Major Drainageway Plan
Willow Creek Tributaries Upstream of Englewood Dam
December 2024

Tributaries Studied	
1	Acres Green Tributary (FHAD)
2	Fox Hill Park Tributary (FHAD)
3	Homestead Tributary
4	Homestead Farms Tributary
5	Jamison Tributary
6	Kettle Tributary
7	Phillips Tributary (FHAD)
8	Spring Creek (FHAD)
9	Spring Creek East - Altair Park Tributaries
10	Spring Creek East - Edgewood Tributaries
11	Trenton Outfall Tributary
12	West Spring Creek
13	Willow Creek East (FHAD)

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ICON ENGINEERING

In cooperation with:

Southeast Metro Stormwater Authority
MHFD MILE HIGH FLOOD DISTRICT
DOUGLAS COUNTY COLORADO
CITY OF LONE TREE COLORADO

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December 23, 2024

Jennifer Winters
South Watershed Manager
Mile High Flood District
12575 W. Bayaud Avenue
Lakewood, CO 80228

RE: Willow Creek Tributaries Upstream of Englewood Dam Major Drainageway Plan Report

Dear Jennifer:

ICON Engineering Inc. is pleased to submit this Major Drainageway Plan (MDP) report for the Willow Creek Tributaries Upstream of Englewood Dam. Enclosed is the MDP report through the proposed Recommended Plan. This report documents the development of the hydrology & hydraulics in the related Flood Hazard Area Delineation (FHAD), as well as documents the MDP Alternatives Analysis processes of Problem Identification, Alternatives Development, and Recommended Improvement Plan.

We would like to acknowledge the help and support of the Mile High Flood District (MHFD), Southeast Metro Stormwater Authority (SEMSWA), South Suburban Parks and Recreation District (SSPRD), Douglas County, and City of Lone Tree in preparation of this study. These alternatives and recommendations will assist MHFD, SEMSWA, and local authorities in administrating development under the increased flood risk and planning for watershed-wide drainage improvements.

Thank you for the opportunity to complete this study.

Sincerely,

ICON ENGINEERING, Inc.

Craig D. Jacobson, P.E., CFM Vice President	James F. Duvall, P.E. Project Manager	Jackson J. Winterrowd, E.I. Project Engineer

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1.0 INTRODUCTION

1.1 AUTHORIZATION

This report was authorized by the Mile High Flood District (MHFD) under joint sponsorship with Southeast Metro Stormwater Authority (SEMSWA) under the January 2018 agreement (Agreement No. 18-12.35) regarding "Major Drainageway Plan and Flood Hazard Area Delineation for Willow Creek Tributaries Upstream of Englewood Dam". Douglas County and the City of Lone Tree were added as funding partners following the Flood Hazard Area Delineation (FHAD), during the Major Drainageway Plan (MDP) phase. The FHAD study, including updated Baseline Hydrology, is documented in a separate report titled *Flood Hazard Area Delineation Willow Creek Tributaries Upstream of Englewood Dam*, *January 2025* by ICON Engineering Inc.

1.2 PURPOSE AND SCOPE

The purpose of this Major Drainageway Plan is to evaluate the tributaries to Willow Creek upstream of Englewood Dam and downstream of County Line Road. The MDP utilizes the updated hydrologic and hydraulic information and provides stream health, flooding, maintenance, and water quality recommendations. The main stem of Willow Creek through the study area is not included in this analysis. Through discussions with sponsors and stakeholders, the main goals and objectives for the MDP study include:

- Engagement with residents of the active neighborhoods
- Coordination and Meetings with MHFD, SEMSWA, Douglas County, City of Lone Tree, and other project stakeholders
- Collect existing information, including previous Major Drainageway Plans, Outfall System Plans, and Flood Hazard Area Delineations for the study area
- Identify drainageway health, flooding, and maintenance problems as well as opportunities for water quality enhancement
- Develop alternatives to address the identified problems and improvement opportunities
- Propose a recommended plan, including estimated costs, to help address the specific needs of the study area and inform maintenance and capital improvement project planning by the localities
- Preparation of a report which builds on and updates the information presented in the previous studies

As documented in the *Arapahoe County Flood Insurance Study* (FIS), previous detailed study of the tributaries to Willow Creek within this project's study area has only been performed for a portion of Spring Creek, from the confluence with Willow Creek to just upstream of County Line Road, in the *Major Drainageway Planning, Little Dry Creek* report completed by McCall-Ellingson and Morrill, Inc. in 1974. Most recently, hydrology for the tributaries to Willow Creek were studied by the MHFD in the *Willow Creek, Little Dry Creek, and Greenwood Gulch Outfall Systems Planning Study*, completed in 2010. Mapping for the tributaries was not incorporated into the *Flood Hazard Area Delineation, Willow Creek* prepared by CH2M Hill in 2010. This current MDP study, and the associated FHAD, supersedes these previous studies.

1.3 PLANNING PROCESS

Progress meetings were held at various stages throughout the project. A summary of these meetings and comment responses can be found below. Minutes from the MDP progress meetings can be found in Appendix A. Baseline Hydrology and FHAD related meeting materials associated with this study can be found in *Flood Hazard Area Delineation Willow Creek Tributaries Upstream of Englewood Dam*, *January 2025.*

MDP Related Meetings:

- November 16, 2022: Alternatives Scoping Meeting
- November 8, 2023: MDP Kickoff Meeting
- January 17, 2024: MDP Progress Meeting
- February 14, 2024: MDP Progress Meeting
- March 13, 2024: MDP Progress Meeting
- April 4, 2024: Public Meeting
- May 8, 2024: MDP Progress Meeting
- June 5, 2024: MDP Progress Meeting
- July 3, 2024: MDP Progress Meeting
- July 30, 2024: MDP Progress Meeting
- October 23, 2024: MDP Comment Response Meeting – MHFD
- November 20, 2024: MDP Comment Response Meeting - SEMSWA

1.4 MAPPING AND SURVEYS

Project mapping was based on Federal Emergency Management Agency (FEMA) 2013 Post-flood LiDAR. The Lidar data was converted into one-foot interval contours for the study area.

The LiDAR mapping has the following attributes.

- Name: 2013 South Platte River Flood Area 1
- Collection Date: Fall 2013 – Spring 2014
- Vertical Accuracy: 9.25 cm RMSE
- Point Spacing: 0.7 m
- Vertical Datum: NAVD88
- Horizontal Datum: NAD83

2020 Denver Regional Council of Governments (DRCOG) LiDAR mapping was used in a limited area along Acres Green Tributary to reflect grading changes since the 2013 LiDAR collection date. The 2020 LiDAR was clipped to the study area and provided to ICON Engineering by MHFD in October 2022. The 2020 LiDAR was used at Acres Green Tributary Sections 330 and 361 only.

- Name: 2020 DRCOG LiDAR – Willow Creek FHAD Study Area
- Collection Date: May 2020 – September 2020 (Collected and Processed by Sanborn Map Company)
- Cell Size: 2 x 2 ft
- Vertical Datum: NAVD88
- Horizontal Datum: NAD83

Additional survey information was provided by MHFD for all roadway crossings and drop structures within the study area. Structure survey was collected by Wilson & Company in January and February 2019.

1.5 DATA COLLECTION

Numerous previous reports were collected and reviewed as part of this study. A summary of these reports can be found below in Table 1-1.

Table 1-1: Data Collected

Title	Date	Author
General Motors Auto Mall Underground Detention Plans	1997	JR Engineering
Panorma Park Regional Pond Improvements Plans	2007	Muller Engineering
Sam's Club Detention Pond Retrofit Drainage Report	2010	CEI Engineering Associates
Basin Improvement Plans for 7817 Park Meadows Drive	2010	CEI Engineering Associates
Flood Hazard Delineation Willow Creek	2010	CH2M Hill
Willow Creek, Little Dry Creek, and Greenwood Gulch Outfall Systems Planning Study	2010	CH2M Hill
Century Highland Park Subdivision Filing No. 2 Plans	2015	Peak Civil Consultants
West Spring Creek Hydrology Update	2018	Olsson Associates
SEMSWA Panorama Pond Improvements	2018	SEMSWA
The Jones District - Phase I Master Drainage Report	2019	Martin / Martin

1.6 ACKNOWLEDGEMENTS

This report was prepared in cooperation with the MHFD and SEMSWA. The representatives who were involved with this study are listed in Table 1-2, below.

Table 1-2: Project Team

Name	Organization	Title
Jennifer Winters, P.E., CFM	MHFD	Project Manager
Jon Villines, P.E.	MHFD	Innovation Manager
Jeff Battiste, P.E.	MHFD	Project Manager/Engineer
Jessica Traynor P.E., CFM	SEMSWA	Floodplain and Master Planning Engineer
Jon Nelson, P.E., CFM	SEMSWA	Capital Improvements Project Manager
Tiffany Clark, P.E., CFM	SEMSWA	Land Development Engineering Manager
Brad Robenstein, P.E., CFM	Douglas County	Drainage and Flood Control Engineer
Jacob James, P.E., CFM	Lone Tree	Deputy Director of Public Works - Engineering
Duncan Rady, P.E.	Lone Tree	Stormwater Engineer
Melissa Reese-Thacker, ASLA, PLA	SSPRD	Planning Manager
Craig Jacobson, P.E., CFM	ICON	Principal-in-Charge
James Duvall, P.E.	ICON	Project Manager
Jackson Winterrowd, E.I.	ICON	Project Engineer

Additional Acknowledgements: Andrew Earles, Vice President of Wright Water Engineers, participated in a peer review of the hydrology update associated with this study.

2.0 STUDY AREA DESCRIPTION

2.1 PROJECT AREA

The study area originates at Englewood Dam and extends upstream along Willow Creek to approximately County Line Road. The basin, generally bounded by Holly Street to the west, Englewood Dam to the north, I-25 to the east, and Park Meadows Drive to the south, has a drainage area of approximately 4.9 square miles and includes tributaries spanning multiple jurisdictions.

The following tributaries outfall into Willow Creek within the study area: Acres Green Tributary, Fox Hill Park Tributary, Homestead Tributary, Homestead Farms Tributary, Jamison Tributary, Kettle Tributary, Phillips Tributary, Spring Creek, Trenton Outfall Tributary, West Spring Creek, and Willow Creek East Tributary. Areas directly tributary to the main stem of Willow Creek were also included in the analysis. The study area includes the communities of the City of Centennial, City of Lone Tree, and areas of unincorporated Arapahoe and Douglas County.

Drainageways within the basin resemble a variety of hydraulic infrastructure originating from development circa the 1980s. Drainageways include a myriad of sections emphasizing open space and native vegetation, manicured blue grass stream systems, boulder revetment, large concrete and grouted drop structures, deep culverts, retaining walls, landscape design features, and concrete baffled dissipation structures. Many, if not most, of the stream systems follow trail segments owned by a combination of South Suburban Parks and Recreation District (SSPRD), neighborhood HOAs, and local business districts.

Currently, the basin is nearly fully developed and includes residential neighborhoods, open space, parks, and commercial business areas. The commercial areas are predominately located along the eastern edge of the basin, with some areas located south of C-470. Elevations within the study area range between 5,572 feet at the Englewood Dam to 5,970 feet in Acres Green Tributary at Wiltshire Drive. The basin is approximately 2.5 miles long along Willow Creek and spans 3 miles at its widest.

The basin is comprised of multiple hydrologic soil types as defined by the Natural Resources Conservation Service (NRCS) (Reference 3). The study area primarily consists of hydrologic soil groups C and D type soil, which possess a lower infiltration capacity than other soil types. HSG Type A and B soils are also present within the basin. The latest soil information was retrieved from the NRCS Soil Survey Geographic (SSURGO) Database in April 2019. More information about the HSG can be found in Section 3.3.5. The distribution of soil through the study area can be found on the interactive map in Appendix B.

Although there are numerous detention facilities within the basin, only five met the criteria to be considered for flood reduction purposes in this study. The numerous other detention basins were further evaluated during the alternative analysis phase. The five detention facilities included in the baseline hydrology are: Panorama Pond, located along Willow Creek East Tributary upstream of South Yosemite Street, Yosemite Pond, located along Phillips Tributary east of Yosemite, Akron Pond, east of South Akron Street on Phillips Tributary, Sam's Club Detention Basin located on Acres Green Tributary just south of C-470, and the detention basin on Spring Creek just upstream of County Line Road.

A study area map, highlighting key features throughout the study area, can be found on Figure 2-2. A watershed map detailing the location of each tributary included in this study can be found on Figure 2-3.

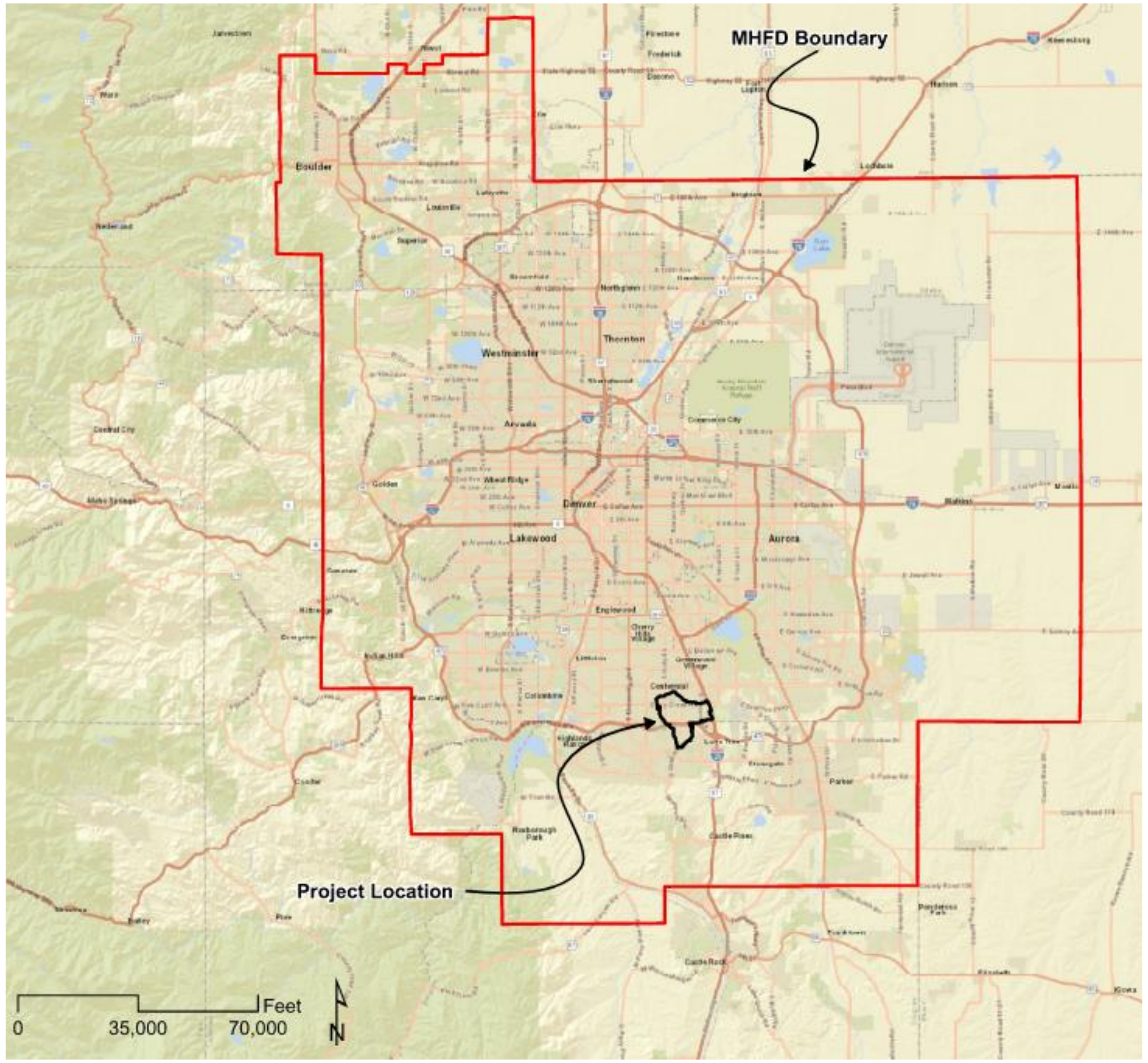


Figure 2-1: Vicinity Map

2.2 LAND USE

Future conditions land use was determined by Comprehensive Plans and zoning data obtained from each jurisdiction. Electronic data was obtained in shapefile format from City of Centennial and City of Lone Tree. Information for unincorporated areas of Arapahoe and Douglas County were digitized from land use maps. After discussion with project sponsors, land use for the C-470 corridor was set at 95 percent impervious.

Percent impervious values were selected for each zoning classifications using Table 6-3 from Volume 1, Chapter 6 of the 2016 Urban Storm Drainage Criteria Manual (USDCM), and can be found in Table 3-4. Future land use for the entire basin can be found in the interactive map, located in Appendix B.

The basin is predominately developed with no significant changes in land use anticipated in the future. After discussion with project sponsors, an existing conditions land use scenario was not deemed necessary given the similarities between existing and future land use projections.

The entire basin has a future impervious value of approximately 51 percent. Impervious values for the entire study area can be found on the interactive map, found in Appendix B.

2.3 WATERSHED DESCRIPTIONS

The study area was separated into twelve separate watersheds. Eleven of the watersheds are tributary to a drainageway before their outfalls into Willow Creek, with the twelfth watershed containing areas directly tributary to the main stem of Willow Creek.

An inventory of all major storm drainage structures for each watershed can be found in Table 2-1 through Table 2-11. Each drainageway and tributary watershed can be found in.

2.3.1 ACRES GREEN TRIBUTARY

Acres Green Tributary Watershed, located in the southwest portion of the study area, is bounded by the Trenton Outfall Tributary Watershed to the west. The watershed, approximately 274 acres in size, extends from the outfall in Willow Creek Park, in Centennial, south into the City of Lone Tree and unincorporated Douglas County. The watershed, originating near the Acres Green Drive and Mercury Drive intersection, drains south to north within the Acres Green subdivision. Street conveyance carries flow downstream to Altair Drive where flow is intercepted in a concrete pan located in the street median. Flow continues north along the median in Acres Green Drive approximately 2,100 feet to Apollo Court, where a storm drain system intercepts and conveys flow to a manhole east of Acres Green Drive just south of C-470.

The western portion of the watershed drains by surface conveyance and storm drain systems into the Sam's Club Detention Basin located at the northwest corner of Park Meadows Drive and Acres Green Drive. Stormwater runoff is conveyed through the outlet structure, east, to the confluence with the storm drain system in Acres Green Drive.

The combined storm drain system conveys flow north; underneath C-470 into the AutoNation Buick GMC Park Meadows underground detention. The underground detention, which consists of sixteen 10 foot diameter corrugated metal pipe (CMP) does not meet the requirements for publicly owned and maintained facilities and was therefore not considered in this study. Downstream of East County Line Road, the storm drain system continues north to East Phillips Circle where an open channel, consisting of riprap and a concrete low flow channel, conveys runoff through the Willow Creek and Willow Creek Townhouses subdivisions. Just north of the south crossing of East Phillips Circle an 18 inch RCP conveys low flow in the same direction as the overflow path. A 72-inch RCP conveys flow underneath East Phillips Circle to the north, where Acres Green Tributary outfalls into Willow Creek after a small pedestrian trail crossing.

Table 2-1: Major Crossing Structure - Acres Green Tributary

Acres Green Tributary			
Street Name	Street Classification	Structure Description	Existing Structure
E Phillips Cir.	Secondary Collector	Culvert	72" RCP

2.3.2 FOX HILL PARK TRIBUTARY

Several amenities are present along Fox Hill Park Tributary, including tennis courts north of East Kettle Avenue

Fox Hill Park Tributary Watershed, approximately 373 acres in size, is located within City of Centennial and unincorporated Douglas County. The watershed borders the western edge of the basin, and is bounded by Spring Creek to the east and the Homestead Farms Tributary to the northwest. Land use upstream of County Line Road primarily consists of commercial and industrial properties. Runoff is conveyed underneath East County Line Road in an 18 inch storm drain. Flows in excess of the 18 inch storm drain are conveyed east along East County Line Road into the West Spring Creek Basin. North of East County Line Road, in the City of Centennial, runoff is conveyed in an open channel bordered by the Foxridge West subdivision to the east and Foxridge Plaza to the west. The open channel continues to northwest after crossing East Otero Avenue in two (2) 36-inch RCP culverts. As the channel enters Foxhill Park, a pedestrian trail parallels the drainageway to East Dry Creek Road. Approximately 500 feet downstream of East Otero Avenue, a pedestrian trail bridge crosses the drainageway to provide access to Foxhill Park.

At East Kettle Avenue, two (2) 45-inch HDPE culverts convey flow underneath the roadway where a 42-inch storm drain outfalls into the drainageway. The storm drain intercepts flow from the west, from the South Holly Street and East Kettle Avenue intersection. The storm drain system extends upstream to the south along South Holly Street, intercepting flow from the private detention basin in the Heritage Greens subdivision.

Downstream of East Kettle Avenue the channel overbanks consist of maintained turf grass near the community pool and tennis courts. A series of drop structures provides grade control for the stream. The channel is confined by residential properties on both sides. Approximately 870 feet downstream of East Kettle Avenue, a pedestrian bridge trail crosses the drainageway, connecting the Homestead Farm 3rd and 6th Filing subdivisions. The tributary continues north to East Dry Creek Road where a series of drop structures lower the channel elevation for the 8 foot by 6 foot RCBC. North of East Dry Creek Road, within the Willow Creek Open Space, the tributary crosses a pedestrian trail before discharging into Willow Creek.

Table 2-2: Major Crossing Structures - Fox Hill Park Tributary

Fox Hill Park Tributary			
Street Name	Street Classification	Structure Description	Existing Structure
E Otero Ave.	Secondary Collector	Culvert	(2) 36" RCPs
Pedestrian Bridge	--	Bridge	
E Kettle Ave.	Minor	Culvert	(2) 45" HDPEs
E Dry Creek Rd.	Arterial	Culvert	8' x 6' RCBC

2.3.3 HOMESTEAD TRIBUTARY

The Homestead Tributary Watershed, approximately a 100 acre watershed, is an right bank tributary of Willow Creek, north of East Dry Creek Road. The headwaters of the basin extend east of South Quebec Street near Dry Creek Elementary School in the Hallcrafts Walnut Hills subdivision. Surface conveyance carries flow to a storm drain system at South Quebec Street and East Hinsdale Avenue intersection. The storm drain system conveys flow west into the Homestead in the Willows subdivision, gradually increasing in size to a 48-inch RCP at South Homestead Parkway and East Geddes Place. West of the intersection the storm drain outfalls into an open channel that crosses a pedestrian trail just north of Homestead Elementary School. The open channel is bordered by residential properties to the north and the school property to the south outfall into Willow Creek.

Table 2-3: Major Crossing Structures - Homestead Tributary

Homestead Tributary			
Street Name	Street Classification	Structure Description	Existing Structure
Pedestrian Bridge	--	Bridge	

2.3.4 HOMESTEAD FARMS TRIBUTARY

The Homestead Farms Tributary Watershed is located in the northwestern portion of the basin. The watershed, approximately 170 acres in size, drains from west to east. The north tributary in the Homestead Farms Tributary watershed collects surface runoff from Medema Park and crosses South Grape Street through a 36-inch RCP. Downstream of the roadway crossing, flow is conveyed in an open channel bordered by residential properties within the Homestead Farms 1st and 2nd Filing subdivisions. The stormwater runoff is conveyed underneath South Holly Street in a 42-inch RCP where the flow confluences with the southern tributary before the outfall into Willow Creek.

