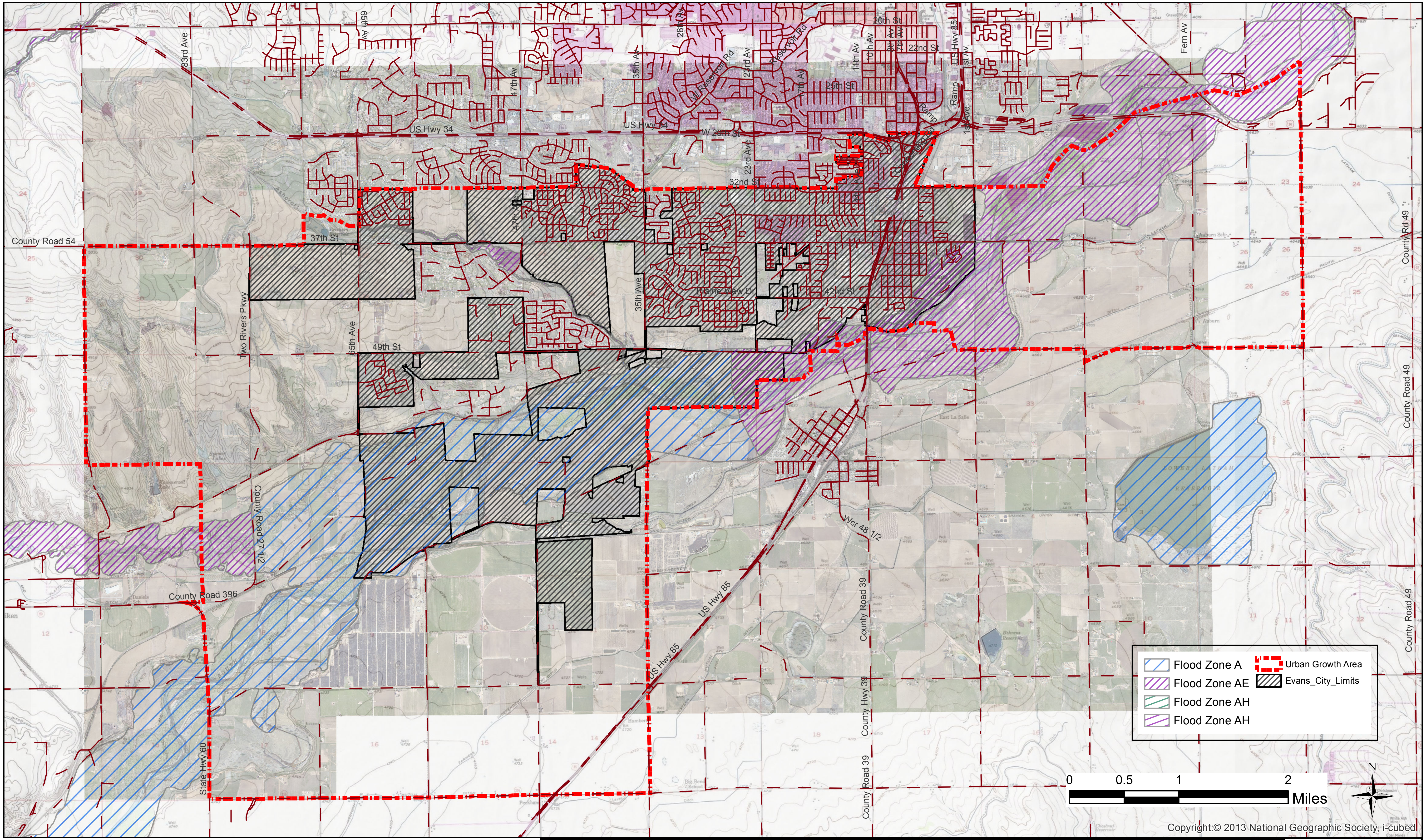
Infrastructure investment is another factor that was considered with the master plan. In some situations, the City is forced to do a comparison between the existing infrastructure and the infrastructure when it is up "to standard" (100-year capacity). Thinking about Area of Concern 9, there are a number of utilities in the road that limit the available space in the road. There is not a lot of vertical grade change on the road either which limits the pipe size. In order to develop an alternative that would function closer to optimal, it was necessary to divert flows away from 37th Street. The system is still undersized in some locations and the City may need to be comfortable with the current infrastructure capacity.

Finally, a major component of stormwater system resiliency is the operations and maintenance of the stormwater system. A stormwater system properly designed and functioning at its optimum should not flood during its design storm. This will safeguard the infrastructure, reduce flooding and protect non-stormwater infrastructure. There are other facets of this as well. Having a GIS database provides a catalog of the City stormwater infrastructure. When there has been an event, it provides the City the locations of the infrastructure that may be impacted so they know where to look. Similarly, if an inlet or culvert plugs, the GIS coordinates can help the City find the inlet or pipe and open it back up.

For each of the proposed improvements an effort was made to include information on how the alternative of choice provided resiliency. This information should help the City secure funding if resiliency is a requirement of the grant.

Appendix A

[City Maps]

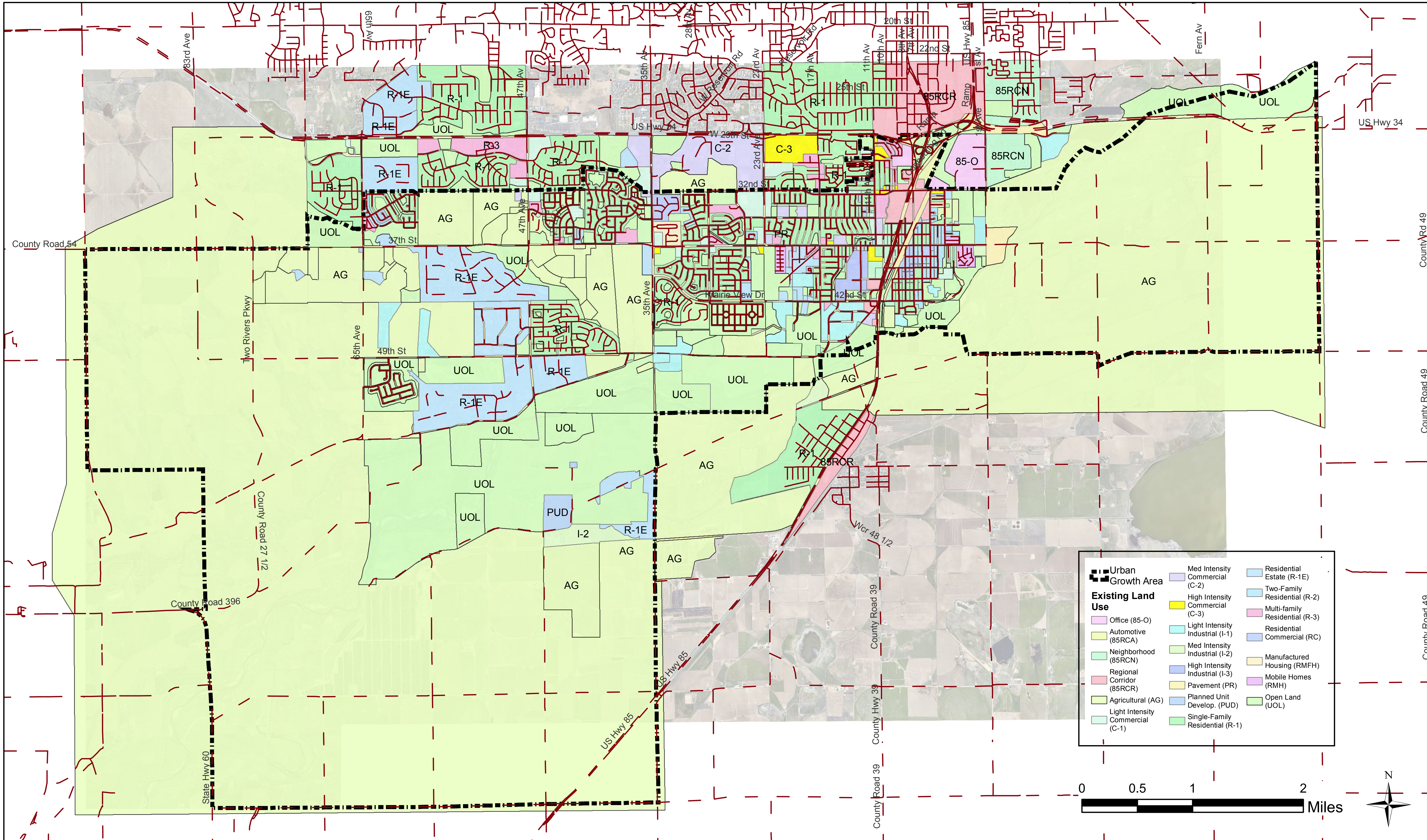


Evans 2016 Stormwater Master Plan
Drainage Study Analysis

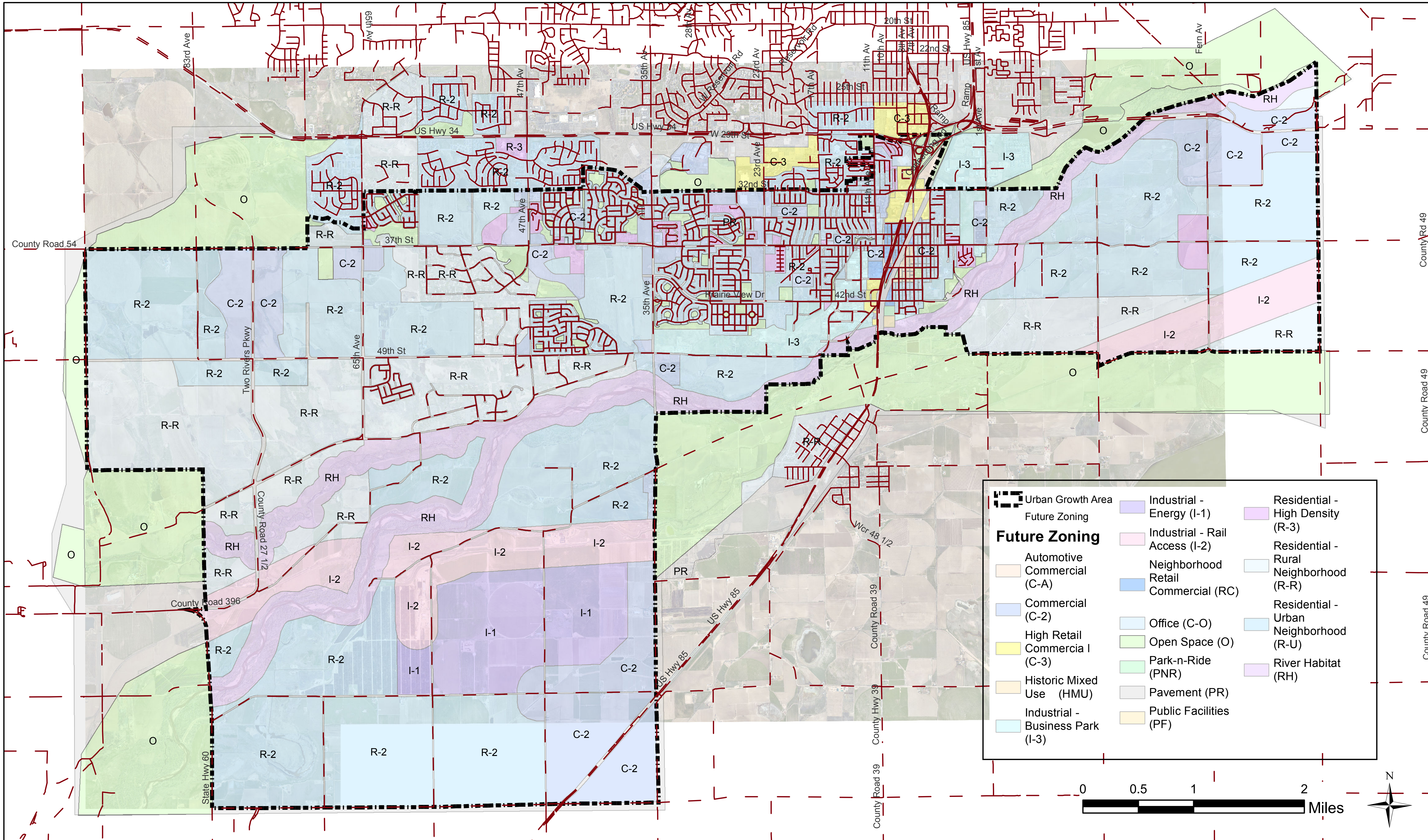
City of Evans Urban Growth Area

May 2016

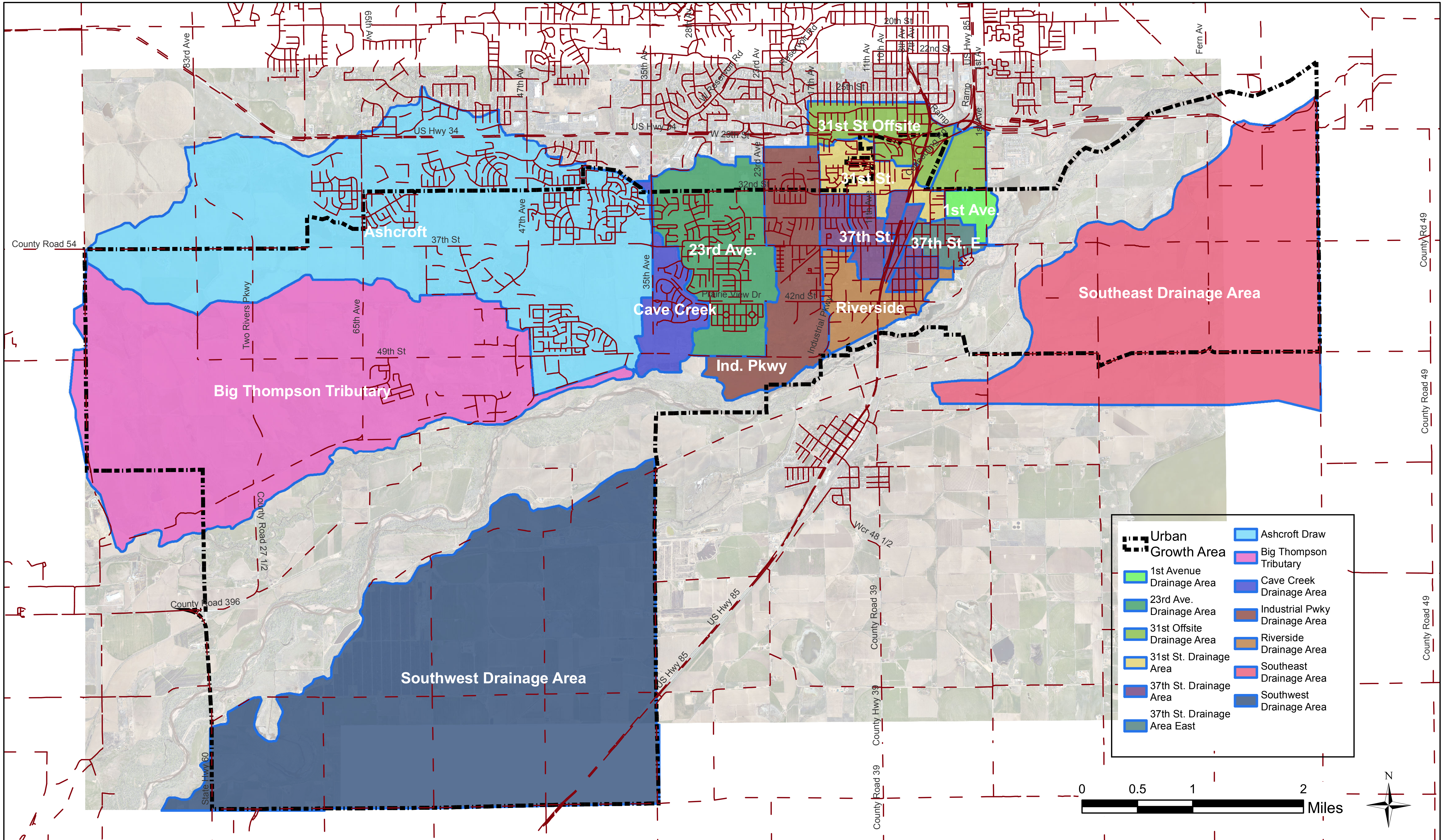
A-1



Evans 2016 Stormwater Master Plan Drainage Study Analysis	Existing Land Use	May 2016 A-2



Evans 2016 Stormwater Master Plan **Drainage Study Analysis**	Future Zoning and Land Use	May 2016 A-3



Evans 2016 Stormwater Master Plan
Drainage Study Analysis

Aggregate Drainage Basins

May 2016

A-4

Table A-1: List of Referenced Reports

Subdivision	Pond ID (Report)	Drainage Report	Date	Author
Ashcroft Draw	Pond #3 Pond #8	Technical Addendum to the Final Drainage Report for Ashcroft Heights Subdivision Phase Two	Feb. 2000	Drexel Barrel & Co.
Grapevine Hollow	Pond #2	*received pond data from City of Evans*		Drexel Barrel & Co.
Landings		*received pond data from City of Evans*		
Hunters Reserve	Pond #1 Pond #2 Pond #3	*received pond data from City of Evans*		Drexel Barrel & Co.
Willowbrook		*received pond data from City of Evans*		
North Point	Detention Pond A	Final Drainage Report for North Point Subdivision	Jan. 2001	Northern Engineering Services, Inc.
Cave Creek		Phase 1 Final Drainage Report for Cave Creek P.U.D	Nov. 1999	Rocky Mountain Consultants, Inc.
Chappelow		*No information avaialble - data obtained in-situ and from 1-ft contours*		
Prairie Ridge	Pond B	Final Drainage Report for Sears Farm Subdivision	Jan. 2002	Pickett Engineering Inc.
Neville's Crossing	Pond 201 Pond 301	Final Drainage Report for Neville's Crossing	May 2001	Drexel Barrel & Co.
Prairie Heights		Weld County School District 6 Prairie Heights Middle School Final Drainage Report	March 2014	Ketterling, Butherus and Norton Engineers, LLC

Appendix B

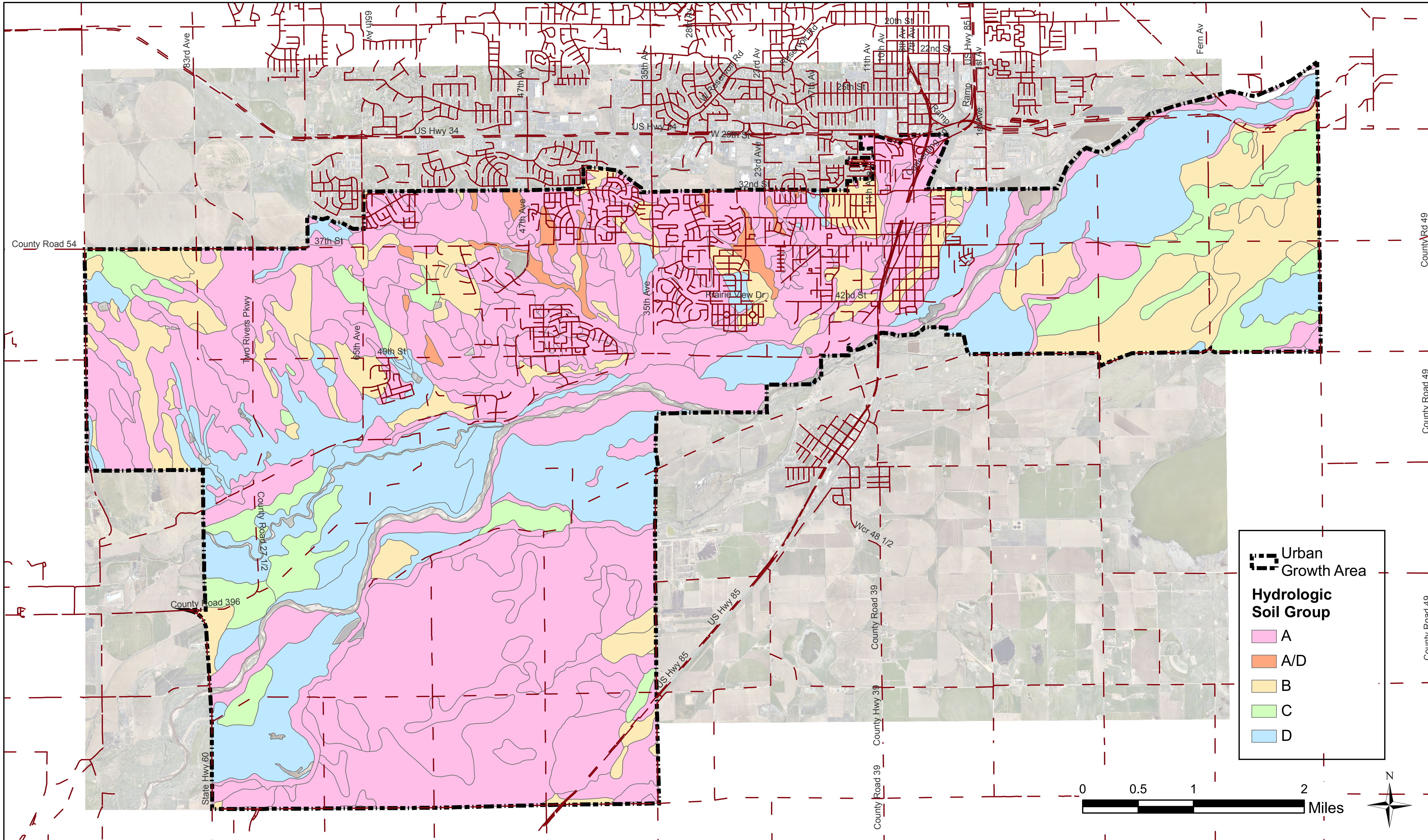
[Project Correspondence]

Table B-1: Project Meetings

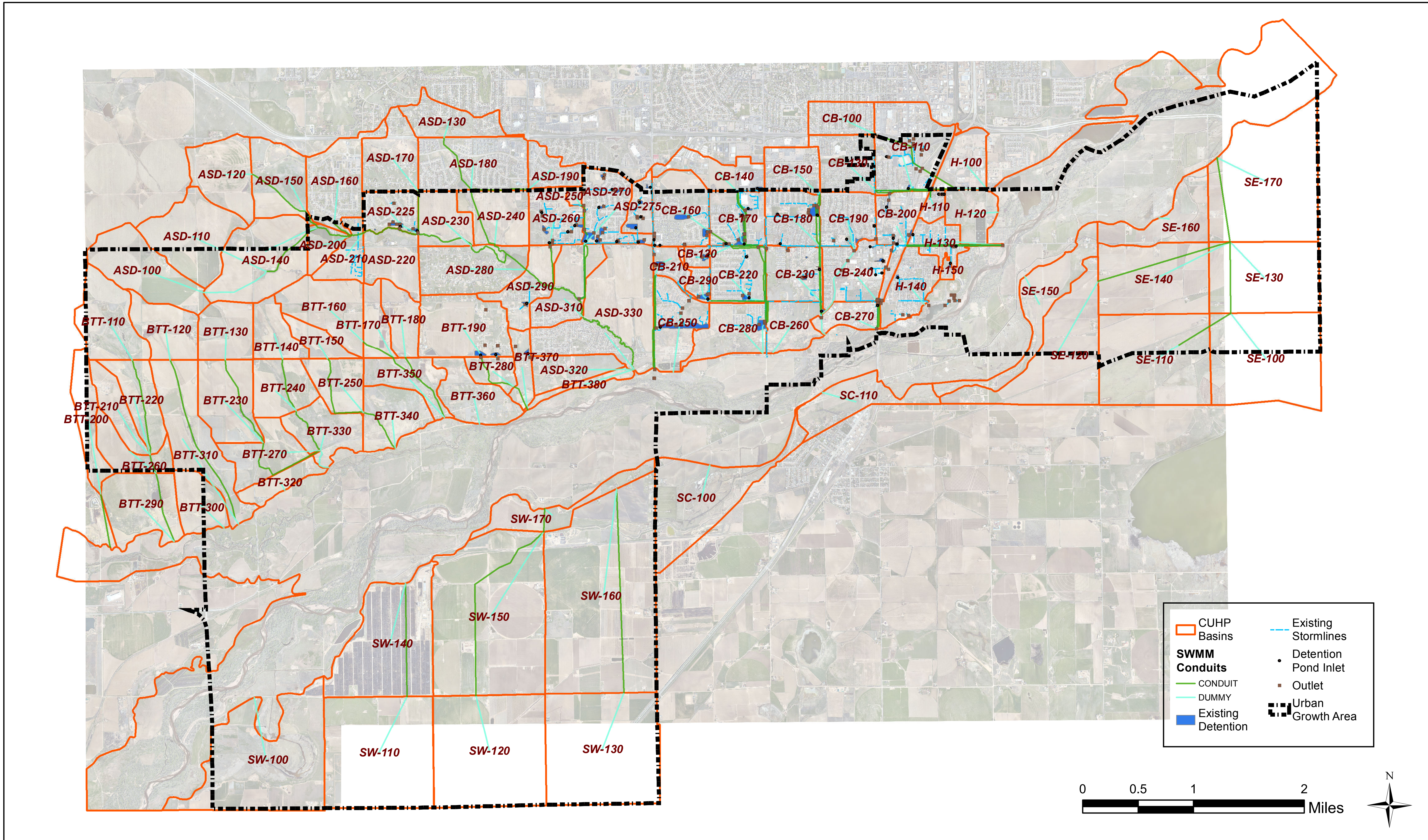
Meeting	Date	Purpose	Key Decisions
Kickoff Meeting	9/3/2015	Review project scope and project approach, identify data needs	
Status Meeting #1	10/12/2015	CUHP/SWMM modeling status update	Evans to prepare list of known infrastructure issues
Status Meeting #2	11/9/2015	Rational analysis status update, discussed selection process for detention pond inclusion. Site visit afterwards	None
Status Meeting #3	12/7/2015	Hydrology update and review; initial discussion of hydraulic analysis	After the meeting, went through files to find all applicable detention pond information
Status Meeting #4	1/12/2016	Review of existing infrastructure analysis	Include large private ponds
Status Meeting #5	2/9/2016	Identifying public meeting goals and exhibits	Provide big exhibits for residents to point to areas of concern. There is a ditch near Industrial Parkway with some flow issues
Public Meeting	2/10/2016	Obtain input from residents regarding observed locations and frequencies of concern	Flow concerns in old town area
Status Meeting #6	3/8/2016	Update on Conceptual Drainage Improvement Plan, discuss concepts	Evans will work on public outreach. Stormwater Management Plan and Criteria Manual to be separate documents.
Status Meeting #7	3/29/2016	Review alternatives analysis for problem area solutions	City to provide some comments
Status Meeting #8	4/12/2016	Solutions for areas of concern 8 and 9	For 8, include both pipe and channel options. For 9, we need to come up with additional flow paths.
Status Meeting #9	5/10/2016	Update on areas of concern 4 and 25	Reduce the size of the pond to be only on the Family Fun Center property. Prefer not to use concrete for channel in area of concern 25
Status Meeting #10	6/21/2016	Update on detention ponds, area of concern 9, operations and maintenance and prioritization	Provide map to illustrate what storm the current system can handle. For area of concern 9, divert flows before they make it to 37th Street
Status Meeting #11	7/12/2016	Maintenance capabilities	MS4 requirements need to be highlighted. Estimate number of man-hours necessary for maintenance of the storm sewer system
Status Meeting #12	8/9/2016	Discuss Criteria Manual, prioritization	Use UDFCD as the basis for the criteria manual. Need examples for developers
Evans Water and Sewer Board Presentation	8/15/2016	Present project to Water and Sewer Board	None
Evans City Council Presentation	9/4/2016	Present project to City Council	None

Appendix C

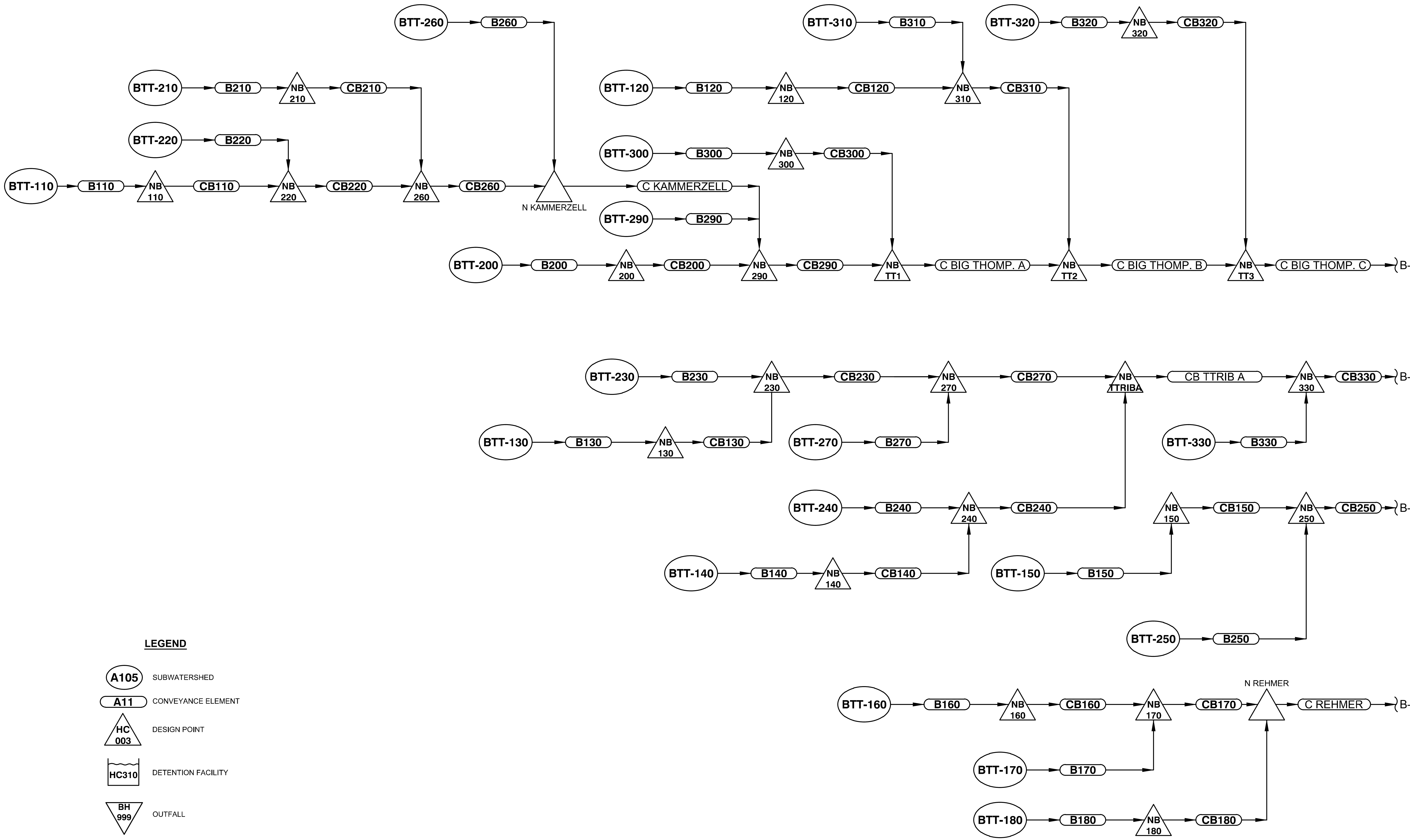
[Hydrologic Analysis]



Evans 2016 Stormwater Master Plan Drainage Study Analysis	Hydrologic Soil Groups within the Urban Growth Area	May 2016
		C-1



Evans 2016 Stormwater Master Plan Drainage Study Analysis	CUHP/SWMM Drainage Basins and Conduits	May 2016
		C-2



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No.	DATE	REVISIONS	APPR.

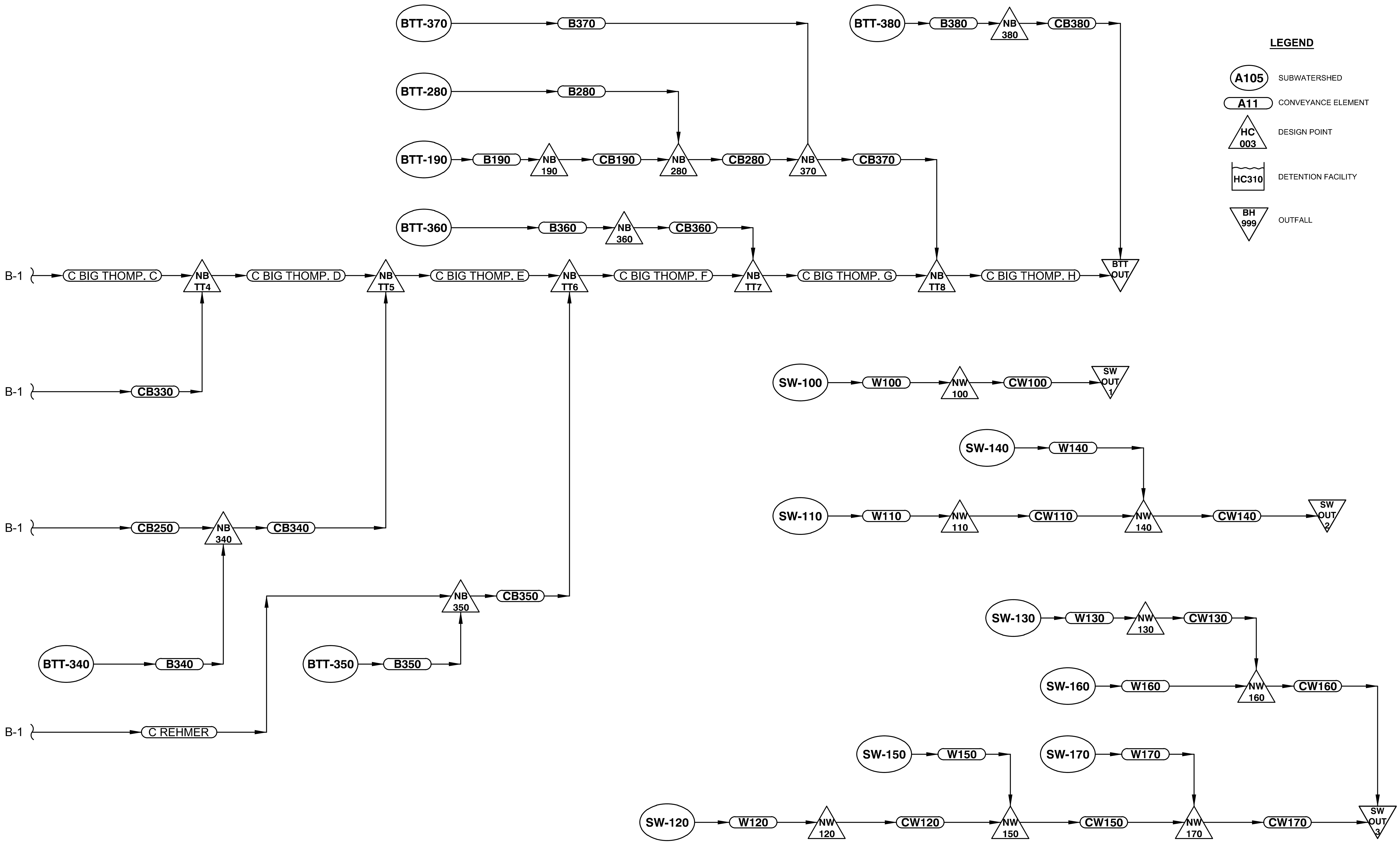
MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

DESIGN SEB
DRAWN TAD
CHECK XXX

EVANS STORMWATER MANAGEMENT PLAN

SWMM SCHEMATIC
EVANS STORMWATER MANAGEMENT PLAN

DATE MAY 2016
FIGURE NO. C-3A



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No.	DATE	REVISIONS	APPR.

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777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

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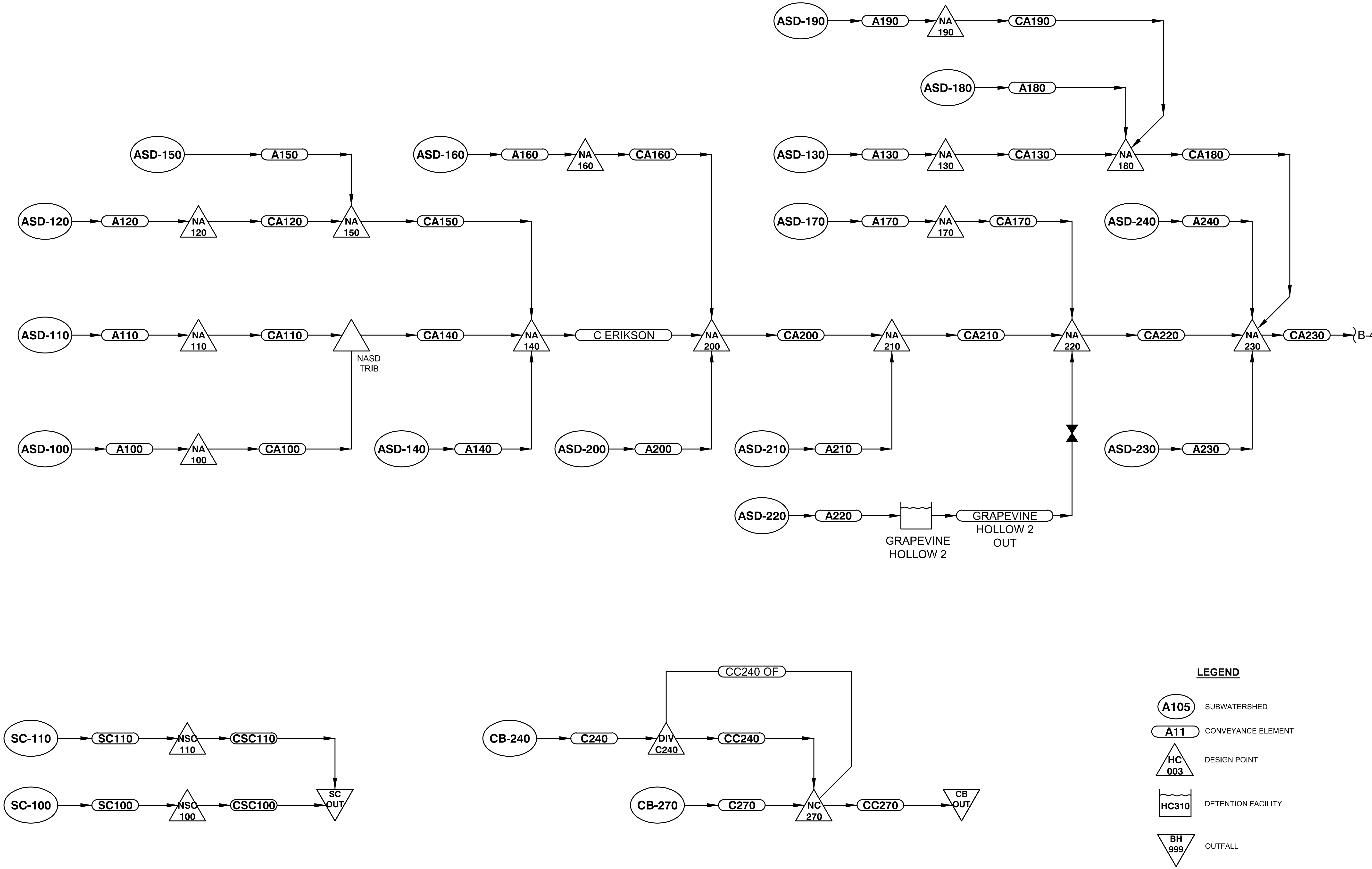
EVANS STORMWATER MANAGEMENT PLAN

SWMM SCHEMATIC
EVANS STORMWATER MANAGEMENT PLAN

DATE MAY 2016
FIGURE NO. C-3B



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No.	DATE	REVISIONS	APPR.