The southern tributary of Homestead Farms intercepts runoff from the Lifetime Fitness facility. A 30-inch storm drain at the East Dry Creek Road and South Glencoe Street intersection intercepts and conveys flow east along East Dry Creek Road. Additional inflow from local subwatersheds are intercepted at the East Dry Creek Road and South Holly Street intersection before the storm drain turns north along South Holly Street. The storm drain intercepts a lateral from the west that collects flow draining South Hudson Way. Ponding in the cul-de-sac near South Hudson Way has been observed during rain events. The 30-inch storm drain outfalls into an open channel, approximately 200 feet south of East Fremont Avenue. The open channel confluences with the northern tributary of Homestead Farms, continuing downstream to the outfall into Willow Creek.

Table 2-4: Major Crossing Structures - Homestead Farms Tributary

Homestead Farms Tributary			
Street Name	Street Classification	Structure Description	Existing Structure
North Trib at S Grape St.	Minor	Culvert	36" RCP
North Trib at S Holly St.	Arterial	Culvert	42" RCP

2.3.5 JAMISON TRIBUTARY

Jamison Tributary conveys flow through open space upstream of the confluence with the Willow Creek East Tributary

Jamison Tributary, a right bank tributary to Willow Creek East Tributary, has a drainage area of approximately 53 acres. The basin extends north of East Dry Creek Road into the Hunters Hill 3rd Filing and Saddle Ridge Condominiums subdivisions. Runoff collects at the East Dry Creek Road and East Hunters Hill Drive intersection and is conveyed south in two 24-inch storm drains. The two systems converge just south of East Dry Creek Road in a 48 inch RCP pipe before discharging into the open channel. Flows in excess of the storm drain follow a similar alignment to the storm drain, heading south into the open channel in the Willow Creek 1st and 2nd Filing subdivisions. Localized drainage issues are known to occur within the watershed. Several pedestrian crossings exist along Jamison Tributary until the outfall with Willow Creek East Tributary, located approximately 490 feet upstream of South Rosemary Way.

Table 2-5: Major Crossing Structures - Jamison Tributary

Jamison Tributary			
Street Name	Street Classification	Structure Description	Existing Structure
Pedestrian Bridge	--	Bridge	
Pedestrian Bridge	--	Bridge	

2.3.6 KETTLE TRIBUTARY

The Kettle Tributary is a left bank tributary to Willow Creek East Tributary. The watershed is approximately 36 acres in size and spans across the Willow Creek 6th Filing subdivision, and the Highland Park and Panorama Park business districts. At the upstream end of the watershed, east of South Yosemite Street, flow collects in the business districts and is intercepted by a minor storm drain system. Flows converge at the intersection of South Yosemite Street and South Willow Way, where a 24-inch RCP crosses beneath the road. Flows in excess of the storm drain capacity overtop the roadway, and discharge into an open channel west of the roadway. A pedestrian trail parallels the open channel following the northwest flow path, where the tributary crosses East Kettle Circle, and continues in an open channel bounded by residential properties. The drainageway crosses East Kettle Circle a second time, conveyed by a 30-inch RCP which transitions to a 24-inch high by 48-inch wide horizontal elliptical RCP at East Kettle Circle to the outfall into Willow Creek East Tributary.

Table 2-6: Major Crossing Structures - Kettle Tributary

Kettle Tributary			
Street Name	Street Classification	Structure Description	Existing Structure
E Kettle Cir.	Minor	Culvert	36" RCP
E Kettle Cir.	Minor	Culvert	30" RCP

2.3.7 PHILLIPS TRIBUTARY

Phillips Tributary is the southeastern most tributary in the basin, with approximately 170 acres in tributary area. Runoff is conveyed generally in a southwestern flow path through the Panorama Office Park 2, Highlands Park, and Willow Creek 10th Filing subdivisions. Bisecting the watershed is an open channel that conveys stormwater runoff through two detention basins and numerous retention ponds not used for flood control.

Yosemite Pond provides stormwater detention as well as a water feature

Upstream of South Akron Street, a network of storm drain pipes convey runoff to a series of retention ponds that outfall into the Akron Pond. Flow continues downstream to the Yosemite Pond, just east of South Yosemite Street. This detention basin was retrofitted as part of the Century Highland Park subdivision development. At the time of this study, SEMSWA has a planned cured in place pipe (CIPP) lining project at Yosemite Street. Downstream of Yosemite Pond, the open channel continues through the Willow Creek 10th Filing subdivision crossing East Phillips Place through an 11 foot by 6.5 foot horizontal elliptical reinforced concrete pipe (HERCP) and a 24-inch corrugated metal pipe (CMP). An open channel conveys flow downstream of East Phillips Place to the outfall into Willow Creek.

Table 2-7: Major Crossing Structures: Phillips Tributary

Phillips Tributary			
Street Name	Street Classification	Structure Description	Existing Structure
S Yosemite St.	Arterial	Culvert	11' x 7' HECMP
E Phillips Pl	Minor	Culvert	11' x 6.5' HECMP

2.3.8 SPRING CREEK

Spring Creek is bounded between the Fox Hill Park Tributary and West Spring Creek to the west, and the Trenton Outfall Tributary to the east. The 680 acre watershed spans the City of Centennial at the downstream end, to City of Lone Tree and unincorporated Douglas County at the upstream end. Flow is conveyed from the upstream end of the watershed through the Highlands Ranch subdivisions. Flow is conveyed under South Quebec Street through three distinct flow paths in unincorporated Douglas County.

The eastern most tributary conveys flow from the Acres Green subdivision through Altair Park to South Quebec Street. A 54-inch storm drain system intercepts the runoff at South Quebec Street and conveys flows underneath the King Soopers parking lot, where the storm drain outfalls into the central tributary storm drain.

The central tributary collects runoff from the Prominence Point Open Space and Acres Green subdivision. The storm water is conveyed in an open channel behind the Highlands Ranch 89 C subdivision to South Quebec Street. The runoff enters a 54-inch storm drain system that conveys the flow through the King Soopers parking lot, intercepting the eastern tributary. The combined flows continue north to Business Center Drive where the storm drain system turns west, increasing in size to a 78-inch RCP storm drain, ultimately discharging into the western tributary storm drain system.

The western tributary of Spring Creek collects stormwater runoff throughout the Highlands Ranch 89 subdivision. A 60-inch RCP conveys flow underneath Chestnut Hill Street to the west, and a 48-inch storm drain system to the east. These two flow paths converge upstream of South Quebec Street before a 60-inch storm drain intercepts the flow. The storm drain system continues within the Highlands Ranch 126A subdivision to the north and to Business Center Drive where flow from the central and eastern flow paths is also intercepted. The combined flow continues north to C-470 in a 108-inch RCP storm drain. After crossing C-470, the runoff is conveyed to the Spring Creek detention basin which detains flow before passing underneath East County Line Road into the City of Centennial. Several drop structures provide grade control as the heavily vegetated channel continues downstream to East Otero Avenue. At East Otero Avenue the channel is conveyed through a 10 foot by 8 foot RCBC crossing structure. Further downstream, the heavily vegetated channel is bounded by residential properties on both sides, including the Ridge at Foxridge subdivision to the west, and The Hillside at Foxridge subdivision to the east. West Spring Creek confluences with Spring Creek just upstream of East Mineral Avenue before flow is conveyed through a 10 foot by 10 foot RCBC. Two pedestrian trail bridges provide access to the trail system in the area as the drainageway continues to the outfall into Willow Creek just upstream of East Dry Creek Road.

Residential development bounds the creek on both sides downstream of East County Line Rd.

Table 2-8: Major Crossing Structures: Spring Creek

Spring Creek			
Street Name	Street Classification	Structure Description	Existing Structure
E Otero Ave	Secondary Collector	Culvert	10' x 8' RCBC
E Mineral Ave	Secondary Collector	Culvert	10' x 10' RCBC
Pedestrian Bridge	--	Bridge	
Pedestrian Bridge	--	Bridge	

2.3.9 TRENTON OUTFALL TRIBUTARY

The Trenton Outfall Tributary Watershed extends from the outfall with Willow Creek in Willow Creek Park, upstream, to just south of East County Line Road. The 87 acre watershed spans the City of Centennial and City of Lone Tree. Stormwater runoff at the upstream end of the watershed collects along East County Line Road, east of Parkway Drive. The runoff is conveyed to the north in a 42-inch storm drain system. Flow is conveyed in an open channel to East Phillips Circle, where a 36-inch RCP conveys flow underneath the roadway. Just downstream of the south crossing of East Phillips Circle, an 18-inch storm drain conveys low flow in a similar flow direction as the overflow path. Trenton Outfall Tributary conveys the flow in an open channel through the Willow Creek 11th Filing subdivision to a pedestrian bridge crossing before continuing to a second crossing of East Phillips Circle. The 42-inch storm drain system intercepts flow at the roadway crossing and conveys flow to the outfall into Willow Creek, through Willow Creek Park in a 48-inch RCP outfall.

Table 2-9: Major Crossing Structures - Trenton Outfall Tributary

Trenton Outfall Tributary			
Street Name	Street Classification	Structure Description	Existing Structure
E Phillips Cir.	Secondary Collector	Culvert	36" RCP
Pedestrian Bridge	--	Bridge	
E Phillips Cir.	Secondary Collector	Culvert	42" RCP

2.3.10 WEST SPRING CREEK

The West Spring Creek Watershed, approximately 117 acres in size, is bounded by Fox Hill Park Tributary to the west, and Spring Creek to the east. Runoff south of East County Line in the business parks is collected along the roadway and is conveyed north through a series of storm drain pipes. North of East County Line Road, in the City of Centennial, a heavily vegetated open channel conveys flow north through the Foxridge West and Foxridge 4th Filing subdivisions to East Phillips Avenue. A 60-inch RCP culvert carries flow through the roadway crossing. Downstream of the crossing, an open channel is bounded by residential properties on both sides within the Foxridge 5th Filing and The Ridge at Foxridge subdivisions. A pedestrian trail crossing along West Spring Creek is located just upstream of the confluence with Spring Creek at East Mineral Avenue. At the time of this study, stream improvements are being designed upstream of East Mineral Avenue. Stabilization of approximately 900 feet of stream is proposed through drop structures and includes a retaining wall of the right bank.

A pedestrian crossing is located on West Spring Creek just upstream of the confluence

Table 2-10: Major Crossing Structures - West Spring Creek

West Spring Creek			
Street Name	Street Classification	Structure Description	Existing Structure
E Phillips Ave.	Secondary Collector	Culvert	60" RCP
Pedestrian Bridge	--	Bridge	

2.3.11 WILLOW CREEK EAST TRIBUTARY

The Willow Creek East Tributary Watershed, located in the northeast portion of the basin, has a tributary area of approximately 406 acres. Stormwater runoff is conveyed from east to west, to the outfall with Willow Creek upstream of South Quebec Street.

Willow Creek East Tributary meanders through open space west of S. Yosemite St.

At the upstream end of the watershed, east of South Chester Street, proposed development is imminent within the Jones District. Current development plans propose to convey stormwater runoff along the historic drainage paths.

East of South Yosemite Street, runoff within the Panorama Corporate Center and Panorama development is collected in a storm drain network in Chester Street and Panorama Drive. The 72-inch storm drain conveys flow west within the Panorama development before discharging flow into Panorama Pond, located at the southeast corner of East Panorama Drive and South Yosemite Street. Flow exiting the flood control facility is conveyed through an open channel as the land use transitions to residential west of South Yosemite Street in the Willow Creek 4th and 6th Filing subdivisions. Two pedestrian crossings occur throughout the maintained turf open space, before the confluence with the Kettle Tributary, a left bank tributary of Willow Creek East Tributary. Flow continues downstream to South Willow Way where a 90-inch CMP crossing conveys flow through the roadway crossing. Downstream of South Willow Way, two pedestrian crossings are present before the confluence with the Jamison Tributary, a right bank tributary of Willow Creek East Tributary. Two additional pedestrian crossings span Willow Creek East Tributary before the roadway crossing of South Rosemary Way, a 16 foot by 8 foot RCBC. Further downstream, the open channel becomes heavily vegetated as flow is conveyed west before turning south and discharging into Willow Creek.

Table 2-11: Major Crossing Structures - Willow Creek East Tributary

Willow Creek East Tributary			
Street Name	Street Classification	Structure Description	Existing Structure
Pedestrian Bridge	--	Bridge	
Pedestrian Bridge	--	Bridge	
S Willow Way	Secondary Collector	Culvert	90" CMP
Pedestrian Bridge	--	Bridge	
Pedestrian Trail	--	Bridge	
S Rosemary Way	Secondary Collector	Culvert	16' x 8' RCBC
S Yosemite St.	Arterial	Culvert	60" RCP
S Chester St.	Secondary Collector	Culvert	66" RCP

2.3.12 WILLOW CREEK DIRECT FLOW AREAS

Subwatersheds conveying runoff directly to the main stem of Willow Creek, not through one of the eleven watersheds described above, were assigned to the direct flow area watershed. These subwatersheds, encompassing nearly 660 acres throughout the study area were modeled but stormwater runoff was not routed in the hydrologic modeling.

2.4 FLOOD HISTORY

No stream gages are present along the tributaries to Willow Creek. ALERT station 1600 is within the basin, located along the main stem of Willow Creek at the Englewood Dam.

On the afternoon of September 6th, 2019, a storm event, causing localized flooding including damages to infrastructure and property, occurred throughout the watershed. Between 3:30 pm and 6:00 pm a total of 2.8 inches of rainfall was recorded at ALERT station 1600. The storm was indicative of a typical Front Range ‘flashy’ storm with the majority (1.92 inches) of the rainfall occurring within the first thirty minutes. The point precipitation within the peak thirty-minute interval exceeded the 100-year design storm point precipitation.

On the evening of September 6th and following morning, flood documentation, including photos and high-water marks, were gathered along the tributaries by ICON Engineering.

Homestead Farms Tributary escaped the left bank eroding the pedestrian trail near Homestead Elementary

Fox Hill Park Tributary overtopped East Kettle Drive and eroded turf along the drainageway

Pedestrian trails were inundated along Spring Creek downstream of East Mineral Avenue

Significant debris collected at Spring Creek Detention Basin but the facility did not overtop County Line Road

The culvert crossing of Westerly Spring Creek at East Phillips Avenue clogged, resulting in flows overtopping the road damaging private property and an electric transformer in the area

Localized flooding caused damage to landscaping rock on South Holly Street near East Kettle Avenue

Figure 2-2: Study Area Map

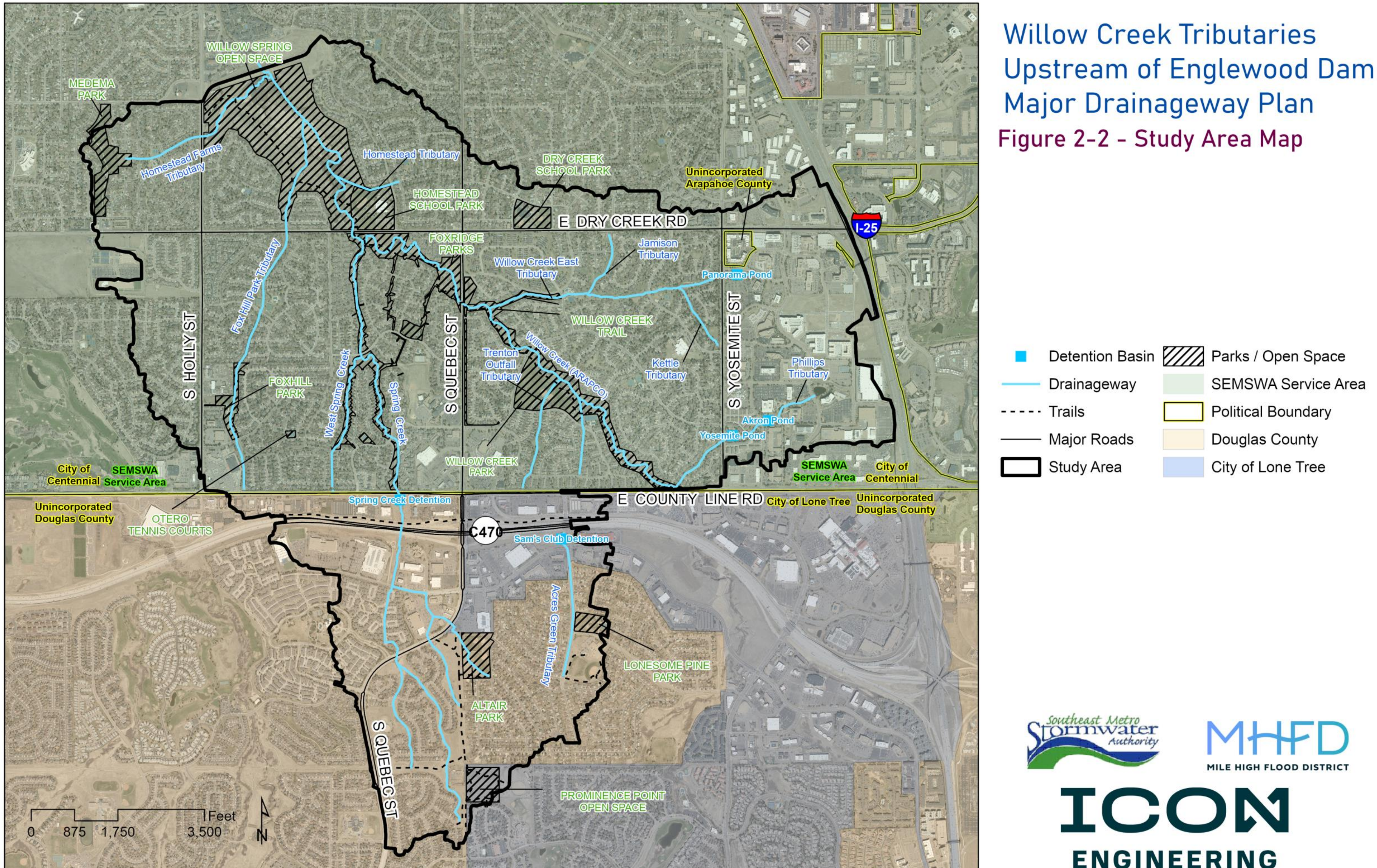
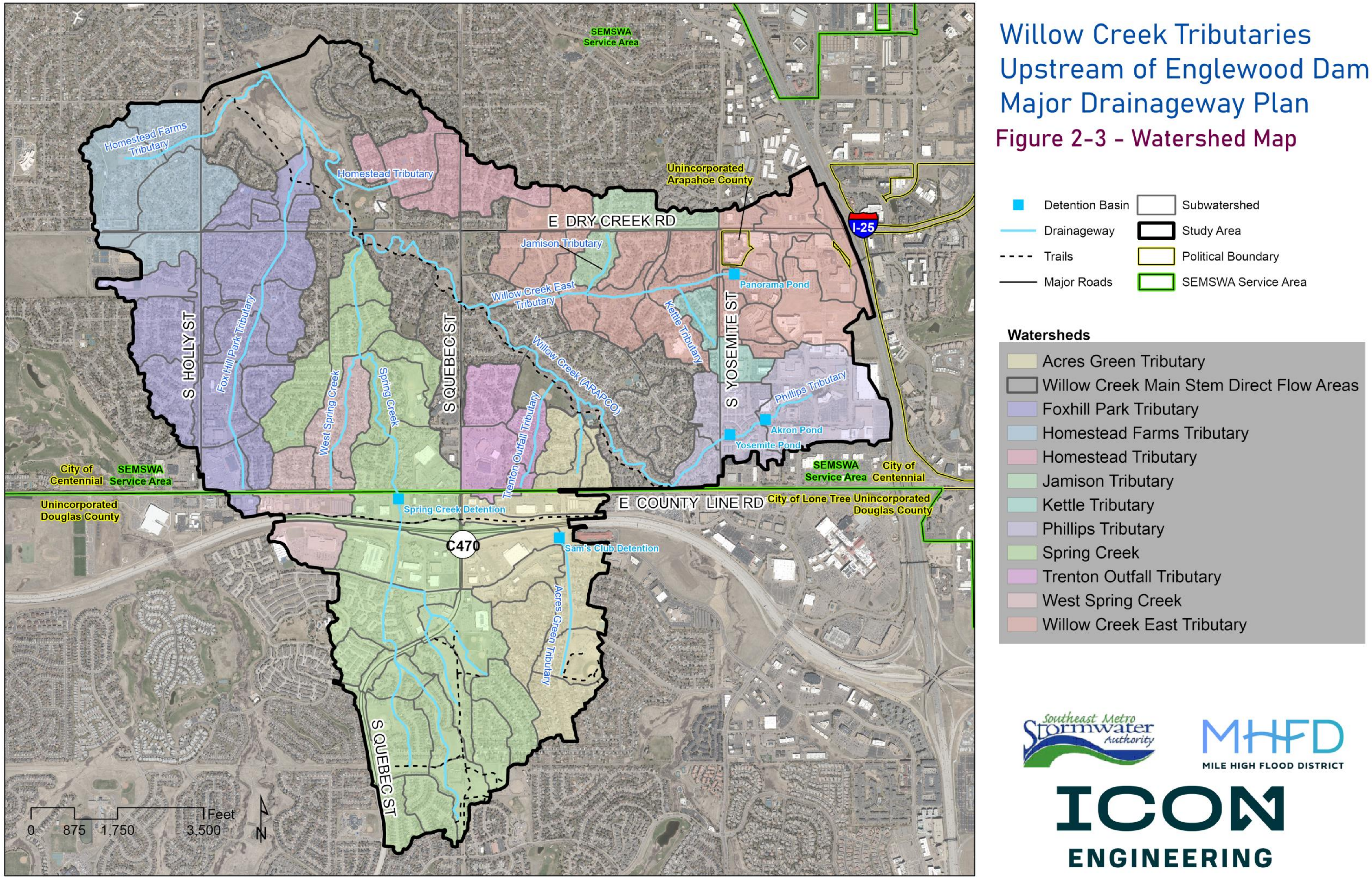


Figure 2-3: Watershed Map



3.0 HYDROLOGIC ANALYSIS

3.1 OVERVIEW

The updated hydrologic analysis presented in this FHAD report includes the full study area from the associated *Willow Creek Tributaries Upstream of Englewood Dam Baseline Hydrology Report* completed by ICON Engineering in 2020. Note that not all tributaries studied in the Baseline Hydrology Report were also included in the 2025 FHAD report.

A new hydrologic model was prepared for the tributaries of Willow Creek upstream of Englewood Dam. The model establishes hydrology for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year design storm frequencies. The Colorado Urban Hydrograph Procedure 2005 version 2.0.0 (CUHP) was used to develop runoff hydrographs for each subwatershed. Subwatershed hydrographs were then routed using the EPA Stormwater Management Model version 5.1.013 (SWMM) to determine discharges at each design point.

The study area was divided into 129 subwatersheds encompassing the 4.9 square mile study area. Subwatersheds were discretized to a more refined level than typical studies to assist the team in quantifying discharge into each tributary and to evaluate more frequent events, such as the annual and water quality events. Subwatersheds ranged in size from 3 acres to 160 acres, with an average size of 24 acres. Percent imperviousness ranged from 14.5 percent to 95.0 percent impervious.

Due to the level of subwatershed discretization, one minute time step between computations was utilized in CUHP.

In general, the hydrologic model included storm drain systems 30-inches, or greater, in diameter; however, exceptions for pipes smaller than 30-inches were made when the flow in the storm drain system diverted flow into a different flow path than the topographic street conveyance.

In addition to the flood frequency analysis to establish baseline conditions flows, historic, water quality, and annual event design flows were established with this study. The process used to calibrate the soil infiltration parameters and the results for the historic, water quality, and annual event can be found in Section 3.7.

3.2 DESIGN RAINFALL

One- and six-hour rainfall depths were obtained from the NOAA Atlas 14 Point Precipitation Frequency Data Server for each study and location within the project area. The point precipitation values for each design storm can be found in Table 3-1.

Storm duration and Depth Reduction Factors (DRFs) were chosen using Table 5-1 of the USCDM. A two-hour storm duration was applied with no reduced factor given that no contiguous watershed exceeded the threshold of two square miles.

Complete rainfall distributions are provided in Appendix B.

Table 3-1: NOAA 14 1- and 6-hour Rainfall Depth

Design Storm	NOAA 14	
Return Period	1-hr	6-hr
2	0.84	1.35
5	1.10	1.72
10	1.34	2.06
25	1.69	2.59
50	1.99	3.03
100	2.30	3.51
500	3.10	4.09

3.3 SUBWATERSHED CHARACTERISTICS

Subwatershed characteristics for each basin delineated as part of this study are further described below and can be found in Appendix B.

3.3.1 SUBWATERSHED DELINEATION

The overall study area was divided into 12 watersheds encompassing the 4.9 square mile basin. Each watershed was further discretized, totaling 129 subwatersheds. Each subwatershed was delineated using the project mapping as described in Section 1.4. Subwatersheds ranged in size from 3 acres to 160 acres, with an average size of 24 acres.

3.3.2 WATERSHED IMPERVIOUSNESS

Characterizations of subwatershed imperviousness were determined for future land use conditions. Given the extent of development already present in the basin, an existing conditions land use characterization was not included in this study.

Future conditions land use projections were determined from zoning data obtained from each jurisdiction. Impervious values for each Zoning classification were selected from Table 6-3 of USDCM (Reference 4). These values can be found in Table 3-4.

Imperviousness for each watershed was computed using the area weighted average of each land use type through GIS software. During review of the zoning data obtained from the local jurisdictions, it was observed the right-of-way was not included in a zoning designation. After discussion with project sponsors, increases in imperviousness were not made for the right-of-way areas and the adjacent zoning designation was used for the calculations.

Subwatersheds varied from 14.5 percent to 95.0 percent impervious.

Impervious values are shown for the watersheds on the impervious map in Appendix B.

3.3.3 LENGTH, CENTROID DISTANCE, SLOPE

CUHP parameters such as subwatershed length, distance to centroid, and slopes were derived for each subwatershed using the project mapping described in Section 1.4. Slopes were computed using the length-weighted, corrected average slope from Equation 6-7 and Figure 6-4 (USDCM). These equations can be found in Figure 3-1 and Figure 3-2.

$$S = \left[\frac{L_1 S_1^{\,0.24} + L_2 S_2^{\,0.24} + \ldots + L_n S_n^{\,0.24}}{L_1 + L_2 + L_3 \ldots L_n} \right]^{4.17} \qquad \text{Equation 6-7}$$

Where:

S = weighted basin waterway slopes in ft/ft

$S_1, S_2, \ldots S_n$ = slopes of individual reaches in ft/ft (after adjustments using Figure 6-4)

$L_1, L_2, \ldots L_n$ = lengths of corresponding reaches in ft.

Figure 3-1: Length Weighted, Corrected Average Slope Equation USDCM Equation 6-7 (Reference 4)

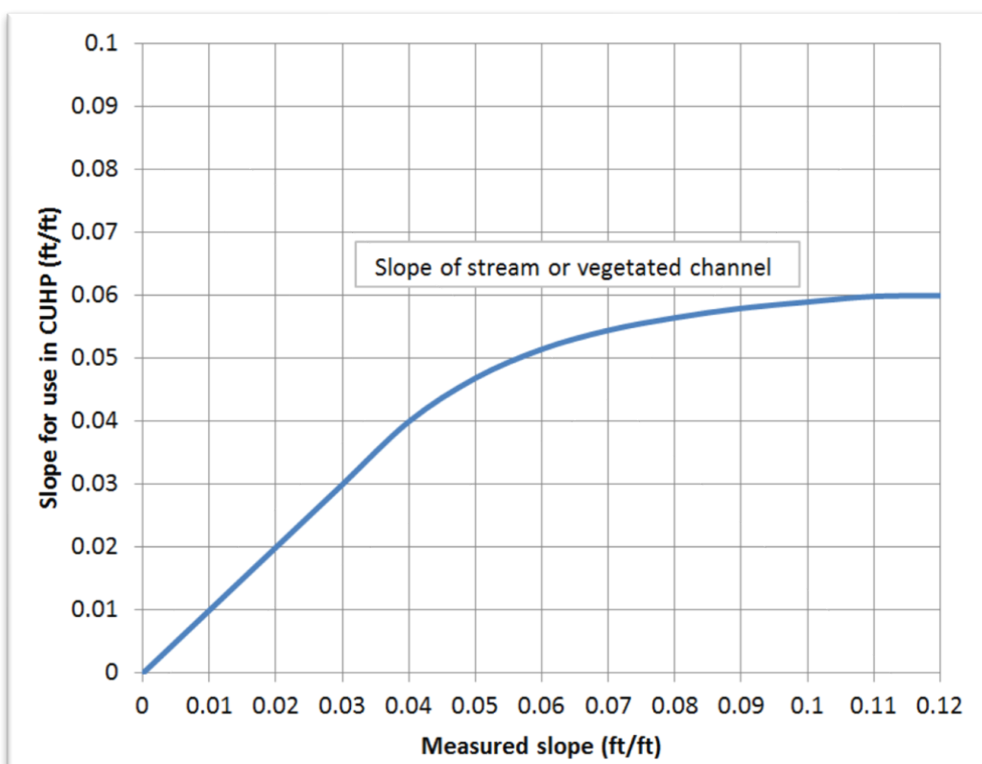


Figure 3-2: Slope correction for streams and vegetated channels USDCM Figure 6-4 (Reference 4)

3.3.4 DEPRESSION LOSSES

Depression storage loss was determined based on Table 6-6 from the USDCM (Reference 4). Aerial imagery was used to examine each subwatershed and apply the appropriate depression losses given the land use of the watershed. These values can be found in Table 3-2, below.

Table 3-2: Typical depression losses for various land covers - Table 6-6 of USDCM

Land Cover	Range in Depression Losses	Recommended
Impervious: Large paved areas	0.05 - 0.15	0.1
Impervious: Roofs - flat	0.1 - 3	0.1
Impervious: Roofs - sloped	0.05 - 0.1	0.05
Pervious: Lawn grass	0.2 - 0.5	0.35
Pervious: Wooded areas and open fields	0.2 - 0.6	0.4

3.3.5 INFILTRATION

Soil data was obtained from Natural Resources Conservation Service (NRCS) web soil survey (Reference 3). Each soil classification is assigned a map unit symbol based on the soil characteristics. Map unit symbols categorization is then summarized into one of the four major soil types ranging from Type A representing well-draining soils, to Type D representing poorly-draining soils. These soil types are each assigned parameters for use in Horton's infiltration equation. Horton's infiltration equation initially infiltrates a high amount of runoff early in the storm, eventually decaying to a steady state constant value. Horton's infiltration method was found to provide a balance between simplicity and a reasonable physical description of the infiltration process for CUHP (USDCM, Reference 4).

The basin predominately contains Type C and D soil, but areas of Type A and Type B soils are also present. USDCM (Reference 4) Table 6-7 provides Horton's infiltration parameters for each soil type. Soil parameters were averaged on an area weighted basis for subwatersheds that contained multiple soil types. Recommended Horton's equation parameters can be found in Table 3-3, below. The distribution of soil through the study area can be found on the interactive map in Appendix B.

Table 3-3: Recommended Horton's Equation Parameters - Table 6-7 of USDCM

NRCS Hydrologic Soil Group	Infiltration (inches per hour) Initial	Final	Decay Coefficient (1/sec)
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

Table 3-4: Future Land Use

Jurisdiction	Zoning Classification	Zoning Description	UDFCD Zoning Classification	Percent Impervious
Arapahoe County	MU	Mixed Use	Business - Suburban Areas	75
Centennial	BP100	Business Park - 100 ft. height	Business - Downtown Areas	95
	BP35	Business Park - 35 ft. height	Business - Downtown Areas	95
	BP50	Business Park - 50 ft. height	Business - Downtown Areas	95
	BP75	Business Park - 75 ft. height	Business - Downtown Areas	95
	CG	Commericial - General	Business - Suburban Areas	75
	ED	Education	Schools	55
	NC12	Neighborhood Conservation, 12,000 sf min.	Residential 0.25 - 0.75 Acres	30
	NC5	Neighborhood Conservation, 5,000 sf min.	Residential < 0.25 Acres	45
	NC6	Neighborhood Conservation, 6,000 sf min.	Residential < 0.25 Acres	45
	NC9	Neighborhood Conservation, 9,000 sf min.	Residential < 0.25 Acres	45
	NCMF	Neighborhood Conservation, Multifamily	Apartments	75
	NCSFA	Neighborhood Conservation, (Existing)	Townhomes	60 [1]
	NCSFA	Neighborhood Conservation, (Existing)	Apartments	75
	OSR	Open Space and Recreation	Parks	10
	PUD	Planned Unit Development	Business - Downtown Areas	95
	UC	Urban Center	Business - Suburban Areas	75
Douglas County	SR	Suburban Residential	Residential < 0.25 Acres	45
Lone Tree	C1	Commercial Subzone C1	Business - Suburban Areas	75
	C2	Commercial Subzone C2	Business - Suburban Areas	75
	C3	Commercial Subzone C3	Business - Suburban Areas	75
	C4	Commercial Subzone C4	Business - Suburban Areas	75
	Institutional / Civic	Insititutional District	Schools	55
	Lone Tree Town Center PD	Planned Development District	Mix	75
	Open Space	Open Space	Open Space	2
	SRM	Suburban Residential	Residential < 0.25 Acres	45

1 - Interpolated Value between Highest Density Residential and Apartments

2 - Zoning Classification and Percent Impervious per 2016 USDCM, Volume 1, Chapter 6, Table 6-3

3.4 HYDROGRAPH ROUTING

3.4.1 ROUGHNESS COEFFICIENT

Roughness coefficients (Manning's n) for pipes were increased by 25% to better represent modeling conditions per USDCM criteria when using EPA SWMM.

3.4.2 CONVEYANCE ELEMENTS

Various conduit types were utilized to convey subwatershed hydrographs to each design point. Closed circular conduits were assigned to storm drain information based on GIS data from each jurisdiction. Typical street cross sections were developed for various right-of-way widths.

Irregular trapezoidal channel elements with varying side slopes and base widths were used to represent open channel conveyance. Outlet offsets were used to adjust the channel slope to better represent the conveyance channel slope, removing the elevation change associated with drop structures from each conduit. Elevation change from drop structures were estimated from project mapping.

A SWMM routing schematic can be found on the interactive map, located in Appendix B.

3.4.3 DETENTION FACILITIES

Detention basins were accounted for peak flow reduction in the baseline hydrology model only if they were deemed hydrologically significant in size and met requirements of being publicly-owned or had a drainage easement and maintenance agreement in place. Numerous detention basins are present throughout the basin, but only four facilities met these requirements to be included in the baseline hydrology model. Stage versus storage curves were developed using project mapping. Stage outlet curves were developed using as-built plans, where available, and supplemented by field inspection.

3.5 PREVIOUS STUDIES

The effective hydrology for the study area from the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS), effective February 17 2017, was most recently updated with the completion of the 2010 OSP and FHAD. The study which encompassed the Willow Creek, Little Dry Creek, and Greenwood Gulch basins provided the 100-year discharges for the study area, including the only FEMA regulated floodplain along Spring Creek.

In 2018, to evaluate alternatives for repairing channel banks along West Spring Creek, Olsson Associates updated the hydrology developed as part of the 2010 OSP and FHAD. Although the improvements were limited to only West Spring Creek, the entire hydrologic model was updated to CUHP v.2.0. The 2018 study updated the rainfall to NOAA 14 point precipitation values and removed the Manning's 'n' calibration factors applied to the 2010 study to correlate back to the previous 1974 study. No subwatershed boundaries, or routing, was changed between 2010 and the 2018 update.

3.6 RESULTS OF ANALYSIS

A comparison of effective discharges, 2018 CUHP v.2.0 discharges, and the flows developed with this current study, at various design points throughout the basin can be found in Table 3-5.

Differences in hydrologic modeling methods can be observed comparing the 2018 update to the 2010 study. No changes were made to basin parameters or routing characteristics other than the update to CUHP v.2.0 in the 2018 update. In general, unit runoff compares favorable between the 2018 update and the current study. Differences in peak flows can be attributed to more refined subwatershed routing, differences in land use assumptions, and changes to subwatershed delineations. Notable differences were observed specifically along Phillips Tributary, at Yosemite Street and Willow Creek, along Homestead Tributary, and just downstream of Panorama Pond along Willow Creek East Tributary near Yosemite Street.

On Phillips Tributary, differences in peak flow are influenced by two detention facilities, the Yosemite and Akron Ponds, not included in the original study. In addition, the level of discretization in the current study, compared to the basins developed in the 2010 study, found portions of the watershed routed to Phillips Tributary in the original study not to actually be part of the watershed.

Basin discretization provided a higher level of detail on Homestead Tributary, where approximately 35% of the 2010 basin delineation was determined to be non-tributary to Homestead Tributary. These areas were included in the analysis as direct flow areas to Willow Creek.

At Panorama Pond, updated basin delineations and hydrologic routing determined portions of the subwatershed previously routed to the detention facility contributed flow directly downstream of the detention basin. Some areas previously contributing to Panorama Pond were also determined to be tributary to the Kettle Tributary, which confluences with Willow Creek East Tributary downstream of the Panorama Pond. At Yosemite Street, additional subwatersheds were determined to be tributary to Willow Creek East Tributary, but contributed flow to the tributary downstream of the basin that were previously routed to Panorama Pond.

A summary of peak flows at design points throughout each watershed can be found in Table 3-6 through Table 3-16. The locations of all key design points can be seen on Figure 3-4. Peak discharge and inflow volumes for each design point during all design storm frequencies for both existing and future land use conditions can be found in Appendix B.

Table 3-5: 100-yr Hydrology Reconciliation

		2010 OSP[2]			2018 CUHP 2.0 Update[3]			2024 MDP			Flow Comparison	
Location	SWMM Junction	Drainage Area (Ac.)	Discharge (cfs)	Unit Runoff (cfs / acre)	Drainage Area (Ac.)	Discharge (cfs)	Unit Runoff (cfs / acre)	Drainage Area (Ac.)	Discharge (cfs)	Unit Runoff (cfs / acre)	Effective vs. 2024 MDP	2018 CUHP 2.0 vs. 2024 MDP
Fox Hill at Willow Creek	FHP_O005	390	1140	2.92	390	820	2.10	373	794	2.13	-30%	-3%
Fox Hill at Kettle Dr.	FHP_J030	268	866	3.23	268	626	2.34	231	524	2.26	-40%	-16%
Spring Creek at Willow Creek [1]	SPC_O005	801	1603	2.00	801	1411	1.76	681	1211	1.78	-24%	-14%
Spring Creek at Confluence with West Spring Creek [1]	SPC_J020	711	1600	2.25	711	1333	1.87	570	1009	1.77	-37%	-24%
Spring Creek at County Line	SPC_S100	455	1260	2.77	455	900	1.98	475	1035	2.18	-18%	15%
Acres Green U/S of C-470	ACR_J055	115	404	3.51	115	305	2.65	186	237	1.27	-41%	-22%
Acres Green at Willow Creek	ACR_O005	313	1059	3.38	313	594	1.90	274	439	1.61	-59%	-26%
Phillips Tributary at Yosemite St. [1]	PHI_J015	154	730	4.74	154	488	3.17	136	273	2.01	-63%	-44%
Phillips Tributary at Willow Creek [1]	PHI_O005	256	730	2.85	256	488	1.91	169	302	1.79	-59%	-38%
Homestead Tributary	HOM_J005	122	387	3.17	122	282	2.31	98	158	1.62	-59%	-44%
Willow Creek East at Willow Creek [1]	WCE_O005	613	1454	2.37	613	920	1.50	495	818	1.65	-44%	-11%
Willow Creek East at Rosemary [1]	WCE_J015	409	1080	2.64	410	765	1.87	413	672	1.63	-38%	-12%
Willow Creek East at S Yosemite St [1]	WCE_J045	217	764	3.52	217	484	2.23	180	329	1.83	-57%	-32%

1 - Unit runoff affected by upstream detention

2 - Effective hydrology used CUHP v.1.3.1

3 - The 2018 study updated the 2010 OSP to CUHP v.2.0

Table 3-6: Hydrologic Results – Acres Green Tributary

Acres Green Tributary Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
ACR 01	Outfall into Willow Creek	ACR_O005	98	142	189	289	358	439	648
ACR 02	Upstream of E Phillips Cir	ACR_J010	84	121	162	246	305	375	557
ACR 03	Downstream E Phillips Cir	ACR_J035	76	110	148	226	281	345	517
ACR 04	Upstream of E County Line Rd	ACR_J045	76	110	148	226	281	345	522
ACR 05	Upstream of C-470	ACR_J055	45	68	95	151	190	237	346
ACR 06	Sam's Club Detention Basin	ACR_S100	54	76	100	148	182	222	315
ACR 07	Upstream of Apollo Ct	ACR_J075	44	67	94	149	188	234	341
ACR 08	Upstream of Maximus Dr	ACR_J080	26	40	55	87	110	136	198

Table 3-7: Hydrologic Results - Fox Hill Park Tributary

Fox Hill Park Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
FHP 01	Outfall into Willow Creek	FHP_O005	149	225	310	503	637	794	1220
FHP 02	Upstream of E Dry Creek Rd	FHP_J015	135	203	280	452	572	711	1033
FHP 03	Downstream of E Kettle Ave	FHP_J020	112	167	229	369	463	572	828
FHP 04	Upstream of E Kettle Ave	FHP_J035	60	89	120	189	235	289	416
FHP 05	Downstream of Fox Hill Park	FHP_J040	50	73	98	150	186	227	325
FHP 06	Upstream of E Otero Ave	FHP_J050	20	27	33	45	53	63	86
FHP 07	Downstream of E County Line Rd	FHP_J055	6	7	7	7	7	7	7
FHP 08	Storm Drain Flow in E Kettle Ave	FHP_J115	38	55	73	73	73	73	73
FHP 08	Street Flow in E Kettle Ave	FHP_J215	0	< 1	6	55	89	128	219

Table 3-8: Hydrologic Results - Homestead Tributary

Homestead Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
HOM 01	Outfall into Willow Creek	HOM_J005	38	61	81	128	147	158	204
HOM 02	Downstream of S Homestead Pkwy	HOM_J015	34	56	73	114	128	135	170
HOM 03	Storm Drain Flow at E Geddes Pl	HOM_L090	11	16	16	16	16	16	16
HOM 03	Surface Flow at E Geddes Pl	HOM_L090_OF	0	2	9	24	34	46	73
HOM 04	Storm Drain Flow North on S Newport Way	HOM_L045	20	31	42	62	62	62	62
HOM 04	Surface Flow South on S Newport Way	HOM_L045_OF	0	0	0	11	29	49	99
HOM 05	Storm Drain Flow at S Quebec St.	HOM_L090	11	16	16	16	16	16	16
HOM 05	Surface Flow at S Quebec St.	HOM_L090_OF	0	2	9	24	34	46	73

Table 3-9: Hydrologic Results - Homestead Farms Tributary

Homestead Farms Tributary Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
HFT 01	North Tributary Outfall	HFT_O010	28	48	85	170	222	285	433
HFT 02	North Tributary at S Holly St	HFT_J005	28	44	64	108	137	172	253
HFT 03	North Tributary at S Grape St	HFT_J010	16	27	39	68	87	109	161
HFT 04	South Tributary Outfall (Storm Drain)	HFT_O005	32	46	47	47	47	47	47
HFT 05	South Tributary Storm Drain Flow North on S Holly St	HFT_L145	12	17	23	35	43	51	51
HFT 05	South Tributary Surface Flow North on S Holly St	HFT_L145_OF	0	0	0	0	0	1	22

Table 3-10: Hydrologic Results - Jamison Tributary

Jamison Tributary Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
JAM 01	Outfall into Willow Creek	JAM_B005 & JAM_J005	24	36	50	78	97	120	173
JAM 02	Downstream of E Dry Creek Rd	JAM_J005	20	28	38	57	70	86	123

Table 3-11: Hydrologic Results - Kettle Tributary

Kettle Tributary Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
KET 01	Outfall into Willow Creek	KET_J005	31	43	56	76	93	112	157
KET 02	Upstream of E Kettle Cir	KET_J035	24	31	38	51	61	72	98

Table 3-12: Hydrologic Results - Phillips Tributary

Phillips Tributary Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
PHI 01	Outfall in Willow Creek	PHI_O005	83	126	155	211	243	302	574
PHI 02	Upstream of E Phillips Pl	PHI_J010	83	126	155	211	243	302	574
PHI 03	Downstream of S Yosemite St	PHI_J015	78	118	142	192	219	273	528
PHI 04	S Yosemite St Pond	PHI_S100	149	200	249	345	417	478	603
PHI 05	S Akron St Pond	PHI_S200	114	152	189	264	320	378	524

Table 3-13: Hydrologic Results - Spring Creek

Spring Creek Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
SPC 01	Outfall into Willow Creek	SPC_O005	275	363	459	810	1013	1211	1621
SPC 02	Drop Structure near E Jamison Ave	SPC_J005	275	364	459	810	1013	1212	1623
SPC 03	Downstream of E Mineral Ave	SPC_J010	266	351	441	788	982	1169	1554
SPC 04	Confluence with West Spring Creek	SPC_J020	238	306	377	707	866	1009	1284
SPC 05	Upstream of E Otero Ave	SPC_J030	165	200	232	539	625	687	802
SPC 06	Downstream of County Line Road	SPC_J035	146	179	209	494	561	614	692
SPC 07	Spring Creek Detention Basin	SPC_S100	199	290	400	656	830	1035	1495
SPC 08	Upstream of E-470	SPC_J040	147	225	321	545	695	869	1246
SPC 09	Business Center Dr	SPC_J055	108	172	252	438	561	707	1029
SPC 10	Upstream of S Quebec St	SPC_J115	26	45	70	129	168	214	321
SPC 11	Western crossing of Chestnut Hill St	SPC_J135	15	26	39	69	89	113	168
SPC 12	Eastern crossing of Chestnut Hill St	SPC_J125	7	14	22	42	55	71	107
SPC 13	Eastern Spring Creek Storm Drain	SPC_J220	42	67	96	163	207	259	378
SPC 14	Eastern Spring Creek at Quebec	SPC_J265	13	21	31	55	70	89	132
SPC 15	Eastern Spring Creek at Quebec	SPC_J250	13	21	29	47	60	74	108

Table 3-14: Hydrologic Results - Trenton Outfall Tributary

Trenton Outfall Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
TRE 01	Western Tributary Outfall	TRE_O010	33	47	63	93	116	142	201
TRE 02	Western Tributary Storm Drain at E Mineral Pl	TRE_L205	33	47	63	93	116	142	145
TRE 02	Western Tributary Surface Flow at E Mineral Pl	TRE_L205_OF	0	0	0	0	0	0	56
TRE 03	Western Tributary Storm Drain at E Phillips Cir	TRE_L225	24	34	44	63	77	93	105
TRE 03	Western Tributary Surface Flow at E Philips Cir	TRE_L225_OF	0	0	0	0	0	0	23
TRE 04	Eastern TributaryOutfall	TRE_O005	11	18	25	41	52	65	94
TRE 05	Upstream of E Phillips Cir	TRE_J030	11	18	25	41	52	65	94
TRE 06	Upstream of E Phillips Cir	TRE_J035	6	9	12	17	20	25	35
TRE 07	Upstream of E County Line Rd	TRE_J045	2	3	4	5	7	8	11

Table 3-15: Hydrologic Results - West Spring Creek

West Spring Creek Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
WSC 01	Outfall into Spring Creek	WSC_J005	66	96	129	196	244	296	392
WSC 02	Downstream of E Phillips Ave	WSC_J010	56	79	104	152	187	223	286
WSC 03	Upstream of E Phillips Ave	WSC_J020	49	68	89	128	157	186	232
WSC 04	Upstream of E County Line Rd	WSC_J030	25	35	44	61	73	82	82
WSC 05	Upstream of C-470	WSC_J050	26	35	44	61	74	89	123

Table 3-16: Hydrologic Results - Willow Creek East Tributary

Willow Creek East Tributary Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
WCE 01	Outfall into Willow Creek	WCE_O005	169	237	312	511	660	818	1312
WCE 02	Upstream S Rosemary Way	WCE_J015	144	197	255	430	549	672	1124
WCE 03	Confluence with Jamison Tributary	WCE_J020	141	192	247	418	534	651	1096
WCE 04	Downstream of S Willow Way	WCE_J025	107	139	174	316	394	476	858
WCE 05	Upstream of S Willow Way	WCE_J030	95	121	159	283	349	430	783
WCE 06	Confluence with Kettle Tributary	WCE_J040	86	106	146	252	315	386	708
WCE 07	Downstream of S Yosemite St	WCE_J045	56	79	128	207	234	329	605
WCE 08	Panorama Pond	WCE_S100	168	224	275	370	453	520	692
WCE 09	Downstream of E Panorama Dr	WCE_J064	140	186	228	307	381	440	596

3.7 WATER QUALITY, ANNUAL EVENT AND HISTORIC CONDITIONS MODELING

As development occurs, a watershed can undergo rapid changes of flow, sediment transport, geometry and vegetation. The largest increases in volume and peak discharge occur in the more frequent events that comprise the critical stream-forming flows (Reference 4).