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LAKEWOOD, COLORADO 80226

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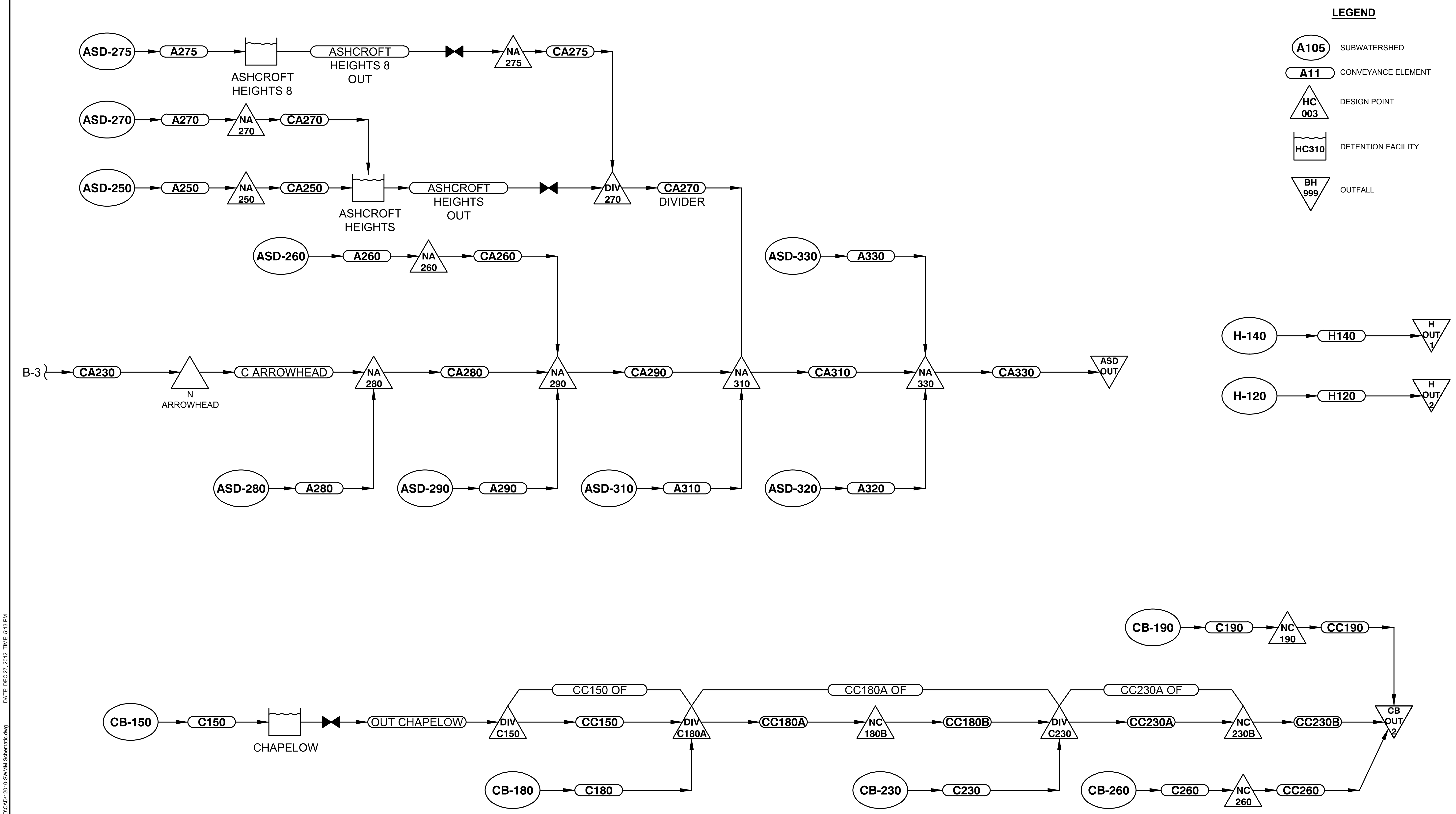
EVANS STORMWATER MANAGEMENT PLAN

SWMM SCHEMATIC
EVANS STORMWATER MANAGEMENT PLAN

DATE MAY 2016
FIGURE NO. C-3C



No.	DATE	REVISIONS	APPR.

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LAKEWOOD, COLORADO 80226

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EVANS STORMWATER MANAGEMENT PLAN

SWMM SCHEMATIC
EVANS STORMWATER MANAGEMENT PLAN

DATE MAY 2016
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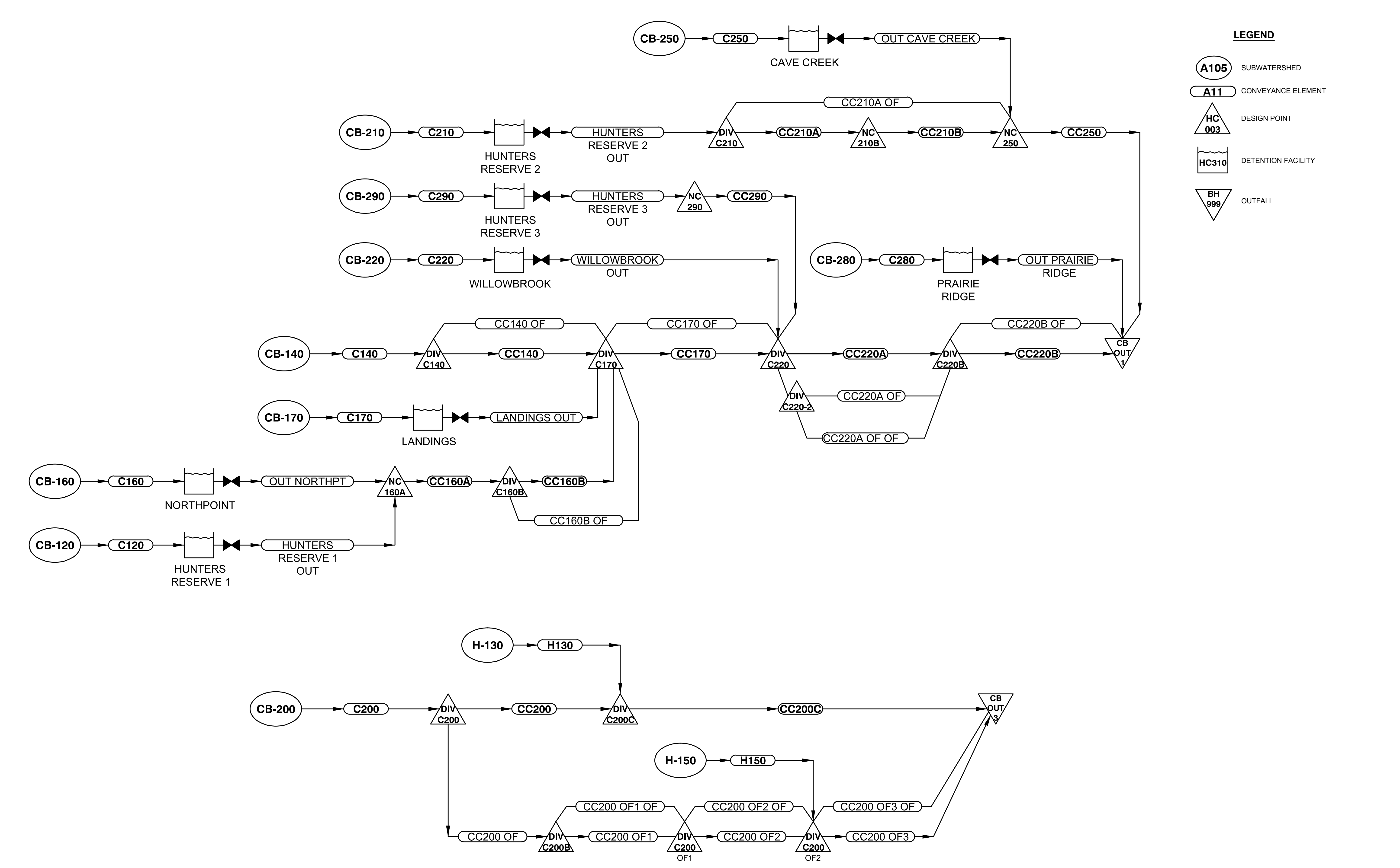

No.	DATE	REVISIONS	APPR.

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LAKEWOOD, COLORADO 80226

DESIGN SEB
DRAWN TAD
CHECK XXX

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

EVANS STORMWATER MANAGEMENT PLAN

SWMM SCHEMATIC
EVANS STORMWATER MANAGEMENT PLAN

DATE MAY 2016
FIGURE NO. C-3E

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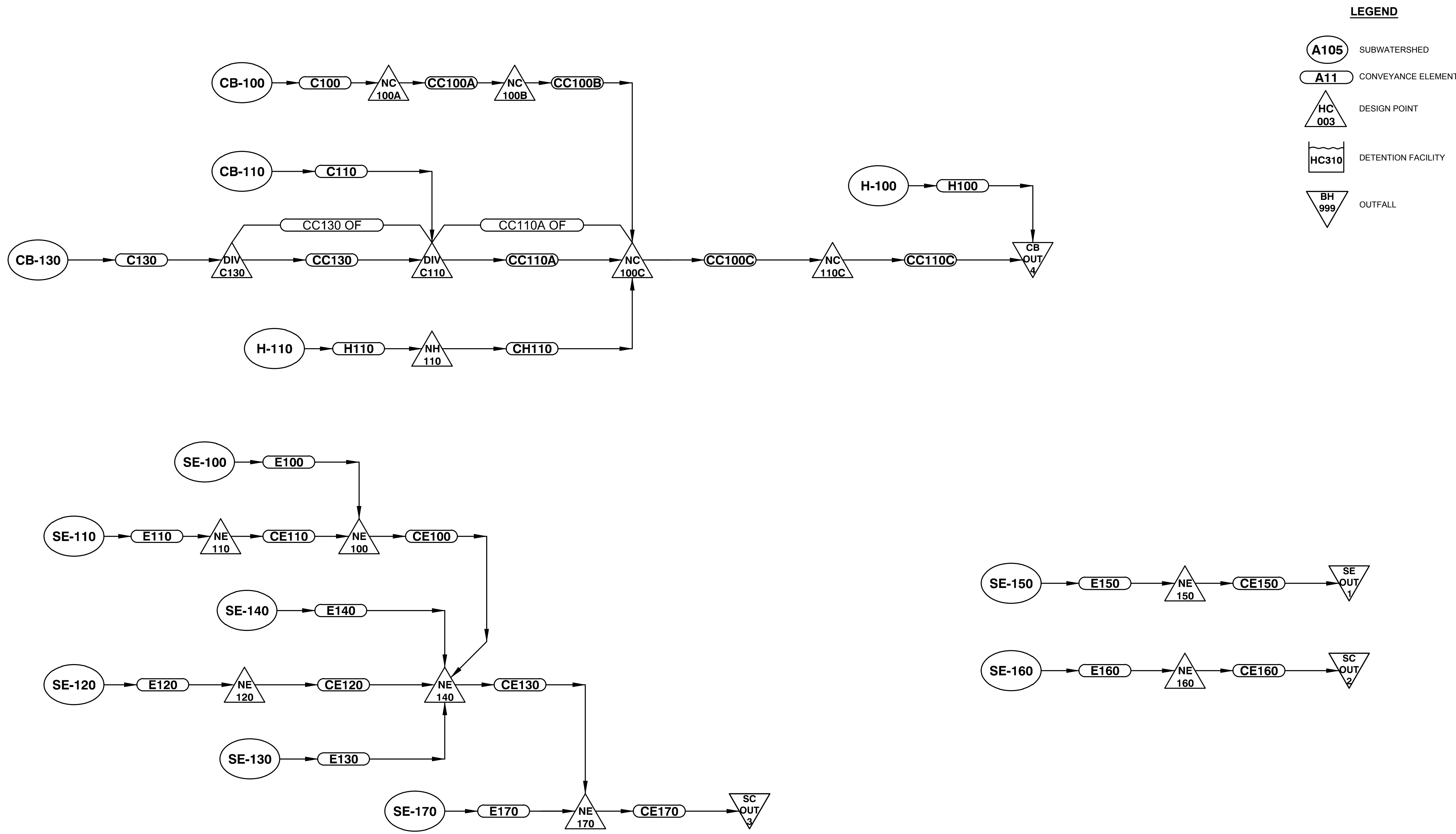

No.	DATE	REVISIONS	APPR.

MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

DESIGN SEB
DRAWN TAD
CHECK XXX

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

EVANS STORMWATER MANAGEMENT PLAN

SWMM SCHEMATIC
EVANS STORMWATER MANAGEMENT PLAN

DATE MAY 2016
FIGURE NO. C-3F

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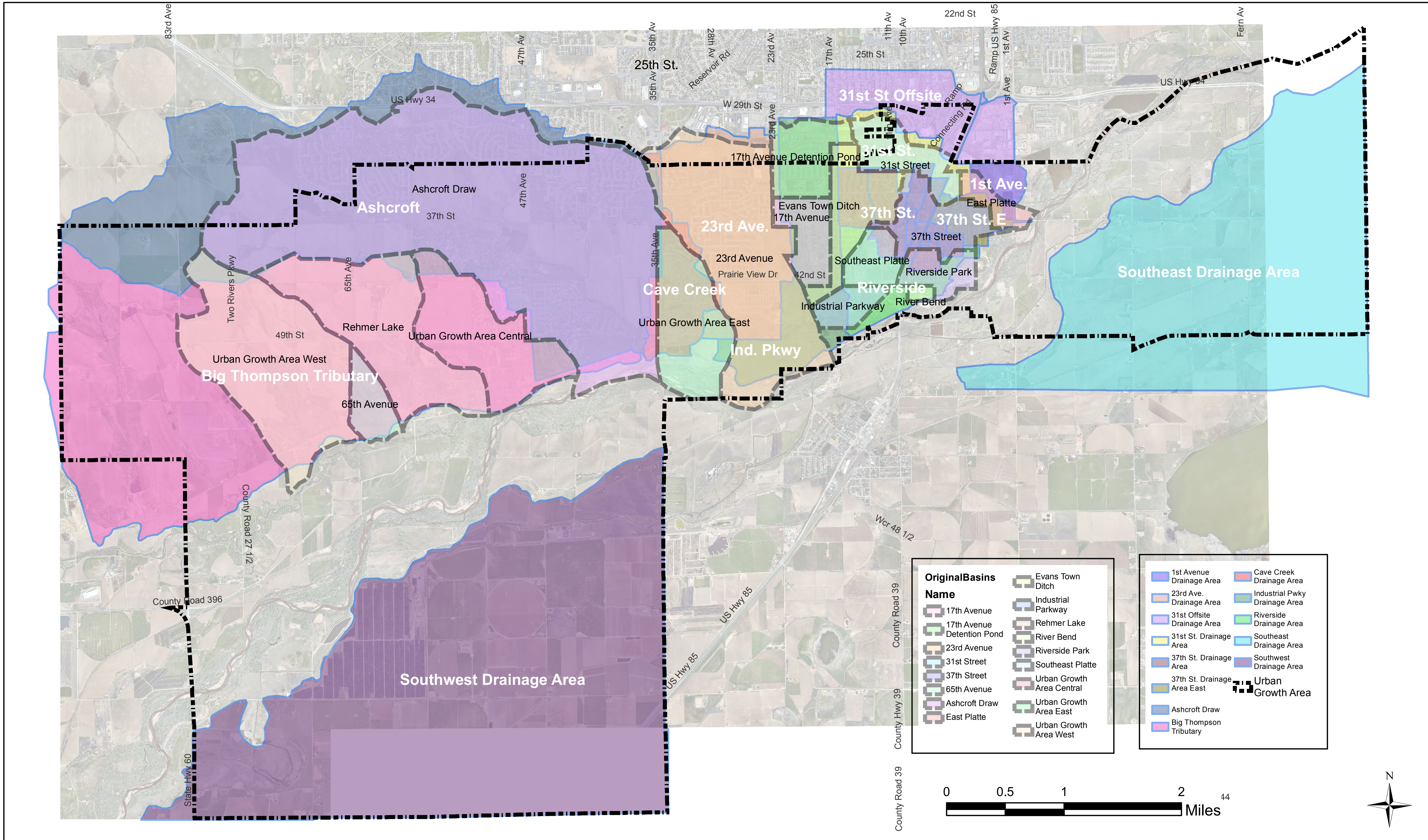
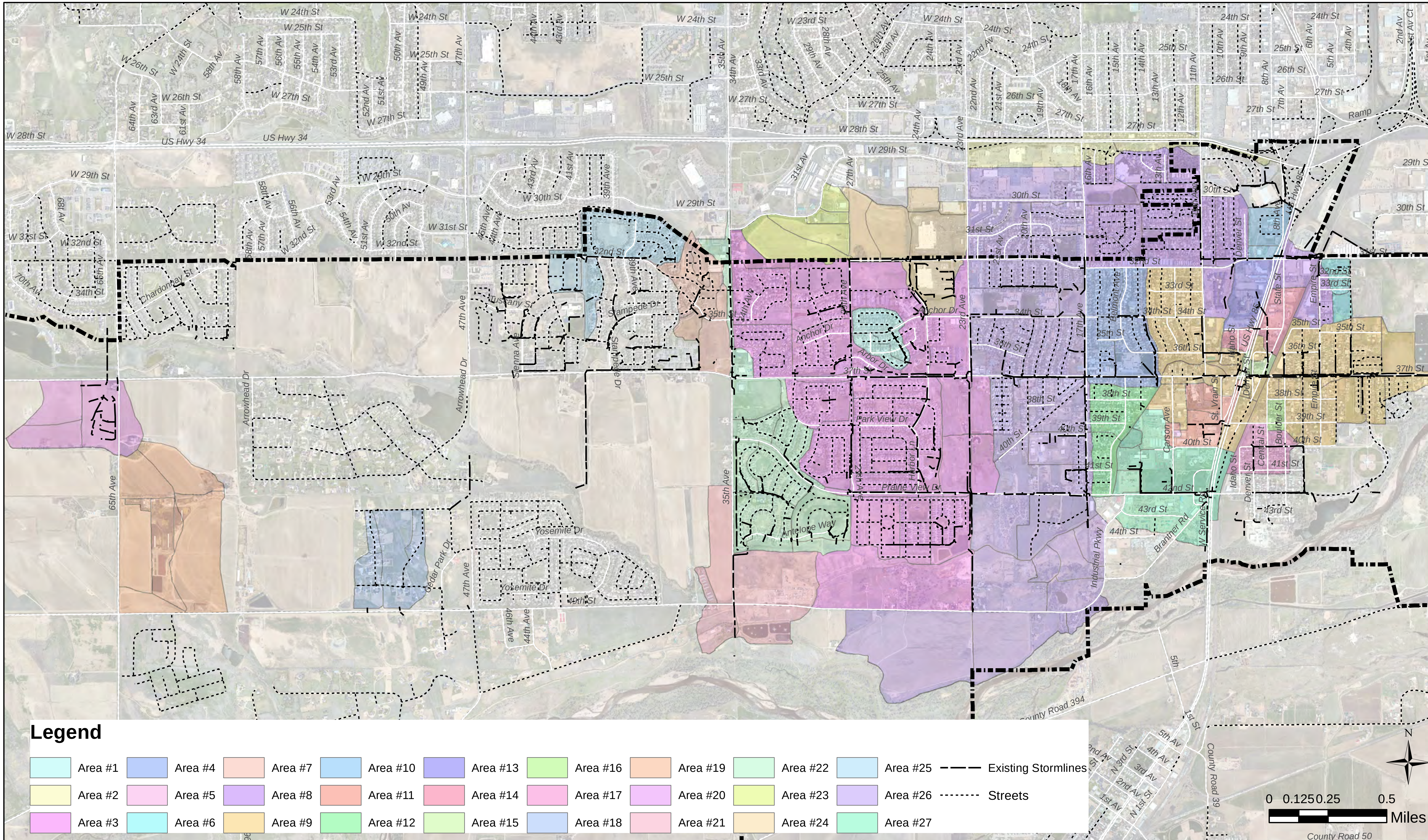


Evans 2016 Stormwater Master Plan Drainage Study Analysis	Aggregeate Drainage Basins Compared with 1997 Drainage Basins	May 2016
		C-4



Evans 2016 Stormwater Master Plan Drainage Study Analysis	Rational Analysis Drainage Basins	October 2016 C-5

Table C-1: CUHP Input

Subcatchment Name	Area		Dist. to Centroid		Length		Slope	Percent Impervious		Depression Storage		Infiltration		
								Existing	Future	Pervious	Impervious	Initial Rate	Decay Coeff.	Final Rate
	acres	sq mi	ft	mi	ft	mi		%	%	WS in	WS in	in/hr	1/s	in/hr
ASD-100	277.7	0.43390	3015	0.571	5864	1.111	0.017564	2	40.7	0.05	0.4	3	0.0018	0.5
ASD-110	297.5	0.46488	3457	0.655	6578	1.246	0.017634	2	16.3	0.05	0.4	4.5	0.0018	0.6
ASD-120	214.3	0.33478	1184	0.224	3439	0.651	0.029662	2	2	0.05	0.4	5	0.0007	1
ASD-130	147.3	0.23015	795	0.151	2649	0.502	0.030199	46.6	50	0.05	0.35	5	0.0007	1
ASD-140	339.6	0.53059	2848	0.539	6629	1.255	0.011616	2.3	57.1	0.05	0.4	5	0.0007	1
ASD-150	209.3	0.32703	2844	0.539	5783	1.095	0.025937	2	2	0.05	0.4	5	0.0007	1
ASD-160	239.7	0.37448	2478	0.469	7856	1.488	0.015785	45	49	0.05	0.35	4.5	0.0018	0.6
ASD-170	191.2	0.29872	1698	0.322	4241	0.803	0.026883	24.3	30.7	0.05	0.4	5	0.0007	1
ASD-180	308.1	0.48133	1486	0.281	4260	0.807	0.015726	56.2	56.2	0.05	0.35	5	0.0007	1
ASD-190	91.5	0.14296	1243	0.235	3683	0.698	0.015204	52	52	0.05	0.35	5	0.0007	1
ASD-200	64.6	0.10086	1713	0.324	3562	0.675	0.024427	2	32.9	0.05	0.4	5	0.0007	1
ASD-210	97.8	0.15289	1514	0.287	3602	0.682	0.023875	11.4	65.4	0.05	0.4	5	0.0007	1
ASD-220	161.3	0.25202	1667	0.316	3800	0.720	0.02737	8.7	43.3	0.05	0.4	5	0.0007	1
ASD-225	115.2	0.18002	1762	0.334	4288	0.812	0.01516	55	55	0.05	0.4	5	0.007	1
ASD-230	139.8	0.21837	1935	0.366	4111	0.779	0.014595	4	52.9	0.05	0.4	5	0.0007	1
ASD-240	178.8	0.27945	1652	0.313	3404	0.645	0.017037	5.6	68.6	0.05	0.4	5	0.0007	1
ASD-250	13.8	0.02163	341	0.065	1288	0.244	0.024075	33.8	60.5	0.05	0.4	5	0.0007	1
ASD-260	148.2	0.23155	1270	0.241	2791	0.529	0.02221	47.9	67.4	0.05	0.4	5	0.0007	1
ASD-270	187.1	0.29239	2012	0.381	4121	0.780	0.018712	55.6	59.9	0.05	0.35	5	0.0007	1
ASD-275	70.1	0.10948	1549	0.293	3620	0.686	0.017793	43.9	69.6	0.05	0.35	5	0.0007	1
ASD-280	253.0	0.39532	3422	0.648	5945	1.126	0.013626	25.3	34.4	0.05	0.4	4.5	0.0018	0.6
ASD-290	151.4	0.23662	1738	0.329	3765	0.713	0.02656	20.8	49.3	0.05	0.4	5	0.0007	1
ASD-310	180.3	0.28170	1965	0.372	4379	0.829	0.019184	18.3	59.6	0.05	0.4	5	0.0007	1
ASD-320	123.3	0.19269	2784	0.527	5985	1.134	0.012531	28.2	37.5	0.05	0.4	5	0.0007	1
ASD-330	489.8	0.76526	2937	0.556	6909	1.309	0.017368	18.2	56.4	0.05	0.4	5	0.0007	1
BTT-110	233.6	0.36507	2267	0.429	5301	1.004	0.037915	2	46.7	0.05	0.4	5	0.0007	1
BTT-120	173.1	0.27054	1156	0.219	4247	0.804	0.034613	2	51.4	0.05	0.4	5	0.0007	1
BTT-130	161.1	0.25166	1342	0.254	4654	0.881	0.01461	2	75.6	0.05	0.4	5	0.0007	1
BTT-140	121.0	0.18900	1523	0.288	3224	0.611	0.0214	2	84.2	0.05	0.4	5	0.0007	1
BTT-150	74.1	0.11583	961	0.182	3365	0.637	0.023772	2	54.8	0.05	0.4	4.5	0.0018	0.6
BTT-160	230.5	0.36012	2263	0.429	5186	0.982	0.017549	2	53.7	0.05	0.4	5	0.0007	1
BTT-170	91.8	0.14351	2411	0.457	4392	0.832	0.019582	20.4	52	0.05	0.4	5	0.0007	1
BTT-180	114.2	0.17839	1873	0.355	4374	0.828	0.018976	10.9	49.3	0.05	0.4	5	0.0007	1
BTT-190	280.7	0.43867	1477	0.280	4441	0.841	0.016439	25.3	45.6	0.05	0.35	5	0.0007	1
BTT-200	138.0	0.21563	3684	0.698	7002	1.326	0.023564	2	14.9	0.05	0.4	5	0.0007	1
BTT-210	109.0	0.17030	2796	0.530	5952	1.127	0.02621	2	30.5	0.1	0.4	5	0.0007	1

Table C-1: CUHP Input

Subcatchment Name	Area		Dist. to Centroid		Length		Slope	Percent Impervious		Depression Storage		Infiltration		
								Existing	Future	Pervious	Impervious	Initial Rate	Decay Coeff.	Final Rate
	acres	sq mi	ft	mi	ft	mi		%	%	WS in	WS in	in/hr	1/s	in/hr
BTT-220	154.7	0.24169	2688	0.509	5829	1.104	0.026592	2	32	0.05	0.4	5	0.0007	1
BTT-230	232.6	0.36339	2441	0.462	4493	0.851	0.026707	2	39.6	0.05	0.4	5	0.0007	1
BTT-240	165.9	0.25924	1224	0.232	3490	0.661	0.037825	2	42.3	0.05	0.4	5	0.0007	1
BTT-250	138.2	0.21598	3262	0.618	5066	0.959	0.014804	2	34.9	0.05	0.4	5	0.0007	1
BTT-260	119.7	0.18706	1929	0.365	4824	0.914	0.026119	2	28	0.05	0.4	5	0.0007	1
BTT-270	176.2	0.27530	2468	0.467	6129	1.161	0.021048	2	37.7	0.1	0.4	3	0.0018	0.5
BTT-280	71.5	0.11167	1088	0.206	3055	0.579	0.020292	12.9	31.6	0.05	0.35	5	0.0007	1
BTT-290	248.5	0.38829	2533	0.480	4553	0.862	0.026573	2	2	0.1	0.4	3	0.0018	0.5
BTT-300	133.2	0.20815	1814	0.343	4023	0.762	0.030079	2	12.8	0.1	0.4	3	0.0018	0.5
BTT-310	328.5	0.51321	4879	0.924	9013	1.707	0.0233	2	32.8	0.1	0.4	5	0.0007	1
BTT-320	82.1	0.12830	468	0.089	882	0.167	0.030612	2	37.5	0.1	0.4	5	0.0007	1
BTT-330	172.1	0.26887	1989	0.377	4227	0.800	0.030048	2	32.2	0.1	0.4	3	0.0018	0.5
BTT-340	180.5	0.28201	1441	0.273	3230	0.612	0.032504	11	35	0.05	0.4	3	0.0018	0.5
BTT-350	146.4	0.22880	2626	0.497	5521	1.046	0.021009	18.1	38.8	0.05	0.35	5	0.0007	1
BTT-360	180.2	0.28153	1311	0.248	4109	0.778	0.022631	25	36.4	0.05	0.35	5	0.0007	1
BTT-370	75.7	0.11834	1817	0.344	3960	0.750	0.030307	34.8	49.6	0.05	0.35	5	0.0007	1
BTT-380	43.4	0.06781	146	0.028	362	0.069	0.085635	8	28.1	0.05	0.35	5	0.0007	1
CB-100	113.1	0.17667	1599	0.303	4418	0.837	0.013129	50.9	50.9	0.05	0.35	5	0.0007	1
CB-110	310.1	0.48460	1905	0.361	4287	0.812	0.008165	73.7	75.4	0.1	0.35	5	0.0007	1
CB-120	27.5	0.04293	1210	0.229	3051	0.578	0.013903	54.2	54.2	0.05	0.35	5	0.0007	1
CB-130	172.5	0.26947	3141	0.595	5181	0.981	0.012545	51.2	52.5	0.05	0.35	4.5	0.0018	0.6
CB-140	140.4	0.21932	2044	0.387	4761	0.902	0.015924	53.1	55.4	0.1	0.35	5	0.0007	1
CB-150	127.4	0.19904	2765	0.524	4728	0.896	0.01565	67	67.9	0.1	0.35	5	0.0007	1
CB-160	214.0	0.33444	3286	0.622	4521	0.856	0.022121	47.3	52.7	0.05	0.35	5	0.0007	1
CB-170	159.5	0.24923	2291	0.434	4664	0.883	0.014057	61.1	79.1	0.1	0.35	5	0.0007	1
CB-180	157.1	0.24546	2809	0.532	5186	0.982	0.014128	60.7	67.5	0.05	0.35	5	0.0007	1
CB-190	152.8	0.23881	2971	0.563	5629	1.066	0.013744	66.9	68.8	0.05	0.35	4.5	0.0018	0.6
CB-200	143.4	0.22401	3604	0.683	5345	1.012	0.000374	85.6	85.8	0.1	0.35	5	0.0007	1
CB-210	55.9	0.08727	607	0.115	1881	0.356	0.011114	50.9	77.2	0.05	0.35	5	0.0007	1
CB-220	166.7	0.26050	2325	0.440	5223	0.989	0.013212	48.1	68.1	0.05	0.35	5	0.0007	1
CB-230	162.3	0.25352	3396	0.643	4767	0.903	0.008941	40.9	61.4	0.05	0.35	5	0.0007	1
CB-240	189.1	0.29541	2076	0.393	3572	0.677	0.004479	71.6	78.1	0.05	0.35	5	0.0007	1
CB-250	195.8	0.30594	2346	0.444	4846	0.918	0.02043	38.1	65.2	0.05	0.4	5	0.0007	1
CB-260	129.9	0.20295	1245	0.236	2530	0.479	0.011874	27.4	81	0.05	0.4	5	0.0007	1
CB-270	83.9	0.13116	625	0.118	1873	0.355	0.004805	74.7	90	0.05	0.4	5	0.0007	1
CB-280	182.9	0.28584	2824	0.535	4678	0.886	0.01753	15.7	70.5	0.05	0.35	5	0.0007	1
CB-290	40.8	0.06378	2246	0.425	3842	0.728	0.011191	63.1	65.2	0.05	0.35	5	0.0007	1

Table C-1: CUHP Input

Subcatchment Name	Area		Dist. to Centroid		Length		Slope	Percent Impervious		Depression Storage		Infiltration		
								Existing	Future	Pervious	Impervious	Initial Rate	Decay Coeff.	Final Rate
	acres	sq mi	ft	mi	ft	mi		%	%	WS in	WS in	in/hr	1/s	in/hr
H-100	135.8	0.21219	1322	0.250	3658	0.693	0.016403	77.8	86.1	0.05	0.35	3	0.0018	0.5
H-110	33.3	0.05208	835	0.158	1609	0.305	0.005595	74.1	74.1	0.1	0.35	3	0.0018	0.5
H-120	121.1	0.18925	1113	0.211	3472	0.658	0.004608	18.6	78.3	0.1	0.4	3	0.0018	0.5
H-130	95.6	0.14938	3042	0.576	5621	1.065	0.003914	70.1	70.1	0.05	0.35	3	0.0018	0.5
H-140	152.8	0.23868	1088	0.206	4251	0.805	0.001411	64	71.5	0.05	0.35	5	0.0007	1
H-150	12.4	0.01938	471	0.089	1434	0.272	0.003164	47.6	51.5	0.05	0.04	3	0.0018	0.5
SC-100	396.9	0.62020	6873	1.302	11867	2.247	0.004214	4.7	4.7	0.05	0.4	3	0.0018	0.5
SC-110	198.6	0.31032	947	0.179	2394	0.453	0.007995	9	9	0.05	0.4	3	0.0018	0.5
SE-100	526.3	0.82228	3890	0.737	7377	1.397	0.009606	2	20.9	0.05	0.4	5	0.0007	1
SE-110	526.9	0.82330	3540	0.670	5698	1.079	0.003861	2	33.2	0.1	0.4	4.5	0.0018	0.6
SE-120	471.6	0.73691	4667	0.884	11412	2.161	0.001755	2	17.2	0.1	0.4	4.5	0.0018	0.6
SE-130	410.3	0.64104	1700	0.322	4937	0.935	0.001013	2	66.7	0.05	0.4	4.5	0.0018	0.6
SE-140	406.2	0.63469	1769	0.335	4096	0.776	0.003662	2	50.3	0.05	0.4	4.5	0.0018	0.6
SE-150	244.8	0.38252	1658	0.314	2203	0.417	0.008169	2	35.6	0.05	0.4	4.5	0.0018	0.6
SE-160	212.0	0.33119	795	0.151	2669	0.505	0.008169	2	60.5	0.05	0.4	3	0.0018	0.5
SE-170	665.4	1.03964	2484	0.470	4869	0.922	0.007495	2	67.3	0.05	0.4	4.5	0.0018	0.6
SW-100	652.1	1.01896	2486	0.471	5128	0.971	0.001643	2	47.6	0.05	0.4	3	0.0018	0.5
SW-110	632.3	0.98789	3163	0.599	6260	1.186	0.001757	2	51	0.05	0.4	5	0.0007	1
SW-120	652.2	1.01908	2649	0.502	7047	1.335	0.002696	2	53.5	0.05	0.4	5	0.0007	1
SW-130	657.9	1.02797	2666	0.505	5908	1.119	0.001016	2	95.4	0.05	0.4	5	0.0007	1
SW-140	524.6	0.81962	2887	0.547	5422	1.027	0.004611	2	63.6	0.05	0.4	5	0.0007	1
SW-150	918.6	1.43533	5575	1.056	9328	1.767	0.004181	2	82	0.05	0.4	5	0.0007	1
SW-160	1119.2	1.74875	5260	0.996	9893	1.874	0.004751	8.8	82.7	0.05	0.4	5	0.0007	1
SW-170	167.7	0.26201	494	0.094	1582	0.300	0.00885	19.4	55.8	0.05	0.4	3	0.0018	0.5

Table C-2: Rational Analysis Inputs

					Land Cover Area										
	Total Basin Area		Total Impervious Area		Pavement	Residential	Lawn/Undeveloped	Gravel	% Impervious						
Basin ID	sqft	acre	sq ft	ac	sq ft	sq ft	sq ft	sq ft	%	C 5yr	C 10yr	C 25yr	C 50yr	C 100yr	HSG
1A	559,061	12.83	352,051.80	8.08	41,538	517,523	0	0	63%	0.39	0.43	0.47	0.49	0.51	A
1B	391,641	8.99	244,601.40	5.62	24,042	367,599	0	0	62%	0.39	0.43	0.47	0.49	0.51	A
1C	314,005	7.21	211,049.40	4.85	56,616	257,389	0	0	67%	0.43	0.47	0.51	0.52	0.54	A
2	582,711	13.38	335,786.50	7.71	172,703	259,242	150,766	0	58%	0.35	0.39	0.43	0.46	0.48	A
2A	2,748,020	63.09	2,219,576.60	50.95	1,790,885	692,427	264,708		81%	0.56	0.6	0.63	0.64	0.66	A
3A	426,356	9.79	275,612.50	6.33	223,696	75,970	126,690	0	65%	0.4	0.44	0.48	0.5	0.52	A
3Aa	522,769	12	181,826.40	4.17	0	283,069	239,700	0	35%	0.21	0.27	0.33	0.36	0.39	A
3Ab	1,722,270	39.54	886,147.90	20.34	0	1,454,608	267,662	0	51%	0.31	0.36	0.4	0.43	0.45	A
3Ac	1,311,950	30.12	779,786.80	17.9	0	1,298,526	13,424	0	59%	0.36	0.4	0.44	0.47	0.49	A
3Ad	1,905,590	43.75	543,019.70	12.47	0	814,073	1,091,517	0	28%	0.18	0.24	0.3	0.33	0.36	A
3Ae	1,534,070	35.22	813,169.50	18.67	0	1,339,029	195,041	0	53%	0.32	0.37	0.41	0.44	0.46	A
3Af	1,621,420	37.22	555,714.40	12.76	0	862,988	758,432	0	34%	0.21	0.27	0.33	0.36	0.39	A
3Ag	504,568	11.58	166,793.50	3.83	0	257,391	247,177	0	33%	0.21	0.27	0.32	0.35	0.38	A
3Ah	703,183	16.14	365,252.70	8.39	0	600,170	103,013	0	52%	0.31	0.36	0.4	0.43	0.45	A
3B	1,259,646	28.92	689,050.50	15.82	279,078	656,262	324,306	0	55%	0.32	0.37	0.42	0.44	0.47	A
3C	186,559	4.28	145,057.40	3.33	93,600	85,108	7,851	0	78%	0.52	0.56	0.59	0.61	0.63	A
3D	1,303,193	29.92	731,381.90	16.79	109,303	1,022,517	171,373	0	56%	0.34	0.39	0.43	0.45	0.48	A
3E	1,465,398	33.64	848,721.30	19.48	85,215	1,262,722	117,461	0	58%	0.35	0.39	0.43	0.46	0.48	A
3F	851,820	19.56	551,301.60	12.66	100,524	751,296	0	0	65%	0.44	0.48	0.53	0.56	0.58	B
3G	934,471	21.45	560,682.60	12.87	0	934,471	0	0	60%	0.41	0.46	0.51	0.54	0.56	B
3H	195,272	4.48	117,163.20	2.69	0	195,272	0	0	60%	0.37	0.41	0.45	0.47	0.5	A
3I	562,965	12.92	337,779.00	7.75	0	562,965	0	0	60%	0.46	0.51	0.57	0.6	0.63	D
3J	815,034	18.71	489,020.40	11.23	0	815,034	0	0	60%	0.37	0.41	0.45	0.47	0.5	A
3K	638,481	14.66	392,737.40	9.02	24,122	614,359	0	0	62%	0.38	0.42	0.46	0.48	0.51	A
3L	270,690	6.21	236,696.80	5.43	185,707	84,983	0	0	87%	0.66	0.69	0.72	0.73	0.75	A
3M	1,240,593	28.48	555,054.70	12.74	94,856	732,567	413,170	0	45%	0.37	0.44	0.51	0.55	0.59	D
3N	865,677	19.87	72,967.60	1.68	31,246	0	834,431	0	8%	0.2	0.29	0.4	0.47	0.53	D
3O	618,953	14.21	78,847.10	1.81	15,052	61,091	542,810	0	13%	0.08	0.15	0.21	0.25	0.29	A
3P	948,497	21.77	101,750.60	2.34	44,176	22,470	881,851	0	11%	0.14	0.22	0.31	0.36	0.4	B
3Q	741,896	17.03	73,096.60	1.68	28,080	16,956	696,860	0	10%	0.2	0.3	0.41	0.47	0.53	D
3R	1,355,953	31.13	252,367.80	5.79	0	335,582	1,020,371	0	19%	0.12	0.19	0.25	0.29	0.32	A
3S	380,374	8.73	125,855.10	2.89	0	194,248	186,126	0	33%	0.32	0.39	0.48	0.53	0.57	D
3T	630,514	14.47	315,682.70	7.25	0	516,649	113,865	0	50%	0.3	0.35	0.4	0.42	0.45	A
3U	1,211,582	27.81	532,161.20	12.22	0	857,422	354,160	0	44%	0.31	0.37	0.43	0.47	0.51	B
3V	4,296,758	98.64	501,931.90	11.52	36,856	450,912	3,758,000	50,990	12%	0.07	0.15	0.21	0.25	0.28	A
4A	865,659	19.87	547,506.20	12.57	70,277	795,382	0	0	63%	0.43	0.48	0.53	0.56	0.58	B
4B	647,110	14.86	402,244.00	9.23	34,945	612,165	0	0	62%	0.43	0.47	0.52	0.55	0.57	B
4C	782,947	17.97	484,267.40	11.12	36,248	746,699	0	0	62%	0.42	0.47	0.52	0.55	0.57	B
4D	664,556	15.26	395,312.50	9.08	58,880	556,634	49,042	0	59%	0.36	0.4	0.44	0.47	0.49	A
4E	595,182	13.66	347,720.20	7.98	216,036	204,958	174,188	0	58%	0.35	0.4	0.44	0.46	0.49	A
4F	367,111	8.43	239,637.50	5.5	61,358	294,748	0	11,005	65%	0.41	0.45	0.49	0.51	0.53	A