To help mitigate these impacts, MHFD recommends incorporating a bankfull channel into stream restoration design. The bankfull channel is the transition point where flow spills into the floodplain terraces, transitioning between the processes of channel and floodplain formation. The discharge that correlates to the bankfull channel, known as the bankfull discharge, can be determined through several different methods.

To establish a bank full discharge several different approaches can be used, which can involve basing the design on a reference reach, an effective design, or based on a return period design storm. The bank full channel is not formed by a specific return period but rather a design flow corresponding to between a 1.5- to 2-year flow. With no gage records available in the project area to assist in evaluating the bank full discharge, hydrologic modeling was conducted as part of the study to develop a water quality, annual, and 2-year design storm scenario. A calibration process for these hydrologic scenarios refined the soil infiltration parameters from the soil parameters used in the typical flood frequency analysis. The calibration process, described in Section 3.7.2, calibrated the soil parameters such that runoff for each watershed began during the threshold event during historic land use conditions. Future conditions land use parameters were then applied to subwatersheds to produce the water quality, annual, and 2-year models.

Wright Water Engineers conducted a literature review of threshold events to determine an appropriate design storm recurrence interval. A summary of their findings can be found in Section 3.7.3, with the entirety of their literature review found in Appendix B.

3.7.1 HISTORIC CONDITIONS MODELING

Several basin parameters were adjusted from the baseline model to represent an undeveloped watershed in the historic conditions modeling. A percent imperviousness value of two percent, representing an undeveloped watershed, was assigned to all watersheds. Depression storage losses for pervious areas in wooden or open fields were assigned to all subwatersheds based on Table 3-2. Horton's Infiltration Parameters were calibrated, further described in Section 3.7, to produce runoff during the threshold event. All routing elements were adjusted to open channel conveyance elements.

Subwatershed delineations and design point locations were not modified as part of this hydrologic scenario. Boundaries and design points were held constant to provide consistent comparisons to the flood frequency analysis. All storage elements were removed from the SWMM model for the historic conditions modeling.

3.7.2 SOIL INFILTRATION PARAMETER CALIBRATION

Saturated hydraulic conductivity, the amount of water that will move through saturated soil, replaced typical Horton's Infiltration Parameter during the calibration process. Saturated hydraulic conductivity was obtained from the Web Soil Survey (Reference 3) for each soil group. Various soil depths, ranging from 0 to 24-inches in depth, were sampled from the Web Soil Survey to determine the most restrictive saturated hydraulic conductivity for each soil group. The area weighted average of the most restrictive saturated hydraulic conductivity for each soil group was computed using GIS software to determine the final infiltration rate for each sub watershed. Initial infiltration was assigned a starting value 25 percent higher than the final saturated conductivity. A decay coefficient corresponding to Type A soils was assigned to all subwatersheds. Soil infiltration parameters were calibrated on a subwatershed by subwatershed basis to produce runoff during the threshold event, described in Section 3.7.3, during the historic land use scenario. Future conditions land use was applied to each subwatershed with the calibrated soil parameters in the Water Quality and Annual Event modeling, as described in Section 3.7.6.

3.7.3 THRESHOLD RUNOFF

Threshold runoff is defined as "the amount of *effective* rainfall of a given duration falling over a watershed that is just enough to cause *bankfull* conditions at the outlet of the draining stream." (References 7, 8).

Initial soil moisture content (or soil moisture deficit) is the most critical factor relating the precipitation to threshold runoff because threshold runoff quantifies the saturated and unsaturated soil condition relationship to direct runoff during varying precipitation events. Several research papers and experiments studies address these hydrologic-hydraulic through experimental studies and modeling applications.

To summarize, threshold runoff is a one-time, physically-based calculation relating watershed characteristics (area, length, slope) to channel properties (bankfull channel width and depth) of a given drainage area. The influence of antecedent soil water content to flow frequency is significant when compared to other hydrologic and hydraulic parameters on threshold runoff estimates. A complete summary of these papers and study can be found in Appendix B.

The literature indicates much variability for threshold runoff based on watershed conditions, and unfortunately, a detailed study of this phenomena has not been conducted in the Denver region. Such a study could potentially be conducted for small watersheds in the metropolitan area using MHFD rainfall and stream gauges.

Absent a detailed study in Colorado, Wright Water Engineers (WWE) supplemented the literature review with some Curve Number calculations to determine typical initial abstractions for different types of land cover. Table 2 presents these results, found in Appendix B. For herbaceous cover in good condition, typical of what would be expected in the Willow Creek Basin, the initial abstraction for Hydrologic Soil Group C is approximately 0.7 inches. The initial abstraction is very similar to the 1-hour, 1-year depth from NOAA Atlas 14 in the study area, which is 0.68 inches. If more woody vegetation is present, the initial abstraction was somewhat higher.

This literature review and supplemental calculations, further described in Appendix B, indicate that threshold runoff is very sensitive to site-specific conditions, including vegetative cover, hydrologic conditions, soils, antecedent moisture, and other watershed characteristics. Detailed data is not available for Colorado, but based on studies in western states and calculations, it seems reasonable to assume a threshold for runoff around the 1-year event for short duration (1- to 3- hour storms) for native grasslands. WWE found similar results in their continuous simulation modeling of the Oak Gulch watershed in Parker, for MHFD. MHFD hopes to collect baseline data in the Oak Gulch watershed before the development is constructed to help verify a range of threshold runoff values for different antecedent conditions.

3.7.4 THRESHOLD RUNOFF CALIBRATION RESULTS

Watersheds within the study area experienced little to no reduction in peak flow rates or total runoff volume between the flood frequency soil infiltration parameters and the hydraulic conductivity calibration described in Section 3.7.2. The hydraulic conductivity of the predominant soil types, Renohill-Buick loams, Fondis-Colby silt loams, Fondis silt loam, Fondis clay loam, closely resemble the Type C and D Horton's Infiltration parameters assigned in the flood frequency analysis. In fact, the calibration process resulted in soil infiltration parameters that both exceeded and were less than the typical Horton's infiltration parameters. As an example, Fondis clay loams were found to infiltration 45 percent slower than typical Horton's infiltration parameters for Type C and D soils. From this perspective, hydraulic conductivity calibration may be more practical in watersheds containing a larger percentage of Type A or B soils, where differences in infiltration capacity and the benefits to flood reduction are much more noticeable. Regardless, the calibration exercise for the study area demonstrated a greater understanding of infiltration potential (or lack thereof) for future flood reduction and water quality recommendations in the master plan. With that said, moderate effects from the hydraulic conductivity calibration were noticeable for some watersheds. An example can be found in in Figure 3-3, where the calibration reduced both the peak discharge and total inflow volume for the Spring Creek Watershed at the outfall into Willow Creek. In addition to the slight reduction in peak discharge for the 2-year design event, the resulting hydrograph also displayed a slight decrease in the time to peak flow.

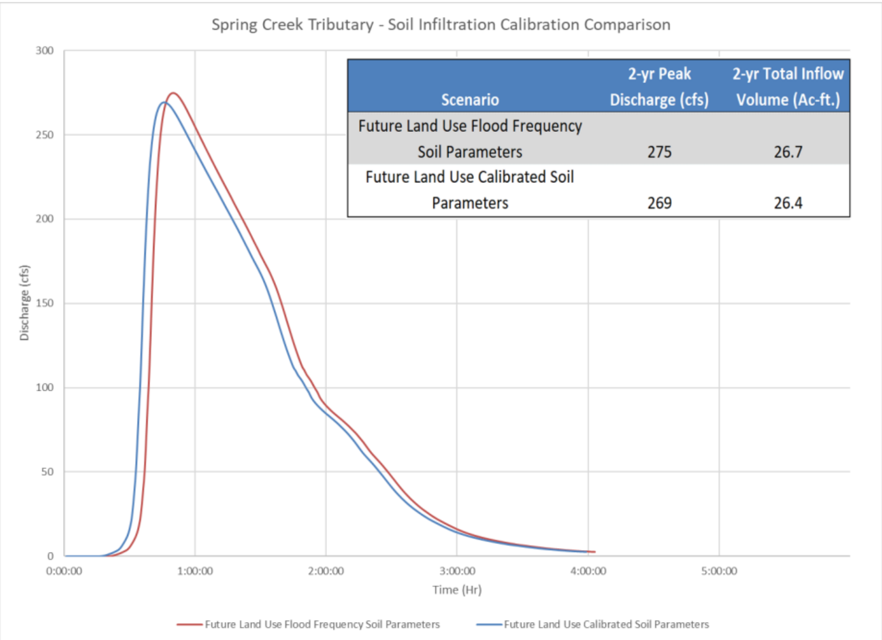


Figure 3-3: Soil Calibration Example

3.7.5 HISTORIC CONDITIONS RESULTS

Peak flows for the historic conditions modeling for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-yr events can be found in Table 3-17 through Table 3-27, below.

Table 3-17: Historic Conditions Results - Acres Green Tributary

Acres Green Tributary Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
ACR 01	Outfall into Willow Creek	ACR_O005	2	14	45	131	196	272	445
ACR 02	Upstream of E Phillips Cir	ACR_J010	2	11	38	115	173	241	397
ACR 03	Downstream E Phillips Cir	ACR_J035	1	9	35	108	163	229	378
ACR 04	Upstream of E County Line Rd	ACR_J045	1	9	35	108	163	229	378
ACR 05	Upstream of C-470	ACR_J055	1	7	27	88	136	191	318
ACR 06	Sam's Club Detention Basin	ACR_S100	< 1	4	15	42	63	87	142
ACR 07	Upstream of Apollo Ct	ACR_J075	< 1	3	12	46	74	106	179
ACR 08	Upstream of Maximus Dr	ACR_J080	< 1	3	9	29	45	63	104

Table 3-18: Historic Conditions Results - Fox Hill Park Tributary

Fox Hill Park Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
FHP 01	Outfall into Willow Creek	FHP_O005	3	20	63	185	277	387	637
FHP 02	Upstream of E Dry Creek Rd	FHP_J015	2	15	51	157	238	335	557
FHP 03	Downstream of E Kettle Ave	FHP_J020	2	14	49	138	204	281	457
FHP 04	Upstream of E Kettle Ave	FHP_J035	< 1	6	24	69	102	140	229
FHP 05	Downstream of Fox Hill Park	FHP_J040	< 1	6	20	54	80	109	177
FHP 06	Upstream of E Otero Ave	FHP_J050	< 1	3	8	17	25	32	51
FHP 07	Downstream of E County Line Rd	FHP_J055	< 1	1	3	6	8	10	16
FHP 08	Flow at E Kettle Ave	FHP_J115	< 1	3	14	44	66	94	155

Table 3-19: Historic Conditions Results - Homestead Tributary

Homestead Farms Tributary Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
HFT 01	North Tributary Outfall	HFT_O010	< 1	1	7	35	56	83	142
HFT 02	North Tributary at S Holly St	HFT_J005	< 1	1	7	35	56	83	142
HFT 03	North Tributary at S Grape St	HFT_J010	< 1	< 1	3	21	36	53	94
HFT 04	South Tributary Outfall	HFT_O005	< 1	4	12	34	50	71	116
HFT 05	South Tributary Flow North on S Holly St	HFT_L145	< 1	3	6	13	18	24	37

Table 3-20: Historic Conditions Results - Homestead Farms Tributary

Homestead Farms Tributary Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
HFT 01	North Tributary Outfall	HFT_O010	< 1	1	7	35	56	83	142
HFT 02	North Tributary at S Holly St	HFT_J005	< 1	1	7	35	56	83	142
HFT 03	North Tributary at S Grape St	HFT_J010	< 1	< 1	3	21	36	53	94
HFT 04	South Tributary Outfall	HFT_O005	< 1	4	12	34	50	71	116
HFT 05	South Tributary Flow North on S Holly St	HFT_L145	< 1	3	6	13	18	24	37

Table 3-21: Historic Condition Results - Jamison Tributary

Jamison Tributary Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
JAM 01	Outfall into Willow Creek	JAM_B005 & JAM_J005	< 1	2	9	26	39	54	90
JAM 02	Downstream of E Dry Creek Rd	JAM_J005	< 1	< 1	4	14	23	33	55

Table 3-22: Historic Conditions Results - Kettle Tributary

Kettle Tributary Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
KET 01	Outfall into Willow Creek	KET_J005	< 1	4	11	26	36	48	76
KET 02	Upstream of E Kettle Cir	KET_J035	< 1	3	6	14	20	27	42

Table 3-23: Historic Conditions Results - Phillips Tributary

Phillips Tributary Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
PHI 01	Outfall in Willow Creek	PHI_O005	2	8	16	79	129	187	322
PHI 02	Upstream of E Phillips Pl	PHI_J010	2	8	16	79	129	187	322
PHI 03	Downstream of S Yosemite St	PHI_J015	2	5	10	67	112	164	287
PHI 04	S Yosemite St Pond	PHI_S100	1	2	6	59	102	151	267
PHI 05	S Akron St Pond	PHI_S200	< 1	2	3	42	74	111	199

Table 3-24: Historic Condition Results - Spring Creek

Spring Creek Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
SPC 01	Outfall into Willow Creek	SPC_O005	4	27	98	352	558	809	1377
SPC 02	Drop Structure near E Jamison Ave	SPC_J005	4	27	98	352	558	809	1377
SPC 03	Downstream of E Mineral Ave	SPC_J010	4	27	96	344	544	789	1342
SPC 04	Confluence with West Spring Creek	SPC_J020	4	25	87	309	489	708	1205
SPC 05	Upstream of E Otero Ave	SPC_J030	3	23	70	243	385	558	952
SPC 06	Downstream of County Line Road	SPC_J035	3	22	69	227	353	505	851
SPC 07	Spring Creek Detention Basin	SPC_S100	3	22	69	227	353	505	851
SPC 08	Upstream of E-470	SPC_J040	3	22	66	212	329	469	790
SPC 09	Business Center Dr	SPC_J055	3	22	61	186	282	397	662
SPC 10	Upstream of S Quebec St	SPC_J115	< 1	7	22	67	101	141	232
SPC 11	Western crossing of Chestnut Hill St	SPC_J135	< 1	< 1	4	24	40	59	103
SPC 12	Eastern crossing of Chestnut Hill St	SPC_J125	< 1	4	12	29	42	56	89
SPC 13	Eastern Spring Creek Storm Drain	SPC_J220	< 1	8	26	70	103	142	230
SPC 14	Eastern Spring Creek at Quebec	SPC_J265	< 1	7	15	34	47	62	97
SPC 15	Eastern Spring Creek at Quebec	SPC_J250	< 1	1	7	19	27	38	61

Table 3-25: Historic Condition Results - Trenton Outfall Tributary

Trenton Outfall Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
TRE 01	Western Tributary Outfall	TRE_O010	< 1	4	12	31	45	61	99
TRE 02	Western Tributary Flow at E Mineral Pl	TRE_L205	< 1	4	12	31	45	61	99
TRE 03	Western Tributary Flow at E Phillips Cir	TRE_L225	< 1	< 1	5	15	23	32	54
TRE 04	Eastern TributaryOutfall	TRE_O005	< 1	4	9	21	30	39	61
TRE 05	Upstream of E Phillips Cir	TRE_J030	< 1	4	9	21	30	39	61
TRE 06	Upstream of E Phillips Cir	TRE_J035	< 1	3	4	8	10	13	19
TRE 07	Upstream of E County Line Rd	TRE_J045	< 1	< 1	1	2	3	3	5

Table 3-26: Historic Conditions Results - West Spring Creek

West Spring Creek Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
WSC 01	Outfall into Spring Creek	WSC_J005	< 1	4	18	56	86	121	200
WSC 02	Downstream of E Phillips Ave	WSC_J010	< 1	3	14	41	61	85	138
WSC 03	Upstream of E Phillips Ave	WSC_J020	< 1	2	10	31	46	65	107
WSC 04	Upstream of E County Line Rd	WSC_J030	< 1	< 1	4	14	22	30	51
WSC 05	Upstream of C-470	WSC_J050	< 1	< 1	4	14	22	31	51

Table 3-27: Historic Conditions Results - Willow Creek East Tributary

Willow Creek East Tributary Watershed Peak Flow Results (cfs)									
Figure ID	Location	SWMM Node	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
WCE 01	Outfall into Willow Creek	WCE_O005	3	29	89	252	370	510	827
WCE 02	Upstream S Rosemary Way	WCE_J015	3	24	75	210	310	426	692
WCE 03	Confluence with Jamison Tributary	WCE_J020	3	23	72	203	300	413	670
WCE 04	Downstream of S Willow Way	WCE_J025	2	19	57	157	230	316	510
WCE 05	Upstream of S Willow Way	WCE_J030	2	17	52	143	209	287	463
WCE 06	Confluence with Kettle Tributary	WCE_J040	2	14	44	123	181	249	405
WCE 07	Downstream of S Yosemite St	WCE_J045	2	10	35	99	147	203	331
WCE 08	Panorama Pond	WCE_S001	1	6	26	80	120	169	278
WCE 09	Downstream of E Panorama Dr	WCE_J064	1	6	23	68	101	141	232

3.7.6 WQ AND ANNUAL EVENT MODEL

The Water Quality Capture Volume (WQCV) event, the 80th percentile storm event, is an event with a total rainfall depth of 0.6 inches in the Denver region (Reference 4). To produce a CUHP 2-hr rainfall distribution equating to 0.6 inches of rainfall, a modified 1-hour point rainfall depth of 0.519 inches was developed to represent the WQCV storm. NOAA 14 point precipitation for the 1-hour and 6-hour storms were obtained for annual and 2-year event with no adjustments. Rainfall values used for each return occurrence interval can be found in Table 3-28, below.

Table 3-28: WQ, Annual, 2-yr NOAA 14 Rainfall

Design Storm Return Period	NOAA 14 1-hr	NOAA 14 6-hr
WQ	0.519 [1]	--
Annual	0.693	1.140
2-yr	0.842	1.350

1 - 1-hr point rainfall to equate to CUHP distribution of 0.6 in event

Future land use projections were applied to the historic condition model with the soil infiltration parameters calibrated to the threshold event described in Section 3.7.2. Depression storage losses were spatially assigned to reflect future land use similar to the flood frequency analysis using Table 3-2.

The baseline hydrology model, a combination of storm drain and surface routing elements was used for the water quality and annual event modeling. No adjustments to subwatershed delineations or location of SWMM design points and routing element were made to the baseline model.

3.7.7 WQ AND ANNUAL EVENT MODEL RESULTS

Peak flows for the water quality, annual event, and 2-year design storm for each design point are presented in Table 3-29 through Table 3-39, below.

Table 3-29: WQ & Annual Results - Acres Green Tributary

Acres Green Tributary Watershed Peak Flow Results (cfs)					
Figure ID	Location	SWMM Node	WQ	Annual	2-yr
ACR 01	Outfall into Willow Creek	ACR_O005	51	75	99
ACR 02	Upstream of E Phillips Cir	ACR_J010	43	63	83
ACR 03	Downstream E Phillips Cir	ACR_J035	39	56	75
ACR 04	Upstream of E County Line Rd	ACR_J045	39	56	75
ACR 05	Upstream of C-470	ACR_J055	22	31	43
ACR 06	Sam's Club Detention Basin	ACR_S100	28	41	54
ACR 07	Upstream of Apollo Ct	ACR_J075	22	31	42
ACR 08	Upstream of Maximus Dr	ACR_J080	13	19	26

Table 3-30: WQ & Annual Results - Fox Hill Park Tributary

Fox Hill Park Watershed Peak Flow Results (cfs)					
Figure ID	Location	SWMM Node	WQ	Annual	2-yr
FHP 01	Outfall into Willow Creek	FHP_O005	72	114	149
FHP 02	Upstream of E Dry Creek Rd	FHP_J015	65	102	134
FHP 03	Downstream of E Kettle Ave	FHP_J020	54	85	113
FHP 04	Upstream of E Kettle Ave	FHP_J035	29	46	60
FHP 05	Downstream of Fox Hill Park	FHP_J040	25	39	50
FHP 06	Upstream of E Otero Ave	FHP_J050	10	16	20
FHP 07	Downstream of E County Line Rd	FHP_J055	3	5	6
FHP 08	Storm Drain Flow in E Kettle Ave	FHP_J115	19	28	37
FHP 08	Street Flow in E Kettle Ave	FHP_J215	0	0	0

Table 3-31: WQ & Annual Results - Homestead Tributary

Homestead Watershed Peak Flow Results (cfs)					
Figure ID	Location	SWMM Node	WQ	Annual	2-yr
HOM 01	Outfall into Willow Creek	HOM_J005	19	28	38
HOM 02	Downstream of S Homestead Pkwy	HOM_J015	17	25	33
HOM 03	Storm Drain Flow at E Geddes Pl	HOM_L090	6	8	11
HOM 03	Surface Flow at E Geddes Pl	HOM_L090_OF	0	0	0
HOM 04	Storm Drain Flow North on S Newport Way	HOM_L045	10	15	20
HOM 04	Surface Flow South on S Newport Way	HOM_L045_OF	0	0	0
HOM 05	Storm Drain Flow at S Quebec St.	HOM_L090	6	8	11
HOM 05	Surface Flow at S Quebec St.	HOM_L090_OF	0	0	0

Table 3-32: WQ & Annual Results - Homestead Farms Tributary

Homestead Farms Tributary Watershed Peak Flow Results (cfs)					
Figure ID	Location	SWMM Node	WQ	Annual	2-yr
HFT 01	North Tributary Outfall	HFT_O010	12	18	26
HFT 02	North Tributary at S Holly St	HFT_J005	12	18	26
HFT 03	North Tributary at S Grape St	HFT_J010	7	10	14
HFT 04	South Tributary Outfall (Storm Drain)	HFT_O005	16	24	32
HFT 05	South Tributary Storm Drain Flow North on S Holly St	HFT_L145	7	10	13
HFT 05	South Tributary Surface Flow North on S Holly St	HFT_L145_OF	0	0	0

Table 3-33: WQ & Annual Results - Jamison Tributary

Jamison Tributary Watershed Peak Flow Results (cfs)					
Figure ID	Location	SWMM Node	WQ	Annual	2-yr
JAM 01	Outfall into Willow Creek	JAM_J005 & JAM_B005	12	18	24
JAM 02	Downstream of E Dry Creek Rd	JAM_J005	10	14	19

Table 3-34: WQ & Annual Results - Kettle Tributary

Kettle Tributary Watershed Peak Flow Results (cfs)					
Figure ID	Location	SWMM Node	WQ	Annual	2-yr
KET 01	Outfall into Willow Creek	KET_J005	17	24	31
KET 02	Upstream of E Kettle Cir	KET_J035	13	19	24

Table 3-35: WQ & Annual Results - Phillips Tributary

Phillips Tributary Watershed Peak Flow Results (cfs)					
Figure ID	Location	SWMM Node	WQ	Annual	2-yr
PHI 01	Outfall in Willow Creek	PHI_O005	34	64	83
PHI 02	Upstream of E Phillips Pl	PHI_J010	34	64	83
PHI 03	Downstream of S Yosemite St	PHI_J015	32	59	77
PHI 04	S Yosemite St Pond	PHI_S100	81	114	147
PHI 05	S Akron St Pond	PHI_S200	63	88	113

Table 3-36: WQ & Annual Results - Spring Creek

Spring Creek Watershed Peak Flow Results (cfs)					
Figure ID	Location	SWMM Node	WQ	Annual	2-yr
SPC 01	Outfall into Willow Creek	SPC_O005	161	227	269
SPC 02	Drop Structure near E Jamison Ave	SPC_J005	161	227	270
SPC 03	Downstream of E Mineral Ave	SPC_J010	157	221	261
SPC 04	Confluence with West Spring Creek	SPC_J020	145	200	234
SPC 05	Upstream of E Otero Ave	SPC_J030	107	145	163
SPC 06	Downstream of County Line Road	SPC_J035	95	127	145
SPC 07	Spring Creek Detention Basin	SPC_S100	101	149	196
SPC 08	Upstream of E-470	SPC_J040	69	109	145
SPC 09	Business Center Dr	SPC_J055	49	80	107
SPC 10	Upstream of S Quebec St	SPC_J115	10	19	26
SPC 11	Western crossing of Chestnut Hill St	SPC_J135	6	10	14
SPC 12	Eastern crossing of Chestnut Hill St	SPC_J125	3	6	8
SPC 13	Eastern Spring Creek Storm Drain	SPC_J220	20	32	43
SPC 14	Eastern Spring Creek at Quebec	SPC_J265	6	10	14
SPC 15	Eastern Spring Creek at Quebec	SPC_J250	6	10	13

Table 3-37: WQ & Annual Results - Trenton Outfall Tributary

Trenton Outfall Watershed Peak Flow Results (cfs)					
Figure ID	Location	SWMM Node	WQ	Annual	2-yr
TRE 01	Western Tributary Outfall	TRE_O010	17	25	33
TRE 02	Western Tributary Storm Drain at E Mineral Pl	TRE_L205	17	25	33
TRE 02	Western Tributary Surface Flow at E Mineral Pl	TRE_L205_OF	0	0	0
TRE 03	Western Tributary Storm Drain at E Phillips Cir	TRE_L225	13	18	24
TRE 03	Western Tributary Surface Flow at E Philips Cir	TRE_L225_OF	0	0	0
TRE 04	Eastern TributaryOutfall	TRE_O005	6	9	12
TRE 05	Upstream of E Phillips Cir	TRE_J030	6	9	12
TRE 06	Upstream of E Phillips Cir	TRE_J035	4	5	7
TRE 07	Upstream of E County Line Rd	TRE_J045	1	2	2

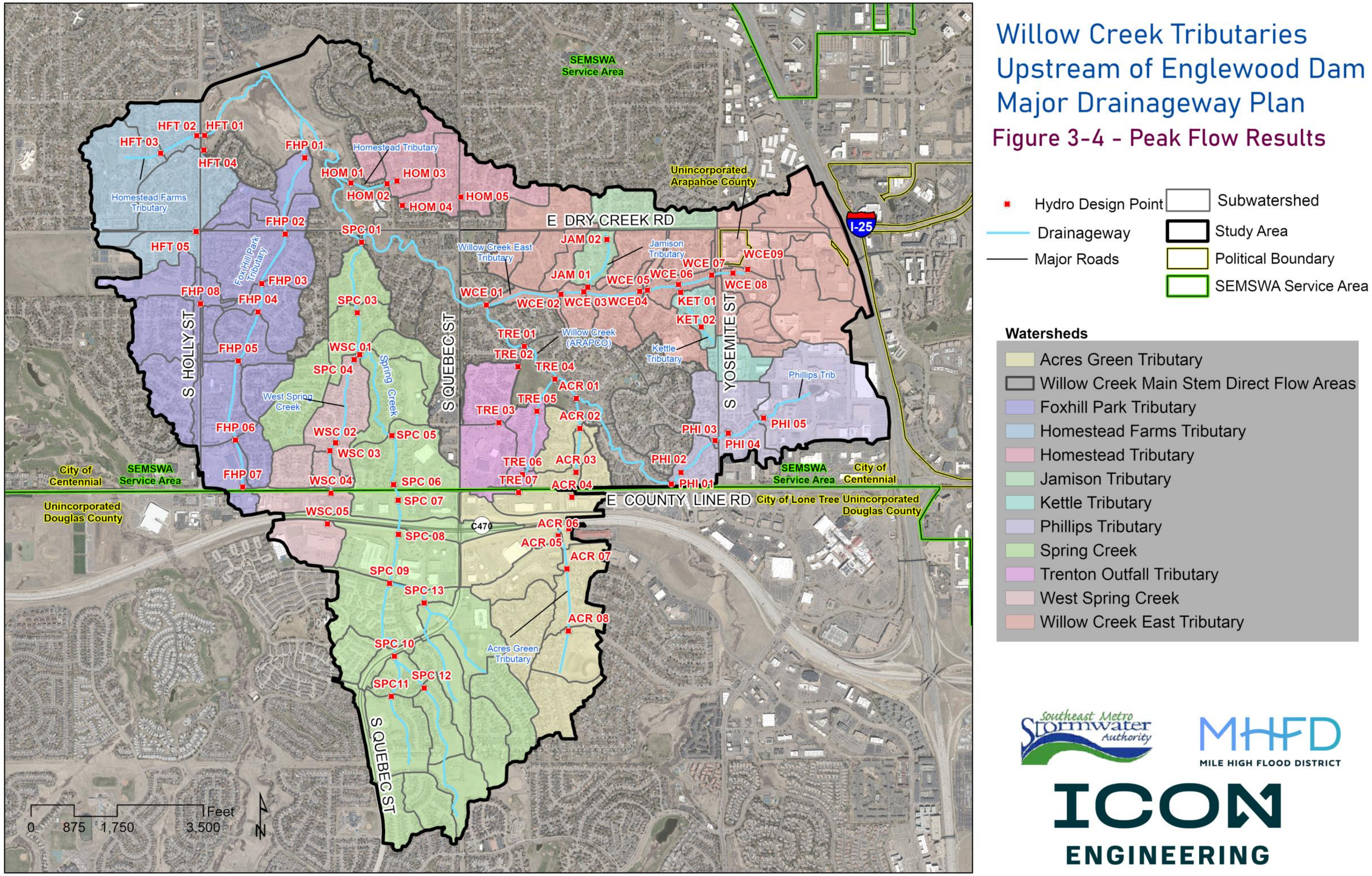
Table 3-38: WQ & Annual Results - West Spring Creek

West Spring Creek Watershed Peak Flow Results (cfs)					
Figure ID	Location	SWMM Node	WQ	Annual	2-yr
WSC 01	Outfall into Spring Creek	WSC_J005	33	50	65
WSC 02	Downstream of E Phillips Ave	WSC_J010	29	43	56
WSC 03	Upstream of E Phillips Ave	WSC_J020	26	37	48
WSC 04	Upstream of E County Line Rd	WSC_J030	14	19	25
WSC 05	Upstream of C-470	WSC_J050	14	19	25

Table 3-39: WQ & Annual Results - Willow Creek East Tributary

Willow Creek East Tributary Watershed Peak Flow Results (cfs)					
Figure ID	Location	SWMM Node	WQ	Annual	2-yr
WCE 01	Outfall into Willow Creek	WCE_O005	97	139	172
WCE 02	Upstream S Rosemary Way	WCE_J015	85	119	145
WCE 03	Confluence with Jamison Tributary	WCE_J020	84	116	142
WCE 04	Downstream of S Willow Way	WCE_J025	68	90	108
WCE 05	Upstream of S Willow Way	WCE_J030	62	81	96
WCE 06	Confluence with Kettle Tributary	WCE_J040	58	74	87
WCE 07	Downstream of S Yosemite St	WCE_J045	43	50	56
WCE 08	Panorama Pond	WCE_S100	92	133	169
WCE 09	Downstream of E Panorama Dr	WCE_J064	76	110	140

Figure 3-4: Watershed Peak Flow Results



4.0 HYDRAULIC ANALYSIS

4.1 FHAD OVERVIEW

A Flood Hazard Area Delineation (FHAD) has been completed for select tributaries to Willow Creek upstream of the Englewood Dam. The purpose of the FHAD is to evaluate existing conditions topography and infrastructure with future conditions hydrology to identify areas, structures, and property which have the potential of being inundated in flood events. In addition to mapping potential inundation zones, floodways have been defined along the modeled tributaries to Willow Creek within the study area.

Flood hazard analysis has previously been performed on the main stem of Willow Creek, with the most recent study being the *Willow Creek FHAD* by CH2M Hill (2010). Previous detailed study for the tributaries to Willow Creek within this project's study area has only been performed for a portion of Spring Creek (*Little Dry Creek MDP*, 1974).

The existing drainageways within the study area primarily consist of native grasses & vegetation or manicured blue grass channel banks with natural channel bottoms. Stream segments with grouted riprap or concrete low flow channels are common as well. The reaches studied also feature concrete weir & grouted boulder structures for grade control and energy dissipation.

4.2 EXISTING CONDITIONS EVALUATION

The tributaries to Willow Creek included in this FHAD study were determined by the project sponsors. Detailed hydraulic analysis was performed for portions of Fox Hill Park Tributary, Spring Creek, Acres Green Tributary, Phillips Tributary, and Willow Creek East Tributary. All tributaries included in the FHAD are located within the SEMSWA service area (City of Centennial and Unincorporated Arapahoe County) with the exception of Spring Creek and Acres Green Tributary which extend south into Douglas County. Detailed Modeling Notes Memos for each tributary are provided in Appendix C. A brief summary of the selected study reaches is provided below.

- *Fox Hill Park Tributary* modeled extents begin at the Willow Creek Open Space at the downstream terminus and extend approximately 5,150 feet upstream to S. Jasmine Circle, approximately 1,400 ft downstream of E. Otero Avenue. The tributary is characterized by a primarily natural channel bottom and with blue grass the banks. The channel also consists of short segments of grouted boulders at drop structures.
- *Spring Creek* modeled extents begin just upstream of E. Dry Creek Road and extend approximately 7,800 feet upstream to Business Center Drive. The tributary is characterized by a primarily natural channel bottom and with native vegetation on the banks. The channel contains short segments of grouted boulders at drop structures.
- *Acres Green Tributary* modeled extents begin at Willow Creek Park at the confluence with Willow Creek and extend approximately 1,600 feet upstream to E. Phillips Circle (southern crossing). The tributary is characterized by a natural channel bottom with native vegetation on the banks downstream of E. Phillips Circle (northern crossing). Upstream of E. Phillips Circle (northern crossing), the channel invert consists of concrete and grouted riprap with manicured blue grass banks.
- *Phillips Tributary* modeled extents begin at the confluence with Willow Creek downstream of E. Phillips Place and extend approximately 1,350 feet upstream to S. Yosemite Street. The tributary is characterized by a natural channel bottom with manicured blue grass banks. The channel contains short segments of grouted boulders at drop structures.
- *Willow Creek East Tributary* modeled extents begin at the confluence with Willow Creek downstream of S. Rosemary Way and extend approximately 5,550 feet upstream to E. Panorama Drive. The tributary is primarily characterized by a natural channel bottom with blue grass banks. Segments of grouted boulders exist at roadway crossings and just downstream of concrete weir-style drop structures.

4.2.1 DEVELOPMENT OF HEC-RAS MODEL

Water surface elevations were determined using the U.S. Army Corps of Engineer's step backwater program HEC-RAS, version 6.4.1. Cross-section data was developed from 2013 FEMA Post-Flood LiDAR mapping and filtered to reduce the number of points in each cross-section. Crossing structures with pipe diameters less than 18-inches were not modeled. All tributaries were modeled with a normal flow depth boundary condition at the downstream end. The updated flow rates utilized in the hydraulic analysis are documented in Section 3.0 of this report. Flood frequencies of 10-, 25-, 50-, 100-, and 500-year were modeled. No two-dimensional (2D) hydraulic modeling was utilized for the FHAD study.

4.2.2 MANNING'S N-VALUES

The Manning's roughness values were determined based on aerial imagery and field observations. Table 4-1 shows typical Manning's roughness values utilized in the models.

Table 4-1: Manning's Roughness Coefficients

Land Cover	Manning's n Values
Channel Areas:	
Grouted Rock/Boulders	0.035
Manicured Blue Grass	0.040
Native Grasses	0.045
Willows and Non-woody Vegetation	0.060
Dense Trees	0.080
Overbanks:	
Blue Grass/Park Areas	0.045
Native Grasses	0.055
Low Density Trees	0.060
Dense Trees	0.080
Private Property & Closed Privacy Fences	0.100

4.2.3 ADVERSE SLOPES

Channel inverts were set according to the LiDAR topography; however, adjustments were made to correct adverse slopes at structures and crossings (per the structure survey) and at instances of "extreme" adverse slope. In the meeting between ICON and MHFD on November 14, 2022, it was determined that a majority of the adverse slope cases were acceptable as they would not impact the 100-year water surface profile. As such, "extreme" cases of adverse slope are defined as locations where the downstream invert is higher than the upstream invert by 1 foot or more. Cross-sections with extreme cases of adverse slope were adjusted by interpolating the corresponding invert(s) between two sections with a positive slope. Additionally, engineering judgement was used to modify the low flow channel geometry in order to accommodate the lowered invert. The cross sections where channel invert has been adjusted are documented in the Modeling Notes Memorandums for each tributary, provided in Appendix C.

4.2.4 INEFFECTIVE FLOW AREAS & BLOCKED OBSTRUCTIONS

Ineffective flow areas were set following the HEC-RAS User Manual guidance at all modeled crossings to remove zones of expansion and contraction from being included as active conveyance. Additionally, non-permanent ineffective flow areas were set along Fox Hill Park Tributary (Sections 2919 and 4746) and Willow Creek East Tributary (Sections 39 – 307) to remove low lying areas adjacent to the main channel from the active flow conveyance. Note that all ineffective flow areas were included in the mapped floodplain.

4.2.5 PONDS & SET WATER SURFACE ELEVATIONS

Set water surface elevations were applied where in-line detention facilities with outlet structures controlled the water surface elevation. Such peak water surface elevations were determined from the corresponding SWMM models for each tributary, as documented in Section 3.0 and Appendix B. Known water surface elevations were set in the Steady Flow files for Spring Creek (XS 6200, Spring Creek Detention Basin) and Willow Creek East Tributary (XS 5220, Panorama Pond).

4.2.6 FLOODWAY ENCROACHMENT ANALYSIS

Based on guidance from project sponsors, encroachments were primarily applied as to only include areas of meaningful active conveyance within the floodway. Otherwise, the floodway was set equivalent to the 100-year floodplain. For areas with set encroachments, the 0.5-foot regulatory floodway was established predominately using Encroachment Method 4 and then converting to Encroachment Method 1. Method 4 encroachment provides an equal loss of conveyance in the cross-section overbanks to achieve a target change in water surface elevation and the resulting energy grade line. In areas where the Method 4 encroachment resulted in floodway surcharges outside of the allowable change in water surface and energy grade elevations, or negative floodway surcharges occurred, either no encroachment or a Method 1 encroachment option was utilized to set floodway equal to 100-year floodplain. For Method 1 encroachment, the exact location of the floodway stationing was defined manually. The floodway left and right widths are measured from the channel stationing line which correlates approximately to the centerline of the channel. Pertinent floodway data is displayed in Appendix C.

4.3 FLOOD HAZARDS

The majority of the 100-year FHAD floodplains delineated for the Willow Creek Tributaries are located on either SSPRD or Homeowners Association (HOA) property. The 100-year FHAD floodplain is predominately contained within the channel corridor throughout the project extents. Street flooding resulting from channel conveyance or capacity issues is minimal. Flooding instances are largely contained to crossing locations where overtopping flows re-enter the channel immediately downstream, rather than spreading laterally or diverting. There are no insurable structures in the 100-year floodplain as a result of this study. The 100-year and 500-year FHAD water surface elevations are presented in Appendix D and delineations can be viewed on the flood hazard figures in Appendix E.

A comparison of the FHAD floodplain to the effective FEMA floodplain can only be made along Spring Creek, where an effective FEMA product exists. For Spring Creek, the FHAD and effective FEMA 100-year floodplains are similar while the FHAD 500-yr floodplain is slightly narrower than the effective FEMA 500-year floodplain, in general. The main differences are observed at the street crossings. In the FHAD, the E. Mineral Ave crossing does not overtop in 100-year event and the E. Otero Ave crossing does not overtop in the 500-year event whereas both crossings overtop in the respective flood event according to the effective FEMA mapping.

4.3.1 EVALUATION OF EXISTING HYDRAULIC STRUCTURES

The performance of modeled existing crossings, including the return interval of the overtopping event as well as overtopping elevation & depth, are summarized in Table 4-2 below. There are a total of 27 crossing structures in the FHAD models, including 16 culverts and 11 bridges. The capacity of these crossing structures is defined by the largest event that can be conveyed without overtopping the existing roadway or walking surface according to the HEC-RAS model results. See Appendix F for HEC-RAS profiles for all modeled structures.

Table 4-2: Modeled Crossing Capacity *

Flooding Source	Street/Location	Type/Size	River Station	Survey Crossing Number	Estimated Capacity	Overtopping Elevation	Over Topping Depth (ft)			
							10-YR	50-YR	100-YR	500-YR
Acres Green Tributary	Pedestrian Bridge - Approx. 330' Upstream of Confluence with Willow Creek Main	Bridge	346	28	500-YR	5689.8	-	-	-	-
Acres Green Tributary	E Phillips Circle	72" Diameter RCP	664	27	100-YR	5695.91	-	-	-	0.71
Fox Hill Park Tributary	Willow Creek Trail - Approx. 1000' Downstream of Dry Creek Rd	30" Diameter	970	6	<10-YR	5595.53	2.03	2.87	3.15	3.8
Fox Hill Park Tributary	Dry Creek Rd	Double 8' (W) X 5.8' (H) RCBC	1972	5	500-YR	5628.85	-	-	-	-
Fox Hill Park Tributary	Jamison Circle Pedestrian Bridge	Bridge	2913	4	<10-YR	5631.45	1.72	2.58	2.92	3.49
Fox Hill Park Tributary	E Kettle Ave	Double 45"	3840	3	10-YR	5657.11	-	0.44	0.87	1.35
Phillips Tributary	E Phillips Place	11' x 7' HECMP	331	34	500-YR	5729.96	-	-	-	-
Phillips Tributary	Pedestrian Bridge - Approx. 700' Upstream of E Phillips St	18" Steel Pipe	1022	41	<10-YR	5745.67	2.24	2.72	3	3.89
Spring Creek Tributary	Pedestrian Bridge at S Monaco Way	Bridge	44	17	100-YR	5614.33	-	-	-	0.01
Spring Creek Tributary	Pedestrian Bridge - Approx. 1000' Downstream of E Mineral Ave	Bridge	1532	16	500-YR	5634.99	-	-	-	-
Spring Creek Tributary	E Mineral Ave	10' (W) X 9.55' (H) RCBC	2400	14	500-YR	5652.78	-	-	-	-
Spring Creek Tributary	Pedestrian Bridge C - Approx. 100' Upstream of East Mineral Ave	Bridge	2619	13	500-YR	5655.38	-	-	-	-
Spring Creek Tributary	Pedestrian Bridge D - Approx. 800' Upstream of East Mineral Ave	Bridge	3099	12	10-YR	5662.66	-	0.61	0.81	1.11
Spring Creek Tributary	E Otero Ave	10' (W) X 8' (H) RCBC	4721	11	500-YR	5696.81	-	-	-	-
Spring Creek Tributary	E County Line Rd	72" Diameter	6009	9	100-YR	5733.45	-	-	-	0.35
Spring Creek Tributary	C-470	Double 7' (W) X 10' (H) RCBC	6758	8	500-YR	5740.55	-	-	-	-
Spring Creek Tributary	Earthen Embankment - Approx. 200' Upstream of C-470	108" Diameter CMP	6989	7	100-YR	5742.43	-	-	-	0.24
Willow Creek East Tributary	Rosemary Way	16' (W) X 8' (H) RCBC	1555	49	500-YR	5685.2	-	-	-	-
Willow Creek East Tributary	Pedestrian Crossing - Approx. 250' Upstream of Rosemary Way	Double 12" CMP	1797	48	<10-YR	5683.78	2.6	3.44	3.49	4.64
Willow Creek East Tributary	Pedestrian Crossing - Approx. 300' Upstream of Rosemary Way	Double 12" CMP, Single 8" PVC	1854	47	<10-YR	5689.41	2.81	3.69	3.94	4.67
Willow Creek East Tributary	Pedestrian Bridge C - Approx. 900' Downstream of S Willow Way	Bridge	2590	56	10-YR	5701.08	-	1.74	2.11	3.31
Willow Creek East Tributary	Pedestrian Bridge D - Approx. 500' Downstream of S Willow Way	Bridge	2946	55	10-YR	5705.83	-	0.48	1.42	0.89
Willow Creek East Tributary	Pedestrian Bridge E - Approx. 300' Downstream of S Willow Way	Bridge	3122	54	<10-YR	5710.75	0.07	0.54	0.62	1.31
Willow Creek East Tributary	S Willow Way	90" Diameter CMP	3443	53	100-YR	5722.85	-	-	-	1.05
Willow Creek East Tributary	Pedestrian Bridge F - Approx. 300' Upstream of S Willow Way	Bridge	3793	52	10-YR	5720.32	-	0.67	1.8	3.78
Willow Creek East Tributary	Pedestrian Bridge G - Approx. 600' Downstream of Yosemite St	Bridge	4424	51	<10-YR	5730.02	1.27	1.71	2.19	3.09
Willow Creek East Tributary	Yosemite St	60" Diameter RCP	5009	50	50-YR	5752.13	-	-	0.41	3.49

*A draft version of Table 4-2 is included in this MDP report for informational purposes only. Refer to *Flood Hazard Area Delineation Willow Creek Tributaries Upstream of Englewood Dam*, *January 2025* for final crossing results.

5.0 ALTERNATIVES ANALYSIS

The Alternatives Analysis phase of the Major Drainageway Plan (MDP) includes Problem Identification, Alternatives Development, and development of a Recommended Plan. These steps were conducted in sequential order, as outlined in the sections below.

5.1 PROBLEM IDENTIFICATION

Identification and evaluation of problems within the Willow Creek Tributaries MDP study area focuses on the following major components: Stream Function, Flooding, Water Quality, and Maintenance Needs. These Problem Identification categories and the metrics by which they were evaluated were selected based on input from stakeholders and project sponsors. The following subsections contain discussion of the analysis performed for each of the Problem Identification categories. Exhibits depicting the problems associated with each category are included in Appendix G.

Problem locations were identified using a combination of field and desktop investigations, including SEMSWA's *Adaptive Management Dashboard* (AMD). The AMD is an interactive, online map and data repository created by Enginuity Engineering Solutions (Reference 9). The dashboard houses a database of field observations related to the health and condition of drainageways and associated crossings, outfalls, and grade control structures within the SEMSWA service area.