Table C-2: Rational Analysis Inputs

	Total Basin Area		Total Impervious Area		Land Cover Area				% Impervious						
					Pavement	Residential	Lawn/Undeveloped	Gravel							
Basin ID	sqft	acre	sq ft	ac	sq ft	sq ft	sq ft	sq ft	%	C 5yr	C 10yr	C 25yr	C 50yr	C 100yr	HSG
5	27,007	0.62	21,618.60	0.5	21,036	0	2,421	3,550	80%	0.59	0.63	0.66	0.68	0.7	B
6A	28,782	0.66	19,506.00	0.45	5,592	23,190	0	0	68%	0.43	0.47	0.51	0.52	0.54	A
6B	33,065	0.76	22,075.80	0.51	5,592	27,473	0	0	67%	0.42	0.46	0.5	0.52	0.54	A
6C	68,339	1.57	52,512.60	1.21	28,773	39,566	0	0	77%	0.51	0.55	0.58	0.6	0.62	A
6D	29,523	0.68	19,883.40	0.46	5,424	24,099	0	0	67%	0.43	0.47	0.51	0.52	0.54	A
6E	43,112	0.99	33,133.20	0.76	18,165	24,947	0	0	77%	0.51	0.55	0.58	0.6	0.62	A
6F	253,615	5.82	48,705.30	1.12	14,765	39,996	198,854	0	19%	0.12	0.19	0.25	0.29	0.32	A
6G	210,779	4.84	96,845.20	2.22	0	156,920	53,858	0	46%	0.32	0.38	0.44	0.48	0.51	B
7A	394,145	9.05	177,640.80	4.08	59,393	184,564	150,188	0	45%	0.27	0.33	0.37	0.4	0.43	A
7B	1,197,900	27.5	660,836.70	15.17	132,685	863,438	201,777	0	55%	0.38	0.43	0.48	0.51	0.54	B
7C	304,920	7	47,882.50	1.1	0	59,339	245,581	0	16%	0.1	0.17	0.23	0.27	0.3	A
8A	326,154	7.49	204,280.80	4.69	21,471	304,683	0	0	63%	0.43	0.47	0.52	0.55	0.57	B
8B	560,517	12.87	78,198.00	1.8	33,106	0	293,393	234,018	14%	0.08	0.16	0.22	0.26	0.29	A
8C	618,378	14.2	371,026.80	8.52	0	618,378	0	0	60%	0.37	0.41	0.45	0.47	0.5	A
8D	405,838	9.32	193,279.00	4.44	0	314,522	91,316	0	48%	0.28	0.34	0.38	0.41	0.44	A
8E	551,644	12.66	298,605.70	6.86	0	492,769	58,885	0	54%	0.37	0.42	0.48	0.51	0.54	B
8F	843,566	19.37	547,263.00	12.56	182,630	602,884	58,052	0	65%	0.44	0.48	0.53	0.56	0.58	B
8G	533,532	12.25	237,406.30	5.45	179,902	72,405	281,225	0	44%	0.27	0.32	0.37	0.4	0.43	A
8H	1,431,142	32.85	858,685.20	19.71	0	1,431,142	0	0	60%	0.37	0.41	0.45	0.47	0.5	A
8I	1,181,548	27.12	756,036.40	17.36	194,802	930,722	56,024	0	64%	0.43	0.48	0.53	0.56	0.58	B
8J	483,843	11.11	277,070.60	6.36	0	459,779	24,064	0	57%	0.35	0.39	0.43	0.46	0.48	A
8K	1,105,749	25.38	656,191.50	15.06	36,334	1,029,794	39,621	0	59%	0.36	0.4	0.44	0.47	0.49	A
8L	818,257	18.78	632,133.10	14.51	472,960	258,015	87,282	0	77%	0.52	0.56	0.59	0.61	0.63	A
8M	419,673	9.63	340,183.70	7.81	336,000	0	83,673	0	81%	0.57	0.61	0.64	0.65	0.67	A
8N	376,195	8.64	225,717.00	5.18	0	376,195	0	0	60%	0.37	0.41	0.45	0.47	0.5	A
8Aa	733,842	16.85	502,055.80	11.53	352,496	237,259	144,087	0	68%	0.47	0.51	0.56	0.59	0.61	B
9Aa	1,437,010	32.99	899,935.20	20.66	144,663	1,255,736	36,611	0	63%	0.43	0.47	0.52	0.55	0.57	B
9Ab	1,235,680	28.37	768,781.30	17.65	190,298	956,753	88,629	0	62%	0.43	0.47	0.52	0.55	0.57	B
9Ac	398,398	9.15	318,581.70	7.31	274,852	68,277	55,269	0	80%	0.58	0.62	0.65	0.67	0.69	B
9A	608,324	13.97	559,759.20	12.85	486,912	121,412	0	0	92%	0.75	0.77	0.79	0.8	0.82	A
9B	164,974	3.79	117,550.40	2.7	46,415	118,559	0	0	71%	0.46	0.5	0.54	0.55	0.57	A
9C	492,228	11.3	303,381.80	6.96	121,978	296,166	74,084	0	62%	0.38	0.42	0.46	0.48	0.51	A
9D	179,767	4.13	98,159.90	2.25	0	162,130	17,637	0	55%	0.32	0.37	0.42	0.44	0.47	A
9E	129,308	2.97	43,410.60	1	0	67,173	62,135	0	34%	0.21	0.27	0.32	0.35	0.38	A
9F	133,294	3.06	86,331.60	1.98	15,888	117,406	0	0	65%	0.4	0.44	0.48	0.5	0.52	A
9G	179,146	4.11	115,850.80	2.66	20,908	158,238	0	0	65%	0.4	0.44	0.48	0.5	0.52	A
9H	117,147	2.69	70,288.20	1.61	0	117,147	0	0	60%	0.37	0.41	0.45	0.47	0.5	A
9I	135,154	3.1	83,704.90	1.92	80,997	0	54,157	0	62%	0.38	0.42	0.46	0.48	0.51	A
9Ia	352,915	8.1	162,691.80	3.73	0	263,720	89,195	0	46%	0.28	0.33	0.38	0.4	0.43	A
9Ib	253,900	5.83	152,340.00	3.5	0	253,900	0	0	60%	0.37	0.41	0.45	0.47	0.5	A
9J	539,107	12.38	269,590.40	6.19	57,726	341,446	139,935	0	50%	0.3	0.35	0.4	0.42	0.45	A

Table C-2: Rational Analysis Inputs

					Land Cover Area										
	Total Basin Area		Total Impervious Area		Pavement	Residential	Lawn/Undeveloped	Gravel	% Impervious						
Basin ID	sqft	acre	sq ft	ac	sq ft	sq ft	sq ft	sq ft	%	C 5yr	C 10yr	C 25yr	C 50yr	C 100yr	HSG
9K	1,302,710	29.91	762,765.60	17.51	119,338	1,062,289	121,083	0	59%	0.35	0.4	0.44	0.46	0.49	A
9L	927,070	21.28	552,674.30	12.69	39,731	851,957	35,382	0	60%	0.4	0.45	0.5	0.53	0.56	B
9M	717,255	16.47	298,004.90	6.84	0	476,622	240,633	0	42%	0.25	0.31	0.35	0.38	0.41	A
9N	888,506	20.4	448,157.90	10.29	37,403	669,454	181,649	0	50%	0.3	0.35	0.4	0.42	0.45	A
9O	578,773	13.29	372,213.80	8.54	62,375	516,398	0	0	64%	0.4	0.44	0.48	0.5	0.52	A
9P	835,925	19.19	132,433.00	3.04	61,761	58,116	716,048	0	16%	0.1	0.17	0.23	0.27	0.3	A
9Q	421,027	9.67	274,131.40	6.29	53,788	367,239	0	0	65%	0.41	0.45	0.49	0.51	0.53	A
10A	220,748	5.07	137,245.00	3.15	31,250	175,491	14,007	0	62%	0.39	0.43	0.47	0.49	0.51	A
10B	804,039	18.46	329,133.00	7.56	45,290	447,101	311,648	0	41%	0.25	0.3	0.35	0.38	0.41	A
11A	209,613	4.81	174,822.60	4.01	122,637	86,976	0	0	83%	0.6	0.64	0.67	0.68	0.7	A
11B	823,284	18.9	493,970.40	11.34	0	823,284	0	0	60%	0.37	0.41	0.45	0.47	0.5	A
11C	462,781	10.62	294,936.10	6.77	107,615	308,296	46,870	0	64%	0.39	0.43	0.47	0.49	0.52	A
12	779,367	17.89	412,795.30	9.48	33,833	621,238	124,390	0	53%	0.31	0.36	0.41	0.43	0.46	A
13	1,314,915	30.19	852,256.00	19.57	363,555	802,060	149,300	0	65%	0.4	0.44	0.48	0.5	0.52	A
14A	966,148	22.18	505,211.30	11.6	28,940	780,747	156,461	0	52%	0.31	0.36	0.41	0.43	0.46	A
14B	341,815	7.85	223,382.20	5.13	45,733	296,082	0	0	65%	0.41	0.45	0.49	0.51	0.53	A
15A	175,592	4.03	89,065.50	2.04	28,577	96,614	50,401	0	51%	0.3	0.35	0.4	0.42	0.45	A
15B	120,226	2.76	100,542.00	2.31	71,016	49,210	0	0	84%	0.6	0.64	0.67	0.68	0.7	A
16	286,038	6.57	171,622.80	3.94	0	286,038	0	0	60%	0.37	0.41	0.45	0.47	0.5	A
17	1,309,679	30.07	725,980.10	16.67	0	1,200,902	108,777	0	55%	0.33	0.38	0.42	0.45	0.47	A
17a	391,949	9	202,557.20	4.65	0	332,654	59,295	0	52%	0.31	0.36	0.4	0.43	0.45	A
17b	476,695	10.94	277,733.50	6.38	0	461,634	15,061	0	58%	0.4	0.45	0.5	0.53	0.55	B
17c	275,361	6.32	165,216.60	3.79	0	275,361	0	0	60%	0.41	0.46	0.51	0.54	0.56	B
18A	239,528	5.5	133,688.70	3.07	0	221,295	18,233	0	56%	0.33	0.38	0.42	0.45	0.47	A
18B	1,115,837	25.62	295,093.50	6.77	35,142	373,092	698,651	8,952	26%	0.17	0.23	0.29	0.32	0.35	A
18C	673,355	15.46	154,507.90	3.55	64,580	105,090	482,564	21,121	23%	0.14	0.21	0.27	0.31	0.34	A
18D	416,688	9.57	263,078.00	6.04	32,663	384,025	0	0	63%	0.39	0.43	0.47	0.49	0.52	A
18E	420,075	9.64	144,887.90	3.33	13,175	202,487	204,413	0	34%	0.21	0.27	0.33	0.36	0.39	A
18F	338,234	7.76	150,226.80	3.45	9,423	226,115	102,696	0	44%	0.27	0.32	0.37	0.4	0.43	A
19A	977,020	22.43	62,688.20	1.44	12,940	0	944,778	19,302	6%	0.03	0.11	0.17	0.21	0.25	A
19B	1,143,102	26.24	63,755.00	1.46	0	0	1,060,603	82,499	6%	0.02	0.1	0.16	0.2	0.24	A
19C	104,068	2.39	20,035.50	0.46	0	24,838	64,590	14,640	19%	0.12	0.19	0.25	0.29	0.32	A
19D	1,415,391	32.49	96,197.30	2.21	26,766	0	1,388,625	0	7%	0.03	0.11	0.17	0.21	0.25	A
19E	1,181,055	27.11	80,223.80	1.84	0	31,296	1,100,281	49,478	7%	0.19	0.28	0.39	0.46	0.52	C
19F	141,399	3.25	7,700.00	0.18	0	0	133,523	7,876	5%	0.02	0.1	0.16	0.2	0.24	A
19G	2,713,601	62.3	154,065.10	3.54	13,372	0	2,629,209	71,020	6%	0.02	0.1	0.16	0.2	0.24	A
19H	592,412	13.6	56,951.20	1.31	27,261	0	547,243	17,908	10%	0.05	0.13	0.19	0.23	0.27	A
20A	835,041	19.17	43,767.40	1	0	0	809,849	25,192	5%	0.02	0.1	0.16	0.2	0.24	A
20B	971,401	22.3	59,343.00	1.36	9,829	0	943,629	17,943	6%	0.03	0.11	0.17	0.21	0.25	A
20C	1,324,516	30.41	301,062.30	6.91	92,716	264,903	953,652	13,245	23%	0.14	0.21	0.27	0.31	0.34	A
20D	579,670	13.31	80,771.40	1.85	26,890	45,680	493,120	13,980	14%	0.08	0.16	0.22	0.26	0.29	A

Table C-2: Rational Analysis Inputs

Basin ID	Total Basin Area sqft	Total Basin Area acre	Total Impervious Area sq ft	Total Impervious Area ac	Land Cover Area: Pavement sq ft	Land Cover Area: Residential sq ft	Land Cover Area: Lawn/Undeveloped sq ft	Land Cover Area: Gravel sq ft	% Impervious %	C 5yr	C 10yr	C 25yr	C 50yr	C 100yr	HSG
21A	1,407,563	32.31	120,962.80	2.78	53,247	0	1,354,316	0	9%	0.04	0.12	0.18	0.22	0.26	A
21B	180,900	4.15	43,663.50	1	0	60,618	104,299	15,983	24%	0.15	0.22	0.28	0.32	0.35	A
21C	782,608	17.97	206,748.40	4.75	11,235	283,221	473,487	14,665	26%	0.17	0.23	0.29	0.32	0.35	A
21D	3,415,039	78.4	602,239.30	13.83	56,499	683,411	2,650,913	24,216	18%	0.11	0.18	0.24	0.28	0.31	A
22A	610,411	14.01	577,847.00	13.27	507,164	109,201	103,247	0	95%	0.78	0.8	0.82	0.83	0.85	A
22B	1,260,565	28.94	430,994.60	9.89	387,333	0	873,232	0	34%	0.21	0.27	0.33	0.36	0.39	A
22C	497,913	11.43	288,761.30	6.63	23,244	439,607	35,062	0	58%	0.35	0.39	0.43	0.46	0.48	A
22D	970,543	22.28	582,325.80	13.37	0	970,543	0	0	60%	0.37	0.41	0.45	0.47	0.5	A
22E	575,728	13.22	332,188.40	7.63	0	551,640	24,088	0	58%	0.35	0.39	0.43	0.46	0.48	A
22F	1,140,183	26.18	704,582.60	16.17	51,182	1,089,001	0	0	62%	0.38	0.42	0.46	0.48	0.51	A
22G	727,692	16.71	395,717.00	9.08	19,409	619,807	88,476	0	54%	0.32	0.37	0.42	0.44	0.47	A
22H	957,105	21.97	470,707.40	10.81	0	768,822	188,283	0	49%	0.29	0.35	0.39	0.42	0.45	A
22I	1,352,760	31.06	738,607.20	16.96	40,583	1,149,846	162,331	0	55%	0.32	0.37	0.42	0.44	0.47	A
22J	349,016	8.01	17,450.80	0.4	0	0	349,016	0	5%	0.02	0.09	0.15	0.19	0.23	A
23A	313,615	7.2	150,970.60	3.47	32,492	189,859	91,264	0	48%	0.29	0.34	0.39	0.41	0.44	A
23B	254,842	5.85	157,775.40	3.62	87,964	111,759	55,119	0	62%	0.38	0.42	0.46	0.48	0.51	A
23C	768,316	17.64	59,330.40	1.36	20,560	0	730,474	17,282	8%	0.04	0.12	0.18	0.22	0.26	A
23D	1,281,553	29.42	80,892.70	1.86	17,700	0	1,263,853	0	6%	0.03	0.11	0.17	0.21	0.25	A
24A	379,867	8.72	313,924.70	7.21	310,454	0	69,413	0	83%	0.59	0.62	0.65	0.66	0.68	A
24B	186,004	4.27	146,965.60	3.37	88,408	97,596	0	0	79%	0.55	0.59	0.62	0.63	0.65	A
24C	826,677	18.98	110,849.30	2.54	48,702	42,270	735,705	0	13%	0.08	0.16	0.22	0.26	0.29	A
24D	1,086,940	24.95	669,926.80	15.38	44,407	1,042,533	0	0	62%	0.38	0.42	0.46	0.48	0.51	A
24E	1,344,998	30.88	1,032,935.40	23.71	1,016,511	0	328,487	0	77%	0.51	0.55	0.58	0.6	0.62	A
24F	1,193,152	27.39	738,173.30	16.95	714,227	0	478,925	0	62%	0.38	0.42	0.46	0.48	0.51	A
25A	154,128	3.54	92,476.80	2.12	0	154,128	0	0	60%	0.37	0.41	0.45	0.47	0.5	A
25B	2,166,443	49.73	1,299,865.80	29.84	0	2,166,443	0	0	60%	0.37	0.41	0.45	0.47	0.5	A
25C	608,190	13.96	364,914.00	8.38	0	608,190	0	0	60%	0.37	0.41	0.45	0.47	0.5	A
25D	621,618	14.27	372,970.80	8.56	0	621,618	0	0	60%	0.37	0.41	0.45	0.47	0.5	A
26A	4,703,362	107.97	270,300.50	6.21	36,982	0	4,666,381	0	6%	0.18	0.28	0.39	0.46	0.52	D
26B	2,033,994	46.69	255,451.80	5.86	19,463	245,932	1,768,599	0	13%	0.08	0.15	0.21	0.25	0.29	A
26C	2,329,202	53.47	196,385.60	4.51	33,205	87,965	2,208,032	0	8%	0.2	0.29	0.4	0.47	0.53	D
26D	392,899	9.02	34,661.10	0.8	0	27,302	365,597	0	9%	0.12	0.21	0.3	0.35	0.39	B
26E	1,147,831	26.35	217,356.40	4.99	32,376	234,923	880,532	0	19%	0.12	0.19	0.25	0.29	0.32	A
26F	745,220	17.11	75,610.00	1.74	3,611	55,888	633,469	52,252	10%	0.14	0.22	0.31	0.36	0.4	B
26G	600,891	13.79	262,960.20	6.04	0	423,483	177,408	0	44%	0.26	0.32	0.36	0.39	0.42	A
26H	1,295,171	29.73	635,109.70	14.58	0	1,037,002	258,169	0	49%	0.29	0.35	0.39	0.42	0.45	A
26I	1,716,089	39.4	656,098.70	15.06	102,446	859,947	753,697	0	38%	0.24	0.29	0.34	0.37	0.4	A
26J	1,514,560	34.77	457,619.00	10.51	22,554	655,391	836,616	0	30%	0.19	0.25	0.31	0.34	0.37	A
26K	1,597,101	36.66	228,057.50	5.24	36,844	205,819	1,354,438	0	14%	0.09	0.16	0.22	0.26	0.3	A
26L	1,696,015	38.94	920,592.70	21.13	79,148	1,382,912	233,956	0	54%	0.32	0.37	0.42	0.44	0.47	A
26M	1,046,244	24.02	582,325.30	13.37	45,866	884,437	115,941	0	56%	0.33	0.38	0.42	0.45	0.47	A

Table C-2: Rational Analysis Inputs

	Total Basin Area		Total Impervious Area		Land Cover Area				% Impervious						
					Pavement	Residential	Lawn/Undeveloped	Gravel							
Basin ID	sqft	acre	sq ft	ac	sq ft	sq ft	sq ft	sq ft	%	C 5yr	C 10yr	C 25yr	C 50yr	C 100yr	HSG
26N	2,584,930	59.34	2,075,021.70	47.64	1,548,871	862,451	173,608	0	80%	0.56	0.6	0.63	0.64	0.66	A
26O	1,313,230	30.15	788,263.10	18.1	131,668	1,086,395	95,167	0	60%	0.37	0.41	0.45	0.47	0.5	A
26P	1,651,790	37.92	967,489.90	22.21	290,036	1,107,938	253,816	0	59%	0.35	0.4	0.44	0.46	0.49	A
26Q	1,996,530	45.83	1,117,410.70	25.65	303,545	1,325,848	367,137	0	56%	0.33	0.38	0.42	0.45	0.47	A
26R	1,339,050	30.74	796,316.60	18.28	586,110	313,745	439,195	0	59%	0.36	0.4	0.44	0.47	0.49	A
26S	1,776,880	40.79	1,079,587.20	24.78	209,914	1,438,773	128,193	0	61%	0.37	0.41	0.45	0.47	0.5	A

Table C-3: Information from Drainage Reports

SUBDIVISION	INTERSECTION	PROBLEM AREA	POND ID	CUHP BASIN	GIS ID	A_D (AC)	A (AC)	V_{MAX} (AF)	Q_{MAX} (CFS)	Notes
Grapevine Hollow	Sauvignon St		Pond 1	ASD-225	52	69		5.71	81	
Prairie Heights MS	37th St. and 65th Ave	Problem Area #20	Detention Pond	ASD-210	13	21.51	0.84	3.51	21.5	Not included in SWMM, but considered in Rational Analysis
Neville's Crossing		Problem Area #18	Pond 201	BTT-190	50	51.59	1.87	7.52	97.9	Not included in SWMM, but considered in Rational Analysis
			Pond 301	BTT-190	49	47.75	1.01	5.45	69.6	
North Point	37th St. and 35th Ave	Problem Area #3	Detention Pond A	CB-160	29	79.56	2.27	13.16	58.2	
Cave Creek	35th Ave and Antelope Way	Problem Area #22	Detention Pond	CB-250	32			21.80	82.6	
Ashcroft Heights	37th St and 35th Ave	Problem Area #7	#3	ASD-270	42	22		25.98	64.8	
			#8	ASD-270	35			15.16	9.2	
Hunters Reserve	37th St. and 29th Ave.	Problem Area #3	Pond 1	CB-120	27		1.34	4.46	54.9	Obtained only rating and storage curve information; City staff scanned relevant rating and storage curves from drainage reports and sent them to Muller
	Pheasant St. and 35th Ave.	Problem Area #22	Pond 2	CB-210	31			6.14	67.4	
	Prairie View Dr. and 29th Ave.	Problem Area #3	Pond 3	CB-290	28			9.61	24.1	
Prairie Ridge	Laurel Dr. and Daylily Way	Problem Area #3	Pond B	CB-280	21	236.6		52.8	54	
Willow Brook	Prairie View Dr. and Harbor Ln.	Problem Area #3	Pond A	CB-220	24			10.53	155	
Landings	37th and Harbor Ln.	Problem Area #3	Detention Pond	CB-170	23		51.46	5.37	38	
Chappelow	34th St. and 17th Ave.		Chappelow Detention Pond	CB-180	14		4.98		50	Inforamtion estimated from contours and known pipe sizes

Note:

Ponds within problem areas are not necessarily the cause of the problem, or modeled within the rational basins; those noted are central to problem are analysis and were included

Table C-4: 100-Year Existing CUHP Results

	Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
Catchment ID	Ct	Cp	W50 min	W50 Before Peak	W75 min	W75 Before Peak	Time to Peak min	Peak cfs	Volume cu ft	Excess inches	Excess cu ct	Time to Peak min	Peak Flow cfs	Total Volume cu ft	Runoff per Unit Area cfs/acre
ASD-100	0.156	0.296	52.5	13.43	27.3	9.49	22.4	248	1,008,041	2.04	2,052,749	55	410	2,051,622	1.48
ASD-110	0.156	0.299	58.5	14.97	30.4	10.58	24.9	238	1,080,007	1.87	2,016,037	60	378	2,014,722	1.27
ASD-120	0.157	0.287	23.8	6.73	12.4	4.76	11.2	423	777,763	0.96	743,327	40	341	742,803	1.59
ASD-130	0.095	0.436	6.8	2.38	3.5	1.59	6.3	1,014	534,673	1.66	886,697	35	627	909,048	4.25
ASD-140	0.156	0.303	58	15.03	30.2	10.62	25	274	1,232,671	0.96	1,187,753	55	253	1,187,137	0.74
ASD-150	0.157	0.286	48.1	12.06	25	8.52	20.1	204	759,749	0.96	726,111	50	184	726,181	0.88
ASD-160	0.085	0.587	12.8	4.46	6.6	2.98	12.1	881	869,985	2.31	2,008,487	40	951	2,005,307	3.97
ASD-170	0.096	0.382	14.6	5.1	7.6	3.41	9.6	615	693,996	1.53	1,058,952	35	528	1,052,093	2.76
ASD-180	0.084	0.62	8.5	2.97	4.4	1.98	9.2	1,703	1,118,233	1.95	2,183,515	35	1,361	2,165,270	4.42
ASD-190	0.1	0.514	10.5	3.68	5.5	2.46	9.4	408	332,132	1.94	645,027	35	355	640,626	3.88
ASD-200	0.208	0.239	47.9	10.31	24.9	7.28	17.2	63	234,325	0.96	223,950	50	56	223,720	0.87
ASD-210	0.149	0.219	35.8	7.53	18.6	5.32	12.5	128	355,192	1.09	385,524	45	117	385,220	1.2
ASD-220	0.101	0.336	18.3	6.22	9.5	4.39	10.4	710	1,003,715	1.4	1,409,518	40	622	1,405,567	2.25
ASD-230	0.157	0.258	43.2	10.06	22.4	7.11	16.8	152	507,315	0.98	498,878	45	136	498,711	0.97
ASD-240	0.146	0.26	32.4	7.98	16.9	5.64	13.3	258	649,221	1.01	653,244	45	223	652,214	1.25
ASD-250	0.208	0.24	13.5	4	7	2.82	6.7	48	50,244	1.48	74,326	35	40	73,758	2.86
ASD-260	0.09	0.496	7.9	2.77	4.1	1.85	7.5	877	537,925	1.76	949,315	35	596	905,423	4.02
ASD-270	0.086	0.581	12.5	4.39	6.5	2.93	11.8	962	933,620	1.89	1,765,833	40	881	1,759,554	3.43
ASD-280	0.093	0.456	23.1	8.08	12	5.4	16	514	918,414	2.15	1,975,734	45	675	1,973,778	2.67
ASD-290	0.102	0.311	18.3	5.89	9.5	4.16	9.8	387	549,716	1.41	776,786	35	338	773,502	2.23
ASD-310	0.112	0.259	29.8	7.43	15.5	5.25	12.4	284	654,436	1.24	814,306	40	271	813,878	1.5
ASD-320	0.101	0.407	26	9.11	13.5	6.09	16	222	447,650	1.6	717,793	45	239	716,515	1.94
ASD-330	0.112	0.301	39.7	10.68	20.7	7.54	17.8	578	1,777,843	1.24	2,209,259	50	587	2,207,964	1.2
BTT-110	0.157	0.29	37.2	9.79	19.3	6.92	16.3	295	848,124	0.96	810,572	45	257	810,045	1.1
BTT-120	0.157	0.278	25.9	7.01	13.5	4.96	11.7	314	628,507	0.96	600,679	40	257	599,295	1.48
BTT-130	0.157	0.275	36.1	9.11	18.8	6.44	15.2	209	584,650	0.96	558,764	45	182	558,719	1.13
BTT-140	0.171	0.263	33.4	8.24	17.4	5.82	13.7	170	439,092	0.96	419,651	45	144	418,884	1.19
BTT-150	0.198	0.243	33.4	7.73	17.4	5.46	12.9	104	269,087	1.87	502,302	45	142	501,493	1.91
BTT-160	0.157	0.29	44.3	11.36	23	8.03	18.9	244	836,631	0.96	799,588	50	217	799,263	0.94
BTT-170	0.134	0.231	43.9	9.31	22.8	6.58	15.5	98	333,409	1.23	410,536	45	100	410,340	1.09
BTT-180	0.144	0.225	43.1	8.96	22.4	6.33	14.9	124	414,438	1.08	447,323	45	118	447,043	1.03
BTT-190	0.099	0.357	17.4	6.09	9.1	4.07	10.5	756	1,019,107	1.46	1,486,775	40	669	1,481,915	2.38
BTT-200	0.164	0.268	68.1	15.52	35.4	10.97	25.9	95	500,949	0.96	478,769	55	88	478,606	0.63
BTT-210	0.177	0.259	59.9	13.42	31.2	9.48	22.4	85	395,650	0.91	358,746	55	74	358,676	0.68
BTT-220	0.159	0.273	49.4	11.85	25.7	8.37	19.8	147	561,492	0.96	536,631	50	132	536,654	0.86
BTT-230	0.157	0.29	38.7	10.13	20.1	7.16	16.9	281	844,221	0.96	806,842	45	247	805,496	1.06
BTT-240	0.157	0.276	23.8	6.55	12.4	4.63	10.9	326	602,266	0.96	575,601	40	263	575,394	1.58
BTT-250	0.164	0.268	61.4	14.15	31.9	10	23.6	106	501,765	0.96	479,549	55	97	479,306	0.7
BTT-260	0.172	0.263	43.5	10.26	22.6	7.25	17.1	129	434,580	0.96	415,339	45	114	415,168	0.95
BTT-270	0.156	0.276	49.9	12.1	26	8.55	20.2	165	639,582	1.99	1,271,088	55	263	1,271,334	1.49

Table C-4: 100-Year Existing CUHP Results

	Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
			W50	W50 Before Peak	W75	W75 Before Peak	Time to Peak	Peak	Volume	Excess	Excess	Time to Peak	Peak Flow	Total Volume	Runoff per Unit Area
Catchment ID	Ct	Cp	min		min		min	cfs	cu ft	inches	cu ct	min	cfs	cu ft	cfs/acre
BTT-280	0.148	0.218	29.3	6.4	15.2	4.52	10.7	114	259,439	1.21	314,689	40	108	314,738	1.51
BTT-290	0.156	0.291	39.4	10.3	20.5	7.28	17.2	296	902,066	1.99	1,792,743	50	443	1,790,366	1.78
BTT-300	0.165	0.265	35.6	8.75	18.5	6.18	14.6	175	483,565	1.99	961,024	45	254	960,576	1.91
BTT-310	0.157	0.306	74	18.87	38.5	13.33	31.4	208	1,192,287	0.91	1,081,076	60	183	1,081,034	0.56
BTT-320	0.193	0.248	11.2	3.63	5.8	2.56	6	345	298,060	0.91	270,258	35	205	265,632	2.5
BTT-330	0.156	0.275	34.7	8.84	18	6.25	14.7	232	624,641	1.99	1,241,396	45	335	1,240,331	1.95
BTT-340	0.122	0.241	22.9	5.72	11.9	4.04	9.5	370	655,163	2.1	1,374,383	40	481	1,374,480	2.66
BTT-350	0.113	0.257	38.1	9.03	19.8	6.38	15	180	531,544	1.28	679,332	45	185	678,926	1.27
BTT-360	0.094	0.402	12.4	4.35	6.5	2.91	8.9	680	654,060	1.58	1,033,907	35	573	1,032,660	3.18
BTT-370	0.112	0.438	14.5	5.09	7.6	3.4	10.6	244	274,918	1.76	484,059	40	221	478,365	2.92
BTT-380	0.209	0.203	4.3	1.5	2.2	1	3.6	475	157,541	1.04	163,876	30	187	141,437	4.31
CB-100	0.094	0.531	12.2	4.25	6.3	2.84	10.8	436	410,449	1.94	797,871	40	391	795,932	3.46
CB-110	0.079	0.694	9.4	3.27	4.9	2.19	10.8	1,554	1,125,827	2.2	2,478,276	35	1,332	2,520,785	4.29
CB-130	0.085	0.561	15.7	5.48	8.1	3.67	13.7	516	626,028	2.31	1,447,345	40	609	1,446,451	3.53
CB-140	0.088	0.551	12	4.18	6.2	2.8	10.9	551	509,517	1.93	984,845	40	488	982,710	3.48
CB-150	0.091	0.535	15	5.26	7.8	3.52	12.8	397	462,417	1.91	881,881	40	400	887,156	3.14
CB-160	0.078	0.663	10.2	3.57	5.3	2.39	11.2	983	776,964	2.24	1,743,408	40	890	1,747,626	4.16
CB-170	0.089	0.487	13.2	4.63	6.9	3.1	10.7	565	579,006	1.73	1,000,718	40	488	989,809	3.06
CB-180	0.083	0.588	13.3	4.65	6.9	3.11	12.5	554	570,255	2.05	1,166,550	40	555	1,172,787	3.53
CB-190	0.083	0.594	8.7	3.04	4.5	2.03	9.1	826	554,813	2.38	1,322,584	35	753	1,306,573	4.92
CB-200	0.082	0.611	35	12.27	18.2	8.2	29.9	192	520,420	2.16	1,126,603	60	275	1,124,674	1.92
CB-210	0.105	0.565	4.3	1.51	2.2	1.01	5.6	608	202,739	2.41	488,260	30	422	592,769	7.56
CB-220	0.086	0.535	14.4	5.03	7.5	3.36	12.3	544	605,189	1.86	1,128,289	40	534	1,134,310	3.2
CB-120	0.151	0.396	12.9	4.51	6.7	3.02	9	100	99,730	1.82	181,640	35	91	181,420	3.31
CB-280	0.091	0.48	16.3	5.71	8.5	3.82	12.5	526	664,063	1.72	1,139,835	40	518	1,144,367	2.83
CB-290	0.121	0.51	18.6	6.51	9.7	4.35	14.6	103	148,181	2.2	325,651	40	118	323,840	2.88
CB-230	0.094	0.414	25.1	8.8	13.1	5.88	15.8	303	588,985	1.61	947,955	45	324	947,090	2
CB-240	0.104	0.296	32	8.77	16.7	6.2	14.6	277	686,303	1.37	937,360	45	286	935,093	1.51
CB-250	0.079	0.716	8.5	2.99	4.4	2	10.3	2,081	1,374,821	2.18	2,996,567	35	1,754	3,058,808	4.63
CB-260	0.128	0.23	25.7	6.04	13.4	4.27	10.1	237	471,489	1.15	542,972	40	211	542,264	1.63
CB-270	0.099	0.547	6.7	2.34	3.5	1.56	7.2	590	304,709	2.06	628,438	35	384	597,488	4.58
SC-100	0.121	0.272	129.2	28.5	67.2	20.14	47.5	144	1,440,839	2.1	3,028,403	90	285	3,028,234	0.72
SC-110	0.121	0.245	50.6	11.02	26.3	7.79	18.4	184	720,933	2.1	1,514,444	55	300	1,514,445	1.51
SE-100	0.157	0.328	14.5	5.08	7.5	3.4	8.6	1,700	1,910,323	0.96	1,825,742	35	1,219	1,815,796	2.32
SE-110	0.156	0.326	72.6	19.7	37.8	13.92	32.8	340	1,912,698	1.82	3,476,689	70	554	3,476,309	1.05
SE-120	0.156	0.321	89.7	23.62	46.7	16.69	39.4	246	1,711,992	1.82	3,111,868	75	416	3,111,348	0.88
SE-130	0.156	0.314	172.5	43.14	89.7	30.49	71.9	111	1,489,273	1.87	2,780,010	110	204	2,779,993	0.5
SE-140	0.156	0.314	68.8	18.07	35.8	12.77	30.1	277	1,474,509	1.87	2,752,450	65	457	2,752,207	1.12
SE-150	0.156	0.291	59.1	14.69	30.7	10.38	24.5	194	888,675	1.87	1,658,880	60	308	1,657,743	1.26

Table C-4: 100-Year Existing CUHP Results

	Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
Catchment ID	Ct	Cp	W50 min	W50 Before Peak	W75 min	W75 Before Peak	Time to Peak min	Peak cfs	Volume cu ft	Excess inches	Excess cu ct	Time to Peak min	Peak Flow cfs	Total Volume cu ft	Runoff per Unit Area cfs/acre
SE-160	0.156	0.284	30.8	8.23	16	5.81	13.7	322	769,409	2.04	1,566,805	45	460	1,565,020	2.17
SE-170	0.156	0.338	20.4	6.8	10.6	4.8	11.3	1,528	2,415,292	1.87	4,508,598	40	1,822	4,507,130	2.74
SW-100	0.156	0.336	67.9	19.05	35.3	13.46	31.8	450	2,367,248	2.04	4,820,603	65	798	4,819,918	1.22
SW-110	0.157	0.337	85.1	23.52	44.2	16.62	39.2	348	2,295,068	0.96	2,193,453	70	326	2,193,377	0.52
SW-120	0.157	0.339	74.3	20.82	38.6	14.71	34.7	412	2,367,527	0.96	2,262,703	65	383	2,262,469	0.59
SW-130	0.157	0.339	86.4	24.01	44.9	16.97	40	357	2,388,180	0.96	2,282,442	70	334	2,282,576	0.51
SW-140	0.157	0.328	62	17.11	32.2	12.09	28.5	397	1,904,134	0.96	1,819,827	60	364	1,819,725	0.69
SW-150	0.157	0.356	103.8	29.93	54	21.15	49.9	415	3,334,559	0.96	3,186,919	80	391	3,186,980	0.43
SW-160	0.134	0.323	94.7	24.96	49.2	17.64	41.6	554	4,062,696	1.06	4,313,305	75	566	4,313,270	0.51
SW-170	0.109	0.268	14	4.39	7.3	3.11	7.3	560	608,692	2.15	1,309,049	35	612	1,303,683	3.65
H-100	0.082	0.623	7.1	2.5	3.7	1.67	8.2	882	487,872	2.52	1,228,393	35	694	1,162,910	5.16
H-110	0.084	0.612	5.2	1.82	2.7	1.22	6.6	1,153	464,640	2.49	1,158,146	35	683	1,111,023	5.34
H-120	0.132	0.234	37.2	8.19	19.4	5.79	13.7	121	348,480	2.09	729,144	45	179	728,700	1.86
H-130	0.085	0.602	19.8	6.93	10.3	4.64	17.8	303	464,640	2.48	1,154,285	45	407	1,153,599	3.18
H-140	0.083	0.589	13.5	4.71	7	3.15	12.6	535	557,568	2.06	1,146,486	40	541	1,154,439	3.52
H-150	0.223	0.214	32.7	6.87	17	4.85	11.4	17	44,141	2.29	101,087	45	26	101,100	2.16

Table C-4: 100-Year Future Land Use CUHP Results

	Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
			W50	W50 Before Peak	W75	W75 Before Peak	Time to Peak	Peak	Volume	Excess	Excess	Time to Peak	Peak Flow	Total Volume	Runoff per Unit Area
Catchment ID	Ct	Cp	min		min		min	cfs	cu ft	inches	cu ct	min	cfs	cu ft	cfs/acre
ASD-100	0.089	0.532	16.7	5.84	8.7	3.91	13.9	780	1,008,041	2.3	2,323,023	40	946	2,321,731	3.41
ASD-110	0.114	0.274	46.6	11.3	24.2	7.98	18.8	299	1,080,007	1.98	2,141,463	50	457	2,139,104	1.54
ASD-120	0.157	0.287	23.8	6.73	12.4	4.76	11.2	423	777,763	0.96	743,327	40	341	742,803	1.59
ASD-130	0.094	0.44	6.7	2.36	3.5	1.58	6.3	1,025	534,673	1.67	890,447	35	630	912,033	4.27
ASD-140	0.085	0.614	15.7	5.5	8.2	3.68	14.9	1,013	1,232,671	1.89	2,324,053	40	995	2,302,256	2.93
ASD-150	0.157	0.286	48.1	12.06	25	8.52	20.1	204	759,749	0.96	726,111	50	184	726,181	0.88
ASD-160	0.084	0.595	12.5	4.37	6.5	2.92	12	900	869,985	2.32	2,018,556	40	960	2,015,750	4.01
ASD-170	0.089	0.506	10.3	3.6	5.3	2.4	9.1	872	693,996	1.74	1,209,128	35	712	1,199,873	3.72
ASD-180	0.084	0.622	8.4	2.95	4.4	1.97	9.2	1,714	1,118,233	1.96	2,191,345	35	1,368	2,172,482	4.44
ASD-190	0.1	0.514	10.5	3.68	5.5	2.46	9.4	408	332,132	1.94	645,630	35	355	641,171	3.88
ASD-200	0.12	0.403	16.5	5.76	8.6	3.85	11	184	234,325	1.68	392,921	40	173	391,387	2.68
ASD-210	0.094	0.563	8.8	3.06	4.6	2.05	8.8	524	355,192	2.08	738,658	35	431	724,845	4.41
ASD-220	0.087	0.573	9.2	3.21	4.8	2.15	9.2	1,411	1,003,715	1.83	1,835,995	35	1,127	1,820,791	4.08
ASD-230	0.087	0.56	11	3.85	5.7	2.57	10.4	595	507,315	1.95	991,592	35	515	993,154	3.69
ASD-240	0.079	0.633	7.2	2.53	3.8	1.69	8.4	1,158	649,221	2.15	1,395,975	35	850	1,335,250	4.75
ASD-250	0.175	0.408	6.7	2.36	3.5	1.58	6	96	50,244	2.01	101,040	30	67	104,517	4.83
ASD-260	0.082	0.606	5.9	2.06	3.1	1.38	7.1	1,180	537,925	2.11	1,132,552	35	695	1,043,418	4.69
ASD-270	0.082	0.639	10.9	3.8	5.6	2.54	11.4	1,111	933,620	2.07	1,931,245	40	992	1,937,170	3.86
ASD-280	0.089	0.525	19.2	6.73	10	4.5	15.4	617	918,414	2.21	2,029,584	45	760	2,025,750	3
ASD-290	0.086	0.554	8.7	3.03	4.5	2.03	8.6	819	549,716	1.91	1,051,952	35	641	1,027,759	4.24
ASD-310	0.083	0.594	9.6	3.35	5	2.24	9.8	883	654,436	2	1,305,983	35	748	1,312,902	4.15
ASD-320	0.094	0.509	19.3	6.75	10	4.51	15.1	300	447,650	1.83	820,408	45	311	818,430	2.53
ASD-330	0.083	0.691	12.7	4.46	6.6	2.98	13.8	1,803	1,777,843	2	3,547,837	40	1,736	3,535,764	3.54
BTT-110	0.086	0.563	10.5	3.69	5.5	2.46	10.1	1,040	848,124	1.84	1,560,293	35	870	1,557,495	3.72
BTT-120	0.084	0.572	6.7	2.35	3.5	1.57	7.4	1,210	628,507	1.93	1,215,614	35	765	1,142,634	4.42
BTT-130	0.077	0.645	7.6	2.65	3.9	1.77	8.7	998	584,650	2.26	1,320,924	35	794	1,283,395	4.93
BTT-140	0.082	0.636	6.6	2.32	3.5	1.55	7.9	854	439,092	2.38	1,043,335	35	593	965,964	4.91
BTT-150	0.105	0.519	8.3	2.89	4.3	1.93	8	421	269,087	2.33	625,850	35	352	599,666	4.75
BTT-160	0.083	0.607	11.2	3.92	5.8	2.62	11.2	964	836,631	1.96	1,643,836	40	846	1,647,217	3.67
BTT-170	0.099	0.523	14.4	5.04	7.5	3.37	12.1	299	333,409	1.94	647,698	40	297	650,274	3.24
BTT-180	0.094	0.53	11.9	4.18	6.2	2.79	10.6	449	414,438	1.91	792,348	40	394	790,785	3.45
BTT-190	0.085	0.6	8.9	3.11	4.6	2.08	9.3	1,482	1,019,107	1.92	1,958,851	35	1,200	1,943,255	4.27
BTT-200	0.116	0.254	50.5	11.36	26.3	8.02	18.9	128	500,949	1.26	633,138	50	137	633,173	0.99
BTT-210	0.1	0.466	18.8	6.59	9.8	4.41	13.7	271	395,650	1.72	680,866	40	273	680,041	2.51
BTT-220	0.089	0.5	15.2	5.31	7.9	3.55	12.2	478	561,492	1.76	990,905	40	462	995,368	2.99
BTT-230	0.086	0.562	11	3.85	5.7	2.57	10.4	992	844,221	1.84	1,551,634	35	832	1,554,286	3.58
BTT-240	0.086	0.544	6.6	2.31	3.4	1.54	7.1	1,180	602,266	1.86	1,122,782	35	728	1,068,633	4.39
BTT-250	0.091	0.505	18.1	6.35	9.4	4.24	14.2	357	501,765	1.8	902,939	40	365	899,336	2.64
BTT-260	0.099	0.445	14.8	5.19	7.7	3.47	10.9	378	434,580	1.68	730,949	40	339	725,224	2.83
BTT-270	0.086	0.545	13.9	4.88	7.2	3.26	12.2	593	639,582	2.32	1,486,006	40	671	1,494,322	3.81

Table C-4: 100-Year Future Land Use CUHP Results

	Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
				W50 Before		W75 Before	Time to					Time to		Total	Runoff per
			W50	Peak	W75	Peak	Peak	Peak	Volume	Excess	Excess	Peak	Peak Flow	Volume	Unit Area
Catchment ID	Ct	Cp	min		min		min	cfs	cu ft	inches	cu ct	min	cfs	cu ft	cfs/acre
BTT-280	0.114	0.443	11	3.86	5.7	2.58	8.8	303	259,439	1.78	462,799	35	258	458,607	3.61
BTT-290	0.156	0.291	39.4	10.3	20.5	7.28	17.2	296	902,066	1.99	1,792,743	50	443	1,790,366	1.78
BTT-300	0.12	0.244	28	6.75	14.6	4.77	11.3	223	483,565	2.09	1,010,566	40	302	1,010,765	2.27
BTT-310	0.088	0.559	22.7	7.96	11.8	5.32	18.8	677	1,192,287	1.74	2,075,142	45	731	2,071,923	2.22
BTT-320	0.107	0.474	3.2	1.13	1.7	0.76	4.5	1,192	298,060	1.8	535,304	30	666	680,231	8.11
BTT-330	0.088	0.511	10.6	3.7	5.5	2.47	9.4	763	624,641	2.29	1,431,913	35	754	1,422,309	4.38
BTT-340	0.088	0.516	7.7	2.7	4	1.81	7.6	1,095	655,163	2.32	1,518,811	35	871	1,439,424	4.83
BTT-350	0.088	0.529	14.5	5.06	7.5	3.39	12.3	474	531,544	1.88	997,685	40	468	1,002,554	3.2
BTT-360	0.087	0.529	8.7	3.05	4.5	2.04	8.4	969	654,060	1.83	1,199,443	35	741	1,166,150	4.11
BTT-370	0.104	0.518	11.4	4	5.9	2.67	10.1	311	274,918	2.01	552,724	35	280	552,174	3.7
BTT-380	0.139	0.351	1.7	0.58	0.9	0.39	3.2	1,227	157,541	1.63	256,579	30	248	217,146	5.72
CB-100	0.094	0.532	12.1	4.24	6.3	2.84	10.7	437	410,449	1.95	799,307	40	392	797,466	3.47
CB-110	0.077	0.711	9	3.14	4.7	2.1	10.7	1,619	1,125,827	2.28	2,571,022	35	1,406	2,624,229	4.53
CB-130	0.085	0.563	15.6	5.45	8.1	3.64	13.7	519	626,028	2.32	1,449,415	40	612	1,448,956	3.55
CB-140	0.088	0.553	11.9	4.16	6.2	2.78	10.9	554	509,517	1.94	988,515	40	491	986,484	3.5
CB-150	0.091	0.538	14.9	5.22	7.8	3.49	12.8	400	462,417	1.92	886,191	40	403	891,777	3.17
CB-160	0.078	0.663	10.2	3.57	5.3	2.39	11.2	983	776,964	2.25	1,744,791	40	891	1,748,880	4.16
CB-170	0.086	0.54	11.4	4	5.9	2.68	10.4	653	579,006	1.87	1,081,630	35	557	1,081,936	3.49
CB-180	0.077	0.646	11.3	3.97	5.9	2.65	11.9	649	570,255	2.32	1,321,270	40	632	1,318,274	4.03
CB-190	0.081	0.616	8.2	2.87	4.3	1.92	9	875	554,813	2.43	1,346,918	35	776	1,322,501	5.08
CB-200	0.082	0.616	34.6	12.11	18	8.09	29.8	194	520,420	2.19	1,138,945	60	280	1,137,594	1.95
CB-210	0.104	0.572	4.2	1.47	2.2	0.98	5.6	622	202,739	2.47	500,706	30	436	615,153	7.81
CB-220	0.077	0.653	10.5	3.67	5.4	2.45	11.3	746	605,189	2.32	1,405,455	40	698	1,410,676	4.19
CB-120	0.137	0.477	9.7	3.4	5	2.27	8.4	133	99,730	2.18	217,227	35	117	213,651	4.24
CB-280	0.082	0.607	11.6	4.07	6	2.72	11.5	738	664,063	2.07	1,373,652	40	678	1,367,835	3.71
CB-290	0.118	0.528	17.5	6.12	9.1	4.09	14.3	110	148,181	2.32	343,596	40	128	342,049	3.13
CB-230	0.081	0.605	14.9	5.21	7.7	3.48	14	511	588,985	2.1	1,238,085	40	537	1,233,245	3.31
CB-240	0.076	0.671	10.4	3.62	5.4	2.42	11.4	856	686,303	2.36	1,618,382	40	804	1,622,853	4.25
CB-250	0.075	0.766	7.6	2.64	3.9	1.77	9.9	2,350	1,374,821	2.45	3,371,722	35	2,019	3,424,157	5.33
CB-260	0.084	0.605	6.4	2.25	3.3	1.51	7.5	946	471,489	2.16	1,016,253	35	609	940,338	4.69
CB-270	0.098	0.554	6.5	2.28	3.4	1.53	7.1	603	304,709	2.1	638,914	35	389	604,382	4.64
SC-100	0.12	0.272	129	28.47	67.1	20.12	47.4	144	1,440,839	2.1	3,029,240	90	285	3,029,121	0.72
SC-110	0.121	0.245	50.5	11.01	26.3	7.78	18.4	184	720,933	2.1	1,514,863	55	300	1,514,836	1.51
SE-100	0.106	0.336	9.5	3.33	4.9	2.22	6.6	2,596	1,910,323	1.33	2,544,818	35	1,755	2,529,815	3.33
SE-110	0.097	0.427	34.2	11.99	17.8	8.01	21.2	721	1,912,698	2.07	3,963,442	50	1,051	3,963,277	1.99
SE-120	0.107	0.322	61	16.61	31.7	11.74	27.7	362	1,711,992	1.98	3,398,067	65	592	3,397,920	1.26
SE-130	0.08	0.713	38.7	13.55	20.1	9.06	37.8	497	1,489,273	2.39	3,561,983	70	811	3,562,238	1.98
SE-140	0.084	0.654	17.7	6.18	9.2	4.13	17.3	1,078	1,474,509	2.3	3,396,876	45	1,340	3,406,881	3.3
SE-150	0.091	0.492	20.3	7.1	10.6	4.75	15.3	566	888,675	2.18	1,939,808	45	707	1,935,784	2.89

Table C-4: 100-Year Future Land Use CUHP Results

	Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
Catchment ID	Ct	Cp	W50 min	W50 Before Peak	W75 min	W75 Before Peak	Time to Peak min	Peak cfs	Volume cu ft	Excess inches	Excess cu ct	Time to Peak min	Peak Flow cfs	Total Volume cu ft	Runoff per Unit Area cfs/acre
SE-160	0.081	0.626	7.3	2.54	3.8	1.7	8.3	1,367	769,409	2.42	1,860,011	35	1,091	1,775,778	5.15
SE-170	0.079	0.774	4.5	1.58	2.3	1.06	7	6,917	2,415,292	2.4	5,805,740	35	3,397	4,981,572	5.11
SW-100	0.086	0.67	18.7	6.54	9.7	4.37	18.5	1,636	2,367,248	2.35	5,565,488	45	2,103	5,565,552	3.23
SW-110	0.084	0.692	22.2	7.76	11.5	5.19	22.1	1,337	2,295,068	1.93	4,427,231	50	1,556	4,423,778	2.46
SW-120	0.083	0.708	18.8	6.59	9.8	4.41	19.6	1,624	2,367,527	1.96	4,643,702	45	1,759	4,622,713	2.7
SW-130	0.074	0.843	16.3	5.7	8.5	3.81	20.1	1,892	2,388,180	2.53	6,049,579	50	2,235	5,999,490	3.4
SW-140	0.081	0.721	14.5	5.09	7.6	3.4	15.9	1,692	1,904,134	2.07	3,933,668	45	1,696	3,895,153	3.23
SW-150	0.077	0.845	21.4	7.49	11.1	5.01	25.6	2,013	3,334,559	2.29	7,649,860	55	2,561	7,634,377	2.79
SW-160	0.076	0.877	19.9	6.96	10.3	4.65	24.8	2,639	4,062,696	2.32	9,440,604	55	3,238	9,428,755	2.89
SW-170	0.082	0.59	4.8	1.69	2.5	1.13	6.2	1,624	608,692	2.4	1,460,035	30	1,034	1,536,695	6.17
H-100	0.08	0.646	6.7	2.34	3.5	1.57	8	941	487,872	2.57	1,255,170	35	693	1,163,362	5.16
H-110	0.083	0.621	5.1	1.78	2.6	1.19	6.5	1,180	464,640	2.51	1,166,720	35	690	1,124,797	5.39
H-120	0.09	0.603	9.8	3.44	5.1	2.3	10.1	458	348,480	2.5	869,686	35	444	875,860	4.63
H-130	0.084	0.609	19.4	6.8	10.1	4.55	17.6	309	464,640	2.5	1,160,401	45	413	1,158,657	3.22
H-140	0.08	0.626	12.2	4.26	6.3	2.85	12.3	591	557,568	2.22	1,236,238	40	590	1,237,197	3.84
H-150	0.187	0.383	15.3	5.34	7.9	3.57	10	37	44,141	2.57	113,613	35	45	112,763	3.71

Table C-5: 10-Yr Existing Land Use CUHP Results

	Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
			W50	W50 Before Peak	W75	W75 Before Peak	Time to Peak	Peak	Volume	Excess	Excess	Time to Peak	Peak Flow	Total Volume	Runoff per Unit Area
Catchment ID	Ct	Cp	min		min		min	cfs	cu ft	inches	cu ct	min	cfs	cu ft	cfs/acre
ASD-100	0.157	0.297	52.5	12.27	27.3	8.67	20.5	248	1,008,041	0.60	603,870	47.0	135	603,860	0.49
ASD-110	0.157	0.301	58.5	13.83	30.4	9.77	23.0	238	1,080,007	0.47	509,376	49.0	109	509,373	0.36
ASD-120	0.158	0.289	23.8	5.57	12.4	3.94	9.3	423	777,763	0.10	75,986	33.0	41	75,986	0.19
ASD-130	0.094	0.446	6.6	2.31	3.4	1.55	4.3	1,045	534,673	0.56	299,287	28.0	210	299,068	1.42
ASD-140	0.158	0.308	58.0	14.02	30.2	9.91	23.4	274	1,232,671	0.10	122,088	47.0	27	122,088	0.08
ASD-150	0.158	0.288	48.1	10.93	25.0	7.73	18.2	204	759,749	0.10	74,226	42.0	20	74,226	0.09
ASD-160	0.092	0.479	20.4	7.15	10.6	4.78	13.0	550	869,985	0.78	679,374	37.0	255	679,310	1.06
ASD-170	0.111	0.265	24.4	5.27	12.7	3.72	8.8	367	693,996	0.27	184,628	35.0	67	184,615	0.35
ASD-180	0.087	0.582	9.3	3.26	4.8	2.18	7.4	1,553	1,118,233	0.68	755,371	31.0	407	754,962	1.32
ASD-190	0.106	0.457	12.4	4.35	6.5	2.91	7.8	345	332,132	0.62	207,285	32.0	94	207,251	1.03
ASD-200	0.210	0.241	47.9	9.17	24.9	6.48	15.3	63	234,325	0.10	22,893	39.0	6	22,893	0.09
ASD-210	0.156	0.224	36.5	6.58	19.0	4.65	11.0	126	355,192	0.15	53,875	37.0	17	53,875	0.17
ASD-220	0.142	0.250	30.9	6.24	16.1	4.41	10.4	245	585,486	0.13	78,206	35.0	30	78,198	0.18
ASD-230	0.160	0.262	43.2	9.00	22.5	6.36	15.0	152	507,315	0.11	54,349	39.0	16	54,348	0.11
ASD-240	0.150	0.266	32.6	6.94	16.9	4.90	11.6	257	649,221	0.12	74,959	36.0	28	74,958	0.16
ASD-250	0.214	0.221	15.1	2.87	7.9	2.02	4.8	43	50,244	0.38	19,028	31.0	8	19,025	0.61
ASD-260	0.093	0.458	8.8	3.09	4.6	2.06	5.7	787	537,925	0.55	297,423	29.0	169	297,424	1.14
ASD-270	0.087	0.535	11.1	3.87	5.8	2.59	8.1	793	679,285	0.67	453,822	32.0	219	453,757	1.17
ASD-275	0.120	0.378	18.2	5.57	9.4	3.93	9.3	181	254,332	0.53	134,369	34.0	49	134,362	0.69
ASD-280	0.107	0.292	41.5	9.60	21.6	6.79	16.0	286	918,414	0.61	564,609	43.0	137	564,598	0.54
ASD-290	0.118	0.243	27.0	5.34	14.0	3.77	8.9	263	549,716	0.23	126,819	35.0	45	126,813	0.29
ASD-310	0.119	0.243	33.7	6.61	17.5	4.67	11.0	251	654,436	0.21	135,711	37.0	41	135,705	0.23
ASD-320	0.115	0.267	45.0	9.54	23.4	6.75	15.9	128	447,650	0.31	138,465	44.0	28	138,465	0.22
ASD-330	0.119	0.283	45.0	10.06	23.4	7.11	16.8	510	1,777,843	0.21	367,074	43.0	85	367,064	0.17
BTT-110	0.158	0.293	37.2	8.65	19.3	6.11	14.4	295	848,124	0.10	82,860	38.0	29	82,859	0.12
BTT-120	0.158	0.280	25.8	5.85	13.4	4.14	9.8	314	628,507	0.10	61,404	34.0	30	61,398	0.17
BTT-130	0.158	0.277	36.1	7.97	18.8	5.63	13.3	209	584,650	0.10	57,119	37.0	20	57,119	0.13
BTT-140	0.173	0.265	33.4	7.09	17.3	5.01	11.8	170	439,092	0.10	42,898	36.0	16	42,896	0.14
BTT-150	0.199	0.244	33.4	6.56	17.4	4.64	10.9	104	269,087	0.47	126,913	37.0	45	126,913	0.61
BTT-160	0.158	0.292	44.3	10.23	23.0	7.23	17.1	244	836,631	0.10	81,737	41.0	24	81,734	0.10
BTT-170	0.138	0.225	46.4	8.32	24.2	5.88	13.9	93	333,409	0.23	75,640	42.0	16	75,637	0.18
BTT-180	0.150	0.231	43.9	8.08	22.8	5.71	13.5	122	414,438	0.15	61,396	39.0	16	61,396	0.14
BTT-190	0.110	0.286	24.1	5.58	12.5	3.95	9.3	547	1,019,107	0.29	293,684	35.0	107	293,660	0.38
BTT-200	0.166	0.270	68.0	14.43	35.4	10.19	24.0	95	500,949	0.10	48,942	48.0	9	48,941	0.07
BTT-210	0.178	0.261	59.9	12.30	31.1	8.70	20.5	85	395,650	0.05	19,267	45.0	4	19,267	0.04
BTT-220	0.160	0.275	49.3	10.73	25.7	7.58	17.9	147	561,492	0.10	54,856	42.0	14	54,855	0.09
BTT-230	0.158	0.292	38.7	8.99	20.1	6.36	15.0	282	844,221	0.10	82,478	39.0	27	82,478	0.12
BTT-240	0.158	0.278	23.8	5.39	12.4	3.81	9.0	327	602,266	0.10	58,840	33.0	31	58,840	0.19

Table C-5: 10-Yr Existing Land Use CUHP Results

	Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
			W50	W50 Before Peak	W75	W75 Before Peak	Time to Peak	Peak	Volume	Excess	Excess	Time to Peak	Peak Flow	Total Volume	Runoff per Unit Area
Catchment ID	Ct	Cp	min		min		min	cfs	cu ft	inches	cu ct	min	cfs	cu ft	cfs/acre
BTT-250	0.166	0.270	61.4	13.05	31.9	9.22	21.7	106	501,765	0.10	49,021	46.0	10	49,021	0.07
BTT-260	0.173	0.265	43.4	9.13	22.6	6.45	15.2	129	434,580	0.10	42,457	39.0	13	42,457	0.10
BTT-270	0.157	0.278	49.9	10.94	25.9	7.73	18.2	166	639,582	0.55	351,804	46.0	82	351,803	0.47
BTT-280	0.166	0.210	34.0	5.77	17.7	4.08	9.6	99	259,439	0.17	43,674	35.0	14	43,673	0.20
BTT-290	0.157	0.292	39.3	9.13	20.5	6.45	15.2	296	902,066	0.55	496,184	42.0	143	496,174	0.58
BTT-300	0.166	0.266	35.6	7.58	18.5	5.35	12.6	175	483,565	0.55	265,986	40.0	83	265,980	0.63
BTT-310	0.158	0.308	74.0	17.79	38.5	12.57	29.7	208	1,192,287	0.05	58,061	54.0	10	58,061	0.03
BTT-320	0.195	0.250	11.1	2.44	5.8	1.73	4.1	345	298,060	0.05	14,515	28.0	16	14,512	0.19
BTT-330	0.157	0.277	34.7	7.67	18.0	5.42	12.8	233	624,641	0.55	343,586	40.0	110	343,587	0.64
BTT-340	0.128	0.240	24.1	4.75	12.5	3.35	7.9	351	655,163	0.64	420,546	34.0	169	420,521	0.93
BTT-350	0.123	0.236	45.1	8.46	23.5	5.98	14.1	152	531,544	0.21	113,570	41.0	26	113,569	0.18
BTT-360	0.110	0.266	21.9	4.77	11.4	3.37	7.9	386	654,060	0.28	186,278	33.0	74	186,249	0.41
BTT-370	0.125	0.293	24.2	5.73	12.6	4.05	9.6	147	274,918	0.41	112,145	35.0	35	112,132	0.47
BTT-380	0.215	0.207	4.3	0.99	2.2	0.70	1.6	471	157,541	0.13	20,904	25.0	43	20,809	1.00
CB-100	0.099	0.463	14.7	5.16	7.7	3.45	9.2	360	410,449	0.61	250,721	33.0	102	250,713	0.90
CB-110	0.080	0.684	9.6	3.36	5.0	2.25	8.9	1,513	1,125,827	0.87	978,912	33.0	475	978,945	1.53
CB-120	0.151	0.394	19.0	6.06	9.9	4.28	10.1	68	99,730	0.65	64,912	35.0	21	64,907	0.78
CB-130	0.089	0.507	18.1	6.33	9.4	4.23	12.2	447	626,028	0.83	518,904	36.0	204	518,855	1.18
CB-140	0.092	0.495	14.2	4.96	7.4	3.32	9.5	464	509,517	0.61	312,843	34.0	125	312,856	0.89
CB-150	0.088	0.570	13.7	4.78	7.1	3.20	10.5	437	462,417	0.79	364,124	35.0	143	364,116	1.12
CB-160	0.091	0.479	16.5	5.77	8.6	3.86	10.6	608	776,964	0.57	441,308	35.0	169	441,295	0.79
CB-170	0.085	0.558	12.5	4.36	6.5	2.92	9.4	600	579,006	0.72	414,698	34.0	175	414,556	1.10
CB-180	0.085	0.555	14.6	5.12	7.6	3.42	10.9	503	570,255	0.73	416,903	35.0	163	416,800	1.04
CB-190	0.083	0.591	14.4	5.04	7.5	3.37	11.4	498	554,813	0.95	527,886	36.0	221	527,886	1.45
CB-200	0.079	0.648	31.7	11.08	16.5	7.41	26.7	212	520,420	1.02	529,987	53.0	114	529,979	0.80
CB-210	0.124	0.417	8.8	3.10	4.6	2.07	5.2	296	202,739	0.61	123,842	29.0	70	123,778	1.25
CB-220	0.091	0.468	17.2	6.04	9.0	4.04	10.8	453	605,189	0.58	349,460	35.0	129	349,418	0.78
CB-230	0.094	0.394	26.9	8.43	14.0	5.95	14.0	283	588,985	0.49	290,941	39.0	79	290,920	0.49
CB-240	0.080	0.626	11.7	4.09	6.1	2.73	9.9	759	686,303	0.86	588,742	34.0	259	588,715	1.37
CB-250	0.096	0.372	20.1	6.04	10.4	4.26	10.1	457	710,757	0.44	311,121	35.0	108	311,099	0.55
CB-260	0.114	0.265	20.5	4.48	10.7	3.17	7.5	296	471,489	0.30	141,493	33.0	56	141,476	0.43
CB-270	0.097	0.566	6.3	2.21	3.3	1.48	5.1	624	304,709	0.86	261,875	29.0	159	261,515	1.90
CB-280	0.123	0.240	44.4	8.47	23.1	5.99	14.1	193	664,063	0.19	127,377	40.0	31	127,374	0.17
CB-290	0.128	0.464	21.6	7.56	11.2	5.05	13.3	89	148,181	0.76	112,425	38.0	33	112,431	0.81
H-100	0.082	0.623	7.1	2.50	3.7	1.67	6.2	892	492,957	1.07	527,047	30.0	314	526,852	2.31
H-110	0.129	0.494	9.9	3.45	5.1	2.31	6.7	158	120,995	1.03	124,866	31.0	63	124,865	1.88
H-120	0.125	0.236	35.1	6.66	18.2	4.71	11.1	162	439,668	0.64	282,927	39.0	79	282,930	0.65
H-130	0.094	0.565	23.4	8.20	12.2	5.48	17.4	191	347,047	1.02	353,604	42.0	104	353,588	1.09

Table C-5: 10-Yr Existing Land Use CUHP Results

	Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
Catchment ID	Ct	Cp	W50 min	W50 Before Peak	W75 min	W75 Before Peak	Time to Peak min	Peak cfs	Volume cu ft	Excess inches	Excess cu ct	Time to Peak min	Peak Flow cfs	Total Volume cu ft	Runoff per Unit Area cfs/acre
H-140	0.084	0.571	14.2	4.95	7.4	3.31	10.8	506	554,506	0.77	426,473	35.0	169	426,352	1.11
H-150	0.199	0.324	19.2	5.08	10.0	3.59	8.5	30	45,014	1.01	45,534	33.0	17	45,529	1.38
SC-100	0.149	0.297	145.7	33.56	75.8	23.72	55.9	128	1,440,839	0.61	880,989	88.0	75	880,986	0.19
SC-110	0.135	0.250	24.2	4.94	12.6	3.49	8.2	385	720,933	0.63	455,354	34.0	186	455,349	0.93
SE-100	0.158	0.331	69.5	17.93	36.1	12.67	29.9	355	1,910,323	0.10	186,634	54.0	35	186,634	0.07
SE-110	0.157	0.328	73.0	18.69	38.0	13.21	31.1	338	1,912,698	0.42	808,385	57.0	139	808,375	0.26
SE-120	0.157	0.322	143.0	35.71	74.4	25.24	59.5	155	1,711,992	0.42	723,559	86.0	65	723,559	0.14
SE-130	0.157	0.316	68.6	16.95	35.7	11.98	28.2	280	1,489,273	0.47	702,403	54.0	129	702,392	0.31
SE-140	0.157	0.315	47.0	11.69	24.5	8.26	19.5	405	1,474,509	0.47	695,440	45.0	182	695,430	0.45
SE-150	0.157	0.292	30.1	7.07	15.7	4.99	11.8	381	888,675	0.47	419,136	37.0	164	419,128	0.67
SE-160	0.157	0.285	23.7	5.50	12.3	3.89	9.2	419	769,409	0.60	460,917	34.0	201	460,923	0.95
SE-170	0.157	0.340	47.0	12.57	24.5	8.88	20.9	663	2,415,292	0.47	1,139,152	46.0	299	1,139,149	0.45
SW-100	0.157	0.338	69.7	18.37	36.2	12.98	30.6	439	2,367,248	0.60	1,418,108	57.0	246	1,418,096	0.38
SW-110	0.158	0.340	85.0	22.48	44.2	15.89	37.5	349	2,295,068	0.10	224,223	61.0	34	224,221	0.05
SW-120	0.158	0.341	74.2	19.76	38.6	13.96	32.9	412	2,367,527	0.10	231,302	57.0	40	231,301	0.06
SW-130	0.158	0.342	86.4	22.97	44.9	16.23	38.3	357	2,388,180	0.10	233,319	62.0	35	233,317	0.05
SW-140	0.158	0.330	62.0	16.02	32.2	11.32	26.7	397	1,904,134	0.10	186,029	50.0	39	186,030	0.07
SW-150	0.158	0.359	103.8	28.94	54.0	20.45	48.2	415	3,334,559	0.10	325,778	72.0	40	325,777	0.04
SW-160	0.141	0.334	96.6	25.09	50.2	17.73	41.8	543	4,062,696	0.13	545,225	68.0	69	545,224	0.06
SW-170	0.114	0.251	11.9	2.60	6.2	1.84	4.3	659	608,692	0.69	419,207	30.0	256	419,188	1.53
ASD-225	0.096	0.501	13.1	4.60	6.8	3.07	8.9	411	418,229	0.81	339,659	33.0	165	339,666	1.43

Table C-5: 10-Yr Future Land Use CUHP Results

	Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
			W50	W50 Before Peak	W75	W75 Before Peak	Time to Peak	Peak	Volume	Excess	Excess	Time to Peak	Peak Flow	Total Volume	Runoff per Unit Area
Catchment ID	Ct	Cp	min		min		min	cfs	cu ft	inches	cu ct	min	cfs	cu ft	cfs/acre
ASD-100	0.094	0.448	20.8	7.26	10.8	4.86	12.4	627	1,008,041	0.81	817,819	37.0	304	817,847	1.09
ASD-110	0.119	0.262	51.0	10.57	26.5	7.47	17.6	273	1,080,007	0.55	598,530	45.0	129	598,521	0.43
ASD-120	0.158	0.289	23.8	5.57	12.4	3.94	9.3	423	777,763	0.10	75,986	33.0	41	75,986	0.19
ASD-130	0.092	0.475	6.1	2.13	3.2	1.43	4.2	1,133	534,673	0.60	320,835	27.0	230	320,232	1.56
ASD-140	0.086	0.597	16.4	5.73	8.5	3.83	13.0	972	1,232,671	0.66	813,700	38.0	293	813,689	0.86
ASD-150	0.158	0.288	48.1	10.93	25.0	7.73	18.2	204	759,749	0.10	74,226	42.0	20	74,226	0.09
ASD-160	0.090	0.514	18.6	6.51	9.7	4.35	12.7	604	869,985	0.81	706,235	37.0	277	706,092	1.15
ASD-170	0.103	0.302	19.9	4.92	10.4	3.48	8.2	450	693,996	0.34	235,432	34.0	91	235,405	0.48
ASD-180	0.087	0.582	9.3	3.26	4.8	2.18	7.4	1,553	1,118,233	0.68	755,371	31.0	407	754,962	1.32
ASD-190	0.106	0.457	12.4	4.35	6.5	2.91	7.8	345	332,132	0.62	207,285	32.0	94	207,251	1.03
ASD-200	0.134	0.271	27.1	5.95	14.1	4.21	9.9	112	234,325	0.37	85,994	37.0	25	85,987	0.38
ASD-210	0.096	0.540	9.4	3.27	4.9	2.19	7.0	490	355,192	0.75	268,085	31.0	134	268,090	1.37
ASD-220	0.093	0.421	12.1	4.21	6.3	2.98	7.0	625	585,486	0.50	293,580	31.0	140	293,532	0.87
ASD-230	0.092	0.493	13.2	4.63	6.9	3.09	8.8	496	507,315	0.61	309,696	33.0	132	309,714	0.94
ASD-240	0.082	0.607	7.8	2.71	4.0	1.81	6.5	1,081	649,221	0.79	513,210	30.0	286	513,339	1.60
ASD-250	0.181	0.385	7.4	2.47	3.8	1.75	4.1	88	50,244	0.70	35,200	28.0	20	35,176	1.47
ASD-260	0.084	0.585	6.2	2.18	3.2	1.46	5.2	1,115	537,925	0.78	418,003	29.0	264	417,376	1.78
ASD-270	0.085	0.565	10.3	3.59	5.3	2.40	7.9	856	679,285	0.72	490,303	32.0	243	490,199	1.30
ASD-275	0.105	0.532	11.2	3.93	5.8	2.63	8.2	292	254,332	0.83	212,198	32.0	96	212,235	1.36
ASD-280	0.098	0.363	30.5	8.80	15.8	6.22	14.7	389	918,414	0.68	623,501	40.0	183	623,503	0.73
ASD-290	0.092	0.471	10.9	3.80	5.7	2.54	7.1	653	549,716	0.57	312,711	31.0	155	312,584	1.02
ASD-310	0.085	0.560	10.5	3.67	5.5	2.45	8.0	806	654,436	0.69	451,717	32.0	216	451,390	1.20
ASD-320	0.105	0.340	32.2	8.73	16.8	6.17	14.6	179	447,650	0.43	192,131	41.0	46	192,119	0.37
ASD-330	0.087	0.625	14.8	5.17	7.7	3.45	12.3	1,555	1,777,843	0.65	1,158,713	37.0	452	1,158,742	0.92
BTT-110	0.092	0.479	13.1	4.59	6.8	3.07	8.5	835	848,124	0.54	457,426	33.0	203	457,386	0.87
BTT-120	0.089	0.498	8.2	2.86	4.3	1.91	5.7	993	628,507	0.59	372,719	29.0	218	372,333	1.26
BTT-130	0.079	0.627	7.9	2.78	4.1	1.86	6.9	950	584,650	0.87	508,462	31.0	272	508,105	1.69
BTT-140	0.083	0.628	6.8	2.38	3.5	1.59	6.0	834	439,092	0.97	425,410	30.0	241	424,927	1.99
BTT-150	0.110	0.469	9.6	3.36	5.0	2.25	6.3	362	269,087	0.83	223,623	30.0	127	223,433	1.71
BTT-160	0.088	0.538	13.4	4.67	6.9	3.12	9.7	809	836,631	0.62	518,565	34.0	219	518,592	0.95
BTT-170	0.105	0.457	17.5	6.11	9.1	4.09	10.7	247	333,409	0.60	200,039	35.0	70	200,032	0.76
BTT-180	0.100	0.452	14.9	5.23	7.8	3.50	9.1	358	414,438	0.57	235,757	33.0	94	235,776	0.82
BTT-190	0.092	0.482	12.0	4.20	6.2	2.81	7.9	1,098	1,019,107	0.55	558,527	32.0	271	558,508	0.97
BTT-200	0.130	0.229	63.0	11.39	32.8	8.05	19.0	103	500,949	0.18	89,322	47.0	16	89,321	0.11
BTT-210	0.116	0.276	37.0	8.14	19.2	5.76	13.6	138	395,650	0.30	119,499	42.0	26	119,492	0.24
BTT-220	0.103	0.302	28.9	7.01	15.0	4.95	11.7	251	561,492	0.36	199,599	38.0	56	199,595	0.36
BTT-230	0.095	0.400	17.0	5.53	8.8	3.90	9.2	641	844,221	0.46	387,908	34.0	149	387,878	0.64
BTT-240	0.094	0.411	9.5	3.31	5.0	2.34	5.5	815	602,266	0.49	295,370	29.0	166	295,206	1.00
BTT-250	0.104	0.321	32.3	8.27	16.8	5.84	13.8	200	501,765	0.39	197,363	41.0	48	197,354	0.35