5.1.1 STREAM FUNCTION

The Stream Function category considers the holistic health of the channel. Function is evaluated in terms of the ability of the stream to convey flows and transport sediment in a manner that is stable (e.g. without excessive erosion or deposition) and promotes a resilient riparian corridor. Stream function is closely related to channel form which includes characteristics such as slope, cross-section shape, and roughness. The data used to analyze stream function was sourced from the AMD, where available, and supplemented by field investigation by ICON Engineering along portions of Homestead Farms Tributary, Acres Green Tributary, and Spring Creek. For the purposes of this study, each stream reach is classified by the "Overall Quality" metric which takes into consideration factors specifically related to Stream Function and assigns a "Poor", "Fair", or "Good" rating.

5.1.2 FLOODING

A goal of the FHAD and MDP is to identify areas, structures, and property which have the potential of being inundated in flood events. For the Flooding category, flood boundaries and roadway crossings were evaluated to identify potential problem locations. Both 100- and 500-year floodplain delineations were developed for the portions of the study area included in the associated FHAD (2025). Roadway crossings were evaluated using the FHAD hydraulic models, where applicable, and with approximate 2-dimensional (HEC-RAS 2D) methods outside of the FHAD extents. Crossings were reviewed to identify instances of inadequate conveyance capacity by comparing modeled overtopping depths in the minor (10-year, or 10% Annual Chance) and major (100-year, or 1% Annual Chance) events to applicable criteria. Roadway overtopping criteria stems from Chapter 11 of the *SEMSWA Stormwater Management Manual*, as agreed upon by all sponsors, see Table 5-1 below. Pedestrian bridges were not included in this flooding analysis.

Table 5-1: SEMSWA Roadway Overtopping Criteria

Roadway Classification	Drainageway Classification	Overtopping Criteria	
		Minor Event	Major Event
Collector	Minor Drainageway	No overtopping allowed	Overtopping by maximum 12 inches at gutter flowline
	Major Drainageway	No overtopping allowed	No overtopping allowed
Arterial	Minor Drainageway	No overtopping allowed	No overtopping allowed
	Major Drainageway	No overtopping allowed	No overtopping allowed

5.1.3 WATER QUALITY

Runoff from storms can pick up sediment and pollutants and carry these contaminants through the local drainage infrastructure into the receiving streams. Poor water quality practices degrade waterways by increasing nutrient loading, reducing dissolved oxygen, increasing dissolved sediment, and increasing temperature. Treatment for water quality takes many forms including regional detention ponds meant to treat large areas or smaller localized treatments (e.g. rain gardens and vegetated buffers) that filter & infiltrate runoff from one site. Analysis of water quality problems for this study focuses on identifying treatment opportunities for portions of the watershed that are not currently receiving formalized in-line water quality treatment.

5.1.4 MAINTENANCE NEEDS

The Maintenance Needs category seeks to identify point locations of varying degrees of failure along the streams and drainage corridors within the Willow Creek Tributaries study area. These locations include structures, such as roadway crossings and grade control structures, as well as bank erosion and vegetation issues. The data used to analyze maintenance needs was sourced from SEMSWA's AMD, where available, and supplemented with field investigation. Additionally, this study incorporates maintenance comments received directly from SEMSWA and South Suburban Parks and Recreation District (SSPRD) staff.

5.2 ALTERNATIVES DEVELOPMENT

Alternatives were developed to address the identified problems throughout the watershed. At the direction of the project sponsors, this MDP does not prescribe specific design alternatives but rather seeks to describe the problem and provide general solutions in sufficient detail for the project sponsors to use for budgeting and long-term planning purposes.

5.2.1 ALTERNATIVE CATEGORIES

5.2.1.1 STREAM FUNCTION AND MAINTENANCE

Stream Function and Maintenance alternatives were developed by overlaying the Stream Function reaches and Maintenance Needs points from the Problem Identification phase. By looking at the drainageways from both an overall health and spot repair perspective, the appropriate scale for the improvements could be assessed. Stream Function and Maintenance reaches were discretized into the following three categories based on assumed project size and level of effort.

1. Vegetation and Debris Management – reflects smaller sections of vegetation maintenance and debris removals to improve flow conveyance.
2. Stream Rehabilitation – reflects point repairs to outfalls, grade control structures, and eroded banks to maintain function of the stream systems.
   Stream Restoration – reflects larger scale capital improvement projects (CIP) involving full channel regrading and construction of new structures.

5.2.1.2 FLOODING

Improved crossings were proposed at locations that were identified as not meeting the overtopping criteria described in Section 5.1.2. Proposed crossings were sized to convey the 100-year event with no overtopping. Analysis was performed in the FHWA HY-8 Culvert Hydraulic Analysis Program, version 7.80.0.2 for the crossings within the detailed FHAD study limits. Approximate 2-dimensional (HEC-RAS 2D) modeling was used for the crossings outside of the FHAD study. While not specifically included in this study, all proposed culvert improvements are recommended to evaluate the addition of safety grating consistent with current MHFD guidance in the final design.

5.2.1.3 WATER QUALITY

Three separate approaches for improving Water Quality were evaluated during the Alternatives Development process. As approach was evaluated independently, instances of overlapping treatment areas with the other approaches are present. The three Water Quality alternative approaches are discussed further below:

1. Existing Pond Retrofits – Existing Pond retrofits were evaluated at existing in-line detention ponds that do not currently provide formal water quality treatment. Potential retrofit locations were filtered to only include ponds on parcels owned by a local public entity or where an existing public easement was in place. The potential retrofits considered include water quality outlet structures, grading, and improved maintenance features such as access roads. WQCV, EURV, and 100-year detention volumes were calculated for each applicable pond and compared to the available ponding volume to determine feasibility and quantify potential water quality benefit. With all proposed improvements, the implemented retrofit should maintain or not exceed the existing conditions outflow from each pond.
2. Vegetated Rundowns – Rundown opportunities were identified at outfalls from the existing stormwater network. These outfall locations include both existing piped connections and curb cuts with concrete swales that connect to the drainageways without providing any formalized treatment. Generally, vegetated rundowns will incorporate a series of planted tiers or baffles to reduce runoff velocity, promote infiltration, and provide nutrient uptake and sediment collection. Recommended examples of water quality rundowns are included in Appendix H.
   Wetland Improvements – Wetland Improvement areas were identified at the downstream end of the tributaries that discharge to Willow Creek within the Englewood Dam Open Space. The goal of these projects is to create new wetlands or improve the quality of existing wetlands. In addition to providing habitat, wetlands introduce complexity to the system and enhance water quality by promoting biological uptake of nutrients and slowing water.

5.2.2 COST ESTIMATING

5.2.2.1 STREAM FUNCTION AND MAINTENANCE

Stream Function and Maintenance costs were determined by assigning a cost to each problem point along the alternative sub-reaches. These point types include outfall repair, grade control replacement, erosion repair, vegetation management, and general maintenance points. Further discussion on costing of the individual problem points is included below. If an alternative was currently under design, the preliminary cost estimate from the design was used to reflect real project costs. Note that “Stream Restoration” alternatives located in Douglas County and City of Lone Tree, and therefore outside of the limits of SEMSWA’s AMD, were estimated by assuming costs equivalent to one erosion problem point per 50 linear feet of stream for the length of the project. This estimation methodology was applied to Spring Creek East Altair Park (SCEA Subreach 1) and Acres Green (AG Subreach 2).

1. Outfalls – Each outfall point includes the cost of pipe removal and replacement, a flared end section, riprap, and revegetation according to unit costs sourced from the *MHFD Bid Item Pricing (November 2023)* database. In addition to material and labor, a 55% increase was added to account for design, permitting, and construction related items (i.e. mobilization, erosion control, contingency, etc.). Assumed costs for outfall maintenance by outfall pipe diameter are presented in Table 5-2 below.

Table 5-2: Outfall Cost Estimate

Outfall Pipe Diameter	Cost (Ea.)
12”	$6,300
15”	$7,200
18”	$7,800
24”	$8,500
30”	$10,700
33”	$11,600
36”	$13,300
42”	$15,000

2. Grade Control – Costs for Grade Control structures were estimated using the "Vertical Grade Control" estimating procedures in the *MHFD Components Costing Tool (2024).* Grade control structures that were 1 to 2 feet in height were assumed to be ungrouted rock structures, and 3-to-5-foot drops were assumed to be grouted boulder structures. The *MHFD Components Costing Tool (2024)* incorporates a 55% added cost for design, permitting, and construction-related items. It is assumed that each grade control structure will be a removal and replacement scenario. Assumed costs for grade control structures by crest to end-sill height are presented in Table 5-3 below.

Table 5-3: Grade Control Structure Cost Estimate

Vertical Height	Cost (Ea.)
1'	$120,000
2'	$175,000
3'	$315,000
4'	$345,000
5'	$375,000

3. Erosion – Erosion problems are site specific and the required response varies greatly from location to location throughout the watershed. Erosion points were estimated on a linear foot basis using a unit cost of $1,200 per linear foot. This unit cost was provided by SEMSWA based on a review of recent stream rehabilitation projects and accounts for total project lifecycle costs including design, permitting, and other construction-related costs. A project length of 50 linear feet was assumed for each erosion point.
4. Vegetation – Vegetation maintenance was estimated using a $700 per linear foot unit cost. This unit cost was provided by SEMSWA based on a review of recent vegetation and debris management projects. A project length of 25 linear feet was assumed for each vegetation maintenance location.
5. General Maintenance – Costs for General Maintenance points were estimated on a point-per-point basis dependent upon the specific needs of each repair. General Maintenance includes trash removal, sediment removal, and wing wall repair. Unit costs were determined using the *MHFD Bid Item Pricing (November 2023)* database and applying a 55% cost increase to cover design, permitting, and construction-related items.

5.2.2.2 FLOODING

Costs for Culvert Upsizing alternatives were estimated using the "Bridge-Culvert" estimating procedures in the *MHFD Components Costing Tool (2024).* The spreadsheet allows for consideration of the complexity of each crossing by including factors such as length, culvert type, road type, and site constraints. The *MHFD Components Costing Tool (2024)* incorporates a 55% added cost for design, permitting, and construction-related items.

5.2.2.3 WATER QUALITY

Cost for Water Quality alternatives were estimated per alternative using items and unit costs from the *MHFD Bid Item Pricing (November 2023)* database. Each cost estimate includes a 55% increase for design, permitting, and construction-related items. The items included in each water quality approach are listed below.

1. Existing Pond Retrofits – Outlet structure (incl. orifice plate), maintenance road, and grading
2. Vegetated Rundowns – Boulders, growing media, revegetation, and underdrain. Note that rundown costs vary depending on the outfall pipe diameter and associated increase in rundown footprint with outfall size, see Table 5-4 below.

Table 5-4: Rundown Cost Estimate

Outfall Pipe Diameter	Cost (Ea.)
≤12"	$42,000
15"-21"	$52,000
24"-36"	$62,500
≥42"	$83,000

3. Wetland Improvements – Wetland Improvements were cost estimated on a per acre basis. Unit costs were derived from past wetland enhancement and rehabilitation projects sourced from the *MHFD Bid Item Pricing (November 2023)* database. This study applied a unit cost of $78,000 per acre for Wetland Improvement alternatives.

5.2.3 ALTERNATIVES EVALUATION & RUBRIC SCORING

A project rubric was utilized to evaluate the effectiveness of each identified alternative in addressing the identified drainageway problems according to the goals of the project stakeholders. The metrics utilized in the rubric follow SEMSWA improvement planning guidance and use SEMSWA's recommended weighting for each category. The metrics evaluated in this study include:

- Complexity
- Cost
- Maintenance Efficiency
- Comprehensive Water Quality Benefit
- WQCV and EURV Provided
- Stream Health
- Flood Capacity
- Public Safety
- Environmental

It was also deemed appropriate by the project team and stakeholders to remove the "Public Access and Aesthetics" and "Feedback" metrics from the rubric used for this MDP as these factors were not distinguishing characteristics in any of the identified alternatives.

The alternatives were individually scored using the project rubric according to the methodology identified in Table 5-5. Each metric was assigned a value from 1 to 5, with 5 indicating a more preferential project. Metric scores were multiplied by the corresponding weight and summed together to calculate a cumulative weighted score for each alternative. The cumulative weighted score was compared to the total possible score and converted to a percentage. Not all metrics were applicable to every alternative. A score of zero indicates that a metric was not used to evaluate that alternative and therefore, not included in the total possible score.

5.2.4 ALTERNATIVES SUMMARY SHEETS

Alternatives Summary Sheets for each tributary within the study area are provided on the following pages. The summary sheets provide a reach scale description of the proposed alternatives identified.

Table 5-5: Ranking Criteria for Willow Creek Tributaries

Weight		11	12	9	8	8	10	10	13	8
Alternatives		Scoring								
Categories	Sub-Category	Complexity	Project Cost	Maintenance Efficiency	Comprehensive WQ	WQCV and EURV	Stream Health	Flood Capacity	Public Safety	Environmental
Stream Function and Maintenance	Vegetation and Debris Management	3: No public easement for site access 5: Public easement for site access	1: Over $1M 2: $500K-$1M 3: $100K-$500K 4: $30K-$100K 5: Less than $30K	2: Maintenance access is greatly restricted 5: Maintenance access is unrestricted	0 (Category not included)	0 (Category not included)	3	2	3: No infrastructure blocked 4: Infrastructure blocked	4
	Stream Rehabilitation	3: Regulatory floodplain present or no public easement for site access 4: Outside of regulatory floodplain or public easement for access	1: Over $1M 2: $500K-$1M 3: $100K-$500K 4: $30K-$100K 5: Less than $30K	2: Maintenance access is greatly restricted 3: Maintenance access is difficult 4: Maintenance access is unrestricted	1: No outfall or erosion repairs on reach 2: Outfall or erosion repairs on reach	0 (Category not included)	3: Overall stream function = good 4: Overall stream function = fair 5: Overall stream function = poor	3	4	3
	Stream Restoration	2: Regulatory floodplain present 3: Outside of regulatory floodplain	1: Over $1M 2: $500K-$1M 3: $100K-$500K 4: $30K-$100K 5: Less than $30K	2: Maintenance access is greatly restricted 3: Maintenance access is difficult 4: Maintenance access is unrestricted	1: No outfall or erosion repairs on reach 2: Outfall or erosion repairs on reach	0 (Category not included)	4: Overall stream function = good/fair 5: Overall stream function = poor	3	4	2
Flooding	Culvert Upsizing	Regulatory floodplain present 3: Collector 4: Arterial Outside of regulatory floodplain 3: Arterial 4: Collector 5: Inlet improvements only	1: Over $1M 2: $500K-$1M 3: $100K-$500K 4: $30K-$100K 5: Less than $30K	5	0 (Category not included)	0 (Category not included)	3: Overall stream function = good 4: Overall stream function = poor/fair	5	4: Arterial road classification 5: Collector road classification	2
Water Quality	Retrofits	2: Regulatory floodplain present 4: Outside of regulatory floodplain	1: Over $1M 2: $500K-$1M 3: $100K-$500K 4: $30K-$100K 5: Less than $30K	1: No existing or proposed maintenance access 3: Existing maintenance access 4: Proposed maintenance access	5	4: WQCV Provided 5: EURV Provided	2: WQCV Provided 3: EURV Provided	2: WQCV Provided 3: EURV Provided	2: No change 3: Significant safety improvement	3: Earthwork involved 4: No earthwork involved
	Vegetated Rundowns	2: Regulatory floodplain present 4: Outside of regulatory floodplain. Compatible with nearby alternatives	1: Over $1M 2: $500K-$1M 3: $100K-$500K 4: $30K-$100K 5: Less than $30K	2: Maintenance access is restricted by trees/structures 3: Maintenance access is unrestricted	3: Outfalls <18" in diameter 4: Outfalls >21" in diameter	2: Park or single-family residential land use 3: Multi-family residential land use 4: Commercial land use	3: Overall stream function = good 4: Overall stream function = poor/fair	0 (Category not included)	0 (Category not included)	5
	Wetland Improvements	2 (Considered alternatives are located on publicly owned parcels or within a comprehensive easement)	1: Over $1M 2: $500K-$1M 3: $100K-$500K 4: $30K-$100K 5: Less than $30K	2	4	2	3	2	0 (Category not included)	4

ACRES GREEN TRIBUTARY

DESCRIPTION

Acres Green Tributary extends from the confluence with Willow Creek to the intersection of Acres Green Drive and Altair Drive at the upstream end. The downstream most segment of Acres Green Tributary is a natural bottom channel. Upstream of E. Phillips Circle, the tributary is a concrete lined trickle channel with manicured bluegrass banks. The channel is piped for an approximately 2000-foot-long section between E. Phillips Circle and Apollo Court. Problems such as erosion, degraded drop structures, outfall deterioration, and vegetation overgrowth are present along this tributary.

STREAM FUNCTION AND MAINTENANCE ALTERNATIVES

Vegetation and Debris Management

There are no identified alternatives for vegetation and debris management on this tributary.

Stream Rehabilitation

One reach of stream rehabilitation was identified at the downstream end of this tributary. Rehabilitation along this reach includes outfall repair, channel erosion, grade control structure repair, and general vegetation maintenance.

Stream Restoration

The reach of Acres Green Tributary from Apollo Court to Altair Drive was identified as a stream restoration alternative. The channel is located within a grassed median between the northbound and southbound travel lanes of Acres Green Drive. The primary restoration goals include vegetation management, improved water quality, addressing erosion due to the undersized trickle channel, and increased pedestrian visibility along the corridor.

FLOODING ALTERNATIVES

A flooding improvement opportunity was identified where Acres Green Tributary enters the piped system, just upstream of Apollo Court. The proposed alternative includes improved inlet configuration to address observed overtopping due to clogging during storm events.

WATER QUALITY ALTERNATIVES

Retrofit Existing Ponds

There are no identified alternatives for retrofit of existing ponds on this tributary.

Vegetated Rundowns

There are no identified alternatives for vegetated rundowns on this tributary.

Wetland Improvements

There are no identified alternatives for wetland improvements on this tributary.

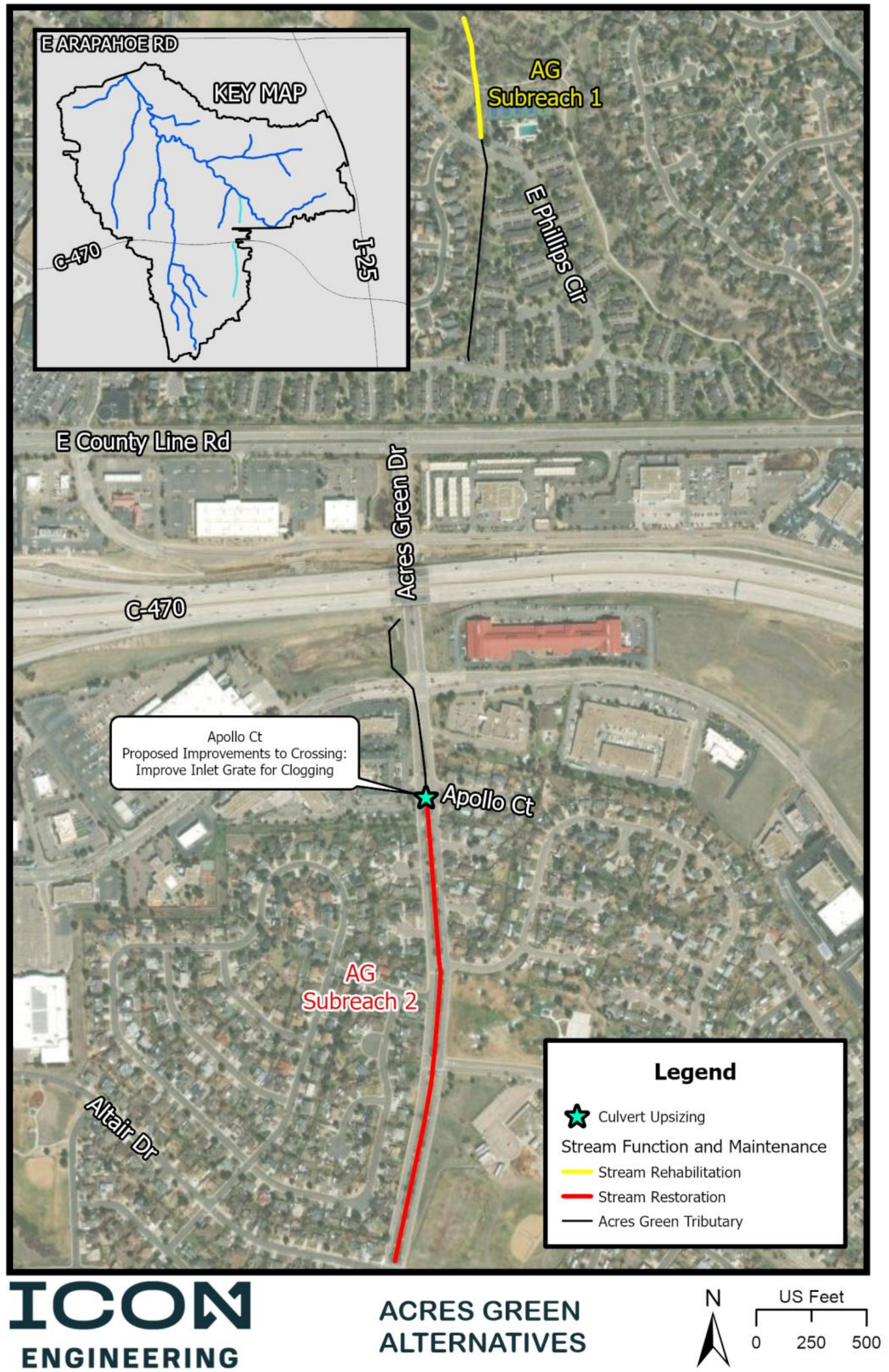


Figure 5-1: Acres Green Tributary Alternatives

FOX HILL PARK TRIBUTARY

DESCRIPTION

Fox Hill Park Tributary extends from the Englewood Dam Open Space upstream to just north of County Line Rd. The tributary is a natural bottom stream with a mix of native vegetation and manicured grass banks. Problems identified along this tributary include culvert overtopping, erosion, degraded drop structures, outfall deterioration, and vegetation overgrowth.

STREAM FUNCTION AND MAINTENANCE ALTERNATIVES

Vegetation and Debris Management

Two reaches of vegetation and debris management were identified in the upstream portion of the tributary.

Stream Rehabilitation

Four reaches of stream rehabilitation were identified along the tributary. Problems addressed by the rehabilitation alternatives include outfall repair, erosion, and grade control structure maintenance.

Stream Restoration

There are no identified stream restoration alternatives on this tributary.

FLOODING ALTERNATIVES

One flooding improvement alternative was identified to upsize the E. Kettle Avenue culvert in order to meet criteria for overtopping depth. The alternative was sized to convey the 100-year flow without overtopping.

WATER QUALITY ALTERNATIVES

Retrofit Existing Ponds

One pond retrofit alternative was identified at the existing detention pond just upstream of E. Otero Avenue. The proposed retrofit includes a new outlet structure and orifice plate to provide treatment of the WQCV.

Vegetated Rundowns

Twelve opportunities for vegetated rundowns were identified on publicly owned land along the tributary.

Wetland Improvements

An opportunity for wetland improvements was identified at the downstream end of the tributary within the Englewood Dam Open Space.