Table C-5: 10-Yr Future Land Use CUHP Results

	Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
Catchment ID	Ct	Cp	W50 min	W50 Before Peak	W75 min	W75 Before Peak	Time to Peak min	Peak cfs	Volume cu ft	Excess inches	Excess cu ct	Time to Peak min	Peak Flow cfs	Total Volume cu ft	Runoff per Unit Area cfs/acre
BTT-260	0.116	0.265	29.1	6.23	15.1	4.40	10.4	193	434,580	0.31	133,414	37.0	39	133,403	0.33
BTT-270	0.095	0.383	22.0	6.76	11.4	4.78	11.3	376	639,582	0.76	487,486	36.0	175	487,440	0.99
BTT-280	0.131	0.266	21.2	4.64	11.0	3.28	7.7	158	259,439	0.36	94,655	33.0	35	94,653	0.48
BTT-290	0.157	0.292	39.3	9.13	20.5	6.45	15.2	296	902,066	0.55	496,184	42.0	143	496,174	0.58
BTT-300	0.131	0.228	32.8	6.05	17.1	4.28	10.1	190	483,565	0.61	294,125	38.0	90	294,107	0.68
BTT-310	0.101	0.345	42.1	11.46	21.9	8.10	19.1	366	1,192,287	0.33	395,957	48.0	77	395,941	0.23
BTT-320	0.119	0.320	5.3	1.61	2.8	1.14	2.7	724	298,060	0.40	118,612	26.0	94	118,500	1.15
BTT-330	0.099	0.328	18.5	4.97	9.6	3.51	8.3	435	624,641	0.73	454,253	34.0	190	454,223	1.10
BTT-340	0.097	0.356	12.3	3.67	6.4	2.59	6.1	686	655,163	0.78	509,367	31.0	276	509,187	1.53
BTT-350	0.098	0.364	23.4	6.84	12.2	4.83	11.4	293	531,544	0.47	247,505	37.0	76	247,492	0.52
BTT-360	0.098	0.349	14.8	4.27	7.7	3.02	7.1	570	654,060	0.43	281,567	31.0	127	281,532	0.71
BTT-370	0.113	0.427	15.0	5.23	7.8	3.70	8.7	236	274,918	0.60	163,652	33.0	66	163,619	0.87
BTT-380	0.159	0.228	2.9	0.81	1.5	0.57	1.3	700	157,541	0.32	50,557	25.0	79	50,216	1.83
CB-100	0.099	0.463	14.7	5.16	7.7	3.45	9.2	360	410,449	0.61	250,721	33.0	102	250,713	0.90
CB-110	0.079	0.691	9.4	3.30	4.9	2.21	8.8	1,541	1,125,827	0.89	1,002,583	33.0	490	1,002,386	1.58
CB-120	0.151	0.394	19.0	6.06	9.9	4.28	10.1	68	99,730	0.65	64,912	35.0	21	64,907	0.78
CB-130	0.088	0.516	17.6	6.17	9.2	4.13	12.1	459	626,028	0.84	525,255	36.0	209	525,196	1.21
CB-140	0.091	0.511	13.5	4.74	7.0	3.17	9.4	486	509,517	0.64	327,783	34.0	133	327,727	0.95
CB-150	0.088	0.574	13.5	4.73	7.0	3.16	10.4	442	462,417	0.80	369,188	35.0	146	369,138	1.14
CB-160	0.088	0.524	14.6	5.11	7.6	3.42	10.3	687	776,964	0.63	491,498	34.0	200	491,521	0.93
CB-170	0.078	0.639	10.0	3.52	5.2	2.35	8.7	744	579,006	0.94	542,283	33.0	253	542,208	1.58
CB-180	0.082	0.591	13.3	4.66	6.9	3.11	10.6	554	570,255	0.81	461,774	35.0	189	461,784	1.20
CB-190	0.082	0.599	14.1	4.92	7.3	3.29	11.3	509	554,813	0.97	536,054	36.0	226	536,108	1.48
CB-200	0.079	0.648	31.6	11.06	16.4	7.40	26.7	213	520,420	1.02	531,307	53.0	115	531,301	0.80
CB-210	0.109	0.540	6.0	2.10	3.1	1.40	4.6	437	202,739	0.92	187,388	28.0	119	187,378	2.13
CB-220	0.082	0.599	12.1	4.24	6.3	2.84	9.8	644	605,189	0.82	494,302	34.0	214	494,265	1.28
CB-230	0.084	0.561	16.8	5.89	8.8	3.94	12.6	452	588,985	0.74	435,331	37.0	154	435,341	0.95
CB-240	0.078	0.652	10.9	3.82	5.7	2.55	9.6	812	686,303	0.94	641,723	34.0	289	641,640	1.53
CB-250	0.083	0.599	10.7	3.76	5.6	2.51	8.7	855	710,757	0.75	534,871	33.0	247	534,689	1.26
CB-260	0.082	0.625	6.3	2.20	3.3	1.47	5.5	968	471,489	0.93	439,290	29.0	264	439,340	2.03
CB-270	0.091	0.608	5.5	1.94	2.9	1.30	4.8	710	304,709	1.04	315,946	28.0	196	316,080	2.34
CB-280	0.081	0.618	11.3	3.96	5.9	2.64	9.4	759	664,063	0.84	561,067	33.0	252	561,088	1.38
CB-290	0.126	0.473	21.0	7.34	10.9	4.91	13.2	91	148,181	0.78	116,026	38.0	35	116,020	0.85
H-100	0.080	0.646	6.7	2.34	3.5	1.56	6.0	953	492,957	1.12	553,986	29.0	327	553,431	2.41
H-110	0.129	0.494	9.9	3.45	5.1	2.31	6.7	158	120,995	1.03	124,866	31.0	63	124,865	1.88
H-120	0.085	0.614	9.1	3.19	4.7	2.13	7.7	623	439,668	1.02	450,391	32.0	229	450,422	1.89
H-130	0.094	0.565	23.4	8.20	12.2	5.48	17.4	191	347,047	1.02	353,604	42.0	104	353,588	1.09
H-140	0.082	0.606	12.9	4.50	6.7	3.01	10.5	557	554,506	0.86	475,027	35.0	196	474,896	1.28
H-150	0.195	0.345	17.7	4.98	9.2	3.52	8.3	33	45,014	1.05	47,175	33.0	18	47,161	1.49

Table C-5: 10-Yr Future Land Use CUHP Results

	Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
			W50	W50 Before Peak	W75	W75 Before Peak	Time to Peak	Peak	Volume	Excess	Excess	Time to Peak	Peak Flow	Total Volume	Runoff per Unit Area
Catchment ID	Ct	Cp	min		min		min	cfs	cu ft	inches	cu ct	min	cfs	cu ft	cfs/acre
SC-100	0.149	0.297	145.7	33.56	75.8	23.72	55.9	128	1,440,839	0.61	880,989	88.0	75	880,986	0.19
SC-110	0.135	0.250	24.2	4.94	12.6	3.49	8.2	385	720,933	0.63	455,354	34.0	186	455,349	0.93
SE-100	0.116	0.294	57.0	13.16	29.6	9.30	21.9	433	1,910,323	0.23	442,552	50.0	79	442,551	0.15
SE-110	0.099	0.393	38.4	11.88	20.0	8.40	19.8	643	1,912,698	0.64	1,217,440	46.0	297	1,217,443	0.56
SE-120	0.118	0.283	122.2	26.89	63.5	19.00	44.8	181	1,711,992	0.52	888,221	81.0	86	888,220	0.18
SE-130	0.082	0.684	16.5	5.77	8.6	3.86	14.9	1,166	1,489,273	0.92	1,367,505	39.0	518	1,367,502	1.26
SE-140	0.089	0.568	14.8	5.17	7.7	3.46	11.2	1,289	1,474,509	0.80	1,176,643	35.0	532	1,176,686	1.31
SE-150	0.097	0.374	14.5	4.48	7.6	3.16	7.5	789	888,675	0.69	611,678	32.0	310	611,531	1.27
SE-160	0.084	0.588	6.2	2.16	3.2	1.45	5.1	1,609	769,409	0.93	714,427	29.0	496	713,492	2.34
SE-170	0.082	0.739	11.2	3.93	5.8	2.63	11.1	2,779	2,415,292	0.92	2,228,337	35.0	1,082	2,228,446	1.63
SW-100	0.090	0.588	23.0	8.05	12.0	5.38	17.8	1,329	2,367,248	0.85	2,016,213	42.0	671	2,016,176	1.03
SW-110	0.089	0.601	27.1	9.49	14.1	6.35	21.3	1,093	2,295,068	0.59	1,350,415	47.0	348	1,350,312	0.55
SW-120	0.088	0.627	22.5	7.86	11.7	5.26	18.5	1,361	2,367,527	0.62	1,461,902	44.0	429	1,461,719	0.66
SW-130	0.074	0.842	16.3	5.71	8.5	3.82	18.1	1,890	2,388,180	1.11	2,646,041	43.0	867	2,645,985	1.32
SW-140	0.083	0.684	15.8	5.52	8.2	3.69	14.3	1,559	1,904,134	0.73	1,399,124	39.0	507	1,399,083	0.97
SW-150	0.077	0.842	21.5	7.54	11.2	5.04	23.7	2,000	3,334,559	0.94	3,145,427	49.0	885	3,145,263	0.96
SW-160	0.077	0.870	20.2	7.06	10.5	4.72	23.0	2,603	4,062,696	0.95	3,865,244	48.0	1,136	3,864,960	1.02
SW-170	0.086	0.539	4.2	1.47	2.2	0.98	3.4	1,875	608,692	0.90	547,886	27.0	476	547,322	2.84
ASD-225	0.096	0.501	13.1	4.60	6.8	3.07	8.9	411	418,229	0.81	339,659	33.0	165	339,666	1.43

Table C-6: 100-Yr Rational Analysis Routing and Results

DIRECT RUNOFF							TOTAL RUNOFF				TRAVEL TIME							REMARKS
AREA	AREA	COEFF	Tc	C*A	I	Q	Tc	Sum C*A	I	Q	L	Slope	Velocity	Tt	Tc	I	Q tot	
DESIGN.	(Ac)	C	(min)	(Ac)		(CFS)	(min)	(Ac)	(In/Hr)	(CFS)	(feet)	(%)	ft/s	(min)	(min)	(in/Hr)		
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(13)
1A	12.83	0.51	16.7	6.57	6.12	40.22					880.0	1.8	2.8	5.33	22.03	5.20	34.2	
1B	8.99	0.51	17.8	4.60	5.94	27.35												
1C	7.21	0.54	15.6	3.91	6.31	24.66												
1A + 1B + 1C							22.0	15.08	5.20	78.39								
1 + 23 + 24							39.8	92.95	3.72	345.67	675.0	0.4	1.4	8.04	47.82	3.30	306.9	
2	13.38	0.48	27.3	6.45	4.64	29.90												
3A	9.79	0.52	10.3	5.13	7.52	38.57					1545.0	2.2	3.0	8.58	18.86	5.77	29.6	
3Aa	12.00	0.39	18.3	4.63	5.77	26.74												
3Ab	39.54	0.45	23.5	17.95	5.07	91.08					1426.0	1.1	2.1	11.32	34.77	4.05	72.6	
3Ac	30.12	0.49	22.2	14.88	5.20	77.34					1812.0	1.5	2.5	12.08	34.28	4.05	60.2	
3Ad	43.75	0.36	23.7	15.84	5.07	80.35												
3Ae	35.22	0.46	20.2	16.27	5.47	88.98												
3Af	37.22	0.39	24.1	14.37	4.96	71.21					1189.0	0.9	2.0	9.91	34.05	4.05	58.1	
3Ag	11.58	0.38	15.7	4.42	6.31	27.93												
3Ah	16.14	0.45	19.0	7.33	5.62	41.16												
3B	28.92	0.47	19.0	13.48	5.77	77.79												
3C	4.28	0.63	15.7	2.70	6.31	17.03												
3D	29.92	0.48	21.4	14.24	5.33	75.89												
3D (with Pond)	*29.92*	*0.48*	*21.40*	*14.24*	*5.33*	*54.90*												*with Hunters Reserve Pond #1*
3E	33.64	0.48	22.7	16.21	5.20	84.29					2170.0	2.6	3.3	11.13	33.86	4.12	66.8	
3E (with Pond)	*33.64*	*0.48*	*22.73*	*16.21*	*5.20*	*24.10*					*2170.0*	*2.6*	*3.3*	*11.13*	*33.86*	*4.12*	*66.8*	*with Hunters Reserve Pond #3*
3F	19.56	0.58	17.2	11.42	5.94	67.85					678.0	0.1	1.4	8.07	25.27	4.85	55.3	
3G	21.45	0.56	18.5	12.01	5.77	69.35												
3H	4.48	0.50	15.9	2.24	6.31	14.15												
3I	12.92	0.63	16.8	8.14	6.12	49.83												
3J	18.71	0.50	14.9	9.36	6.52	60.97												
3K	14.66	0.51	14.4	7.42	6.52	48.33												
3L	6.21	0.75	15.9	4.65	6.31	29.33												
3M	28.48	0.59	27.0	16.75	4.64	77.65												
3M (with Pond)	*28.48*	*0.59*	*27.02*	*16.39*	*4.64*	*76.00*												*with Willow Brook*
3N	19.87	0.53	17.6	10.45	5.94	62.10												
3O	14.21	0.29	17.3	4.09	5.94	24.31												
3P	21.77	0.40	19.4	8.71	5.62	48.91												
3Q	17.03	0.53	19.6	8.99	5.62	50.50												
3R	31.13	0.32	16.0	9.90	6.12	60.58					832.0	1.6	2.6	5.33	21.38	5.33	52.8	
3S	8.73	0.57	10.9	4.98	7.52	37.43					999.0	1.3	2.3	7.24	18.10	5.77	28.7	
3T	14.47	0.45	12.9	6.51	6.98	45.45												
3U	27.81	0.51	14.3	14.07	6.52	91.72												
3V	98.64	0.28	30.9	28.01	4.36	122.20												
3Aa+3Ab+3Ad							34.8	38.42	4.05	155.48	742.0	0.4	1.4	8.83	43.61	3.50	134.3	
3Aa-Ae							43.6	69.57	3.50	243.21	1292.0	1.4	2.4	8.97	52.58	3.09	215.0	
3Aa+3Ah							52.6	95.69	3.09	295.78								
3C+ 3D							15.7	2.70	6.31	71.93	2442.0	1.8	2.8	14.80	30.50	4.36	66.7	
3F + 3G							18.5	23.43	5.77	135.28	918.0	1.1	2.1	7.29	25.78	4.85	113.5	
3E+K							22.7	23.63	5.20	122.84								
3F+3G+3I							18.5	33.82	5.77	195.23								
Above + 3J + 3H							18.5	45.41	5.77	262.17								
3(E-M)							33.9	80.78	4.64	374.59	674.0	1.0	2.0	5.62	39.47	3.72	300.4	

Table C-6: 100-Yr Rational Analysis Routing and Results

DIRECT RUNOFF							TOTAL RUNOFF				TRAVEL TIME							
AREA	AREA	COEFF	Tc	C*A	I	Q	Tc	Sum C*A	I	Q	L	Slope	Velocity	Tt	Tc	I	Q tot	REMARKS
DESIGN.	(Ac)	C	(min)	(Ac)		(CFS)	(min)	(Ac)	(In/Hr)	(CFS)	(feet)	(%)	ft/s	(min)	(min)	(in/Hr)		
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(13)
3T + 3R							21.4	16.41	5.33	87.46	574.0	2.3	2.9	3.30	24.68	4.96	81.3	
To Landings 24+3Af+1+3Ah							39.8	93.79	3.72	348.79								
with pond							*39.8*	*93.79*	*3.72*	*38.00*								*With Landings Pond*
23 + 3Ab + 3Ad							34.8	51.74	4.05	209.39	755.0	0.7	1.6	7.86	42.64	3.55	183.6	
with pond							*34.8*	*51.7*	*4.0*	*58.2*								*with North Point Pond*
Above + 3Ac+ 3Ae							34.3	31.15	4.05	184.26	1196.0	1.3	2.3	8.67	42.95	3.55	182.5	
Above + 3Ag							34.3	31.15	4.05	185.99	667.0	0.7	1.6	6.95	41.23	3.60	114.0	with Arbor Gardens
Above + 'to Landings'							41.2	31.15	3.60	210.2	1021.0	0.5	1.4	12.15	53.38	3.05	193.0	
Above + 3C+ 3D + 3B + 3A							53.4	52.45	3.05	313.0	1156.0	1.6	2.5	7.71	61.09	2.81	300.2	Junction at 23rd Ave.
Above + 3N+3O							61.1	67.00	2.81	282.9	1345.0	1.2	2.2	10.19	71.28	2.81	282.9	
3 (M): 3F,G,I,M,K,E,H,J,L							33.9	73.69	4.12	303.69	638.0	0.9	2.0	5.32	39.17	3.72	274.1	
Above 2 + 3P + 3Q							71.3	165.48	2.81	559.68	1072.0	1.3	2.3	7.77	79.05	2.81	559.7	
Above + …to 3U							79.0	200.94	2.81	659.34	1390.0	0.7	1.8	12.87	91.92	2.81	659.3	
with pond							*79.0*	*200.94*	*2.81*	*271.00*	*1390.0*	*0.7*	*1.8*	*12.87*	*91.92*	*2.81*	*564.7*	*With Prairie View Ridge Pond*
Above + 3V							30.9	28.01	4.36	393.20								
4A	19.87	0.58	12.2	11.49	6.98	80.15					618.0	0.6	1.5	6.87	19.07	5.62	64.5	
4B	14.86	0.57	19.2	8.50	5.62	47.72												
4C	17.97	0.57	20.9	10.17	5.47	55.64												
4D	15.26	0.49	21.2	7.54	5.33	40.16					1766.0	1.0	2.0	14.72	35.91	3.98	30.0	
4E	13.66	0.49	18.0	6.67	5.94	39.61												
4F	8.43	0.53	20.2	4.47	5.47	24.43												
4A + 4B							19.2	19.98	5.62	112.23	857.0	1.5	2.5	5.71	24.90	4.96	99.0	
4A + 4B + 4C							24.9	30.16	4.96	149.46	540.0	1.1	2.1	4.29	29.19	4.45	134.2	
4 (A - F)							35.9	48.83	3.98	194.14	2063.0	1.1	2.1	16.37	52.28	3.09	150.9	
5	0.62	0.56	5.0	0.35	9.43	3.27												
6A	0.66	0.60	10.4	0.40	7.52	2.99												
6B	0.76	0.54	10.9	0.41	7.52	3.06												
6C	1.57	0.62	12.8	0.97	6.98	6.79												
6D	0.68	0.54	11.3	0.37	7.24	2.66												
6E	0.99	0.62	11.9	0.61	7.24	4.44												
6F	5.82	0.32	14.8	1.89	6.52	12.29												
6G	4.84	0.51	13.5	2.47	6.74	16.63												
6E + 6F							14.8	2.50	6.52	16.29								
6E + 6F + 6D							14.8	2.87	6.52	18.69	271.0	0.22	0.7	6.45	21.29	5.33	15.3	
6 C+F+G							14.8	5.33	6.52	34.72								
6 A-F							14.8	7.11	6.52	46.35								
7A	9.05	0.43	14.8	3.89	6.52	25.36					1128.0	3.0	3.3	5.78	20.60	5.47	21.3	
7B	27.50	0.54	21.2	14.85	5.33	79.14												
7C	7.00	0.30	13.0	2.10	6.74	14.15												
7D	23.25	0.56	30.6	13.02	4.36	56.79												
7A + 7B + 7C							21.2	20.84	5.33	111.06								
8A	7.49	0.57	16.2	4.28	6.12	26.21												
8B	12.87	0.29	16.6	3.76	6.12	23.00												
8C	14.20	0.50	11.5	7.10	7.24	51.38												

Table C-6: 100-Yr Rational Analysis Routing and Results

DIRECT RUNOFF							TOTAL RUNOFF				TRAVEL TIME							
AREA	AREA	COEFF	Tc	C*A	I	Q	Tc	Sum C*A	I	Q	L	Slope	Velocity	Tt	Tc	I	Q tot	REMARKS
DESIGN.	(Ac)	C	(min)	(Ac)		(CFS)	(min)	(Ac)	(In/Hr)	(CFS)	(feet)	(%)	ft/s	(min)	(min)	(in/Hr)		
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(13)
8D	9.32	0.44	16.3	4.08	6.12	24.97												
8E	12.66	0.54	18.5	6.79	5.77	39.19												
8F	19.37	0.58	10.9	11.31	7.52	85.06												
8G	12.25	0.43	17.1	5.22	5.94	31.00												
8H	32.85	0.50	24.6	16.43	4.96	81.41												
8I	27.12	0.58	21.9	15.68	5.33	83.55												
8J	11.11	0.48	18.3	5.35	5.77	30.91												
8K	25.38	0.49	21.2	12.54	5.33	66.83												
8L	18.78	0.63	17.6	11.83	5.94	70.31												
8M	9.63	0.67	16.8	6.47	6.12	39.62												
8N	8.64	0.50	19.6	4.32	5.62	24.25												
8Aa	16.85	0.61	18.7	10.24	5.77	59.13												
8A + 8B							16.6	8.04	6.12	49.21	714.0	0.8	1.8	6.61	23.21	5.07	40.8	
8F + 8G							17.1	16.53	5.94	98.19	891.0	1.3	2.8	5.40	22.48	5.20	85.9	
8F + 8G + 8H							24.6	32.95	4.96	163.32	809.0	0.6	1.5	8.99	33.63	4.12	135.8	
8(A-E)							23.2	26.01	5.07	131.96	1460.0	1.1	2.1	11.59	34.80	4.05	105.2	
8(A-E) + 8(F-H) + 8I							34.8	74.64	4.05	302.07	303.0	2.3	2.1	2.40	37.20	3.84	286.8	
8(A-I) + 8J							37.2	79.99	3.84	307.41	732.0	3.4	3.8	3.25	40.46	3.66	292.8	
8(A-J) + 8K+8Aa							40.5	102.78	3.66	376.16	757.0	0.7	1.8	7.21	47.67	3.30	339.4	
8(A-K) + 10							47.7	112.94	3.30	372.92	879.0	0.8	1.8	8.14	55.80	2.98	336.3	
8L + 8M + 8N							19.6	22.63	5.62	127.07								
8(A-N) + 10							55.8	135.57	2.98	403.71								
9Aa	32.99	0.57	22.7	18.87	5.20	98.09					1318.0	1.1	2.1	10.46	33.12	4.12	77.8	See secondary spreadsheet for Area 9 calcs
9Ab	28.37	0.57	20.9	16.23	5.47	88.74												
9Ac	9.15	0.69	9.3	6.33	7.83	49.56												
9A	13.97	0.82	13.3	11.42	6.74	76.98												
9B	3.79	0.57	15.3	2.16	6.31	13.62												
9C	11.30	0.51	18.3	5.72	5.77	33.01												
9D	4.13	0.47	11.3	1.92	7.24	13.92												
9E	2.97	0.38	15.9	1.13	6.31	7.16												
9F	3.06	0.52	6.6	1.60	8.96	14.37												
9G	4.11	0.52	13.6	2.16	6.74	14.52												
9H	2.69	0.50	12.6	1.34	6.98	9.38												
9I	3.10	0.51	13.7	1.57	6.74	10.58												
9Ia	8.10	0.43	18.4	3.52	5.77	20.30												
9Ib	5.83	0.50	12.9	2.91	6.98	20.34												
9J	12.38	0.45	14.3	5.57	6.52	36.30												
9K	29.91	0.49	19.8	14.59	5.62	81.96												
9L	21.28	0.56	20.3	11.83	5.47	64.72												
9M	16.47	0.41	16.3	6.82	6.12	41.72												
9N	20.40	0.45	20.9	9.18	5.47	50.20												
9O	13.29	0.52	17.5	6.96	5.94	41.36												
9P	19.19	0.30	27.9	5.76	4.64	26.70												
9Q	9.67	0.53	19.1	5.12	5.62	28.77												
10A	5.07	0.51	8.0	2.59	8.17	21.20												
10B	18.46	0.41	17.1	7.57	5.94	44.96												
10A + 10B							17.1	10.16	5.94	60.38								

Table C-6: 100-Yr Rational Analysis Routing and Results

DIRECT RUNOFF							TOTAL RUNOFF				TRAVEL TIME							REMARKS
AREA	AREA	COEFF	Tc	C*A	I	Q	Tc	Sum C*A	I	Q	L	Slope	Velocity	Tt	Tc	I	Q tot	
DESIGN.	(Ac)	C	(min)	(Ac)		(CFS)	(min)	(Ac)	(In/Hr)	(CFS)	(feet)	(%)	ft/s	(min)	(min)	(in/Hr)		
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(13)
11A	4.81	0.70	15.1	3.35	6.31	21.14												
11B	18.90	0.50	22.5	9.45	5.20	49.12												
11C	10.62	0.52	12.2	5.50	6.98	38.40												
11A + 11B + 11C							22.5	12.80	5.20	72.91	828.0	0.5	1.5	9.20	31.65	4.28	61.1	
12A	17.89	0.46	12.8	8.19	6.98	57.18												
12B	30.53	0.47	24.4	14.35	4.96	71.10												
							24.4	22.54	4.96	111.72								
13	30.19	0.52	18.8	15.82	5.77	91.32					1576.0	0.6	1.5	17.51	36.27	3.91	61.8	
14A	22.18	0.46	19.5	10.16	5.62	57.05												
14Aa	16.03	0.47	17.1	7.53	5.94	44.75												
14Ab	6.15	0.43	13.8	2.65	6.74	17.83												
14B	7.85	0.53	16.6	4.16	6.12	25.45												
14A + 14B							19.5	14.32	5.62	80.41								
14+13							19.5	30.13	5.62	169.24								
15A	4.03	0.45	12.6	1.81	6.98	12.66												
15B	2.76	0.70	13.6	1.92	6.74	12.95												
15A + 15B							13.6	3.73	6.74	25.17								
15B+9A-E							33.1	65.70	4.12	270.76								
16	6.57	0.50	13.3	3.28	6.74	22.13												
17	30.07	0.47	17.7	14.13	5.94	83.95												
18A	5.50	0.47	15.6	2.58	6.31	16.31												
18B	25.62	0.35	20.9	9.07	5.47	49.59												
18C	15.46	0.34	15.7	5.22	6.31	32.97												
18D	9.57	0.52	13.1	4.96	6.74	33.39												
18E	9.64	0.39	12.9	3.72	6.98	25.98												
18F	7.76	0.43	13.1	3.31	6.74	22.29												
18A - 18F							20.9	28.86	5.47	157.85								
with pond										91.50								
19A	22.43	0.25	18.1	5.56	5.77	32.11												
19B	26.24	0.24	22.2	6.30	5.20	32.74					3488.0	1.3	1.8	33.22	55.39	2.98	18.8	
19C	2.39	0.32	11.8	0.77	7.24	5.60												
19D	32.49	0.25	21.9	8.06	5.33	42.94												
19E	27.11	0.52	22.8	14.15	5.20	73.57												
19F	3.25	0.24	16.7	0.78	6.12	4.77												
19G	62.30	0.24	29.9	14.95	4.45	66.53												
19H	13.60	0.27	18.2	3.70	5.77	21.36												
19A + 19C							18.08	6.34	5.77	36.58	2790.0	1.8	2.0	23.25	41.33	3.60	22.8	
19A+C+D							41.33	14.39	3.60	51.88								
19A+C+D+H							41.33	18.09	3.60	65.21								
19A+C-E+H							41.33	32.25	3.60	116.22								
19B+F+G							55.39	22.03	2.98	65.60								
19A - 19H							55.4	54.28	2.98	161.63								

Table C-6: 100-Yr Rational Analysis Routing and Results

	DIRECT RUNOFF						TOTAL RUNOFF				TRAVEL TIME							
AREA	AREA	COEFF	Tc	C*A	I	Q	Tc	Sum C*A	I	Q	L	Slope	Velocity	Tt	Tc	I	Q tot	REMARKS
DESIGN.	(Ac)	C	(min)	(Ac)		(CFS)	(min)	(Ac)	(In/Hr)	(CFS)	(feet)	(%)	ft/s	(min)	(min)	(in/Hr)		
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(13)
20A	19.17	0.24	20.0	4.60	5.47	25.16												
20B	22.30	0.25	21.8	5.53	5.33	29.47												
20A + 20B							21.8	10.13	5.33	53.99	950.0	1.1	2.0	7.92	29.71	4.45	45.1	
20C	30.41	0.34	19.5	10.28	5.62	57.72												
20D	13.31	0.29	20.0	3.89	5.47	21.25												
20A - 20D							29.7	24.29	4.45	108.11								
21A	32.31	0.26	25.5	8.53	4.85	41.33												
21B	4.15	0.35	14.9	1.44	6.52	9.36												
21C	17.97	0.35	15.9	6.36	6.31	40.14												
21D	78.40	0.31	21.6	24.46	5.33	130.35												
21A - 21D							25.5	40.79	4.85	197.62								
22A	13.50	0.61	15.7	8.23	6.31	51.96												
22B	28.94	0.39	17.9	11.17	5.94	66.36												
22C	11.43	0.48	18.4	5.51	5.77	31.81												
22D	22.28	0.50	25.9	11.14	4.85	53.97					1733.0	1.67	2.0	14.44	40.36	3.66	40.8	
22E	13.22	0.48	16.5	6.37	6.12	38.99												
22F	26.18	0.51	18.4	13.24	5.77	76.46												
22G	16.71	0.47	16.6	7.78	6.12	47.64												
22H	21.97	0.45	17.3	9.80	5.94	58.22												
22I	31.06	0.47	16.7	14.47	6.12	88.57												
22J	8.01	0.23	17.0	1.86	6.12	11.38												
22A + 22B + 22C							18.4	24.91	5.77	143.82	1639.0	1.22	2.0	13.66	32.08	4.20	104.6	
22(A-C) + 22E							32.1	31.3	4.2	131.3	1785.0	1.46	2.5	11.90	43.98	3.50	109.4	
22A - 22H							40.4	89.6	3.5	313.2	2258.0	2.30	2.9	12.98	53.34	3.05	273.4	
22A-22H							44.0	96.0	3.5	335.5								
21 + 22							25.5	40.79	4.85	280.22								with Cave Creek
23A	7.20	0.44	6.4	3.18	8.96	28.52												
23B	5.85	0.51	14.4	2.96	6.52	19.29												
23C	17.64	0.26	22.6	4.52	5.20	23.47												
23D	29.42	0.25	24.1	7.30	4.96	36.16												
23A + 23B							14.4	6.14	6.52	40.03	712.0	0.84	0.9	13.19	27.54	4.64	28.5	
23C + 23D							24.1	11.81	4.96	58.54								
23A - 23D							27.5	17.95	4.64	83.25	1160.0	2.16	2.9	6.67	34.21	4.05	72.7	
24A	8.72	0.68	12.5	5.96	6.98	41.62												
24B	4.27	0.65	5.9	2.78	9.43	26.17												
24C	18.98	0.29	19.9	5.54	5.62	31.12												
24D	24.95	0.51	17.7	12.63	5.94	75.01												
24E	30.88	0.62	22.5	19.14	5.20	99.51												
24F	27.39	0.51	16.9	13.86	6.12	84.82												
24A - 24E							22.5	46.05	5.20	239.38	1432.0	2.51	3.3	7.34	29.88	4.45	204.9	
24A - 24F							29.9	59.91	4.45	266.61	1189.0	1.01	2.0	9.91	39.79	3.72	222.8	
25A	49.73	0.45	24.9	22.58	4.96	111.90												
25B	3.54	0.56	15.7	1.98	6.31	12.50												
25C	13.96	0.41	15.8	5.78	6.31	36.48												

Table C-6: 100-Yr Rational Analysis Routing and Results

DIRECT RUNOFF							TOTAL RUNOFF				TRAVEL TIME							
AREA	AREA	COEFF	Tc	C*A	I	Q	Tc	Sum C*A	I	Q	L	Slope	Velocity	Tt	Tc	I	Q tot	REMARKS
DESIGN.	(Ac)	C	(min)	(Ac)		(CFS)	(min)	(Ac)	(In/Hr)	(CFS)	(feet)	(%)	ft/s	(min)	(min)	(in/Hr)		
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(13)
25D	14.27	0.33	16.8	4.77	6.12	29.17												
25A + 25B							24.9	24.56	5.0	121.72	1747.0	2.40	2.4	12.13	37.07	3.84	94.4	
25 A-D							37.1	35.11	3.8	134.92								
IPwy1	107.97	0.52	29.3	56.15	4.45	249.85					2106.0	0.52	1.4	25.07	54.41	3.02	169.3	
IPwy2	46.69	0.29	25.1	13.45	4.85	65.16												
IPwy3	53.47	0.53	21.9	28.13	5.33	149.88												
IPwy4	9.02	0.39	14.0	3.54	6.52	23.04												
IPwy5	26.35	0.32	16.0	8.38	6.31	52.88												
IPwy6	17.11	0.40	17.9	6.84	5.94	40.66												
IPwy7	13.79	0.42	16.8	5.82	6.12	35.63												
IPwy8	29.73	0.45	20.5	13.26	5.47	72.52												
IPwy9	39.40	0.40	24.7	15.84	4.96	78.49												
IPwy10	34.77	0.37	23.8	12.86	5.07	65.28					2058.0	0.63	1.2	28.58	52.42	3.09	39.8	
IPwy11	36.66	0.30	23.8	10.85	5.07	55.07												
IPwy12	38.94	0.47	18.2	18.14	5.77	104.74												
IPwy13	24.02	0.47	21.9	11.29	5.33	60.16												
IPwy14	59.34	0.66	27.2	39.17	4.64	181.61					1481.0	1.08	1.5	16.46	43.62	3.50	136.9	
IPwy15	30.15	0.50	19.1	15.07	5.62	84.65					1240.0	1.53	1.5	13.78	32.83	4.20	63.3	
IPwy16	37.92	0.49	23.4	18.50	5.07	93.89												
IPwy17	45.83	0.47	27.2	21.54	4.64	99.89												
IPwy18	30.74	0.49	20.6	15.19	5.47	83.05												
IPwy19	40.79	0.50	22.9	20.40	5.20	106.02					1404.0	1.28	2.2	10.64	33.49	4.12	84.1	
IPwy20	40.95	0.49	25.0	20.23	4.85	98.00											99.0	
IPwy1-5							54.4	109.64	3.02	330.6								
IPwy14-16							43.6	72.74	3.50	254.3	869.0	1.73	2.5	5.79	49.41	3.21	233.8	
IPwy14-18							49.4	109.47	3.21	351.8	1350.0	0.89	1.8	12.50	61.91	2.81	307.6	
IPwy14-20							33.5	40.62	4.12	217.4	1240.0	1.21	2.1	9.84	43.33	3.50	192.0	
IPwy14-20,12							43.3	58.77	3.50	255.4	2078.0	0.05	1.5	23.09	66.42	2.81	215.1	with Chapelow Outflow
IPwy12-20							66.4	70.06	2.81	246.9	688.7	0.15	1.5	7.65	74.07	2.81	246.9	
IPwy12-20,8,9							74.1	99.15	2.81	328.6	746.0	1.34	2.2	5.65	79.72	2.81	328.6	
IPwy8-20							79.7	112.02	2.81	383.8	1083.0	0.74	1.4	12.89	92.61	2.81	383.8	includes pond #6 (South 17th Ave)
IPwy6-20							79.7	124.68	2.81	419.4								To ditch, excluding previous Evans ditch flow
IPwy1-20							79.7	234.32	2.81	727.4								If/when pond overflows to ditch/road
IPwy4-20							79.7	136.60	2.81	452.9								
27A	12.18	0.50	17.9	6.09	5.94	36.19					1021.0	0.98	2.0	8.51	26.37	4.74	28.9	
27B	3.52	0.38	14.4	1.34	6.52	8.72												
27C	6.52	0.64	14.9	4.20	6.52	27.36					534.0	0.56	1.4	6.36	21.28	5.33	22.4	
27D	6.45	0.41	14.0	2.66	6.74	17.90												
27E	17.32	0.47	18.4	8.17	5.77	47.19												
27F	22.16	0.46	18.2	10.19	5.77	58.85												
27G	7.61	0.36	17.5	2.76	5.94	16.37												
27H	3.35	0.42	14.0	1.40	6.74	9.44												
27I	33.38	0.56	19.5	18.69	5.62	104.98												
27J	9.44	0.50	14.8	4.72	6.52	30.75												
27C+D							14.0	2.66	6.74	18.87	730.0	1.51	2.5	4.89	18.86	5.77	16.3	with pond #7 (Burlington Ave.)
27A-E (EXCEPT B)							26.4	16.92	4.74	81.15	870.0	0.34	1.4	10.36	36.73	3.91	67.1	
27A-H (EXCEPT B)							36.7	31.27	3.26	102.83	985.0	0.51	1.4	11.73	48.45	3.26	102.8	
27A-J (EXCEPT B)							48.5	54.69	3.26	179.08								

Table C-6: 100-Yr Rational Analysis Routing and Results (Area #9)

DESIGN	DIRECT RUNOFF							TOTAL RUNOFF				TRAVEL TIME							REMARKS
	AREA DESIGN.	AREA (Ac)	COEFF C	Tc (min)	C*A (Ac)	I	Q (CFS)	Tc (min)	Sum C*A (Ac)	I (In/Hr)	Q (CFS)	L (feet)	Slope (%)	Velocity ft/s	Tt (min)	Tc (min)	I (in/Hr)	Q tot	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(13)
	4A	19.87	0.58	12.2	11.49	6.98	80.15					618	0.6	1.5	6.87	19.07	5.62	64.5	
	4B	14.86	0.57	19.2	8.5	5.62	47.72												
	4C	17.97	0.57	20.9	10.17	5.47	55.64												
	4D	15.26	0.49	21.2	7.54	5.33	40.16					1766	1	2	14.72	35.91	3.98	30	
	4E	13.66	0.49	18	6.67	5.94	39.61												
	4F	8.43	0.53	20.2	4.47	5.47	24.43												
	4A + 4B							19.2	19.98	5.62	112.23	857	1.5	2.5	5.71	24.9	4.96	99	
	4A + 4B + 4C							24.9	30.16	4.96	149.46	540	1.1	2.1	4.29	29.19	4.45	134.2	
	4 (A - F)							35.9	48.83	3.98	194.14	2063	1.1	2.1	16.37	52.28	3.09	150.9	
												1030	0.4	1.4	12.26	12.26	6.98	0	
	5	0.62	0.56	5	0.35	9.43	3.27												
	9Aa	32.99	0.57	22.7	18.87	5.2	98.09					1318	1.1	2.1	10.46	33.12	4.12	77.8	
	9Ab	28.37	0.57	20.9	16.23	5.47	88.74												
	9Ac	9.15	0.69	9.3	6.33	7.83	49.56					503	3.8	3.8	2.21	11.54	7.24	45.8	
	9A	13.97	0.82	13.3	11.42	6.74	76.98												
	9B	3.79	0.57	15.3	2.16	6.31	13.62												
	9C	11.3	0.51	18.3	5.72	5.77	33.01												
	9D	4.13	0.47	11.3	1.92	7.24	13.92												
	9E	2.97	0.38	15.9	1.13	6.31	7.16												
	9F	3.06	0.52	6.6	1.6	8.96	14.37												
	9G	4.11	0.52	13.6	2.16	6.74	14.52												
	9H	2.69	0.5	12.6	1.34	6.98	9.38												
	9I	3.1	0.51	13.7	1.57	6.74	10.58												
	9Ia	8.1	0.43	18.4	3.52	5.77	20.3												
	9Ib	5.83	0.5	12.9	2.91	6.98	20.34					1060	0.1	1.4	12.62	25.52	4.85	14.1	
	9J	12.38	0.45	14.3	5.57	6.52	36.3												
	9K	29.91	0.49	19.8	14.59	5.62	81.96					708	0.4	1.4	8.43	28.2	4.54	66.3	
	9L	21.28	0.56	20.3	11.83	5.47	64.72												
	9M	16.47	0.58	16.3	9.58	6.12	58.65												
	9N	20.4	0.6	20.9	12.24	5.47	66.93												
	9O	13.29	0.65	17.5	8.58	5.94	50.99												
	9P	19.19	0.54	27.9	10.36	4.64	48.05												
	9Q	9.67	0.65	19.1	6.28	5.62	35.28												
	11A	4.81	0.7	15.1	3.35	6.31	21.14												
	11B	18.9	0.5	22.5	9.45	5.2	49.12												
	11C	10.62	0.52	12.2	5.5	6.98	38.4												
	11A + 11B + 11C							22.5	12.8	5.2	72.91	420	0.5	1.4	5	27.45	4.64	59.3	Includes Pond #8 (Community Center)
	13	30.19	0.52	18.8	15.82	5.77	91.32					1576	0.6	1.5	17.51	36.27	3.91	61.8	
	14A	22.18	0.46	19.5	10.16	5.62	57.05												
	14Ab	6.15	0.43	13.8	2.67	6.74	18												
	14Aa	16.03	0.47	17.1	7.53	5.94	44.75												
	14B	7.85	0.53	16.6	4.16	6.12	25.45												
	14A + 14B							19.5	14.32	5.62	80.41								
	14+13							19.5	30.13	5.62	169.24	530	0.4	1.4	6.31	25.83	4.85	146	
	15A	4.03	0.45	12.6	1.81	6.98	12.66												
	15B	2.76	0.44	13.6	1.22	6.74	8.22												
	15A + 15B							13.6	3.03	6.74	20.45								
	15B+9A-E							33.1	65	4.12	267.87								
	9Ra	8.15	0.56	13.4	4.57	6.74	30.77												
	9Rb	9.66	0.54	13.4	5.26	6.74	35.43												

Table C-6: 100-Yr Rational Analysis Routing and Results (Area #9)