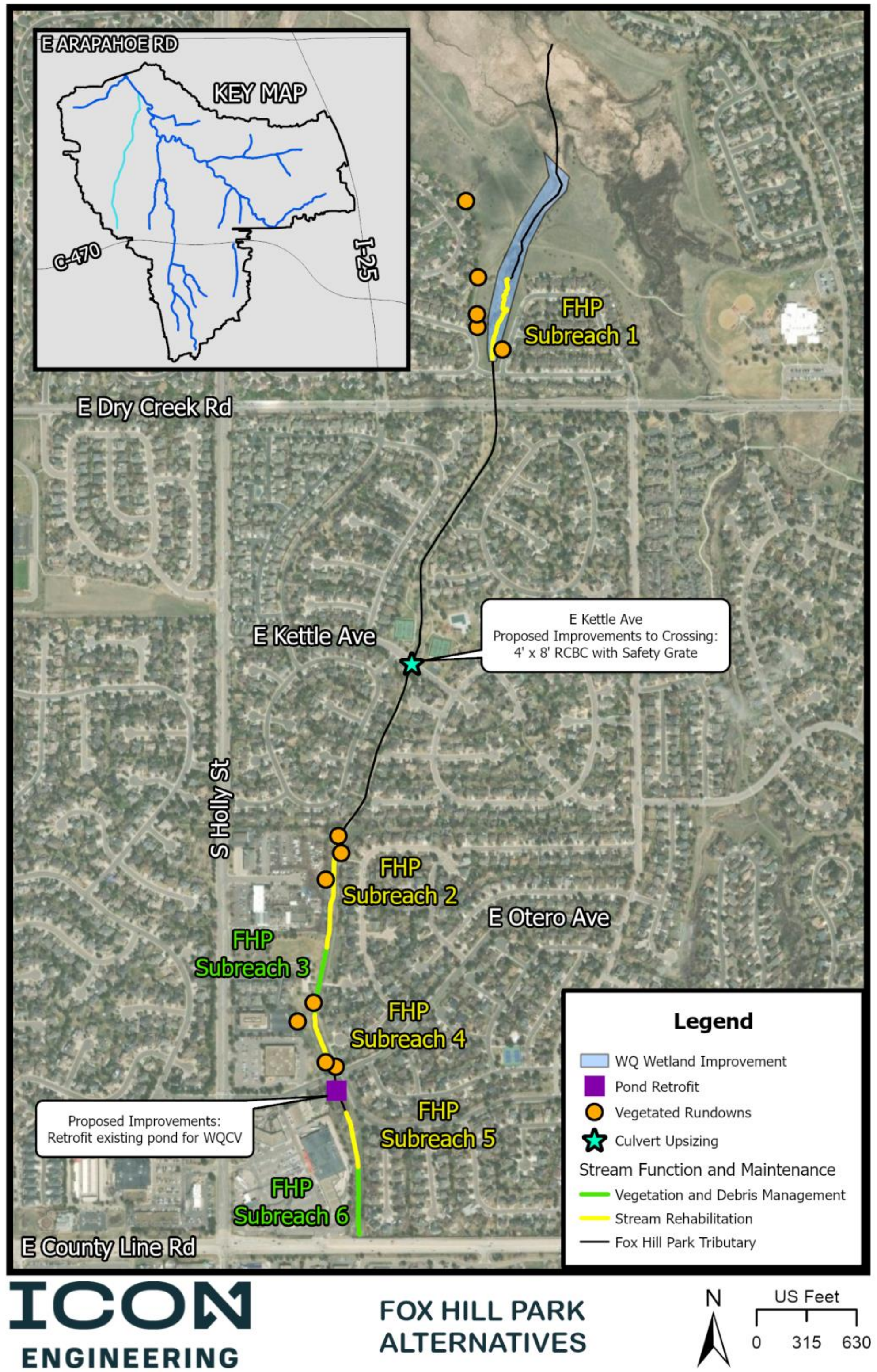


Figure 5-2: Fox Hill Park Tributary Alternatives

HOMESTEAD TRIBUTARY

DESCRIPTION

The open channel portion of Homestead Tributary extends from the confluence with Willow Creek within the Englewood Dam Open Space upstream to S. Homestead Parkway. The tributary receives flow from a subsurface stormwater network upstream of S. Homestead Parkway. Homestead Tributary is a natural bottom channel with native vegetation on the overbanks. Problems identified along this tributary include erosion, degraded drop structures, and vegetation overgrowth.

STREAM FUNCTION AND MAINTENANCE ALTERNATIVES

Vegetation and Debris Management

One reach of vegetation and debris management was identified to address the presence of invasive Russian Olives within the Open Space.

Stream Rehabilitation

One reach of stream rehabilitation was identified at the downstream end of the tributary. Rehabilitation along this reach includes grade control structure maintenance.

Stream Restoration

There are no identified stream restoration alternatives on this tributary.

FLOODING ALTERNATIVES

There are no identified flooding alternatives on this tributary.

WATER QUALITY ALTERNATIVES

Retrofit Existing Ponds

There are no identified alternatives for retrofit of existing ponds on this tributary.

Vegetated Rundowns

One opportunity was identified for a vegetated rundown on publicly owned land along this tributary.

Wetland Improvements

An opportunity for wetland improvements was identified at the downstream end of the tributary within the Englewood Dam Open Space.

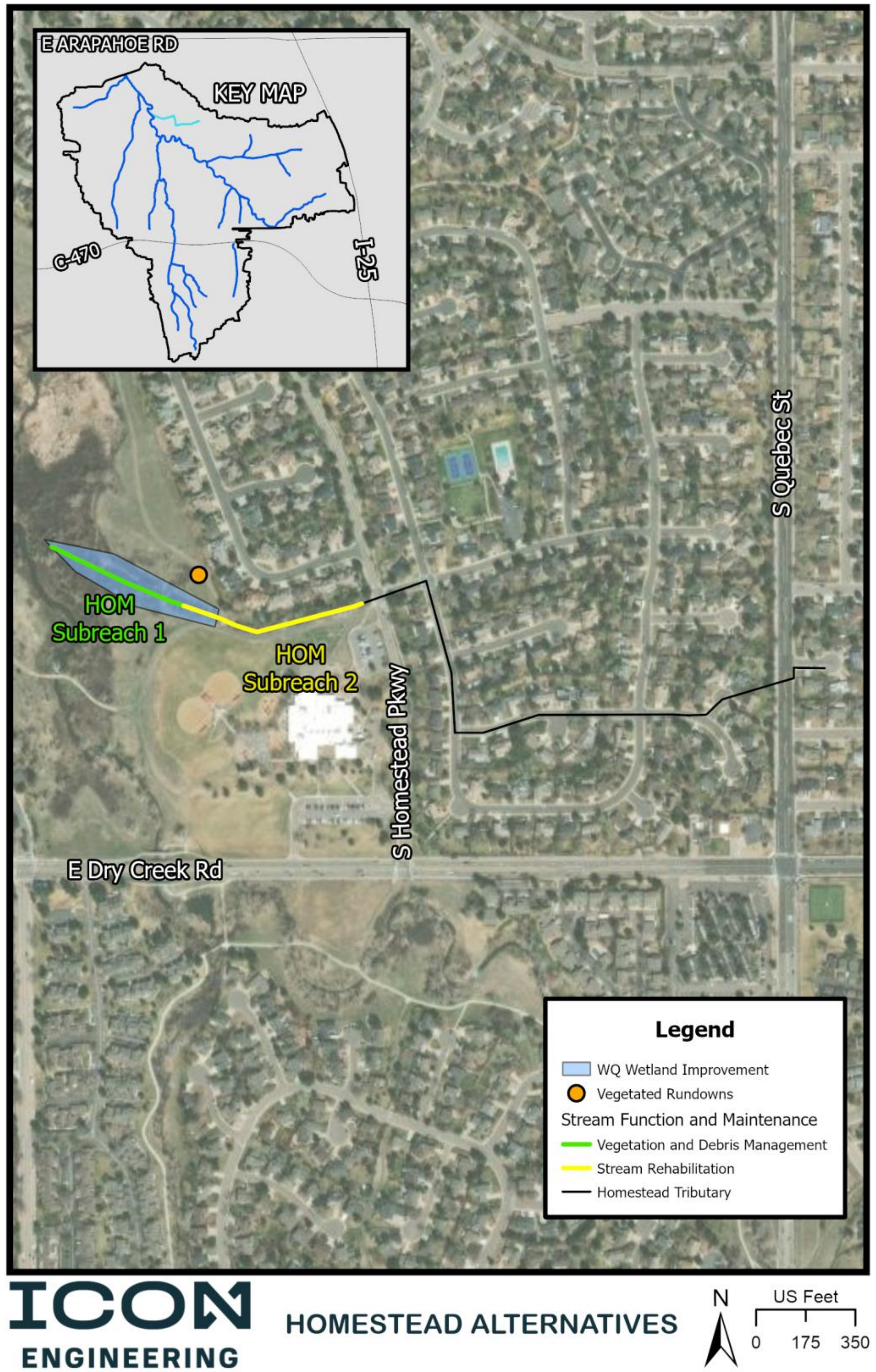


Figure 5-3: Homestead Tributary Alternatives

HOMESTEAD FARMS TRIBUTARY

DESCRIPTION

Homestead Farms Tributary extends from the confluence with Willow Creek within the Englewood Dam Open Space upstream to Medema Park in the Homestead Farms neighborhood. Upstream of Holly Street, the tributary is a cobble lined channel with manicured grass overbanks. Downstream of Holly Street, the tributary is a vegetated channel with dense cattails present. Problems identified along this tributary include erosion, degraded drop structures, outfall deterioration, and vegetation overgrowth.

STREAM FUNCTION AND MAINTENANCE ALTERNATIVES

Vegetation and Debris Management

One reach of vegetation and debris management was identified at the downstream end of the tributary within the open space to address the cattail monoculture and overgrowth.

Stream Rehabilitation

Two reaches of stream rehabilitation were identified along this tributary. Rehabilitation along this tributary includes outfall structure repair, channel erosion, and crossing maintenance.

Stream Restoration

There are no identified stream restoration alternatives on this tributary.

FLOODING ALTERNATIVES

Flooding improvement alternatives were identified to upsize the existing culverts at Holly Street and Grape Street in order to meet criteria for overtopping depth. The alternatives were sized to convey the 100-year flow without overtopping.

WATER QUALITY ALTERNATIVES

Retrofit Existing Ponds

There are no identified alternatives for retrofit of existing ponds on this tributary.

Vegetated Rundowns

Three opportunities for vegetated rundowns were identified on publicly owned land downstream of Holly Street.

Wetland Improvements

An opportunity for wetland improvements was identified at the downstream end of the tributary within the Englewood Dam Open Space.

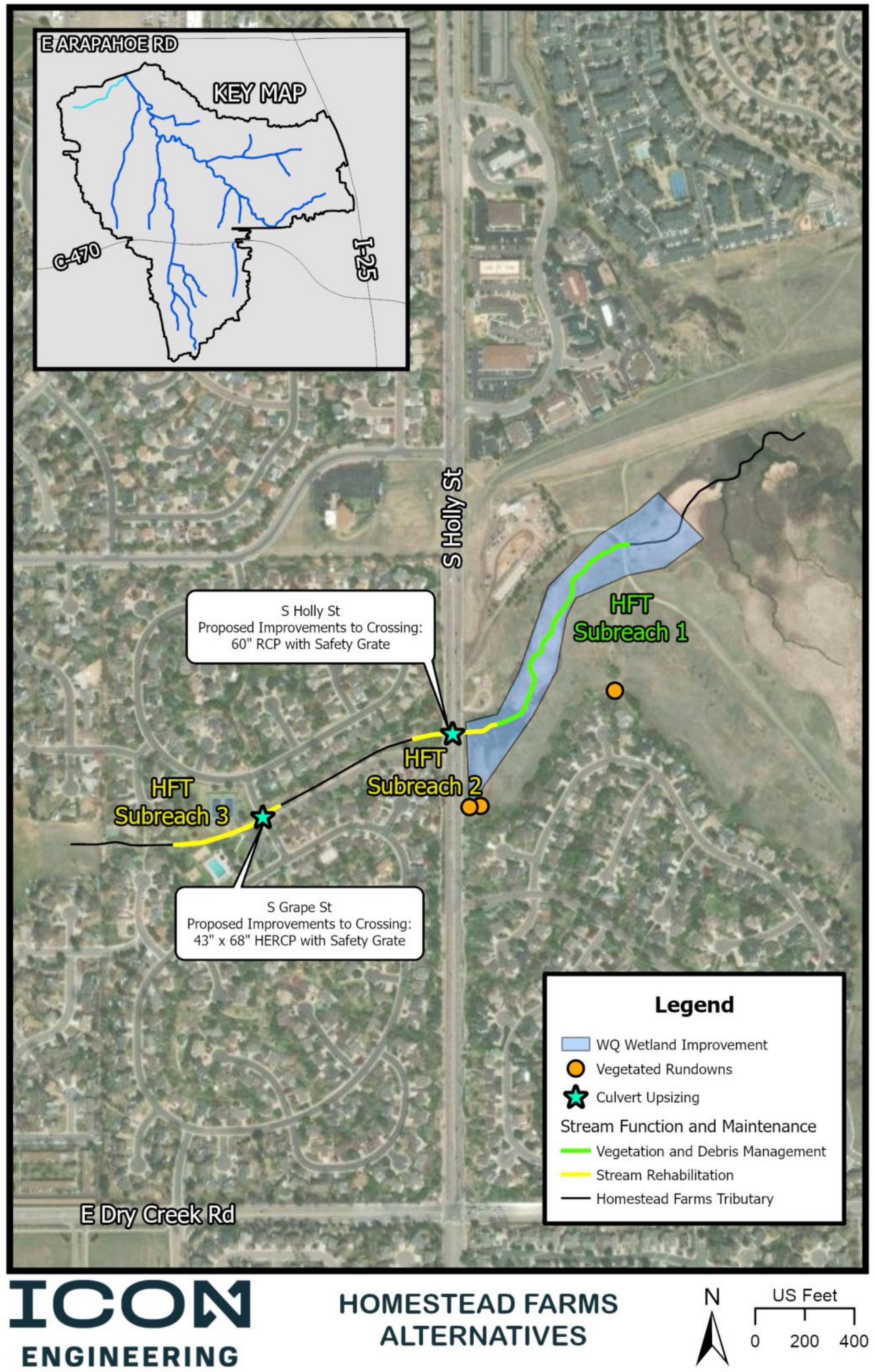


Figure 5-4: Homestead Farms Tributary Alternatives

JAMISON TRIBUTARY

DESCRIPTION

Jamison Tributary extends from the confluence with Willow Creek East Tributary upstream to E. Dry Creek Road. The channel is natural bottom with manicured bluegrass overbanks. Problems identified along this tributary include outfall deterioration, sedimentation, and vegetation overgrowth.

STREAM FUNCTION AND MAINTENANCE ALTERNATIVES

Vegetation and Debris Management

One reach of vegetation and debris management was identified to remove Russian Olives.

Stream Rehabilitation

One reach of stream rehabilitation was identified at the downstream end of the tributary, just upstream of the confluence with Willow Creek East Tributary. Rehabilitation along this reach is currently under design by SEMSWA with the goals of addressing the submerged S. Trenton Drive outfall and channel maintenance concerns.

Stream Restoration

There are no identified stream restoration alternatives on this tributary.

FLOODING ALTERNATIVES

There are no identified flooding alternatives on this tributary.

WATER QUALITY ALTERNATIVES

Retrofit Existing Ponds

There are no identified alternatives for retrofit of existing ponds on this tributary.

Vegetated Rundowns

There are no identified alternatives for vegetated rundowns on this tributary.

Wetland Improvements

There are no identified alternatives for wetland improvements on this tributary.

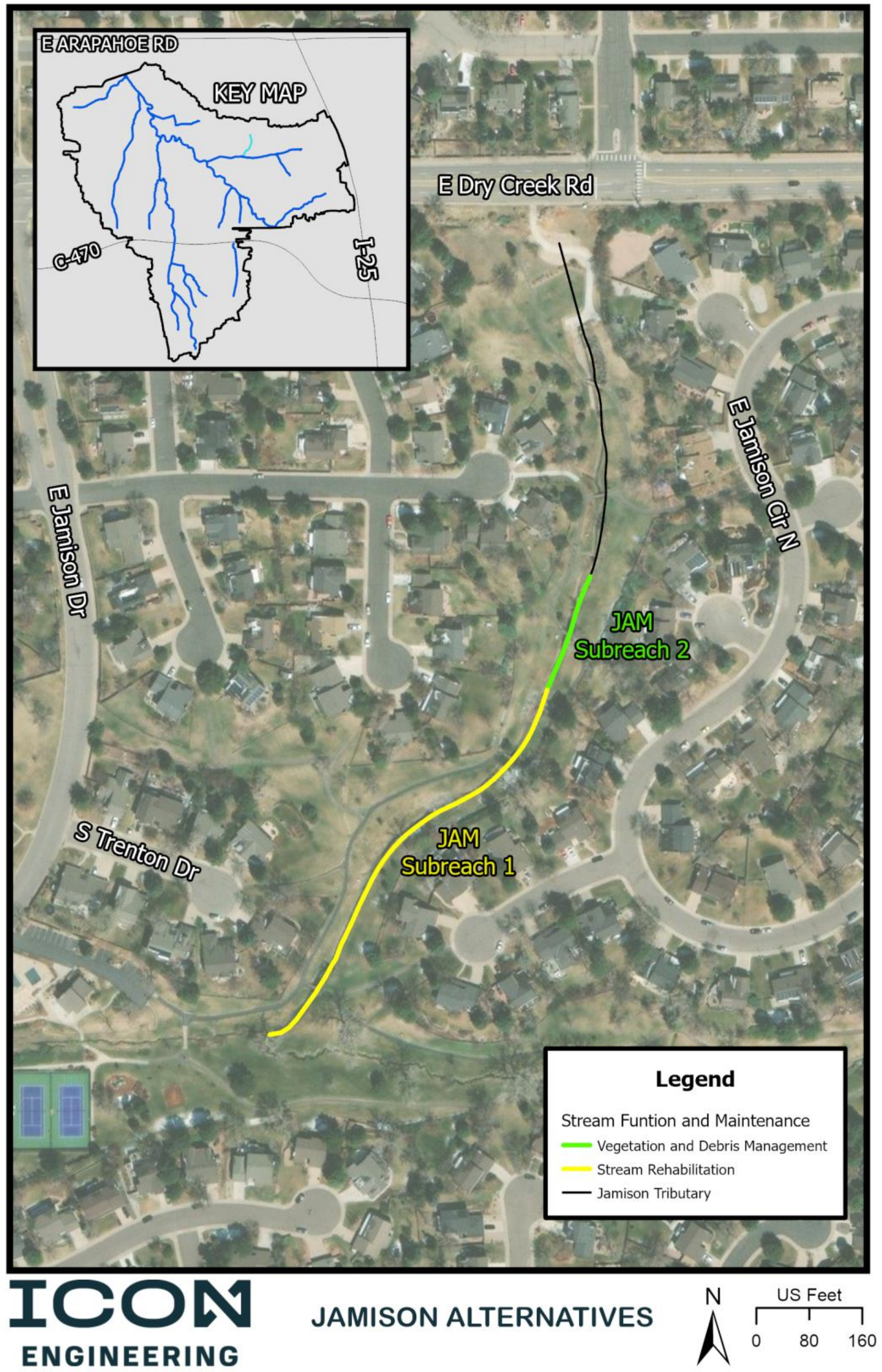


Figure 5-5: Jamison Tributary Alternatives

KETTLE TRIBUTARY

DESCRIPTION

Kettle Tributary extends from the confluence with Willow Creek East Tributary to S. Yosemite Street. The tributary consists of a natural bottom channel with a mix of native and manicured grass vegetation on the overbanks. Problems identified along this tributary include erosion and undersized crossings.

STREAM FUNCTION AND MAINTENANCE ALTERNATIVES

Vegetation and Debris Management

There are no identified alternatives for vegetation and debris management on this tributary.

Stream Rehabilitation

One reach of stream rehabilitation was identified at the upstream end of the tributary to address channel erosion.

Stream Restoration

There are no identified stream restoration alternatives on this tributary.

FLOODING ALTERNATIVES

Flooding improvement alternatives were identified to upsize both crossings of E. Kettle Circle in order to meet criteria for overtopping depth. The alternatives were sized to convey the 100-year flow without overtopping.

WATER QUALITY ALTERNATIVES

Retrofit Existing Ponds

There are no identified alternatives for retrofit of existing ponds on this tributary.

Vegetated Rundowns

There are no identified alternatives for vegetated rundowns on this tributary.

Wetland Improvements

There are no identified alternatives for wetland improvements on this tributary.

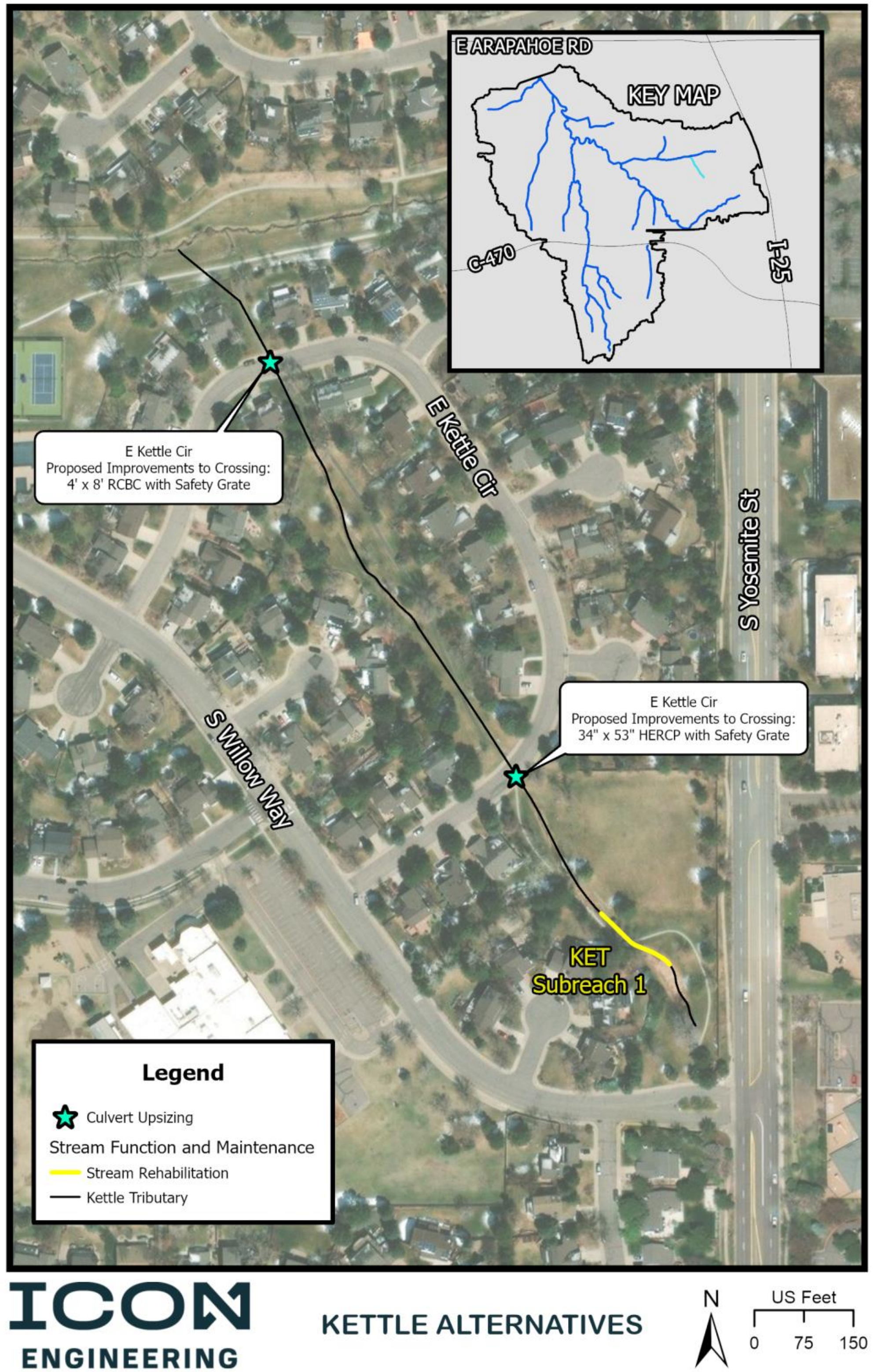


Figure 5-6: Kettle Tributary Alternatives

PHILLIPS TRIBUTARY

DESCRIPTION

Phillips Tributary extends from the confluence with Willow Creek near County Line Road to just upstream of S. Chester Street. Upstream of S. Yosemite Street, the tributary is comprised of a series of in-line retention ponds. Downstream of S. Yosemite Street, the tributary has a natural channel bottom with manicured grass banks. Problems identified along this tributary include vegetation overgrowth.