DESIGN	DIRECT RUNOFF							TOTAL RUNOFF				TRAVEL TIME							REMARKS
	AREA DESIGN.	AREA (Ac)	COEFF C	Tc (min)	C*A (Ac)	I	Q (CFS)	Tc (min)	Sum C*A (Ac)	I (In/Hr)	Q (CFS)	L (feet)	Slope (%)	Velocity ft/s	Tt (min)	Tc (min)	I (in/Hr)	Q tot	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(13)
	9Rc	8.37	0.56	13.4	4.69	6.74	31.59												
	16	6.57	0.5	13.3	3.28	6.74	22.13												
	17	30.07	0.47	17.7	14.13	5.94	83.95												
Existing																			
	9(A-J) + 11 + 13+ 14 +15							33.1	121.99	4.12	509.11	1173	0.4	1.4	13.96	47.09	3.3	409.2	Includes Pond #10 (Riverside Parkway)
	9(A-K) + 11 + 13+ 14 +15							47.1	128.42	3.3	495.6	708	0.4	1.4	8.43	55.51	2.98	454	
	9(A-M) + 11 + 13+ 14 +15							55.5	149.84	2.98	517.8	675	0.3	1.4	8.04	63.55	2.81	492.6	
	9(A-O) + 11 + 13 + 15							63.6	162.08	2.81	535.5	2062	0.4	1.4	24.55	88.1	2.81	535.5	Includes Pond #9 (Timberline)
	9(A-Q) + 11 + 13 + 15							88.1	178.72	2.81	582.3								
Alternative 3																			
37th St. (W)	9Aa + 9Ab							33.1	35.1	4.12	144.63	851	1.88	2.6	5.46	38.58	3.78	132.6	
	Above + 9Ac + 9D + 9E							38.6	44.48	3.78	168.1	320	1.25	2.2	2.42	41	3.6	160.3	
	Above + 15B							41	45.7	3.6	171.09	389	0.257	1.4	4.63	45.63	3.4	155.2	
	Above + 15A+14Aa + 9G-I							45.6	60.12	3.4	210.54	358	0.279	1.4	4.26	49.89	3.21	193.2	
37th St. (E)	Above + 15A+14Aa							45.6	60.1	3.4	210.54	358	0.3	1.4	4.26	49.89	3.21	193.2	
	Above + 9K							49.9	60.12	3.21	264.76	708	0.4	1.4	8.43	58.32	2.87	237.9	
	Above + 9L							58.3	74.71	2.87	286.26	675	0.3	1.4	8.04	66.36	2.81	275.1	
	Above + 9N							66.4	86.95	2.81	315.87	2062	0.4	1.4	24.55	90.91	2.81	309.5	
	Above + 9P +9Q							90.9	103.6	2.81	362.64								
39th Street	9Ia + 9Ib + 16							18.4	9.71	5.77	56.06	373	0.13	1.4	4.44	22.88	5.2	50.5	
main	Above + 9Ra							22.9	14.28	5.2	74.21	401	0.12	1.4	4.77	27.66	4.64	66.2	
main	Above + 9Rb							27.7	19.53	4.64	90.58	348	0.14	1.4	4.14	31.8	4.28	83.6	
main	Above +9Rc							31.8	24.22	4.28	103.62	644	0.62	1.5	7.16	38.96	3.78	91.5	
optional	Above + 9M							39	33.8	3.78	127.75	274	1.09	2.1	2.17	41.13	3.6	121.8	
optional	Above + 9O							41.1	42.39	3.6	152.76								
Carson St.	4 + 9B + 9C							35.9	56.7	3.98	225.46	1040	0.2	1.4	12.38	48.29	3.26	184.7	
	Above + 9A							48.3	68.13	3.26	221.89								
	With Pond (Proposed)							48.3	24.56	3.26	80								
	South of Pond																		

Table C-7: 10 Yr Rational Analysis Routing and Results

DIRECT RUNOFF							TOTAL RUNOFF				TRAVEL TIME							
AREA	AREA	COEFF	Tc	C*A	I	Q	Tc	Sum C*A	I	Q	L	Slope	Velocity	Tt	Tc	I	Q tot	REMARKS
DESIGN.	(Ac)	C	(min)	(Ac)		(CFS)	(min)	(Ac)	(In/Hr)	(CFS)	(feet)	(%)	ft/s	(min)	(min)	(in/Hr)		
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(13)
1A	12.83	0.43	16.7	5.47	3.87	21.18					880	1.8	2.8	5.33	22.03	3.29	18	
1B	8.99	0.43	17.8	3.83	3.76	14.4												
1C	7.21	0.47	15.6	3.36	4	13.42												
1A + 1B + 1C							22	12.66	3.29	41.65								
1 + 23 + 24							39.8	72.66	2.35	171.05	675	0.4	1.4	8.04	47.82	2.09	151.9	
2	13.38	0.39	27.3	5.24	2.94	15.4												
3A	9.79	0.44	10.3	4.33	4.76	20.6					1545	2.2	3	8.58	18.86	3.66	15.8	
3Aa	12	0.27	18.3	3.29	3.66	12.02												
3Ab	39.54	0.36	23.5	14.08	3.21	45.21					1426	1.1	2.1	11.32	34.77	2.56	36.1	
3Ac	30.12	0.4	22.2	12.17	3.29	40.04					1812	1.5	2.5	12.08	34.28	2.56	31.2	
3Ad	43.75	0.24	23.7	10.59	3.21	34												
3Ae	35.22	0.37	20.2	12.96	3.46	44.87												
3Af	37.22	0.27	24.1	10.2	3.14	32					1189	0.9	2	9.91	34.05	2.56	26.1	
3Ag	11.58	0.27	15.7	3.1	4	12.4												
3Ah	16.14	0.36	19	5.75	3.56	20.44												
3B	28.92	0.37	19	10.82	3.66	39.53												
3C	4.28	0.56	15.7	2.42	4	9.65												
3D	29.92	0.39	21.4	11.55	3.37	38.96												
3D (with Pond)	29.92	0.39	21.4	16.27	3.37	54.9												with Hunters Reserve Pond #1
3E	33.64	0.48	22.7	16.21	3.29	53.36					2170	2.6	3.3	11.13	33.86	2.61	42.3	
3E (with Pond)	33.64	0.48	22.73	7.32	3.29	24.1					2170	2.6	3.3	11.13	33.86	2.61	19.1	with Hunters Reserve Pond #3
3F	19.56	0.58	17.2	11.42	3.76	42.95					678	0.1	1.4	8.07	25.27	3.07	35	
3G	21.45	0.56	18.5	12.01	3.66	43.91												
3H	4.48	0.5	15.9	2.24	4	8.96												
3I	12.92	0.63	16.8	8.14	3.87	31.54												
3J	18.71	0.5	14.9	9.36	4.13	38.6												
3K	14.66	0.51	14.4	7.42	4.13	30.6												
3L	6.21	0.75	15.9	4.65	4	18.57												
3M	28.48	0.59	27	16.75	2.94	49.17												
3M (with Pond)	28.48	0.59	27.02	25.89	2.94	76												with Willow Brook
3N	19.87	0.53	17.6	10.45	3.76	39.31												
3O	14.21	0.29	17.3	4.09	3.76	15.39												
3P	21.77	0.22	19.4	4.79	3.56	17.03												
3Q	17.03	0.3	19.6	5.04	3.56	17.93												
3R	31.13	0.19	16	5.85	3.87	22.67					832	1.6	2.6	5.33	21.38	3.37	19.7	
3S	8.73	0.39	10.9	3.42	4.76	16.3					999	1.3	2.3	7.24	18.1	3.66	12.5	
3T	14.47	0.35	12.9	5.07	4.42	22.38												
3U	27.81	0.37	14.3	10.35	4.13	42.69												
3V	98.64	0.15	30.9	14.4	2.76	39.76												
3Aa+3Ab+3Ad							34.8	27.95	2.56	71.61	742	0.4	1.4	8.83	43.61	2.21	61.9	
3Aa-Ae							43.6	53.08	2.21	117.46	1292	1.4	2.4	8.97	52.58	1.96	103.9	
3Aa+3Ah							52.6	72.13	1.96	141.16								
3C+ 3D							15.7	2.42	4	64.55	2442	1.8	2.8	14.8	30.5	2.76	61.6	
3F + 3G							18.5	23.43	3.66	85.65	918	1.1	2.1	7.29	25.78	3.07	71.9	
3E+K							22.7	23.63	3.29	77.77								
3F+3G+3I							18.5	33.82	3.66	123.6								
Above + 3J + 3H							18.5	45.41	3.66	165.99								
3(E-M)							33.9	80.78	2.94	237.18	674	1	2	5.62	39.47	2.35	190.2	

Table C-7: 10 Yr Rational Analysis Routing and Results

DIRECT RUNOFF							TOTAL RUNOFF				TRAVEL TIME							
AREA	AREA	COEFF	Tc	C*A	I	Q	Tc	Sum C*A	I	Q	L	Slope	Velocity	Tt	Tc	I	Q tot	REMARKS
DESIGN.	(Ac)	C	(min)	(Ac)		(CFS)	(min)	(Ac)	(In/Hr)	(CFS)	(feet)	(%)	ft/s	(min)	(min)	(in/Hr)		
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(13)
3T + 3R							21.4	10.92	3.37	36.84	574	2.3	2.9	3.3	24.68	3.14	34.3	
To Landings 24+3Af+1+3Ah							39.8	75.83	2.35	178.51								
with pond							39.8	75.83	2.35	38								With Landings Pond
23 + 3Ab + 3Ad							34.8	34.79	2.56	89.14	755	0.7	1.6	7.86	42.64	2.25	78.2	
with pond							34.8	34.8	2.6	58.2								with North Point Pond
Above + 3Ac+ 3Ae							34.3	25.13	2.56	122.58	1196	1.3	2.3	8.67	42.95	2.25	128.5	
Above + 3Ag							34.3	25.13	2.56	124.31	667	0.7	1.6	6.95	41.23	2.28	59	with Arbor Gardens
Above + Landings							41.2	25.13	2.28	155.3	1021	0.5	1.4	12.15	53.38	1.93	146.5	
Above + 3C+ 3D + 3B + 3A							53.4	42.68	1.93	235.3	1156	1.6	2.5	7.71	61.09	1.78	228.8	Junction at 23rd Ave.
Above + 3N+3O							61.1	57.23	1.78	196.5	1345	1.2	2.2	10.19	71.28	1.78	196.4	
3F,G,I,M,K,E,H,J,L							33.9	64.8	2.61	169.07	638	0.9	2	5.32	39.17	2.35	152.5	
Above 2 + 3P + 3Q							71.3	147.84	1.78	357.69	1072	1.3	2.3	7.77	79.05	1.78	357.7	
Above + ...to 3U							79	172.53	1.78	401.61	1390	0.7	1.8	12.87	91.92	1.78	401.6	
with pond							79	172.53	1.78	271	1390	0.7	1.8	12.87	91.92	1.78	306.9	With Prairie View Ridge Pond
Above + 3V							30.9	14.4	2.76	310.76								
4A	19.87	0.48	12.2	9.5	4.42	41.97					618	0.6	1.5	6.87	19.07	3.56	33.8	
4B	14.86	0.47	19.2	7.01	3.56	24.93												
4C	17.97	0.47	20.9	8.38	3.46	29												
4D	15.26	0.4	21.2	6.16	3.37	20.8					1766	1	2	14.72	35.91	2.52	15.5	
4E	13.66	0.4	18	5.44	3.76	20.45												
4F	8.43	0.45	20.2	3.79	3.46	13.13												
4A + 4B							19.2	16.51	3.56	58.71	857	1.5	2.5	5.71	24.9	3.14	51.8	
4A + 4B + 4C							24.9	24.89	3.14	78.1	540	1.1	2.1	4.29	29.19	2.82	70.1	
4 (A - F)							35.9	40.28	2.52	101.39	2063	1.1	2.1	16.37	52.28	1.96	78.8	
5	0.62	0.46	5	0.29	5.97	1.7												
6A	0.66	0.51	10.4	0.33	4.76	1.59												
6B	0.76	0.46	10.9	0.35	4.76	1.66												
6C	1.57	0.55	12.8	0.87	4.42	3.83												
6D	0.68	0.47	11.3	0.32	4.58	1.45												
6E	0.99	0.55	11.9	0.55	4.58	2.5												
6F	5.82	0.19	14.8	1.13	4.13	4.66												
6G	4.84	0.38	13.5	1.84	4.27	7.84												
6E + 6F							14.8	1.68	4.13	6.91								
6E + 6F + 6D							14.8	1.99	4.13	8.22	271	0.22	0.7	6.45	21.29	3.37	6.7	
6 C+F+G							14.8	3.83	4.13	15.82								
6 A-F							14.8	5.38	4.13	22.19								
7A	9.05	0.33	14.8	2.99	4.13	12.32					1128	3	3.3	5.78	20.6	3.46	10.3	
7B	27.5	0.43	21.2	11.83	3.37	39.9												
7C	7	0.17	13	1.19	4.27	5.08												
7D	23.25	0.46	30.6	10.7	2.76	29.53												
7A + 7B + 7C							21.2	16	3.37	53.99								
8A	7.49	0.47	16.2	3.53	3.87	13.69												
8B	12.87	0.16	16.6	2.03	3.87	7.88												
8C	14.2	0.41	11.5	5.82	4.58	26.67												

Table C-7: 10 Yr Rational Analysis Routing and Results

DIRECT RUNOFF							TOTAL RUNOFF				TRAVEL TIME							REMARKS
AREA	AREA	COEFF	Tc	C*A	I	Q	Tc	Sum C*A	I	Q	L	Slope	Velocity	Tt	Tc	I	Q tot	
DESIGN.	(Ac)	C	(min)	(Ac)		(CFS)	(min)	(Ac)	(In/Hr)	(CFS)	(feet)	(%)	ft/s	(min)	(min)	(in/Hr)		
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(13)
8D	9.32	0.34	16.3	3.15	3.87	12.2												
8E	12.66	0.42	18.5	5.37	3.66	19.63												
8F	19.37	0.48	10.9	9.37	4.76	44.63												
8G	12.25	0.32	17.1	3.97	3.76	14.93												
8H	32.85	0.41	24.6	13.47	3.14	42.27												
8I	27.12	0.48	21.9	12.97	3.37	43.75												
8J	11.11	0.39	18.3	4.35	3.66	15.91												
8K	25.38	0.4	21.2	10.26	3.37	34.6												
8L	18.78	0.56	17.6	10.59	3.76	39.85												
8M	9.63	0.61	16.8	5.9	3.87	22.84												
8N	8.64	0.41	19.6	3.54	3.56	12.59												
8Aa	16.85	0.51	18.7	8.66	3.66	31.65												
8A + 8B							16.6	5.57	3.87	21.57	714	0.8	1.8	6.61	23.21	3.21	17.9	
8F + 8G							17.1	13.34	3.76	50.18	891	1.3	2.8	5.4	22.48	3.29	43.9	
8F + 8G + 8H							24.6	26.81	3.14	84.14	809	0.6	1.5	8.99	33.63	2.61	70	
8(A-E)							23.2	19.91	3.21	63.94	1460	1.1	2.1	11.59	34.8	2.56	51	
8(A-E) + 8(F-H) + 8I							34.8	59.68	2.56	152.91	303	2.3	2.1	2.4	37.2	2.43	145.2	
8(A-I) + 8J							37.2	64.04	2.43	155.8	732	3.4	3.8	3.25	40.46	2.32	148.4	
8(A-J) + 8K+8Aa							40.5	82.95	2.32	192.2	757	0.7	1.8	7.21	47.67	2.09	173.4	
8(A-K) + 10							47.7	90.65	2.09	189.46	879	0.8	1.8	8.14	55.8	1.89	170.9	
8L + 8M + 8N							19.6	20.03	3.56	71.23								
8(A-N) + 10							55.8	110.68	1.89	208.63								
9Aa	32.99	0.47	22.7	15.57	3.29	51.24					1318	1.1	2.1	10.46	33.12	2.61	40.6	See secondary spreadsheet for Area 9 calc
9Ab	28.37	0.47	20.9	13.39	3.46	46.35												
9Ac	9.15	0.62	9.3	5.67	4.96	28.11												
9A	13.97	0.77	13.3	10.7	4.27	45.63												
9B	3.79	0.5	15.3	1.89	4	7.57												
9C	11.3	0.42	18.3	4.72	3.66	17.26												
9D	4.13	0.37	11.3	1.54	4.58	7.07												
9E	2.97	0.27	15.9	0.8	4	3.18												
9F	3.06	0.44	6.6	1.35	5.67	7.67												
9G	4.11	0.44	13.6	1.82	4.27	7.75												
9H	2.69	0.41	12.6	1.1	4.42	4.87												
9I	3.1	0.42	13.7	1.3	4.27	5.53												
9Ia	8.1	0.33	18.4	2.71	3.66	9.89												
9Ib	5.83	0.41	12.9	2.39	4.42	10.56												
9J	12.38	0.35	14.3	4.33	4.13	17.87												
9K	29.91	0.4	19.8	11.9	3.56	42.33												
9L	21.28	0.45	20.3	9.66	3.46	33.45												
9M	16.47	0.31	16.3	5.04	3.87	19.52												
9N	20.4	0.35	20.9	7.14	3.46	24.72												
9O	13.29	0.44	17.5	5.87	3.76	22.09												
9P	19.19	0.17	27.9	3.26	2.94	9.58												
9Q	9.67	0.45	19.1	4.35	3.56	15.47												
10A	5.07	0.43	8	2.16	5.17	11.17												
10B	18.46	0.3	17.1	5.54	3.76	20.83												
10A + 10B							17.1	7.7	3.76	28.95								

Table C-7: 10 Yr Rational Analysis Routing and Results

DIRECT RUNOFF							TOTAL RUNOFF				TRAVEL TIME							
AREA	AREA	COEFF	Tc	C*A	I	Q	Tc	Sum C*A	I	Q	L	Slope	Velocity	Tt	Tc	I	Q tot	REMARKS
DESIGN.	(Ac)	C	(min)	(Ac)		(CFS)	(min)	(Ac)	(In/Hr)	(CFS)	(feet)	(%)	ft/s	(min)	(min)	(in/Hr)		
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(13)
11A	4.81	0.64	15.1	3.06	4	12.23												
11B	18.9	0.41	22.5	7.75	3.29	25.5												
11C	10.62	0.43	12.2	4.61	4.42	20.37												
11A + 11B + 11C							22.5	10.81	3.29	41.95	828	0.5	1.5	9.2	31.65	2.71	35.7	
12A	17.89	0.36	12.8	6.48	4.42	28.61												
12B	30.53	0.38	24.4	11.6	3.14	36.4												
							24.4	18.08	3.14	56.72								
13	30.19	0.44	18.8	13.34	3.66	48.77					1576	0.6	1.5	17.51	36.27	2.47	33	
14A	22.18	0.36	19.5	8.03	3.56	28.55												
14Aa	16.03	0.38	17.1	6.09	3.76	22.9												
14Ab	6.15	0.33	13.8	2.03	4.27	8.66												
14B	7.85	0.45	16.6	3.53	3.87	13.68												
14A + 14B							19.5	11.56	3.56	41.11								
14+13							19.5	24.9	3.56	88.55								
15A	4.03	0.35	12.6	1.41	4.42	6.23												
15B	2.76	0.64	13.6	1.76	4.27	7.49												
15A + 15B							13.6	3.17	4.27	13.51								
15B+9A-E							33.1	56.04	2.61	146.21								
16	6.57	0.41	13.3	2.69	4.27	11.49												
17	30.07	0.38	17.7	11.43	3.76	42.97												
18A	5.5	0.38	15.6	2.09	4	8.35												
18B	25.62	0.23	20.9	5.99	3.46	20.75												
18C	15.46	0.21	15.7	3.28	4	13.1												
18D	9.57	0.43	13.1	4.15	4.27	17.71												
18E	9.64	0.27	12.9	2.64	4.42	11.67												
18F	7.76	0.32	13.1	2.52	4.27	10.73												
18A - 18F							20.9	20.67	3.46	71.56								
19A	22.43	0.11	18.1	2.42	3.66	8.85												
19B	26.24	0.1	22.2	2.62	3.29	8.64					3488	1.3	1.8	33.22	55.39	1.89	4.9	
19C	2.39	0.19	11.8	0.46	4.58	2.12												
19D	32.49	0.11	21.9	3.51	3.37	11.84												
19E	27.11	0.28	22.8	7.7	3.29	25.34												
19F	3.25	0.1	16.7	0.32	3.87	1.26												
19G	62.3	0.1	29.9	6.23	2.82	17.55												
19H	13.6	0.13	18.2	1.8	3.66	6.56												
19A + 19C							18.08	2.89	3.66	10.55	2790	1.8	2	23.25	41.33	2.28	6.6	
19A+C+D							41.33	6.4	2.28	14.59								
19A+C+D+H							41.33	8.19	2.28	18.68								
19A+C-E+H							41.33	15.89	2.28	36.25								
19B+F+G							55.39	9.18	1.89	17.3								
19A - 19H							55.4	25.07	1.89	47.25								

Table C-7: 10 Yr Rational Analysis Routing and Results

DIRECT RUNOFF							TOTAL RUNOFF				TRAVEL TIME							REMARKS
AREA	AREA	COEFF	Tc	C*A	I	Q	Tc	Sum C*A	I	Q	L	Slope	Velocity	Tt	Tc	I	Q tot	
DESIGN.	(Ac)	C	(min)	(Ac)		(CFS)	(min)	(Ac)	(In/Hr)	(CFS)	(feet)	(%)	ft/s	(min)	(min)	(in/Hr)		
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(13)
20A	19.17	0.1	20	1.92	3.46	6.64												
20B	22.3	0.11	21.8	2.41	3.37	8.13												
20A + 20B							21.8	4.33	3.37	14.59	950	1.1	2	7.92	29.71	2.82	12.2	
20C	30.41	0.21	19.5	6.45	3.56	22.92												
20D	13.31	0.16	20	2.1	3.46	7.28												
20A - 20D							29.7	12.87	2.82	36.27								
21A	32.31	0.12	25.5	4.01	3.07	12.29												
21B	4.15	0.22	14.9	0.93	4.13	3.84												
21C	17.97	0.23	15.9	4.2	4	16.8												
21D	78.4	0.18	21.6	14.27	3.37	48.14												
21A - 21D							25.5	23.41	3.07	71.8								
22A	13.5	0.54	15.7	7.29	4	29.12												
22B	28.94	0.27	17.9	7.93	3.76	29.82												
22C	11.43	0.39	18.4	4.48	3.66	16.38												
22D	22.28	0.41	25.9	9.14	3.07	28.02					1733	1.67	2	14.44	40.36	2.32	21.2	
22E	13.22	0.39	16.5	5.18	3.87	20.07												
22F	26.18	0.42	18.4	10.94	3.66	39.99												
22G	16.71	0.37	16.6	6.25	3.87	24.2												
22H	21.97	0.35	17.3	7.6	3.76	28.59												
22I	31.06	0.37	16.7	11.61	3.87	44.99												
22J	8.01	0.09	17	0.72	3.87	2.79												
22A + 22B + 22C							18.4	19.7	3.66	72	1639	1.22	2	13.66	32.08	2.66	52.4	
22(A-C) + 22E							32.1	24.9	2.7	66.1	1785	1.46	2.5	11.9	43.98	2.21	55.1	
22A - 22H							40.4	71.1	2.2	157.4	2258	2.3	2.9	12.98	53.34	1.93	137.4	
22A-22H							44	76.3	2.2	168.9								
21 + 22							25.5	23.41	3.07	154.4								with Cave Creek
23A	7.2	0.34	6.4	2.46	5.67	13.97												
23B	5.85	0.42	14.4	2.45	4.13	10.09												
23C	17.64	0.12	22.6	2.05	3.29	6.73												
23D	29.42	0.11	24.1	3.18	3.14	9.97												
23A + 23B							14.4	4.91	4.13	20.25	712	0.84	0.9	13.19	27.54	2.94	14.4	
23C + 23D							24.1	5.22	3.14	16.39								
23A - 23D							27.5	10.13	2.94	29.75	1160	2.16	2.9	6.67	34.21	2.56	26	
24A	8.72	0.62	12.5	5.44	4.42	24.04												
24B	4.27	0.59	5.9	2.51	5.97	14.99												
24C	18.98	0.16	19.9	3	3.56	10.66												
24D	24.95	0.42	17.7	10.43	3.76	39.23												
24E	30.88	0.55	22.5	17.04	3.29	56.09												
24F	27.39	0.42	16.9	11.45	3.87	44.36												
24A - 24E							22.5	38.43	3.29	126.46	1432	2.51	3.3	7.34	29.88	2.82	108.2	
24A - 24F							29.9	49.87	2.82	140.5	1189	1.01	2	9.91	39.79	2.35	117.4	
25A	49.73	0.36	24.9	17.71	3.14	55.56												
25B	3.54	0.46	15.7	1.63	4	6.5												
25C	13.96	0.31	15.8	4.27	4	17.07												

Table C-7: 10 Yr Rational Analysis Routing and Results

DIRECT RUNOFF							TOTAL RUNOFF				TRAVEL TIME							
AREA	AREA	COEFF	Tc	C*A	I	Q	Tc	Sum C*A	I	Q	L	Slope	Velocity	Tt	Tc	I	Q tot	REMARKS
DESIGN.	(Ac)	C	(min)	(Ac)		(CFS)	(min)	(Ac)	(In/Hr)	(CFS)	(feet)	(%)	ft/s	(min)	(min)	(in/Hr)		
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(13)
25D	14.27	0.21	16.8	2.94	3.87	11.39												
25A + 25B							24.9	19.33	3.1	60.67	1747	2.4	2.4	12.13	37.07	2.43	47	
25 A-D							37.1	26.55	2.4	64.58								
IPwy1	107.97	0.28	29.3	30.23	2.82	85.17					2106	0.52	1.4	25.07	54.41	1.91	57.7	
IPwy2	46.69	0.15	25.1	7.1	3.07	21.77												
IPwy3	53.47	0.29	21.9	15.61	3.37	52.68												
IPwy4	9.02	0.21	14	1.88	4.13	7.74												
IPwy5	26.35	0.19	16	4.95	4	19.8												
IPwy6	17.11	0.22	17.9	3.76	3.76	14.16												
IPwy7	13.79	0.32	16.8	4.39	3.87	16.99												
IPwy8	29.73	0.35	20.5	10.29	3.46	35.62												
IPwy9	39.4	0.29	24.7	11.5	3.14	36.1												
IPwy10	34.77	0.25	23.8	8.69	3.21	27.92					2058	0.63	1.2	28.58	52.42	1.96	17	
IPwy11	36.66	0.16	23.8	6.01	3.21	19.31												
IPwy12	38.94	0.37	18.2	14.56	3.66	53.22												
IPwy13	24.02	0.38	21.9	9.13	3.37	30.79												
IPwy14	59.34	0.6	27.2	35.61	2.94	104.54					1481	1.08	1.5	16.46	43.62	2.21	78.8	
IPwy15	30.15	0.41	19.1	12.36	3.56	43.95					1240	1.53	1.5	13.78	32.83	2.66	32.9	
IPwy16	37.92	0.4	23.4	15.09	3.21	48.48												
IPwy17	45.83	0.38	27.2	17.42	2.94	51.14												
IPwy18	30.74	0.4	20.6	12.42	3.46	42.99												
IPwy19	40.79	0.41	22.9	16.72	3.29	55.04					1404	1.28	2.2	10.64	33.49	2.61	43.6	
IPwy20	40.95	0.4	25	16.54	3.07	50.73											75.4	
IPwy1-5							54.4	59.77	1.91	114.1								
IPwy14-16							43.6	63.06	2.21	139.5	869	1.73	2.5	5.79	49.41	2.04	128.3	
IPwy14-18							49.4	92.89	2.04	189	1350	0.89	1.8	12.5	61.91	1.78	165.3	
IPwy14-20							33.5	33.27	2.61	136.8	1240	1.21	2.1	9.84	43.33	2.21	73.6	
IPwy14-20,12							43.3	47.83	2.21	155.8	2078	0.05	1.5	23.09	66.42	1.78	135.1	with Chapelow Outflow
IPwy12-20							66.4	56.96	1.78	151.3	688.7	0.15	1.5	7.65	74.07	1.78	151.3	
IPwy12-20,8,9							74.1	78.75	1.78	190.1	746	1.34	2.2	5.65	79.72	1.78	190.1	
IPwy8-20							79.7	87.44	1.78	224.6	1083	0.74	1.4	12.89	92.61	1.78	224.6	includes pond #6 (South 17th Ave)
IPwy6-20							79.7	95.59	1.78	239.1								To ditch, excluding previous Evans ditch fl
IPwy1-20							79.7	155.36	1.78	345.4								If/when pond overflows to ditch/road
IPwy4-20							79.7	102.42	1.78	251.2								
27A	12.18	0.36	17.9	4.39	3.76	16.5					1021	0.98	2	8.51	26.37	3	13.2	
27B	3.52	0.19	14.4	0.67	4.13	2.76												
27C	6.52	0.56	14.9	3.65	4.13	15.06					534	0.56	1.4	6.36	21.28	3.37	12.3	
27D	6.45	0.24	14	1.53	4.27	6.55												
27E	17.32	0.32	18.4	5.61	3.66	20.51												
27F	22.16	0.3	18.2	6.65	3.66	24.3												
27G	7.61	0.24	17.5	1.84	3.76	6.93												
27H	3.35	0.31	14	1.05	4.27	4.46												
27I	33.38	0.46	19.5	15.36	3.56	54.6												
27J	9.44	0.41	14.8	3.87	4.13	15.96												
27C+D							14	1.53	4.27	7.52	730	1.51	2.5	4.89	18.86	3.66	6.6	with pond #7 (Burlington Ave.)
27A-E (EXCEPT B)							26.4	11.53	3	35.57	870	0.34	1.4	10.36	36.73	2.47	29.5	
27A-H (EXCEPT B)							36.7	21.07	2.06	44.41	985	0.51	1.4	11.73	48.45	2.06	44.4	
27A-J (EXCEPT B)							48.5	40.29	2.06	84.05								

Table C-7: 10 Yr Rational Analysis Routing and Results (Area #9)

DESIGN	DIRECT RUNOFF							TOTAL RUNOFF				TRAVEL TIME							REMARKS
	AREA DESIGN.	AREA (Ac)	COEFF C	Tc (min)	C*A (Ac)	I	Q (CFS)	Tc (min)	Sum C*A (Ac)	I (In/Hr)	Q (CFS)	L (feet)	Slope (%)	Velocity ft/s	Tt (min)	Tc (min)	I (in/Hr)	Q tot	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(13)
	4A	19.87	0.48	12.2	9.5	4.42	41.97					618	0.6	1.5	6.87	19.07	3.56	33.8	
	4B	14.86	0.47	19.2	7.01	3.56	24.93												
	4C	17.97	0.47	20.9	8.38	3.46	29												
	4D	15.26	0.4	21.2	6.16	3.37	20.8					1766	1	2	14.72	35.91	2.52	15.5	
	4E	13.66	0.4	18	5.44	3.76	20.45												
	4F	8.43	0.45	20.2	3.79	3.46	13.13												
	4A + 4B							19.2	16.51	3.56	58.71	857	1.5	2.5	5.71	24.9	3.14	51.8	
	4A + 4B + 4C							24.9	24.89	3.14	78.1	540	1.1	2.1	4.29	29.19	2.82	70.1	
	4 (A - F)							35.9	40.28	2.52	101.39	2063	1.1	2.1	16.37	52.28	1.96	78.8	
	5	0.62	0.46	5	0.29	5.97	1.7												
	9Aa	32.99	0.47	22.7	15.57	3.29	51.24					1318	1.1	2.1	10.46	33.12	2.61	40.6	
	9Ab	28.37	0.47	20.9	13.39	3.46	46.35												
	9Ac	9.15	0.62	9.3	5.67	4.96	28.11												
	9A	13.97	0.77	13.3	10.7	4.27	45.63												
	9B	3.79	0.5	15.3	1.89	4	7.57												
	9C	11.3	0.42	18.3	4.72	3.66	17.26												
	9D	4.13	0.37	11.3	1.54	4.58	7.07												
	9E	2.97	0.27	15.9	0.8	4	3.18												
	9F	3.06	0.44	6.6	1.35	5.67	7.67												
	9G	4.11	0.44	13.6	1.82	4.27	7.75												
	9H	2.69	0.41	12.6	1.1	4.42	4.87												
	9I	3.1	0.42	13.7	1.3	4.27	5.53												
	9Ia	8.1	0.33	18.4	2.71	3.66	9.89												
	9Ib	5.83	0.41	12.9	2.39	4.42	10.56					1060	0.1	1.4	12.62	25.52	3.07	7.3	
	9J	12.38	0.35	14.3	4.33	4.13	17.87												
	9K	29.91	0.4	19.8	11.9	3.56	42.33					708	0.4	1.4	8.43	28.2	2.88	34.2	
	9L	21.28	0.45	20.3	9.66	3.46	33.45												
	9M	16.47	0.42	16.3	6.98	3.87	27.05												
	9N	20.4	0.46	20.9	9.38	3.46	32.48												
	9O	13.29	0.53	17.5	7.1	3.76	26.68												
	9P	19.19	0.32	27.9	6.14	2.94	18.03												
	9Q	9.67	0.54	19.1	5.22	3.56	18.56												
	11A	4.81	0.64	15.1	3.06	4	12.23												
	11B	18.9	0.41	22.5	7.75	3.29	25.5												
	11C	10.62	0.43	12.2	4.61	4.42	20.37												
	11A + 11B + 11C							22.5	10.81	3.29	41.95	420	0.5	1.4	5	27.45	2.94	31.7	Includes Pond #8 (Community Cente
	13	30.19	0.44	18.8	13.34	3.66	48.77					1576	0.6	1.5	17.51	36.27	2.47	33	
	14A	22.18	0.36	19.5	8.03	3.56	28.55												
	14Ab	6.15	0.33	13.8	2.06	4.27	8.77												
	14Aa	16.03	0.38	17.1	6.09	3.76	22.9												
	14B	7.85	0.45	16.6	3.53	3.87	13.68												
	14A + 14B							19.5	11.56	3.56	41.11								
	14+13							19.5	24.9	3.56	88.55	530	0.4	1.4	6.31	25.83	3.07	76.4	
	15A	4.03	0.35	12.6	1.41	4.42	6.23												
	15B	2.76	0.34	13.6	0.94	4.27	4.03												
	15A + 15B							13.6	2.35	4.27	10.05								
	15B+9A-E							33.1	55.23	2.61	144.09								
	9Ra	2.76	0.44	13.6	1.22	4.27	5.2												
	9Rb	8.15	0.56	13.4	4.57	4.27	19.48												

Table C-7: 10 Yr Rational Analysis Routing and Results (Area #9)

DESIGN	DIRECT RUNOFF							TOTAL RUNOFF				TRAVEL TIME							REMARKS
	AREA	AREA	COEFF	Tc	C*A	I	Q	Tc	Sum C*A	I	Q	L	Slope	Velocity	Tt	Tc	I	Q tot	
	DESIGN.	(Ac)	C	(min)	(Ac)		(CFS)	(min)	(Ac)	(In/Hr)	(CFS)	(feet)	(%)	ft/s	(min)	(min)	(in/Hr)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(13)
	9Rc	9.66	0.54	13.4	5.26	4.27	22.43												
	16	6.57	0.5	13.3	3.28	6.74	22.13												
	17	30.07	0.47	17.7	14.13	5.94	83.95												
Existing																			
	9(A-J) + 11 + 13+ 14 +15							33.1	102.25	2.61	273.16	1173	0.4	1.4	13.96	47.09	2.09	220.1	Includes Pond #10 (Riverside Parkwa
	9(A-K) + 11 + 13+ 14 +15 + 4							47.1	107.35	2.09	295.9	708	0.4	1.4	8.43	55.51	1.89	273.9	
	9(A-M) + 11 + 13+ 14 +15 + 4							55.5	123.99	1.89	305.3	675	0.3	1.4	8.04	63.55	1.78	292.1	
	9(A-O) + 11 + 13 + 15 + 4							63.6	133.37	1.78	317.4	2062	0.4	1.4	24.55	88.1	1.78	317.4	Includes Pond #9 (Timberline)
	9(A-Q) + 11 + 13 + 15 + 4							88.1	144.74	1.78	337.6								
Alternative 1																			
37th St. (W)	9Aa + 9Ab							33.1	28.96	2.61	75.56	851	1.88	2.6	5.46	38.58	2.39	69.3	
	Above + 9Ac + 9D + 9E							38.6	36.97	2.39	88.47	320	1.25	2.2	2.42	41	2.28	84.3	
	Above + 15B							41	37.91	2.28	92.86	389	0.257	1.4	4.63	45.63	2.15	81.5	
	Above + 15A+14Aa + 9G-I							45.6	49.63	2.15	113.09	358	0.279	1.4	4.26	49.89	2.04	101	
37th St. (E)	Above + 15A+13+14							45.6	49.6	2.2	113.09	358	0.3	1.4	4.26	49.89	2.04	101	
	Above + 9K							49.9	49.63	2.04	172.54	708	0.4	1.4	8.43	58.32	1.82	155.5	
	Above + 9L							58.3	61.53	1.82	183.53	675	0.3	1.4	8.04	66.36	1.78	174.6	
	Above + 9N							66.4	70.92	1.78	197.7	2062	0.4	1.4	24.55	90.91	1.78	191.3	
	Above + 9P +9Q							90.9	82.28	1.78	217.91								
39th Street	9Ia + 9Ib + 16							18.4	8.38	3.66	30.61	373	0.13	1.4	4.44	22.88	3.29	27.6	
main	Above + 9Ra							22.9	9.6	3.29	31.58	401	0.12	1.4	4.77	27.66	2.94	28.2	
main	Above + 9Rb							27.7	14.16	2.94	41.58	348	0.14	1.4	4.14	31.8	2.71	38.3	
main	Above +9Rc							31.8	19.42	2.71	52.59	644	0.62	1.5	7.16	38.96	2.39	46.5	
optional	Above + 9M							39	26.4	2.39	63.18	274	1.09	2.1	2.17	41.13	2.28	60.2	
optional	Above + 9O							41.1	33.5	2.28	76.4								
Carson St.	4 + 9B + 9C							35.9	46.9	2.52	118.04	1040	0.2	1.4	12.38	48.29	2.06	96.7	
	Above + 9A							48.3	57.6	2.06	118.76								
	With Pond (Proposed)							48.3	38.8	2.06	80								
	South of Pond																		

Table C-8: 1997 and 2016 Flowrate Comparison

Basin(s)						100-YR Peak Flows (cfs)		% Change	
1997 Study	Area (ac)	% Impervious	2016 Study	Area (ac)	% Impervious	1997 Study	2016 Study	Area	Flow Rate
Urban Growth Area West	1085	2		1241.1	22	917	1411	14%	54%
65th Avenue	121.6	2		180.5	2	176	460	48%	161%
Rehmer Lake	780.3	10		763.1	11	729	847	-2%	16%
Urban Growth Area Central	566.6	8		428	14	581	672	-24%	16%
Ashcroft Draw	1218.3	23		4690.6	25	1273	2379	285%	87%
Urban Growth Area East	289.8	53		251.7	41	1124	133	-13%	-88%
23rd Avenue				931.9	45		713		
17th Avenue				162.3	64		278		
17th Ave. Detention				284.5	41		514		
Evans Town Ditch	48.4	42		152.8	67	180	569	216%	216%
Industrial Parkway	79.9	85		83.9	72	303	435	5%	43%
Southeast Platte	128.6	83		189.1	75	456	728	47%	60%
River Bend	17.8	42		152.8	64	66	510	79%	84%
Riverside Park	67.7	27				211			
37th Street	46.57	65		251.4	66	213	558	440%	162%
31st Street	85.8	53		764.8	78	264	1108	791%	320%
East Platte	86.3	65		121.1	19	264	238	40%	-10%

Appendix D

[Hydraulic Analysis]

Table D-1: Infrastructure Predicted to Flood

Link	Link Shape/Size	Overflow Link	Q_{MAX}, Existing			Q_{MAX}, Future			Max/Full D		Overflow Depth	Basin		Overflows to...
			Link	Overflow	Total	Link	Overflow	Total	Existing	Future		CUHP	Rational	
C_A270	42" Concrete Pipe	C_A270_Overflow	146.5	0	146.5	162.4	36.7	199.2	0	0.1	3	ASD-310	n/a	field
C_C110A	48" Concrete Pipe	C_C110A_OF	185.1	1539.9	1725	185	1567.3	1752.3	0.7	0.7	1.5	CB-110	10, 8	31st St, then park, residential
C_C130	30" Concrete Pipe	C_C130_OF	52.4	490.1	542.5	52.3	499.2	551.6	0.6	0.6	1.5		8	
C_C140	24" Concrete Pipe	C_C140_OF	37.3	398.4	435.7	37.3	415.1	452.4	0.6	0.6	1	CB-170	24	Harbor Ln
C_C150	24" Concrete Pipe	C_C150_OF	19.5	29.3	48.7	19.5	29.4	48.8	0.2	0.2	1	CB-180	n/a	17th Ave
C_C160B	36" Circluar Pipe	C_C160B_OF	75.2	355	430.2	75.2	400.5	475.7	0.5	0.6	1.5	CB-170	n/a	37th St., then residential
C_C170	54" Circular Pipe	C_C170_OF	212	805.4	1017.4	211.9	937.2	1149.1	0.4	0.5	3	CB-220	3	Open Area
C_C180A	36" Concrete Pipe	C_C180A_OF	64.9	448.9	513.9	64.9	494.1	559	0.5	0.6	1.3	CB-230	n/a	17th Ave, then residential
C_C180B	48" Concrete Pipe		62.7		62.7	62.6		62.6			1.3			
C_C200	42" Concrete Pipe	C_C200_OF1	55.7		55.7	55.7		55.7				H-130	9	37th St., then residential
C_C200C	54" Concrete Pipe	C_C200_OF2	237.9		237.9	237.9		237.9						
C_C200_OF1	26" Concrete Pipe	C_C200_OF1_OF	10.1	251.1	317	10.1	251.8	261.9	0.6	0.6	1.5			
C_C200_OF2	30" Concrete Pipe	C_C200_OF2_OF	21.8	274.4	534.1	21.8	275.1	296.9	0.9	0.9	1			
C_C200_OF3	42" Concrete Pipe	C_C200_OF3_OF	74.5	245.9	320.5	74.5	246.4	321	0.9	0.9	1.3			
C_C210A	25" Concrete Pipe	C_C210A_OF	33.3	31.9	65.2	33.3	81.1	114.4	0.1	0.2	3	CB-250	22	Swale/sidewalk, then Cave Creek
C_C210B	42" Concrete Pipe	C_C210B_OF	32.7		32.7	32.7		32.7			3.5			35th Ave
C_C220A	72" Concrete Pipe	C_C220A_OF	427.1		427.1	426.9		426.9				CB-280	3	Dirt road/ open field
C_C220A_OF	72" Concrete Pipe	C_C220A_OF_OF	403.5	454.8	858.2	403.6	714	1117.6	0.5	0.7	1			
C_C230A	60" Concrete Pipe	C_C230A_OF	241.1	578.9	820	241.1	785	1026.1	0.2	0.2	2	CB-260	n/a	17th Ave (local, unpaved road)
C_C240	34" Concrete Pipe	C_C240_OF	41.7	669.3	711	41.7	716.4	758.1	0.8	0.9	1.5	CB-270	n/a	SH85/ Residential
C_C220B	72" Concrete Pipe	C_C220B_OF	301.2	411.6	712.7	301.3	1040	1341.3	0.3	0.4	3	CB-280	3	23rd Avenue and open fields
C_C100C	7' Open Channel	C_C100C_OF	2047.4		2047.4	2072.7		2072.7	0.7	0.7	4	CB-110	10, 8	31st St and park
C_A160	3' Open Channel	C_A160_OF	662.9		662.9	703.9		703.9	0.3	0.3	4	ASD-160	n/a	Swale/park
C_A180	5' Open Channel	C_A180_OF	1571.8		1571.8	1596.2		1596.2	0.3	0.3	6	ASD-240	n/a	Open Field (Arrowhead)
C_A220	3' Open Channel	C_A220_OF	1933.7		1933.7	3009.4		3009.4	0.2	0.2	7	ASD-230	n/a	Open field then 37th St
C_A230	4' Open Channel	C_A230_OF	2604.5		2604.5	3937.1		3937.1	0.4	0.4	10	ASD-280	n/a	Open area
C_A290	9' Open Channel	C_A290_OF	2971.5		2971.5	4320.6		4320.6	0.5	0.6	9	ASD-310	n/a	Open field/pasture
C_A310	12' Open Channel	C_A310_OF	3064.6		3064.6	4344.8		4344.8	0.3	0.4	7	ASD-330	n/a	Open area (North) Residential (South)
C_B190	3' Open Channel	C_B190_OF	511.9		511.9	883.7		883.7	0.3	0.4	5	BTT-180	18	Open field/pasture
C_B270	5' Open Channel	C_B270_OF	553.5		553.5	1418.4		1418.4	0.1	0.1	24	BTT-270	n/a	CR 378, then open fields
C_C100A	3' Open Channel	C_C100A_OF	342		342	342		342	0.3	0.3	5	CB-170	2	Grass buffer along SH85

Table D-2: CUHP Input of Proposed Infrastructure

								Percent Impervious		Depression Storage		Infiltration		
	Area		Dist to Centroid		Length		Slope	Existing	Future	Pervious	Impervious	Initial Rate	Decay Coeff.	Final Rate
Subcatchment Name	acres	sqmi	ft	mi	ft	mi		%	%	WS in	WS in	in/hr	1/s	in/hr
ASD-100	277.7	0.434	3015	0.57094	5864	1.11069	0.01756	2	40.7	0.05	0.4	3	0.0018	0.5
ASD-110	297.5	0.465	3457	0.654695	6578	1.24588	0.01763	2	16.3	0.05	0.4	4.5	0.0018	0.6
ASD-120	214.3	0.335	1184	0.224325	3439	0.65129	0.02966	2	2	0.05	0.4	5	0.0007	1
ASD-130	147.3	0.230	795	0.150566	2649	0.50173	0.03020	46.6	50	0.05	0.35	5	0.0007	1
ASD-140	339.6	0.531	2848	0.539397	6629	1.25547	0.01162	2.3	57.1	0.05	0.4	5	0.0007	1
ASD-150	209.3	0.327	2844	0.538565	5783	1.09532	0.02594	2	2	0.05	0.4	5	0.0007	1
ASD-160	239.7	0.374	2478	0.469278	7856	1.4878	0.01578	45	49	0.05	0.35	4.5	0.0018	0.6
ASD-170	191.2	0.299	1698	0.321589	4241	0.80313	0.02688	24.3	30.7	0.05	0.4	5	0.0007	1
ASD-180	308.1	0.481	1486	0.281483	4260	0.80689	0.01573	56.2	56.2	0.05	0.35	5	0.0007	1
ASD-190	91.5	0.143	1243	0.235381	3683	0.69759	0.01520	52	52	0.05	0.35	5	0.0007	1
ASD-200	64.6	0.101	1713	0.324372	3562	0.67454	0.02443	2	32.9	0.05	0.4	5	0.0007	1
ASD-210	97.8	0.153	1514	0.28667	3602	0.68221	0.02388	11.4	65.4	0.05	0.4	5	0.0007	1
ASD-220	161.3	0.252	1667	0.315778	3800	0.71966	0.02737	8.7	43.3	0.05	0.4	5	0.0007	1
ASD-230	139.8	0.218	1935	0.366422	4111	0.77861	0.01459	4	52.9	0.05	0.4	5	0.0007	1
ASD-240	178.8	0.279	1652	0.312971	3404	0.64478	0.01704	5.6	68.6	0.05	0.4	5	0.0007	1
ASD-250	13.8	0.022	341	0.064674	1288	0.24388	0.02407	33.8	60.5	0.05	0.4	5	0.0007	1
ASD-260	148.2	0.232	1270	0.240509	2791	0.52869	0.02221	47.9	67.4	0.05	0.4	5	0.0007	1
ASD-270	187.1	0.292	2012	0.381111	4121	0.78049	0.01871	55.6	59.9	0.05	0.35	5	0.0007	1
ASD-275	70.1	0.109	1549	0.293431	3620	0.68561	0.01779	43.9	69.6	0.05	0.35	5	0.0007	1
ASD-280	253.0	0.395	3422	0.648084	5945	1.1259	0.01363	25.3	34.4	0.05	0.4	4.5	0.0018	0.6
ASD-290	151.4	0.237	1738	0.329185	3765	0.71307	0.02656	20.8	49.3	0.05	0.4	5	0.0007	1
ASD-310	180.3	0.282	1965	0.372225	4379	0.82929	0.01918	18.3	59.6	0.05	0.4	5	0.0007	1
ASD-320	123.3	0.193	2784	0.527219	5985	1.13351	0.01253	28.2	37.5	0.05	0.4	5	0.0007	1
ASD-330	489.8	0.765	2937	0.556164	6909	1.30861	0.01737	18.2	56.4	0.05	0.4	5	0.0007	1
BTT-110	233.6	0.365	2267	0.429435	5301	1.00404	0.03792	2	46.7	0.05	0.4	5	0.0007	1
BTT-120	173.1	0.271	1156	0.218954	4247	0.80435	0.03461	2	51.4	0.05	0.4	5	0.0007	1
BTT-130	161.1	0.252	1342	0.254171	4654	0.88148	0.01461	2	75.6	0.05	0.4	5	0.0007	1
BTT-140	121.0	0.189	1523	0.288401	3224	0.61067	0.02140	2	84.2	0.05	0.4	5	0.0007	1
BTT-150	74.1	0.116	961	0.182081	3365	0.63738	0.02377	2	54.8	0.05	0.4	4.5	0.0018	0.6
BTT-160	230.5	0.360	2263	0.428612	5186	0.98212	0.01755	2	53.7	0.05	0.4	5	0.0007	1
BTT-170	91.8	0.144	2411	0.456601	4392	0.83176	0.01958	20.4	52	0.05	0.4	5	0.0007	1
BTT-180	114.2	0.178	1873	0.354815	4374	0.82839	0.01898	10.9	49.3	0.05	0.4	5	0.0007	1
BTT-190	280.7	0.439	1477	0.27969	4441	0.84105	0.01644	25.3	45.6	0.05	0.35	5	0.0007	1
BTT-200	138.0	0.216	3684	0.697671	7002	1.32618	0.02356	2	14.9	0.05	0.4	5	0.0007	1
BTT-210	109.0	0.170	2796	0.529598	5952	1.12725	0.02621	2	30.5	0.1	0.4	5	0.0007	1
BTT-220	154.7	0.242	2688	0.509055	5829	1.10395	0.02659	2	32	0.05	0.4	5	0.0007	1
BTT-230	232.6	0.363	2441	0.46227	4493	0.85098	0.02671	2	39.6	0.05	0.4	5	0.0007	1
BTT-240	165.9	0.259	1224	0.231785	3490	0.66093	0.03783	2	42.3	0.05	0.4	5	0.0007	1
BTT-250	138.2	0.216	3262	0.617712	5066	0.9595	0.01480	2	34.9	0.05	0.4	5	0.0007	1
BTT-260	119.7	0.187	1929	0.365356	4824	0.91366	0.02612	2	28	0.05	0.4	5	0.0007	1
BTT-270	176.2	0.275	2468	0.467374	6129	1.16076	0.02105	2	37.7	0.1	0.4	3	0.0018	0.5
BTT-280	71.5	0.112	1088	0.206079	3055	0.57866	0.02029	12.9	31.6	0.05	0.35	5	0.0007	1
BTT-290	248.5	0.388	2533	0.479756	4554	0.86241	0.02657	2	2	0.1	0.4	3	0.0018	0.5
BTT-300	133.2	0.208	1814	0.343481	4023	0.76188	0.03008	2	12.8	0.1	0.4	3	0.0018	0.5
BTT-310	328.5	0.513	4879	0.924031	9013	1.70695	0.02330	2	32.8	0.1	0.4	5	0.0007	1
BTT-320	82.1	0.128	468	0.088686	882	0.16705	0.03061	2	37.5	0.1	0.4	5	0.0007	1
BTT-330	172.1	0.269	1989	0.376799	4227	0.80048	0.03005	2	32.2	0.1	0.4	3	0.0018	0.5
BTT-340	180.5	0.282	1441	0.272933	3230	0.61181	0.03250	11	35	0.05	0.4	3	0.0018	0.5
BTT-350	146.4	0.229	2626	0.497382	5521	1.04573	0.02101	18.1	38.8	0.05	0.35	5	0.0007	1
BTT-360	180.2	0.282	1311	0.248304	4109	0.7783	0.02263	25	36.4	0.05	0.35	5	0.0007	1

Table D-2: CUHP Input of Proposed Infrastructure

								Percent Impervious		Depression Storage		Infiltration		
	Area		Dist to Centroid		Length		Slope	Existing	Future	Pervious	Impervious	Initial Rate	Decay Coeff.	Final Rate
Subcatchment Name	acres	sqmi	ft	mi	ft	mi		%	%	WS in	WS in	in/hr	1/s	in/hr
BTT-370	75.7	0.118	1817	0.344191	3960	0.74991	0.03031	34.8	49.6	0.05	0.35	5	0.0007	1
BTT-380	43.4	0.068	146	0.027611	362	0.06856	0.08564	8	28.1	0.05	0.35	5	0.0007	1
CB-100	113.1	0.177	1599	0.302889	4418	0.83667	0.01313	50.9	50.9	0.05	0.35	5	0.0007	1
CB-110	325.8	0.509	1944	0.36823	5629	1.06607	0.01210	73.7	75.4	0.1	0.35	5	0.0007	1
CB-120	27.5	0.043	1210	0.229188	3051	0.57784	0.01390	54.2	54.2	0.05	0.35	5	0.0007	1
CB-130	172.5	0.269	3141	0.594813	5181	0.98128	0.01255	51.2	52.5	0.05	0.35	4.5	0.0018	0.6
CB-140	140.4	0.219	2044	0.38712	4761	0.9017	0.01592	53.1	55.4	0.1	0.35	5	0.0007	1
CB-150	127.4	0.199	2765	0.523703	4728	0.89552	0.01565	67	67.9	0.1	0.35	5	0.0007	1
CB-160	214.0	0.334	3286	0.622423	4521	0.85617	0.02212	47.3	52.7	0.05	0.35	5	0.0007	1
CB-170	159.5	0.249	2291	0.43396	4664	0.88325	0.01406	61.1	79.1	0.1	0.35	5	0.0007	1
CB-180	157.1	0.245	2809	0.531935	5186	0.98221	0.01413	60.7	67.5	0.05	0.35	5	0.0007	1
CB-190	89.0	0.139	1465	0.277537	4031	0.76346	0.01290	66.9	68.8	0.05	0.35	4.5	0.0018	0.6
CB-191	63.4	0.099	944	0.178836	3035	0.57481	0.00990	66.9	68.8	0.05	0.35	4.5	0.0018	0.6
CB-200	54.4	0.085	931	0.176259	2668	0.50526	0.01270	85.6	85.8	0.1	0.35	5	0.0007	1
CB-201	65.3	0.102	1178	0.22307	2648	0.5016	0.00420	85.6	85.8	0.1	0.35	5	0.0007	1
CB-210	55.9	0.087	607	0.115039	1881	0.35633	0.01111	50.9	77.2	0.05	0.35	5	0.0007	1
CB-220	166.7	0.261	2325	0.440315	5223	0.98912	0.01321	48.1	68.1	0.05	0.35	5	0.0007	1
CB-230	162.3	0.254	3396	0.643232	4767	0.90291	0.00894	40.9	61.4	0.05	0.35	5	0.0007	1
CB-240	157.4	0.246	3883	0.73545	6260	1.18565	0.00480	71.6	78.1	0.05	0.35	5	0.0007	1
CB-241	55.0	0.086	818	0.154843	2032	0.38492	0.00890	71.6	78.1	0.05	0.35	5	0.0007	1
CB-250	195.8	0.306	2346	0.444315	4846	0.91779	0.02043	38.1	65.2	0.05	0.4	5	0.0007	1
CB-260	129.9	0.203	1245	0.235802	2530	0.47924	0.01187	27.4	81	0.05	0.4	5	0.0007	1
CB-270	83.9	0.131	625	0.11832	1873	0.35478	0.00480	74.7	90	0.05	0.4	5	0.0007	1
CB-280	182.9	0.286	2824	0.534912	4678	0.88592	0.01753	15.7	70.5	0.05	0.35	5	0.0007	1
CB-290	40.8	0.064	2246	0.425454	3842	0.7277	0.01119	63.1	65.2	0.05	0.35	5	0.0007	1
H-100	135.8	0.212	1322	0.250382	3658	0.69279	0.01640	77.8	86.1	0.05	0.35	3	0.0018	0.5
H-110	33.3	0.052	835	0.15815	1609	0.30468	0.00560	74.1	74.1	0.1	0.35	3	0.0018	0.5
H-120	121.1	0.189	1113	0.210819	3472	0.65766	0.00461	18.6	78.3	0.1	0.4	3	0.0018	0.5
H-130	95.6	0.149	3042	0.576151	5621	1.0646	0.00391	70.1	70.1	0.05	0.35	3	0.0018	0.5
H-140	48.0	0.075	996	0.188591	2649	0.50172	0.00190	64	71.5	0.05	0.35	5	0.0007	1
H-141	104.3	0.163	2119	0.401344	2883	0.5461	0.00140	64	71.5	0.05	0.35	5	0.0007	1
H-150	12.4	0.019	471	0.089269	1434	0.27151	0.00316	47.6	51.5	0.05	0.04	3	0.0018	0.5
SC-100	396.9	0.620	6873	1.30175	11867	2.24745	0.00421	4.7	4.7	0.05	0.4	3	0.0018	0.5
SC-110	198.6	0.310	947	0.1793399	2394	0.45348	0.00800	9	9	0.05	0.4	3	0.0018	0.5
SE-100	526.3	0.822	3890	0.736677	7377	1.39724	0.00961	2	20.9	0.05	0.4	5	0.0007	1
SE-110	526.9	0.823	3540	0.670416	5698	1.07923	0.00386	2	33.2	0.1	0.4	4.5	0.0018	0.6
SE-120	471.6	0.737	4667	0.883933	11412	2.1614	0.00175	2	17.2	0.1	0.4	4.5	0.0018	0.6
SE-130	410.3	0.641	1700	0.322054	4937	0.93508	0.00101	2	66.7	0.05	0.4	4.5	0.0018	0.6
SE-140	406.2	0.635	1769	0.33511	4096	0.77582	0.00366	2	50.3	0.05	0.4	4.5	0.0018	0.6
SE-150	244.8	0.383	1658	0.31409	2203	0.41732	0.00817	2	35.6	0.05	0.4	4.5	0.0018	0.6
SE-160	212.0	0.331	795	0.150635	2669	0.50542	0.00817	2	60.5	0.05	0.4	3	0.0018	0.5
SE-170	665.4	1.040	2484	0.470364	4869	0.92221	0.00749	2	67.3	0.05	0.4	4.5	0.0018	0.6
SW-100	652.1	1.019	2486	0.470747	5128	0.97122	0.00164	2	47.6	0.05	0.4	3	0.0018	0.5
SW-110	632.2	0.988	3163	0.599072	6260	1.18552	0.00176	2	51	0.05	0.4	5	0.0007	1
SW-120	652.2	1.019	2649	0.501726	7047	1.3347	0.00270	2	53.5	0.05	0.4	5	0.0007	1
SW-130	657.9	1.028	2666	0.504997	5908	1.11897	0.00102	2	95.4	0.05	0.4	5	0.0007	1
SW-140	524.6	0.820	2887	0.546727	5422	1.02691	0.00461	2	63.6	0.05	0.4	5	0.0007	1
SW-150	918.6	1.435	5575	1.055868	9328	1.76665	0.00418	2	82	0.05	0.4	5	0.0007	1
SW-160	1119.2	1.749	5260	0.996199	9893	1.8737	0.00475	8.8	82.7	0.05	0.4	5	0.0007	1
SW-170	167.7	0.262	494	0.093641	1582	0.2996	0.00885	19.4	55.8	0.05	0.4	3	0.0018	0.5
ASD-225	115.2	0.180	1762	0.333655	4288	0.81203	0.01516	55	55	0.05	0.4	5	0.007	1

Table D-3: CUHP Output for Proposed Infrastructure (100-Yr Existing)

	Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
			W50	W50 Before Peak	W75	W75 Before Peak	Time to Peak	Peak	Volume	Excess	Excess	Time to Peak	Peak Flow	Total Volume	Runoff per Unit Area
Catchment ID	Ct	Cp	min		min		min	cfs	cu ft	inches	cu ft	min	cfs	cu ft	cfs/acre
ASD-100	0.156	0.296	52.5	12.23	27.3	8.64	20.4	248	1,008,041	2.04	2,055,751	56	408	2,055,708	1.47
ASD-110	0.156	0.299	58.5	13.77	30.4	9.73	22.9	238	1,080,007	1.87	2,020,566	60	377	2,020,555	1.27
ASD-120	0.157	0.287	23.8	5.53	12.4	3.91	9.2	423	777,763	0.96	745,076	40	336	745,080	1.57
ASD-130	0.093	0.459	6.4	2.23	3.3	1.49	4.2	1,082	534,673	1.71	912,608	32	672	911,809	4.56
ASD-140	0.156	0.305	58	13.9	30.2	9.83	23.2	274	1,232,671	0.96	1,185,751	55	252	1,185,752	0.74
ASD-150	0.157	0.286	48.1	10.86	25	7.67	18.1	204	759,749	0.96	727,819	51	183	727,825	0.87
ASD-160	0.091	0.487	20	7	10.4	4.68	13	562	869,985	2.2	1,916,970	43	707	1,916,912	2.95
ASD-170	0.109	0.274	23	5.16	12	3.65	8.6	389	693,996	1.29	897,977	40	354	897,853	1.85
ASD-180	0.086	0.591	9.1	3.18	4.7	2.13	7.4	1,588	1,118,233	1.88	2,099,640	36	1,253	2,097,974	4.07
ASD-190	0.105	0.466	12.1	4.23	6.3	2.83	7.7	355	332,132	1.8	598,662	37	310	598,573	3.39
ASD-200	0.208	0.239	47.9	9.11	24.9	6.44	15.2	63	234,325	0.96	224,477	49	56	224,475	0.87
ASD-210	0.149	0.219	35.8	6.33	18.6	4.47	10.5	128	355,192	1.09	386,777	44	117	386,759	1.2
ASD-220	0.137	0.245	30.6	6.05	15.9	4.28	10.1	247	585,486	1.05	614,463	42	217	614,451	1.34
ASD-230	0.158	0.259	43.2	8.88	22.5	6.27	14.8	152	507,315	0.98	499,515	48	136	499,497	0.97
ASD-240	0.147	0.261	32.5	6.81	16.9	4.81	11.3	258	649,221	1.01	653,343	43	224	653,334	1.25
ASD-250	0.21	0.231	14.2	2.83	7.4	2	4.7	46	50,244	1.46	73,234	36	37	73,207	2.69
ASD-260	0.092	0.47	8.5	2.99	4.4	2	5.6	814	537,925	1.71	918,561	34	586	917,936	3.95
ASD-270	0.086	0.544	10.8	3.78	5.6	2.53	8	811	679,285	1.87	1,268,131	37	690	1,267,565	3.69
ASD-275	0.119	0.39	17.5	5.52	9.1	3.9	9.2	188	254,332	1.66	422,055	39	180	422,030	2.57
ASD-280	0.106	0.3	39.9	9.48	20.7	6.7	15.8	298	918,414	2.03	1,867,421	50	440	1,867,349	1.74
ASD-290	0.115	0.25	25.7	5.23	13.4	3.69	8.7	276	549,716	1.24	679,747	41	253	679,701	1.67
ASD-310	0.117	0.248	32.3	6.46	16.8	4.57	10.8	261	654,436	1.2	782,907	43	248	782,862	1.37
ASD-320	0.113	0.279	42.3	9.36	22	6.61	15.6	137	447,650	1.36	608,630	49	148	608,599	1.2
ASD-330	0.117	0.288	43.1	9.84	22.4	6.95	16.4	532	1,777,843	1.19	2,124,007	49	537	2,123,978	1.1
BTT-110	0.157	0.29	37.2	8.59	19.3	6.07	14.3	295	848,124	0.96	812,479	46	256	812,478	1.09
BTT-120	0.157	0.278	25.9	5.81	13.5	4.11	9.7	314	628,507	0.96	602,092	41	254	602,035	1.47
BTT-130	0.157	0.275	36.1	7.91	18.8	5.59	13.2	209	584,650	0.96	560,078	45	180	560,080	1.12
BTT-140	0.171	0.263	33.4	7.04	17.4	4.98	11.7	170	439,092	0.96	420,638	44	144	420,617	1.19
BTT-150	0.198	0.243	33.4	6.53	17.4	4.62	10.9	104	269,087	1.87	503,430	45	141	503,431	1.9
BTT-160	0.157	0.29	44.3	10.16	23	7.18	16.9	244	836,631	0.96	801,469	49	217	801,446	0.94
BTT-170	0.135	0.23	44.3	8.13	23	5.75	13.6	97	333,409	1.23	410,120	48	99	410,109	1.08
BTT-180	0.144	0.226	43.1	7.78	22.4	5.5	13	124	414,438	1.08	448,172	47	117	448,165	1.03
BTT-190	0.107	0.296	22.7	5.47	11.8	3.86	9.1	580	1,019,107	1.32	1,347,307	40	535	1,347,162	1.91
BTT-200	0.164	0.268	68.1	14.32	35.4	10.12	23.9	95	500,949	0.96	479,896	57	88	479,892	0.64
BTT-210	0.177	0.259	59.9	12.22	31.2	8.63	20.4	85	395,650	0.91	359,635	54	74	359,628	0.68
BTT-220	0.159	0.273	49.4	10.65	25.7	7.53	17.8	147	561,492	0.96	537,894	51	132	537,879	0.85
BTT-230	0.157	0.29	38.7	8.93	20.1	6.31	14.9	281	844,221	0.96	808,740	47	246	808,739	1.06
BTT-240	0.157	0.276	23.8	5.35	12.4	3.78	8.9	326	602,266	0.96	576,955	40	259	576,957	1.56
BTT-250	0.164	0.268	61.4	12.95	31.9	9.15	21.6	106	501,765	0.96	480,677	55	97	480,675	0.7
BTT-260	0.172	0.263	43.5	9.06	22.6	6.41	15.1	129	434,580	0.96	416,316	48	114	416,314	0.95
BTT-270	0.156	0.276	49.9	10.9	26	7.7	18.2	165	639,582	1.99	1,272,992	54	262	1,272,988	1.49
BTT-280	0.16	0.207	33.2	5.59	17.3	3.95	9.3	101	259,439	1.12	289,906	43	92	289,906	1.29
BTT-290	0.156	0.291	39.4	9.1	20.5	6.43	15.2	296	902,066	1.99	1,795,429	50	440	1,795,383	1.77
BTT-300	0.165	0.265	35.6	7.55	18.5	5.33	12.6	175	483,565	1.99	962,464	47	252	962,442	1.89
BTT-310	0.157	0.306	74	17.67	38.5	12.49	29.4	208	1,192,287	0.91	1,083,756	62	184	1,083,753	0.56
BTT-320	0.193	0.248	11.2	2.43	5.8	1.71	4	345	298,060	0.91	270,928	35	206	270,877	2.51
BTT-330	0.156	0.275	34.7	7.64	18	5.4	12.7	232	624,641	1.99	1,243,256	47	333	1,243,259	1.93
BTT-340	0.126	0.238	23.9	4.66	12.4	3.29	7.8	355	655,163	2.09	1,367,045	41	460	1,366,900	2.55
BTT-350	0.12	0.24	43.3	8.27	22.5	5.85	13.8	159	531,544	1.2	638,494	48	160	638,479	1.09
BTT-360	0.108	0.276	20.6	4.67	10.7	3.3	7.8	409	654,060	1.32	861,327	39	366	861,266	2.03

Table D-3: CUHP Output for Proposed Infrastructure (100-Yr Existing)

			Unit Hydrograph Parameters and Results							Excess Precip.		Storm Hydrograph			
			W50	W50 Before Peak	W75	W75 Before Peak	Time to Peak	Peak	Volume	Excess	Excess	Time to Peak	Peak Flow	Total Volume	Runoff per Unit Area
Catchment ID	Ct	Cp	min		min		min	cfs	cu ft	inches	cu ft	min	cfs	cu ft	cfs/acre
BTT-370	0.123	0.306	22.8	5.65	11.8	3.99	9.4	156	274,918	1.49	410,066	41	153	410,067	2.02
BTT-380	0.209	0.203	4.3	0.97	2.2	0.68	1.6	475	157,541	1.04	164,325	30	200	163,530	4.6
CB-100	0.099	0.473	14.3	5.01	7.4	3.35	9.2	370	410,449	1.78	731,797	38	345	731,761	3.05
CB-110	0.079	0.693	9.9	3.46	5.1	2.31	9.3	1,545	1,182,509	2.17	2,570,538	38	1,370	2,569,498	4.21
CB-120	0.15	0.401	18.6	6.02	9.7	4.25	10	69	99,730	1.84	183,680	40	72	183,686	2.61
CB-130	0.088	0.513	17.8	6.23	9.3	4.17	12.2	454	626,028	2.25	1,411,096	42	551	1,411,003	3.2
CB-140	0.091	0.504	13.8	4.83	7.2	3.23	9.4	477	509,517	1.8	916,442	39	438	916,461	3.12
CB-150	0.088	0.575	13.5	4.71	7	3.15	10.4	443	462,417	2.05	949,037	40	435	948,879	3.42
CB-160	0.091	0.491	15.9	5.58	8.3	3.73	10.5	629	776,964	1.72	1,335,746	40	602	1,335,355	2.81
CB-170	0.084	0.565	12.2	4.29	6.4	2.87	9.4	611	579,006	1.95	1,126,755	38	558	1,126,398	3.5
CB-180	0.085	0.561	14.4	5.03	7.5	3.36	10.8	512	570,255	1.96	1,116,832	40	506	1,116,544	3.22
CB-190	0.098	0.547	11.3	3.95	5.9	2.64	8.4	370	322,925	2.38	769,715	37	375	769,794	4.21
CB-191	0.108	0.52	9.9	3.48	5.2	2.32	7.1	299	229,997	2.38	548,214	36	284	548,019	4.49
CB-200	0.106	0.562	7.9	2.76	4.1	1.85	6.2	323	197,472	2.39	472,230	35	266	472,241	4.89
CB-201	0.1	0.577	10.6	3.7	5.5	2.47	8.3	290	236,966	2.39	566,676	37	278	566,696	4.25
CB-210	0.123	0.426	8.6	3.01	4.5	2.01	5.2	305	202,739	1.78	361,466	34	224	361,354	4.01
CB-220	0.09	0.48	16.7	5.84	8.7	3.91	10.7	468	605,189	1.73	1,048,978	40	457	1,049,002	2.74
CB-230	0.094	0.411	25.6	8.36	13.3	5.91	13.9	297	588,985	1.61	946,585	44	318	946,516	1.96
CB-240	0.08	0.613	20.7	7.25	10.8	4.85	16.8	356	571,507	2.15	1,228,655	47	429	1,228,684	2.72
CB-241	0.111	0.524	8	2.8	4.2	1.87	5.9	323	199,795	2.15	429,530	34	253	429,246	4.59
CB-250	0.095	0.388	19	5.97	9.9	4.22	10	483	710,757	1.54	1,092,417	40	455	1,092,332	2.32
CB-260	0.112	0.276	19.3	4.39	10	3.11	7.3	315	471,489	1.35	634,617	38	278	634,597	2.14
CB-270	0.096	0.569	6.2	2.19	3.2	1.46	5	630	304,709	2.17	661,082	33	435	660,235	5.18
CB-280	0.12	0.242	42.9	8.29	22.3	5.86	13.8	200	664,063	1.16	771,737	48	197	771,724	1.08
CB-290	0.127	0.469	21.2	7.43	11	4.97	13.3	90	148,181	2	296,427	43	104	296,417	2.54
H-100	0.082	0.624	7.1	2.49	3.7	1.66	6.2	896	492,957	2.52	1,241,530	34	730	1,240,875	5.38
H-110	0.128	0.496	9.8	3.44	5.1	2.3	6.7	159	120,995	2.48	300,224	36	152	300,178	4.57
H-120	0.124	0.24	34.2	6.59	17.8	4.66	11	166	439,668	2.09	918,804	46	238	918,775	1.96
H-130	0.094	0.567	23.3	8.15	12.1	5.45	17.4	192	347,047	2.47	856,540	48	270	856,438	2.83
H-140	0.12	0.485	16.9	5.91	8.8	3.95	11	133	174,240	2.02	351,303	40	142	351,226	2.95
H-141	0.095	0.544	19	6.66	9.9	4.45	13.7	257	378,682	2.02	763,499	43	287	763,425	2.76
H-150	0.198	0.328	18.9	5.06	9.8	3.58	8.4	31	45,014	2.46	110,664	39	40	110,661	3.22
SC-100	0.147	0.295	145.5	33.26	75.6	23.5	55.4	128	1,440,839	2.05	2,958,376	97	253	2,958,375	0.64
SC-110	0.132	0.247	24	4.86	12.5	3.43	8.1	388	720,933	2.08	1,496,352	41	505	1,496,257	2.54
SE-100	0.157	0.328	69.5	17.8	36.1	12.58	29.7	355	1,910,323	0.96	1,830,037	62	329	1,830,023	0.63
SE-110	0.156	0.326	73	18.6	38	13.15	31	338	1,912,698	1.82	3,484,711	69	551	3,484,681	1.05
SE-120	0.156	0.321	143	35.55	74.4	25.12	59.2	155	1,711,992	1.82	3,119,048	99	273	3,119,048	0.58
SE-130	0.156	0.314	68.7	16.87	35.7	11.92	28.1	280	1,489,273	1.87	2,786,256	66	461	2,786,217	1.12
SE-140	0.156	0.314	47.1	11.64	24.5	8.23	19.4	405	1,474,509	1.87	2,758,634	54	609	2,758,603	1.5
SE-150	0.156	0.291	30.2	7.03	15.7	4.97	11.7	381	888,675	1.87	1,662,607	45	504	1,662,582	2.06
SE-160	0.156	0.284	23.7	5.48	12.3	3.87	9.1	419	769,409	2.04	1,569,096	41	545	1,569,114	2.57
SE-170	0.156	0.338	47.1	12.51	24.5	8.84	20.9	663	2,415,292	1.87	4,518,727	55	1,002	4,518,698	1.51
SW-100	0.156	0.336	69.7	18.3	36.2	12.93	30.5	439	2,367,248	2.04	4,827,651	68	780	4,827,629	1.2
SW-110	0.157	0.337	85.1	22.32	44.2	15.77	37.2	348	2,295,068	0.96	2,198,612	69	326	2,198,607	0.52
SW-120	0.157	0.339	74.3	19.62	38.6	13.86	32.7	412	2,367,527	0.96	2,268,026	64	383	2,268,021	0.59
SW-130	0.157	0.339	86.4	22.81	44.9	16.12	38	357	2,388,180	0.96	2,287,811	70	334	2,287,798	0.51
SW-140	0.157	0.328	62	15.91	32.2	11.24	26.5	397	1,904,134	0.96	1,824,108	58	365	1,824,118	0.7
SW-150	0.157	0.356	103.8	28.73	54	20.3	47.9	415	3,334,559	0.96	3,194,416	79	391	3,194,411	0.43
SW-160	0.137	0.327	95.6	24.3	49.7	17.17	40.5	549	4,062,696	1.05	4,269,519	74	557	4,269,484	0.5
SW-170	0.113	0.255	11.6	2.57	6	1.82	4.3	677	608,692	2.14	1,299,623	35	664	1,299,750	3.96
ASD-225	0.096	0.506	12.9	4.53	6.7	3.03	8.9	418	418,229	2.17	906,440	38	437	906,461	3.79

Table D-4: CUHP Output for Proposed Infrastructure (10-Yr Existing)

	Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
			W50	W50 Before	W75	W75 Before	Time to Peak	Peak	Volume	Excess	Excess	Time to Peak	Peak Flow	Total Volume	Runoff per Unit
Catchment ID	Ct	Cp	min		min		min	cfs	cu ft	inches	cu ft	min	cfs	cu ft	cfs/acre
ASD-100	0.157	0.297	52.5	12.27	27.3	8.67	20.5	248	1,008,041	0.6	603,870	47	135	603,860	0.49
ASD-110	0.157	0.301	58.5	13.83	30.4	9.77	23	238	1,080,007	0.47	509,376	49	109	509,373	0.36
ASD-120	0.158	0.289	23.8	5.57	12.4	3.94	9.3	423	777,763	0.1	75,986	33	41	75,986	0.19
ASD-130	0.094	0.446	6.6	2.31	3.4	1.55	4.3	1,045	534,673	0.56	299,287	28	210	299,068	1.42
ASD-140	0.158	0.308	58	14.02	30.2	9.91	23.4	274	1,232,671	0.1	122,088	47	27	122,088	0.08
ASD-150	0.158	0.288	48.1	10.93	25	7.73	18.2	204	759,749	0.1	74,226	42	20	74,226	0.09
ASD-160	0.092	0.479	20.4	7.15	10.6	4.78	13	550	869,985	0.78	679,374	37	255	679,310	1.06
ASD-170	0.111	0.265	24.4	5.27	12.7	3.72	8.8	367	693,996	0.27	184,628	35	67	184,615	0.35
ASD-180	0.087	0.582	9.3	3.26	4.8	2.18	7.4	1,553	1,118,233	0.68	755,371	31	407	754,962	1.32
ASD-190	0.106	0.457	12.4	4.35	6.5	2.91	7.8	345	332,132	0.62	207,285	32	94	207,251	1.03
ASD-200	0.21	0.241	47.9	9.17	24.9	6.48	15.3	63	234,325	0.1	22,893	39	6	22,893	0.09
ASD-210	0.156	0.224	36.5	6.58	19	4.65	11	126	355,192	0.15	53,875	37	17	53,875	0.17
ASD-220	0.142	0.25	30.9	6.24	16.1	4.41	10.4	245	585,486	0.13	78,206	35	30	78,198	0.18
ASD-230	0.16	0.262	43.2	9	22.5	6.36	15	152	507,315	0.11	54,349	39	16	54,348	0.11
ASD-240	0.15	0.266	32.6	6.94	16.9	4.9	11.6	257	649,221	0.12	74,959	36	28	74,958	0.16
ASD-250	0.214	0.221	15.1	2.87	7.9	2.02	4.8	43	50,244	0.38	19,028	31	8	19,025	0.61
ASD-260	0.093	0.458	8.8	3.09	4.6	2.06	5.7	787	537,925	0.55	297,423	29	169	297,424	1.14
ASD-270	0.087	0.535	11.1	3.87	5.8	2.59	8.1	793	679,285	0.67	453,822	32	219	453,757	1.17
ASD-275	0.12	0.378	18.2	5.57	9.4	3.93	9.3	181	254,332	0.53	134,369	34	49	134,362	0.69
ASD-280	0.107	0.292	41.5	9.6	21.6	6.79	16	286	918,414	0.61	564,609	43	137	564,598	0.54
ASD-290	0.118	0.243	27	5.34	14	3.77	8.9	263	549,716	0.23	126,819	35	45	126,813	0.29
ASD-310	0.119	0.243	33.7	6.61	17.5	4.67	11	251	654,436	0.21	135,711	37	41	135,705	0.23
ASD-320	0.115	0.267	45	9.54	23.4	6.75	15.9	128	447,650	0.31	138,465	44	28	138,465	0.22
ASD-330	0.119	0.283	45	10.06	23.4	7.11	16.8	510	1,777,843	0.21	367,074	43	85	367,064	0.17
BTT-110	0.158	0.293	37.2	8.65	19.3	6.11	14.4	295	848,124	0.1	82,860	38	29	82,859	0.12
BTT-120	0.158	0.28	25.8	5.85	13.4	4.14	9.8	314	628,507	0.1	61,404	34	30	61,398	0.17
BTT-130	0.158	0.277	36.1	7.97	18.8	5.63	13.3	209	584,650	0.1	57,119	37	20	57,119	0.13
BTT-140	0.173	0.265	33.4	7.09	17.3	5.01	11.8	170	439,092	0.1	42,898	36	16	42,896	0.14
BTT-150	0.199	0.244	33.4	6.56	17.4	4.64	10.9	104	269,087	0.47	126,913	37	45	126,913	0.61
BTT-160	0.158	0.292	44.3	10.23	23	7.23	17.1	244	836,631	0.1	81,737	41	24	81,734	0.1
BTT-170	0.138	0.225	46.4	8.32	24.2	5.88	13.9	93	333,409	0.23	75,640	42	16	75,637	0.18
BTT-180	0.15	0.231	43.9	8.08	22.8	5.71	13.5	122	414,438	0.15	61,396	39	16	61,396	0.14
BTT-190	0.11	0.286	24.1	5.58	12.5	3.95	9.3	547	1,019,107	0.29	293,684	35	107	293,660	0.38
BTT-200	0.166	0.27	68	14.43	35.4	10.19	24	95	500,949	0.1	48,942	48	9	48,941	0.07
BTT-210	0.178	0.261	59.9	12.3	31.1	8.7	20.5	85	395,650	0.05	19,267	45	4	19,267	0.04
BTT-220	0.16	0.275	49.3	10.73	25.7	7.58	17.9	147	561,492	0.1	54,856	42	14	54,855	0.09
BTT-230	0.158	0.292	38.7	8.99	20.1	6.36	15	282	844,221	0.1	82,478	39	27	82,478	0.12
BTT-240	0.158	0.278	23.8	5.39	12.4	3.81	9	327	602,266	0.1	58,840	33	31	58,840	0.19
BTT-250	0.166	0.27	61.4	13.05	31.9	9.22	21.7	106	501,765	0.1	49,021	46	10	49,021	0.07
BTT-260	0.173	0.265	43.4	9.13	22.6	6.45	15.2	129	434,580	0.1	42,457	39	13	42,457	0.1
BTT-270	0.157	0.278	49.9	10.94	25.9	7.73	18.2	166	639,582	0.55	351,804	46	82	351,803	0.47
BTT-280	0.166	0.21	34	5.77	17.7	4.08	9.6	99	259,439	0.17	43,674	35	14	43,673	0.2
BTT-290	0.157	0.292	39.3	9.13	20.5	6.45	15.2	296	902,066	0.55	496,184	42	143	496,174	0.58
BTT-300	0.166	0.266	35.6	7.58	18.5	5.35	12.6	175	483,565	0.55	265,986	40	83	265,980	0.63
BTT-310	0.158	0.308	74	17.79	38.5	12.57	29.7	208	1,192,287	0.05	58,061	54	10	58,061	0.03
BTT-320	0.195	0.25	11.1	2.44	5.8	1.73	4.1	345	298,060	0.05	14,515	28	16	14,512	0.19
BTT-330	0.157	0.277	34.7	7.67	18	5.42	12.8	233	624,641	0.55	343,586	40	110	343,587	0.64
BTT-340	0.128	0.24	24.1	4.75	12.5	3.35	7.9	351	655,163	0.64	420,546	34	169	420,521	0.93
BTT-350	0.123	0.236	45.1	8.46	23.5	5.98	14.1	152	531,544	0.21	113,570	41	26	113,569	0.18
BTT-360	0.11	0.266	21.9	4.77	11.4	3.37	7.9	386	654,060	0.28	186,278	33	74	186,249	0.41
BTT-370	0.125	0.293	24.2	5.73	12.6	4.05	9.6	147	274,918	0.41	112,145	35	35	112,132	0.47

Table D-4: CUHP Output for Proposed Infrastructure (10-Yr Existing)

	Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
			W50	W50 Before	W75	W75 Before	Time to Peak	Peak	Volume	Excess	Excess	Time to Peak	Peak Flow	Total Volume	Runoff per Unit
Catchment ID	Ct	Cp	min		min		min	cfs	cu ft	inches	cu ft	min	cfs	cu ft	cfs/acre
BTT-380	0.215	0.207	4.3	0.99	2.2	0.7	1.6	471	157,541	0.13	20,904	25	43	20,809	1
CB-100	0.099	0.463	14.7	5.16	7.7	3.45	9.2	360	410,449	0.61	250,721	33	102	250,713	0.9
CB-110	0.08	0.689	10	3.49	5.2	2.34	9.3	1,529	1,182,509	0.87	1,028,197	33	487	1,028,104	1.5
CB-120	0.151	0.394	19	6.06	9.9	4.28	10.1	68	99,730	0.65	64,912	35	21	64,907	0.78
CB-130	0.089	0.507	18.1	6.33	9.4	4.23	12.2	447	626,028	0.83	518,904	36	204	518,855	1.18
CB-140	0.092	0.495	14.2	4.96	7.4	3.32	9.5	464	509,517	0.61	312,843	34	125	312,856	0.89
CB-150	0.088	0.57	13.7	4.78	7.1	3.2	10.5	437	462,417	0.79	364,124	35	143	364,116	1.12
CB-160	0.091	0.479	16.5	5.77	8.6	3.86	10.6	608	776,964	0.57	441,308	35	169	441,295	0.79
CB-170	0.085	0.558	12.5	4.36	6.5	2.92	9.4	600	579,006	0.72	414,698	34	175	414,556	1.1
CB-180	0.085	0.555	14.6	5.12	7.6	3.42	10.9	503	570,255	0.73	416,903	35	163	416,800	1.04
CB-190	0.098	0.544	11.4	3.98	5.9	2.66	8.4	367	322,925	0.95	307,252	32	149	307,212	1.67
CB-191	0.109	0.517	10	3.5	5.2	2.34	7.1	297	229,997	0.95	218,834	31	114	218,707	1.8
CB-200	0.106	0.56	7.9	2.78	4.1	1.86	6.2	321	197,472	1.02	201,102	30	105	201,110	1.93
CB-201	0.1	0.576	10.6	3.72	5.5	2.48	8.3	288	236,966	1.02	241,322	33	107	241,360	1.63
CB-210	0.124	0.417	8.8	3.1	4.6	2.07	5.2	296	202,739	0.61	123,842	29	70	123,778	1.25
CB-220	0.091	0.468	17.2	6.04	9	4.04	10.8	453	605,189	0.58	349,460	35	129	349,418	0.78
CB-230	0.094	0.394	26.9	8.43	14	5.95	14	283	588,985	0.49	290,941	39	79	290,920	0.49
CB-240	0.081	0.609	21	7.33	10.9	4.9	16.8	352	571,507	0.86	490,264	42	146	490,251	0.92
CB-241	0.112	0.52	8.1	2.83	4.2	1.89	5.9	319	199,795	0.86	171,393	30	93	171,337	1.69
CB-250	0.096	0.372	20.1	6.04	10.4	4.26	10.1	457	710,757	0.44	311,121	35	108	311,099	0.55
CB-260	0.114	0.265	20.5	4.48	10.7	3.17	7.5	296	471,489	0.3	141,493	33	56	141,476	0.43
CB-270	0.097	0.566	6.3	2.21	3.3	1.48	5.1	624	304,709	0.86	261,875	29	159	261,515	1.9
CB-280	0.123	0.24	44.4	8.47	23.1	5.99	14.1	193	664,063	0.19	127,377	40	31	127,374	0.17
CB-290	0.128	0.464	21.6	7.56	11.2	5.05	13.3	89	148,181	0.76	112,425	38	33	112,431	0.81
H-100	0.082	0.623	7.1	2.5	3.7	1.67	6.2	892	492,957	1.07	527,047	30	314	526,852	2.31
H-110	0.129	0.494	9.9	3.45	5.1	2.31	6.7	158	120,995	1.03	124,866	31	63	124,865	1.88
H-120	0.125	0.236	35.1	6.66	18.2	4.71	11.1	162	439,668	0.64	282,927	39	79	282,930	0.65
H-130	0.094	0.565	23.4	8.2	12.2	5.48	17.4	191	347,047	1.02	353,604	42	104	353,588	1.09
H-140	0.121	0.48	17.1	6	8.9	4.01	11	131	174,240	0.77	134,009	35	46	133,973	0.96
H-141	0.095	0.539	19.3	6.76	10	4.52	13.8	253	378,682	0.77	291,245	38	93	291,234	0.89
H-150	0.199	0.324	19.2	5.08	10	3.59	8.5	30	45,014	1.01	45,534	33	17	45,529	1.38
SC-100	0.149	0.297	145.7	33.56	75.8	23.72	55.9	128	1,440,839	0.61	880,989	88	75	880,986	0.19
SC-110	0.135	0.25	24.2	4.94	12.6	3.49	8.2	385	720,933	0.63	455,354	34	186	455,349	0.93
SE-100	0.158	0.331	69.5	17.93	36.1	12.67	29.9	355	1,910,323	0.1	186,634	54	35	186,634	0.07
SE-110	0.157	0.328	73	18.69	38	13.21	31.1	338	1,912,698	0.42	808,385	57	139	808,375	0.26
SE-120	0.157	0.322	143	35.71	74.4	25.24	59.5	155	1,711,992	0.42	723,559	86	65	723,559	0.14
SE-130	0.157	0.316	68.6	16.95	35.7	11.98	28.2	280	1,489,273	0.47	702,403	54	129	702,392	0.31
SE-140	0.157	0.315	47	11.69	24.5	8.26	19.5	405	1,474,509	0.47	695,440	45	182	695,430	0.45
SE-150	0.157	0.292	30.1	7.07	15.7	4.99	11.8	381	888,675	0.47	419,136	37	164	419,128	0.67
SE-160	0.157	0.285	23.7	5.5	12.3	3.89	9.2	419	769,409	0.6	460,917	34	201	460,923	0.95
SE-170	0.157	0.34	47	12.57	24.5	8.88	20.9	663	2,415,292	0.47	1,139,152	46	299	1,139,149	0.45
SW-100	0.157	0.338	69.7	18.37	36.2	12.98	30.6	439	2,367,248	0.6	1,418,108	57	246	1,418,096	0.38
SW-110	0.158	0.34	85	22.48	44.2	15.89	37.5	349	2,295,068	0.1	224,223	61	34	224,221	0.05
SW-120	0.158	0.341	74.2	19.76	38.6	13.96	32.9	412	2,367,527	0.1	231,302	57	40	231,301	0.06
SW-130	0.158	0.342	86.4	22.97	44.9	16.23	38.3	357	2,388,180	0.1	233,319	62	35	233,317	0.05
SW-140	0.158	0.33	62	16.02	32.2	11.32	26.7	397	1,904,134	0.1	186,029	50	39	186,030	0.07
SW-150	0.158	0.359	103.8	28.94	54	20.45	48.2	415	3,334,559	0.1	325,778	72	40	325,777	0.04
SW-160	0.141	0.334	96.6	25.09	50.2	17.73	41.8	543	4,062,696	0.13	545,225	68	69	545,224	0.06
SW-170	0.114	0.251	11.9	2.6	6.2	1.84	4.3	659	608,692	0.69	419,207	30	256	419,188	1.53
ASD-225	0.096	0.501	13.1	4.6	6.8	3.07	8.9	411	418,229	0.81	339,659	33	165	339,666	1.43

Appendix E

[Prioritization Analysis]

Table E-1: Criteria List and Weighting Options

CRITERIA			DESCRIPTION	Weighting Options		
No.	Main	Subcriteria		all-equal	cost-based	risk-based
1	Flooding Risk	Frequency (Potential)	how undersized is the infrastructure (return period)?	1	1	2
		Severity	how undersized is the infrastructure (flow)?	1	1	2
2	Impact	Area Impacted	approximate total area affected by flooded system	1	1	1
		Critical Structures	are there houses or emergency svs in the flooding area?	1	2	5
		Stormwater Infrastructure	impact, either upstream or downstream does the undersized section have on stormwater system?	1	2	3
		Construction	What level of disruption to the community is expected from the construction of the improvement?	1	1	1
3	Easements Required		what land is needed to implement the chosen solution?	1	2	1
5	Finance	Cost	how much does this cost?	1	5	2
		Payment Options	developer vs City?	1	3	1
6	Water Quality Impacts		Are there any potential impacts to water quality caused by the issue?	1	1	1

Table E-2: Ranking Descriptions

RANK	FREQUENCY	SEVERITY	AREA	RISK	SW IMPACT	IMPACT OF CONSTRUCTION	EASEMENTS	CAPITAL $	PAYMENT OP.	WQ Issues
5	< 5 YR system	> 400 cfs	> 35 acres	Highly developed area, at severe risk of flooding	Area currently impacts SW infrastructure	No road closures needed, area impacted not in heavily traveled area	No additional area required; replacement of existing structure	$0 - $499K	concern area contained in parcel that will be developed	If WQ issues are already present and need correcting
4	5 YR system	300 - 399 cfs	26 - 35 acres	Highly developed area, possible risk of flooding		Lane closure necessary, alt. routes avialble, and not on a major road	Likely to be contained in existing ROW	$500K - $900K	concern area contained in parcel that *may* be developed	No evidence of WQ issues, but likely site for issues
3	10 YR system	200 - 299 cfs	15 - 25 acres	Medium level development, most of overflow diverted away from structures	No impacts currently, or probably after implementation	Road or lane closures necessary, but in less busy areas and alt. routes available	Area is in ROW, but space may be limited	$1 M - $2.49 M	concern area is spread over several developable properties	If WQ issues can be prevented by adding a BMP
2	25 - 50 YR system	100 - 199 cfs	6 - 15 acres	Exists in a mostly open area, overflow diverted off of properties		Road or lane closures necessary, in less busy areas, few alt. routes	Relatively small area required	$2.5 M - $4.9 M	area is on private property, but will likely not be re-developed	No clear options for BMPs but WQ may be improved by
1	100 YR system	< 100 cfs	< 5 acres	Exists in open area or floodplain	Area does not have infrastructure now, but will if replaced or added	Road or lane closures necessary, in busy area with few alt. access routes	Large area required	> $5 M	no opportunity for developer payment options	If no WQ issues exist and there are no clear opps for BMPs

Table E-3: Alternative Descriptions and Rankings

AREA OF CONCERN		CRITERIA																			
		FREQUENCY		SEVERITY		AREA		RISK		STORMWATER IMPACTS		CONSTRUCTION IMPACTS		EASEMENTS		CAPITAL $		PAYMENT OP.		WQ Issues	
ID	PARTIAL	1		2		3		4		5		6		7		9		10		11	
1		10-Yr	3	33 cfs (major storm)	1	0.5 acres	1	the area is entirely residential; the sump in the road would overflow to driveways and possibly garages	5	SW drains to Landings Pond,	3	Within a neighborhood, crews likely not disturbing much of road	1	no	5	$114,092	5	within residential area	2	ponding on the street may cause pollutants to settle out on the pavement	5
3	N of 49th	10yr and above	3	474 cfs (major)	5	15 acres	3	49th St. and several residences; area is mostly open space; overflows first into Evans Town Ditch	2	pond upstream cannot release at design rate due to undersized pipe	5	very little development in the area - no major roads or commercial lots in area	4	possibly additional ROW required along 23rd Ave.	4	$366,224	5	outlet of regional pond, City maintained	1		1
	S of 49th	*no infra-structure*	5	1132 cfs (major)	5	22 acres	3	dirt access road, abandoned (?) agricultural lot	1	none	3	no development, exists within the floodplain	5	needed along current agricultural field	3	$1,625,234	3		1		1
4	15th Avenue	All storms	5	88 cfs (major)	1	2 acres	1	medium density residential	3	overflow to pond/ street may cause additional flow to 37th St.	4	Area is highly residential, road or lane closures necessary	1	none	5	$5,041,985	1	within residential area	1		1
	Outfall to Evans Ditch	All storms	5	194 cfs (major)	2	7 acres	2	discharges into ETD	5	impact to ditch unknown; will impact DS pipes if implemented	5	area is heavily developed with residential lots; road or lane closures necessary	1	none; unless alternative 1 is chosen	5	$5,041,985	1	discharge to ditch (City maintained)	1		1
5		All storms	5	3.3 cfs (major)	1	0.2 acres	1	commercial building, may spill onto Carson Ave.	2	none	2	medium commercial area; short section of pipe, to be installed in back lot	3	needed in building's back lot to connect existing pipes	2	$63,950	5	Could be defered to property owner when lot redevelops	4		1
6		All storms	5	25 cfs (50-yr); 100yr contained in street	1	5 acres	1	residential neighborhoods, raised by 0.5-1.0 ft above curb	3	none	3	Road or lane closure necessary; could be done in phases, and there's an easy alt access to west	3	none	5	$526,420	4	rain garden may be implemented by developer	2	site of possible rain garden	3
7		25yr and above	2	48.7 cfs (major storm), 2 cfs in 50-yr storm	1	16 acres	3	overflow will largely go into open lots, there is one house potentially in the way, but it is elevated; flow channelizes along 35th Ave.	3	overflow causes downstream pond to overflow	4	Initial pipe is not along a roadway, so no resident access issues, DS pipe is under a grassed/paved walking area N of the road	4	none, except possibly for channel over existing pipe south of 37th	5	$1,708,434	3	Developer could be responsible for overflow channel to Ashcroft Draw	3		2
8	31st St.	All storms	5	318 cfs (major storm)	4	15 acres	2	flows south, into commercial lots and open (unpaved lots?) spaces; will also flow along W Service Rd and Hwy 85 to a sump 1200 ft south	4	may cause backflow along 11th Ave connecting pipe or pond along ETD	3	Several pipes underneath road near a major intersection (31st St and Hwy 85)	1	none	5	$2,228,572	3	within ROW, discharges to regional channel	1		1
	DS Channel	50yr and above	2	792 cfs (major storm); 292 cfs (50yr)	5	18 acres	3	overflows over 31st St., but then to open field to south; there are several lots used for parking or storage potentially effected	3	backflow may cause flooding in initial channel section, and back into 31st St system	4	channel is next to roadway, so access may require lane closures; major road but not within a commercial or residential area	2	will need to coordinate with Greeley and CDOT, may need additional ROW along roadway for channel	2		3	Greeley and CDOT may contribute to funding	4		1
9	37th and UPR	All storms	5	345 cfs (major storm); 132 cfs (5yr)	4	23 acres	3	primarily neighborhoods; flooding shown to occur in commercial lots	5	may cause backup upstream along 37th St System	5	Along a major road, and across a major intersection and railway	1	none; unless alternative 1 is chosen	5	$703,242	4	within area to be developed during renovations, but in ROW	1		1
	37th and 1st St	All storms	5	315 cfs (major storm)	4	34 acres	4	Abandoned trailer park, open field, old WWTP	2	may cause backup upstream along 37th St System	4	Construction to take place on 39th St.; within a dense residential area, project area is long, making alt access more cumbersome	1	none	5	$2,892,573	2	main discharge point, City maintained	1		1
11	Outlet across Hwy 85 to 37th St.	All storms	5	79 cfs (major storm)	1	3 acres	1	flooding possible along or across Hwy 85; overflow contained initially in commercial parking lot	4	addressing system without adjusting the system may add pressure to 37th St.	2	Within commercial area, and near major highway. Work contained along Service Rd and then across open field	4	possibly, to take SW pipe across railroad and into Railroad Pond	5	$560,609	4	developer could contribute during redevelopement	4	possible site for permeable pavement	3

Table E-3: Alternative Descriptions and Rankings

AREA OF CONCERN		CRITERIA																			
		FREQUENCY		SEVERITY		AREA		RISK		STORMWATER IMPACTS		CONSTRUCTION IMPACTS		EASEMENTS		CAPITAL $		PAYMENT OP.		WQ Issues	
ID	PARTIAL	1		2		3		4		5		6		7		9		10		11	
12		All storms	5	57 cfs (major storm)	1	4 acres	1	SW naturally goes to the open area E of Belmont, however, if it overtops it will go into Evans Ditch or the commercial/industrial (mostly parking lot) to the E	2	solving this issue may place additional pressure to the system downstream (along 42nd), however at least some of the SW drains to this system currently	1	channel work next to residential road, alt routes mostly accessbile (cul-de-sacs have none); work along short section of 42nd st (major road, not w/i very commercial or residential area)	3	yes, to construct channel E of Belmont	2	$402,307	5		2	currently no infrastructure, so a channel would help improve WQ	4
13		All storms	5	89 cfs (major storm)	1	4 acres	1	overflow may be contained partially in parking lot	4	increasing capacity without rerouting the system may add pressure to 37th St.	2	short section of pipe, but crosses highway	3	none	5	$413,558	4	crosses highway	1		1
14		All storms	5	167 cfs (major storm)	2	10 acres	2	commercial area	5	addressing system without adjusting the system may add pressure to 37th St.	2	crosses railroad, new pipe to be buried under 35th St, road or lane closures necessary	3	possibly, to take across railroad and through open area W of 1st Ave	1	$2,346,331	3		1	adding pipe will keep SW from picking up TSS from unpaved roads	2
15		All storms	5	400 cfs (major storm)	4	6 acres	2	at the intersection of US Hwy 85 and 37th St.; commercial areas adjacent to intersection	5	addressing system without adjusting the system may add pressure to 37th St.	2	At a major intersection (37th and Hwy 85), large pipe to be installed (timely, need more space)	1	none	5	$733,028	4		1	increasing pipe size will aid pond function	4
16		All storms	5	20.4 cfs (main storm)	1	6 acres	2	low-density housing, but flat so they will get flooded	5	none	3	within dense residential area, alt routes available	3	none	5	$259,332	5		1		2
17		5-Yr	4	51 cfs (major storm)	1	16 acres	3	low-density housing, but flat so they will get flooded	5	construction of pond will require pipes DS to be replaced	2	Pond at corner of res. lot, DS pipe along road, alternative routes available	4	none	5	$1,085,916	3		1	full-spectrum detention would be provided	3
18		All storms	5	52 cfs (major storm)	1	15 acres	2	one structure exists in the immediate flood area (it appears to be a residential building); further DS are multiple large urban estates	2	none	3	culverts to be installed across 49th, in area that is mostly agricultural and open space	4	improving existing, natural channel may require permitting	4	$234,537	5		1	sediment released to natural channel	5
19		All storms	5	116 cfs (major storm)	2	6 acres	2	an industrial center is located in the center of the basin, but the remainder of the area is open or agricultural space	1	none	3	culverts to be installed across 49th, in area that is mostly agricultural and open space	4	possibly, for a sediment basin north of 49th St.	4	$212,606	5		2	sediment released to natural channel	5
20		5-Yr	4	89 cfs (major storm)	1	3 acres	1	overflow will likely first spread out onto 37th Ave.; the Priarie Heights Middle School is located south of the flooding	2	none	3	In school zone, pipe to be placed under roadway near intersection (near school entrance), channel immediately next to roadway	3	probably none (existing channel improvements likely already in ROW)	5	$254,993	5		2		1
21		10-Yr	3	92 cfs (major storm)	1	8 acres	2	residential area to the east of 35th Ave (pipe corridor); there's open space to the west; WWTP near the outlet of the basin	3	none	3	Pipe is along 35th, at intersection; not within a major commercial or residential area	4	possibly, for future lateral pipes	3	$504,115	4	Most of area is undeveloped, so when it develops lateral pipes can be paid by developers	3		1
22	Cave Creek	100-Yr	1	0 cfs	1	44 acres	5	if Cave Creek overflows, the flow will spill into an open area and likely disperse and remain shallow sheet flow by the time it comes across the industrial center north of 49th St.; eventually flows will enter the ETD	2	none	3	within residnetial area, but no additional or replacement infrastructure is needed	5	none	5	$0	5		2	maintenace will improve pond function	4

Table E-3: Alternative Descriptions and Rankings

AREA OF CONCERN		CRITERIA																			
		FREQUENCY		SEVERITY		AREA		RISK		STORMWATER IMPACTS		CONSTRUCTION IMPACTS		EASEMENTS		CAPITAL $		PAYMENT OP.		WQ Issues	
ID	PARTIAL	1		2		3		4		5		6		7		9		10		11	
24		NA	1	NA	1	NA	1	The risk is not to infrastructure, but to public safety	4	none	3	Area is confined to street corner in medium residential area	5	none	5	$100,419	5		1	area collects trash and debris	4
25		100-Yr	1	0 cfs	1	0 acres	1	Although the channel isn't flooding, it is flowing with very high velocities due to its steep grade; this can cause erosion and safety issues	2	none	3	surrounding area is medium-density residential; not impacting raodways; adaquate open area available for staging site	5	permits may be required to alter the channel	5	$1,440,673	3		3	erosion and sediment movement	5
26	38th St Rd to 40th and 42nd to Sandstone Rd.	All Storms	5	372 cfs in the most restricted section (major storm)	4	10 acres	2	Northern section of pipe is within medium-density residential area; southern area will likely spill to commercial lot and open field	4	may cause backup in 17th St. pipe system	4	medium to dense residential area, road or lane closures necessary along major roadway	1	none	5	$741,630	4		1		1
	S of Evans Ditch	All storms	5	269 cfs in the most restricted section (major storm)	3	31 acres	4	Will flow onto Brantner road and potentially back up into industrial area; will flow mostly south to River	3	may cause back-flow along channel, but probably not into 17th Ave pond	3	adjacent to and industrial/ storage yard, but exists within floodplain	4	none	5	$174,102	5		1	erosion along channel possible w/o riprap	3

Table E-4: Prioritization Results for Equal-Weights (Criteria Weighting Option 1)

AREA OF CONCERN		CRITERIA																				SCORE	
		FREQUENCY		SEVERITY		AREA		RISK		STORM. IMPACTS		CONST. IMPACTS		EASEMENTS		CAPITAL $		PAYMENT OP.		WQ ISSUES			
		1		*1*		*1*		*1*		*1*		*1*		*1*		*1*		*1*		*1*			
ID	PARTIAL	1		2		3		4		5		6		7		9		10		11		TOTAL	AVG
1	Undersized inlets	3	3	1	1	1	1	5	5	3	3	1	1	5	5	5	5	2	2	5	5	31	2.8
3	No convenyance south of 49th St.	3	3	5	5	3	3	2	2	5	5	4	4	4	4	5	5	1	1	1	1	33	3.0
	Undersized pipe north of 49th St.	5	5	5	5	3	3	1	1	3	3	5	5	3	3	3	3	1	1	1	1	30	2.7
4	Undersized pipe along 15th Ave.	5	5	1	1	1	1	3	3	4	4	1	1	5	5	1	1	1	1	1	1	23	2.1
	Discharging to ETD	5	5	2	2	2	2	5	5	5	5	1	1	5	5	1	1	1	1	1	1	28	2.5
5	Lack of pipe connection	5	5	1	1	1	1	2	2	2	2	3	3	2	2	5	5	4	4	1	1	26	2.4
6	Lack of infrastructure	5	5	1	1	1	1	3	3	3	3	3	3	5	5	4	4	2	2	3	3	30	2.7
7	Undersized pond outlet	2	2	1	1	3	3	3	3	4	4	4	4	5	5	3	3	3	3	2	2	30	2.7
8	Undersized pipe along 31st St.	5	5	4	4	2	2	4	4	3	3	1	1	5	5	3	3	1	1	1	1	29	2.6
	Downstream channel sizing	2	2	5	5	3	3	3	3	4	4	2	2	2	2	3	3	4	4	1	1	29	2.6
9	Undersized pipe at 37th and UPR	5	5	4	4	3	3	5	5	5	5	1	1	5	5	4	4	1	1	1	1	34	3.1
	Undersized pipe at 37th and 1st St	5	5	4	4	4	4	2	2	4	4	1	1	5	5	2	2	1	1	1	1	29	2.6
11	Outlet across Hwy 85 to 37th St.	5	5	1	1	1	1	4	4	2	2	4	4	5	5	4	4	4	4	3	3	33	3.0
12	Lack of infrastructure	5	5	1	1	1	1	2	2	1	1	3	3	2	2	5	5	2	2	4	4	26	2.4
13	Undersized pipe across US Hwy 85	5	5	1	1	1	1	4	4	2	2	3	3	5	5	4	4	1	1	1	1	27	2.5
14	Undersized pipe along Center Ave	5	5	2	2	2	2	5	5	2	2	3	3	1	1	3	3	1	1	2	2	26	2.4
15	Undersized pipe at 37th and Hwy 85	5	5	4	4	2	2	5	5	2	2	1	1	5	5	4	4	1	1	4	4	33	3.0
16	Undersized inlets	5	5	1	1	2	2	5	5	3	3	3	3	5	5	5	5	1	1	2	2	32	2.9
17	Abandoned pond	4	4	1	1	3	3	5	5	2	2	4	4	5	5	3	3	1	1	3	3	31	2.8
18	Undersized culverts	5	5	1	1	2	2	2	2	3	3	4	4	4	4	5	5	1	1	5	5	32	2.9
19	Undersized culverts	5	5	2	2	2	2	1	1	3	3	4	4	4	4	5	5	2	2	5	5	33	3.0
20	Undersized channel	4	4	1	1	1	1	2	2	3	3	3	3	5	5	5	5	2	2	1	1	27	2.5
21	No infrastructure to discharge point	3	3	1	1	2	2	3	3	3	3	4	4	3	3	4	4	3	3	1	1	27	2.5
22	No maintenance given to Cave Creek	1	1	1	1	5	5	2	2	3	3	5	5	5	5	5	5	2	2	4	4	33	3.0
24	Safety concern	1	1	1	1	1	1	4	4	3	3	5	5	5	5	5	5	1	1	4	4	30	2.7
25	Scouring channel	1	1	1	1	1	1	2	2	3	3	5	5	5	5	3	3	3	3	5	5	29	2.6
26	Undersized pipe along 23rd Ave.	5	5	4	4	2	2	4	4	4	4	1	1	5	5	4	4	1	1	1	1	31	2.8
	Undersized culverts south of ETD	5	5	3	3	4	4	3	3	3	3	4	4	5	5	5	5	1	1	3	3	36	3.3

LEGEND:			
	highest score	*medium score*	*low score*

Table E-5: Prioritization Results for Cost-Weighted Analysis (Criteria Weighting Option 2)

AREA OF CONCERN		CRITERIA																				SCORE	
		FREQUENCY		SEVERITY		AREA		RISK		STORM. IMPACTS		CONST. IMPACTS		EASEMENTS		CAPITAL $		PAYMENT OP.		WQ ISSUES			
		1		*1*		*1*		*2*		*2*		*1*		*2*		*5*		*3*		*1*			
ID	PARTIAL	1		2		3		4		5		6		7		9		10		11		TOTAL	AVG
1	Undersized inlets	3	3	1	1	1	1	5	10	3	6	1	1	5	10	5	25	2	6	5	5	68	6.2
3	No convenyance south of 49th St.	3	3	5	5	3	3	2	4	5	10	4	4	4	8	5	25	1	3	1	1	66	6.0
	Undersized pipe north of 49th St.	5	5	5	5	3	3	1	2	3	6	5	5	3	6	3	15	1	3	1	1	51	4.6
4	Undersized pipe along 15th Ave.	5	5	1	1	1	1	3	6	4	8	1	1	5	10	1	5	1	3	1	1	41	3.7
	Discharging to ETD	5	5	2	2	2	2	5	10	5	10	1	1	5	10	1	5	1	3	1	1	49	4.5
5	Lack of pipe connection	5	5	1	1	1	1	2	4	2	4	3	3	2	4	5	25	4	12	1	1	60	5.5
6	Lack of infrastructure	5	5	1	1	1	1	3	6	3	6	3	3	5	10	4	20	2	6	3	3	61	5.5
7	Undersized pond outlet	2	2	1	1	3	3	3	6	4	8	4	4	5	10	3	15	3	9	2	2	60	5.5
8	Undersized pipe along 31st St.	5	5	4	4	2	2	4	8	3	6	1	1	5	10	3	15	1	3	1	1	55	5.0
	Downstream channel sizing	2	2	5	5	3	3	3	6	4	8	2	2	2	4	3	15	4	12	1	1	58	5.3
9	Undersized pipe at 37th and UPR	5	5	4	4	3	3	5	10	5	10	1	1	5	10	4	20	1	3	1	1	67	6.1
	Undersized pipe at 37th and 1st St	5	5	4	4	4	4	2	4	4	8	1	1	5	10	2	10	1	3	1	1	50	4.5
11	Outlet across Hwy 85 to 37th St.	5	5	1	1	1	1	4	8	2	4	4	4	5	10	4	20	4	12	3	3	68	6.2
12	Lack of infrastructure	5	5	1	1	1	1	2	4	1	2	3	3	2	4	5	25	2	6	4	4	55	5.0
13	Undersized pipe across US Hwy 85	5	5	1	1	1	1	4	8	2	4	3	3	5	10	4	20	1	3	1	1	56	5.1
14	Undersized pipe along Center Ave	5	5	2	2	2	2	5	10	2	4	3	3	1	2	3	15	1	3	2	2	48	4.4
15	Undersized pipe at 37th and Hwy 85	5	5	4	4	2	2	5	10	2	4	1	1	5	10	4	20	1	3	4	4	63	5.7
16	Undersized inlets	5	5	1	1	2	2	5	10	3	6	3	3	5	10	5	25	1	3	2	2	67	6.1
17	Abandoned pond	4	4	1	1	3	3	5	10	2	4	4	4	5	10	3	15	1	3	3	3	57	5.2
18	Undersized culverts	5	5	1	1	2	2	2	4	3	6	4	4	4	8	5	25	1	3	5	5	63	5.7
19	Undersized culverts	5	5	2	2	2	2	1	2	3	6	4	4	4	8	5	25	2	6	5	5	65	5.9
20	Undersized channel	4	4	1	1	1	1	2	4	3	6	3	3	5	10	5	25	2	6	1	1	61	5.5
21	No infrastructure to discharge point	3	3	1	1	2	2	3	6	3	6	4	4	3	6	4	20	3	9	1	1	58	5.3
22	No maintenance given to Cave Creek	1	1	1	1	5	5	2	4	3	6	5	5	5	10	5	25	2	6	4	4	67	6.1
24	Safety concern	1	1	1	1	1	1	4	8	3	6	5	5	5	10	5	25	1	3	4	4	64	5.8
25	Scouring channel	1	1	1	1	1	1	2	4	3	6	5	5	5	10	3	15	3	9	5	5	57	5.2
26	Undersized pipe along 23rd Ave.	5	5	4	4	2	2	4	8	4	8	1	1	5	10	4	20	1	3	1	1	62	5.6
	Undersized culverts south of ETD	5	5	3	3	4	4	3	6	3	6	4	4	5	10	5	25	1	3	3	3	69	6.3

LEGEND:		*highest score*		*medium score*		*low score*

Table E-6: Prioritization Results for Risk-Weighted Analysis (Criteria Weighting Option 3)

AREA OF CONCERN		CRITERIA																				SCORE	
		FREQUENCY		SEVERITY		AREA		RISK		STORM. IMPACTS		CONST. IMPACTS		EASEMENTS		CAPITAL $		PAYMENT OP.		WQ ISSUES			
		2		*2*		*1*		*5*		*3*		*1*		*1*		*2*		*1*		*1*			
ID	PARTIAL	1		2		3		4		5		6		7		9		10		11		TOTAL	AVG
1	Undersized inlets	3	6	1	2	1	1	5	25	3	9	1	1	5	5	5	10	2	2	5	5	66	6.0
3	No convenyance south of 49th St.	3	6	5	10	3	3	2	10	5	15	4	4	4	4	5	10	1	1	1	1	64	5.8
	Undersized pipe north of 49th St.	5	10	5	10	3	3	1	5	3	9	5	5	3	3	3	6	1	1	1	1	53	4.8
4	Undersized pipe along 15th Ave.	5	10	1	2	1	1	3	15	4	12	1	1	5	5	1	2	1	1	1	1	50	4.5
	Discharging to ETD	5	10	2	4	2	2	5	25	5	15	1	1	5	5	1	2	1	1	1	1	66	6.0
5	Lack of pipe connection	5	10	1	2	1	1	2	10	2	6	3	3	2	2	5	10	4	4	1	1	49	4.5
6	Lack of infrastructure	5	10	1	2	1	1	3	15	3	9	3	3	5	5	4	8	2	2	3	3	58	5.3
7	Undersized pond outlet	2	4	1	2	3	3	3	15	4	12	4	4	5	5	3	6	3	3	2	2	56	5.1
8	Undersized pipe along 31st St.	5	10	4	8	2	2	4	20	3	9	1	1	5	5	3	6	1	1	1	1	63	5.7
	Downstream channel sizing	2	4	5	10	3	3	3	15	4	12	2	2	2	2	3	6	4	4	1	1	59	5.4
9	Undersized pipe at 37th and UPR	5	10	4	8	3	3	5	25	5	15	1	1	5	5	4	8	1	1	1	1	77	7.0
	Undersized pipe at 37th and 1st St	5	10	4	8	4	4	2	10	4	12	1	1	5	5	2	4	1	1	1	1	56	5.1
11	Outlet across Hwy 85 to 37th St.	5	10	1	2	1	1	4	20	2	6	4	4	5	5	4	8	4	4	3	3	63	5.7
12	Lack of infrastructure	5	10	1	2	1	1	2	10	1	3	3	3	2	2	5	10	2	2	4	4	47	4.3
13	Undersized pipe across US Hwy 85	5	10	1	2	1	1	4	20	2	6	3	3	5	5	4	8	1	1	1	1	57	5.2
14	Undersized pipe along Center Ave	5	10	2	4	2	2	5	25	2	6	3	3	1	1	3	6	1	1	2	2	60	5.5
15	Undersized pipe at 37th and Hwy 85	5	10	4	8	2	2	5	25	2	6	1	1	5	5	4	8	1	1	4	4	70	6.4
16	Undersized inlets	5	10	1	2	2	2	5	25	3	9	3	3	5	5	5	10	1	1	2	2	69	6.3
17	Abandoned pond	4	8	1	2	3	3	5	25	2	6	4	4	5	5	3	6	1	1	3	3	63	5.7
18	Undersized culverts	5	10	1	2	2	2	2	10	3	9	4	4	4	4	5	10	1	1	5	5	57	5.2
19	Undersized culverts	5	10	2	4	2	2	1	5	3	9	4	4	4	4	5	10	2	2	5	5	55	5.0
20	Undersized channel	4	8	1	2	1	1	2	10	3	9	3	3	5	5	5	10	2	2	1	1	51	4.6
21	No infrastructure to discharge point	3	6	1	2	2	2	3	15	3	9	4	4	3	3	4	8	3	3	1	1	53	4.8
22	No maintenance given to Cave Creek	1	2	1	2	5	5	2	10	3	9	5	5	5	5	5	10	2	2	4	4	54	4.9
24	Safety concern	1	2	1	2	1	1	4	20	3	9	5	5	5	5	5	10	1	1	4	4	59	5.4
25	Scouring channel	1	2	1	2	1	1	2	10	3	9	5	5	5	5	3	6	3	3	5	5	48	4.4
26	Undersized pipe along 23rd Ave.	5	10	4	8	2	2	4	20	4	12	1	1	5	5	4	8	1	1	1	1	68	6.2
	Undersized culverts south of ETD	5	10	3	6	4	4	3	15	3	9	4	4	5	5	5	10	1	1	3	3	67	6.1

LEGEND:		*highest score*		*medium score*		*low score*