STREAM FUNCTION AND MAINTENANCE ALTERNATIVES

Vegetation and Debris Management

Two reaches of vegetation and debris management were identified on this tributary to address the presence of invasive Russian Olives.

Stream Rehabilitation

There are no identified alternatives for stream rehabilitation on this tributary.

Stream Restoration

There are no identified stream restoration alternatives on this tributary.

FLOODING ALTERNATIVES

There are no identified flooding alternatives on this tributary.

WATER QUALITY ALTERNATIVES

Retrofit Existing Ponds

There are no identified alternatives for retrofit of existing ponds on this tributary. The pond located upstream of S. Yosemite Street currently provides water quality treatment for the upstream area.

Vegetated Rundowns

There are no identified alternatives for vegetated rundowns on this tributary.

Wetland Improvements

There are no identified alternatives for wetland improvements on this tributary.

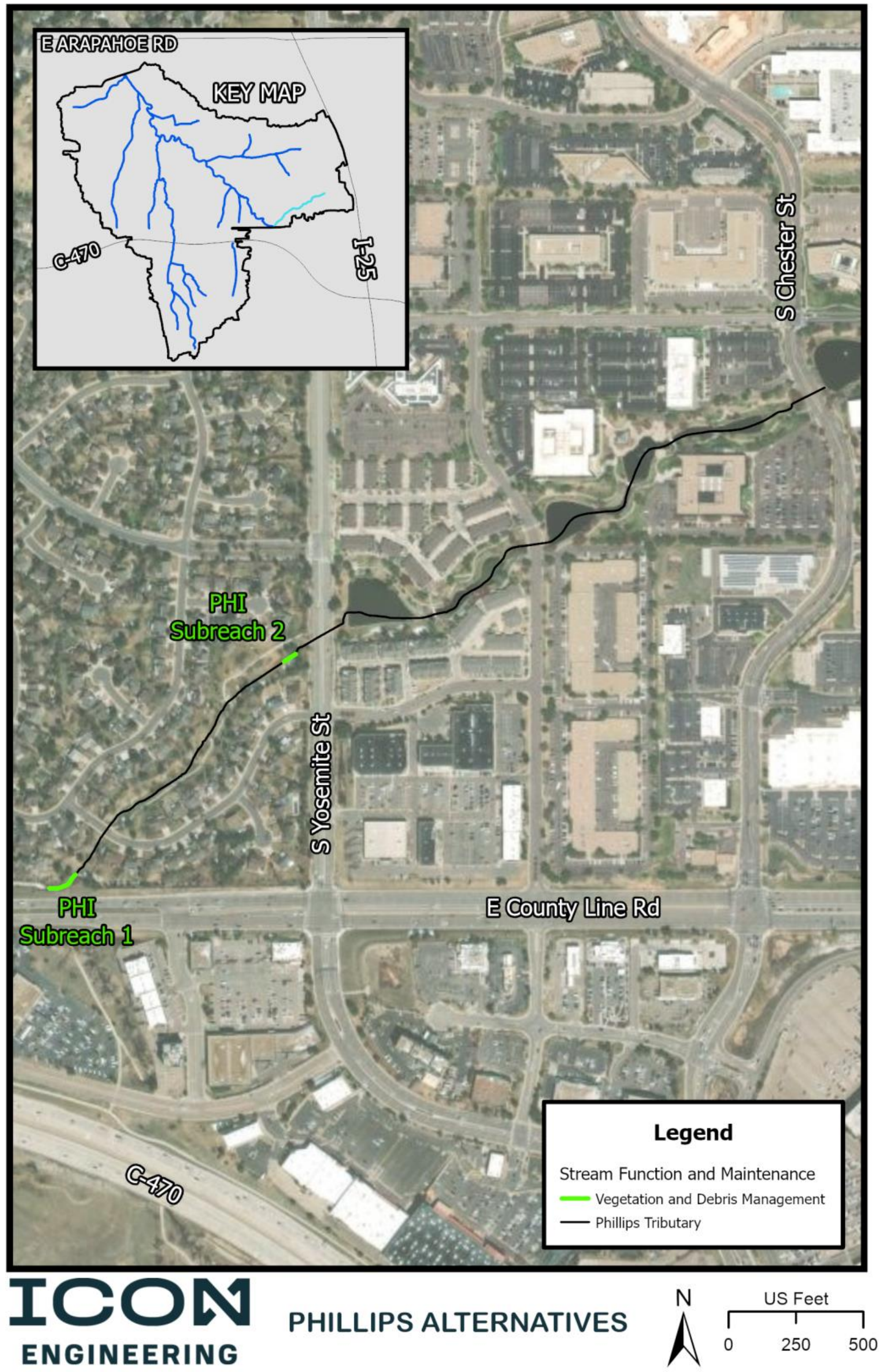


Figure 5-7: Phillips Tributary Alternatives

SPRING CREEK

DESCRIPTION

Spring Creek extends from the confluence with Willow Creek upstream to Business Center Drive, south of C-470. The tributary is a natural bottom channel with sections of both native and manicured grass overbanks. Problems identified along this tributary include erosion, degraded drop structures, outfall deterioration, and vegetation overgrowth.

STREAM FUNCTION AND MAINTENANCE ALTERNATIVES

Vegetation and Debris Management

Five reaches of vegetation and debris management were identified along the tributary.

Stream Rehabilitation

Three reaches of stream rehabilitation were identified on this tributary. Rehabilitation along this tributary includes outfall repairs, channel erosion, and grade control structure maintenance.

Stream Restoration

Two reaches along Spring Creek were identified as stream restoration alternatives. The primary restoration goals include addressing vegetation management (Russian olives and large woody debris), headcuts, vertical bank erosion, and outfall structure replacement.

FLOODING ALTERNATIVES

There are no identified flooding alternatives on this tributary.

WATER QUALITY ALTERNATIVES

Retrofit Existing Ponds

One pond retrofit alternative was identified at the existing detention pond just downstream of C-470. The proposed retrofit includes a new outlet structure and orifice plate to provide treatment of the WQCV. A maintenance access road was not included in the cost estimate due to feasibility concerns; however, future analysis should further investigate the potential for improving maintenance access.

Vegetated Rundowns

Nineteen opportunities for vegetated rundowns were identified on publicly owned land along the tributary.

Wetland Improvements

There are no identified alternatives for wetland improvements on this tributary.

Figure 5-8: Spring Creek Alternatives

SPRING CREEK EAST - ALTAIR PARK TRIBUTARIES

DESCRIPTION

Upstream of S. Quebec Street, Spring Creek branches into four smaller tributaries. The two eastern-most tributaries extend south along the existing crusher fines trail and southeast into Altair Park, respectively. Both tributaries are lined with native vegetation. Problems identified along these tributaries include severe bank erosion and vegetation overgrowth.

STREAM FUNCTION AND MAINTENANCE ALTERNATIVES

Vegetation and Debris Management

There are no identified alternatives for vegetation and debris management on these tributaries.

Stream Rehabilitation

There are no identified alternatives for stream rehabilitation on these tributaries.

Stream Restoration

One reach of upper Spring Creek was identified as an opportunity for stream restoration. The section of channel within Altair Park is experiencing vertical bank erosion and the overall function is listed as "poor".

FLOODING ALTERNATIVES

There are no identified flooding alternatives on this tributary.

WATER QUALITY ALTERNATIVES

Retrofit Existing Ponds

One pond retrofit alternative was identified at the existing detention pond just upstream of S. Quebec Street. The proposed retrofit includes a maintenance access road and a new outlet structure, including orifice plate, to provide treatment of the WQCV.

Vegetated Rundowns

Two opportunities for vegetated rundowns were identified on publicly owned land along the tributary.

Wetland Improvements

There are no identified alternatives for wetland improvements on this tributary.

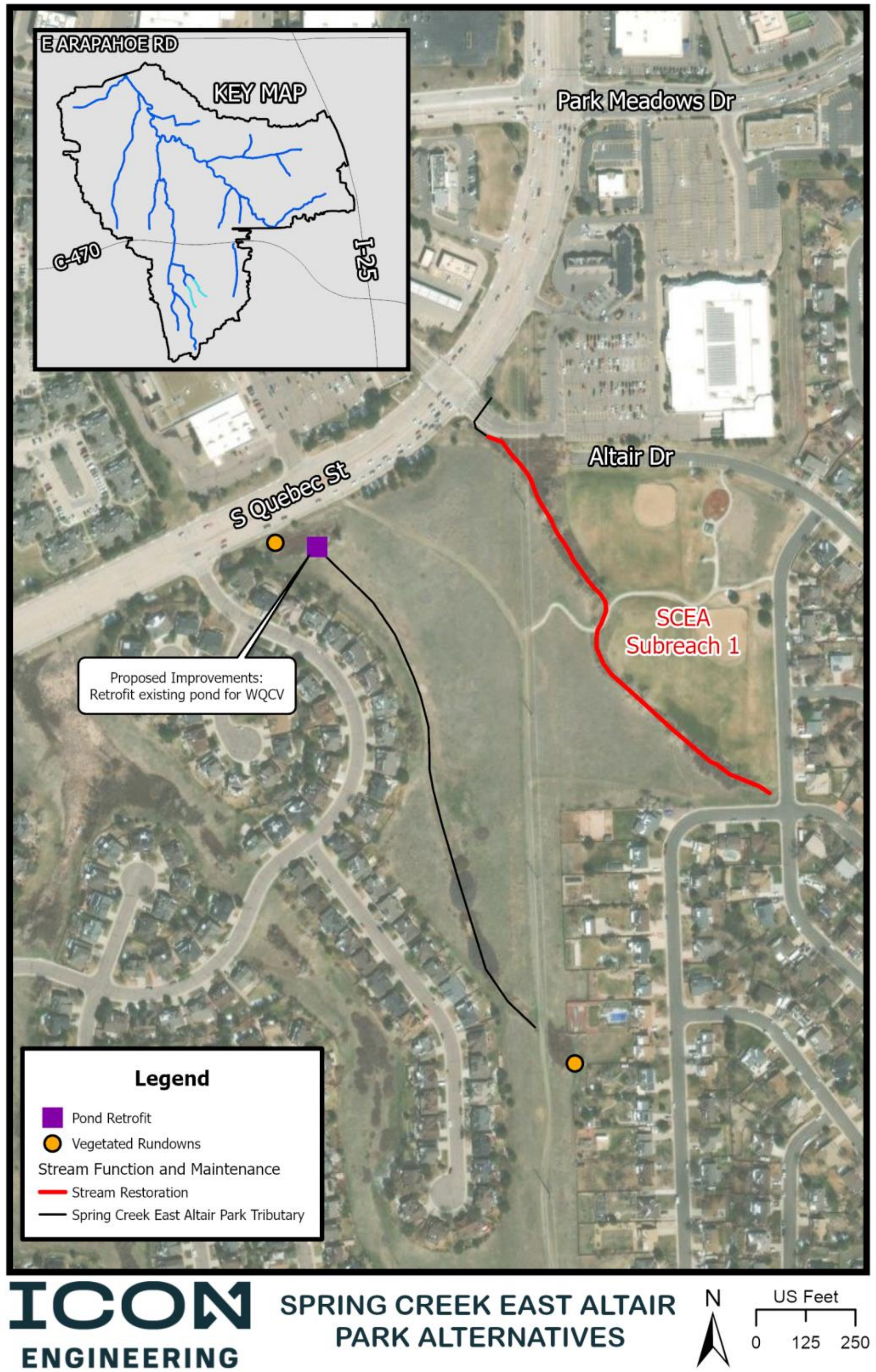


Figure 5-9: Spring Creek East Altair Park Alternatives

SPRING CREEK EAST - EDGEWOOD TRIBUTARIES

DESCRIPTION

Upstream of S. Quebec Street, Spring Creek branches into four smaller tributaries. The two western-most tributaries extend south to the Prominence Point Open Space. Both tributaries are located in native, vegetated open areas that converge at an existing detention structure just upstream of S. Quebec Street. Problems identified along these tributaries include erosion, degraded drop structures, outfall deterioration, and vegetation overgrowth.

STREAM FUNCTION AND MAINTENANCE ALTERNATIVES

Vegetation and Debris Management

One reach of vegetation and debris management was identified at the upstream end of the western tributary.

Stream Rehabilitation

Three reaches of stream rehabilitation were identified between the two tributaries. Rehabilitation along these tributaries includes outfall repair, channel erosion, and grade control structure maintenance.

Stream Restoration

There are no identified stream restoration alternatives on this tributary.

FLOODING ALTERNATIVES

There are no identified flooding alternatives on this tributary.

WATER QUALITY ALTERNATIVES

Retrofit Existing Ponds

One pond retrofit alternative was identified at the existing detention pond just upstream of S. Quebec Street. The proposed retrofit includes a maintenance access road and new outlet structure, including orifice plate, to provide treatment of the WQCV.

Vegetated Rundowns

Nine opportunities for vegetated rundowns were identified on publicly owned land along the tributary.

Wetland Improvements

There are no identified alternatives for wetland improvements on this tributary.

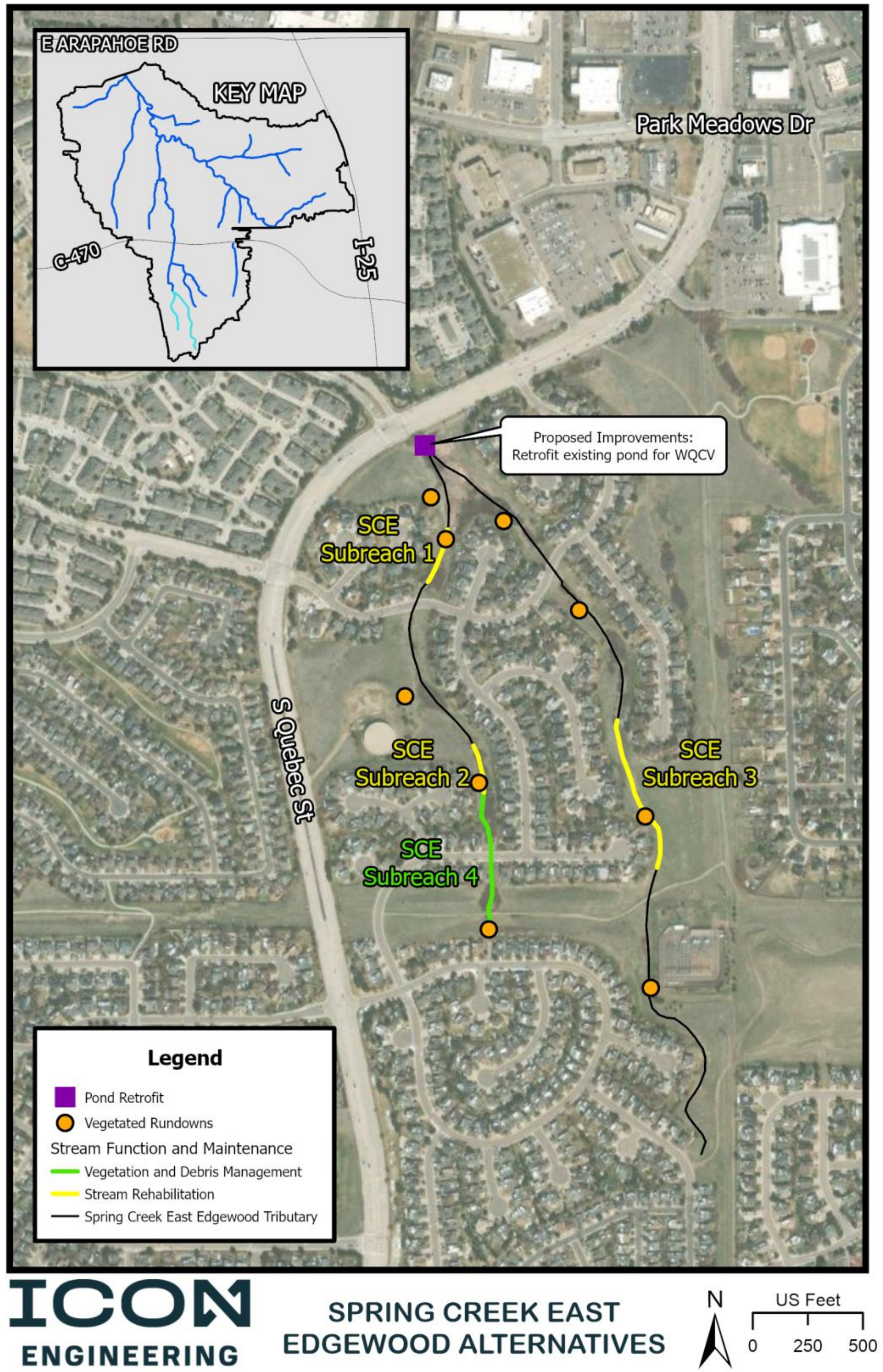


Figure 5-10: Spring Creek East Edgewood Alternatives

TRENTON OUTFALL TRIBUTARY

DESCRIPTION

Trenton Outfall Tributary extends from the confluence with Willow Creek upstream to E. County Line Rd. Upstream of E. Phillips Circle, the tributary is a natural bottom channel with sections of both native and manicured grass overbanks. The tributary is piped downstream of E. Phillips Circle. Problems identified along this tributary include degraded drop structures.

STREAM FUNCTION AND MAINTENANCE ALTERNATIVES

Vegetation and Debris Management

There are no identified alternatives for vegetation and debris management on this tributary.

Stream Rehabilitation

One reach of stream rehabilitation was identified on this tributary to address grade control structure maintenance.

Stream Restoration

There are no identified stream restoration alternatives on this tributary.

FLOODING ALTERNATIVES

There are no identified flooding alternatives on this tributary.

WATER QUALITY ALTERNATIVES

Retrofit Existing Ponds

There are no identified alternatives for retrofit of existing ponds on this tributary.

Vegetated Rundowns

There are no identified alternatives for vegetated rundowns on this tributary.

Wetland Improvements

There are no identified alternatives for wetland improvements on this tributary.

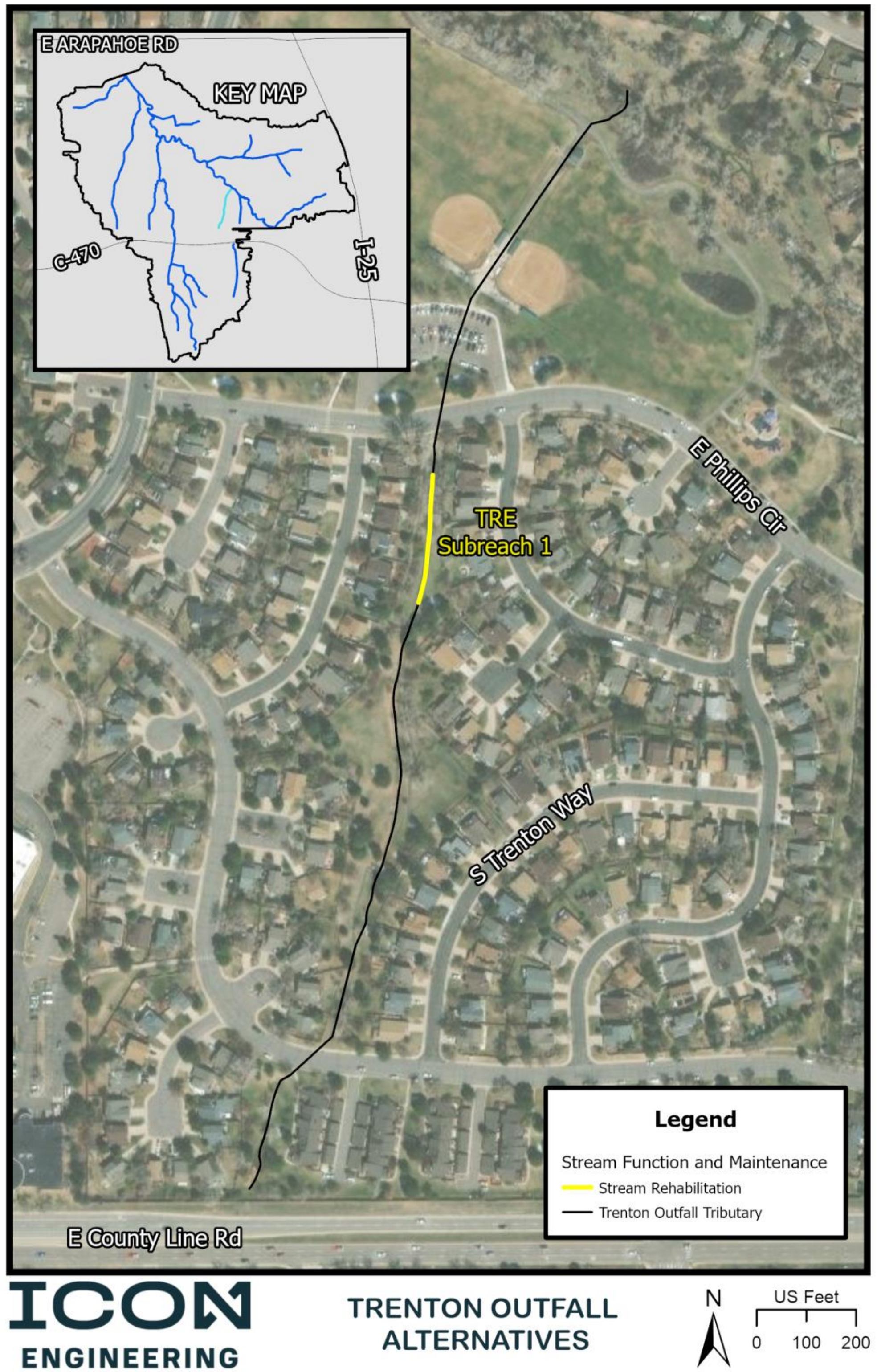


Figure 5-11: Trenton Outfall Tributary Alternatives

WEST SPRING CREEK

DESCRIPTION

West Spring Creek extends from the confluence with Spring Creek near E. Mineral Avenue to E. County Line Road at the upstream end. This tributary is a natural bottom channel with a mix of native and manicured grass overbanks. Problems identified along this tributary include erosion, degraded drop structures, outfall deterioration, crossing overtopping, and vegetation overgrowth.

STREAM FUNCTION AND MAINTENANCE ALTERNATIVES

Vegetation and Debris Management

One reach of vegetation and debris management was identified at the upstream end of this tributary. This reach includes outfall repairs and erosion maintenance problems but is categorized as a vegetation and debris management alternative due to the challenging access along the reach that precludes a stream rehabilitation project.

Stream Rehabilitation

There are no identified alternatives for stream rehabilitation on this tributary.

Stream Restoration

One reach of West Spring Creek between E. Mineral Avenue and E. Phillips Avenue was identified as a stream restoration alternative. A previous project incorporated channel stabilization and sculpted concrete drop structures up to approximately 500 feet upstream of E. Mineral Avenue. Upstream of the previous project, the channel is entrenched and rated as “poor” stream function. The primary restoration goals for this alternative include addressing outfall repair, failing retaining walls, vegetation management, bank erosion, headcuts, and grade control structure repair. A project along this reach is currently under design by SEMSWA and includes proposed elements such as channel grading, grouted boulder drop structures, utility protection, and retaining walls.

FLOODING ALTERNATIVES

A flooding alternative was identified upstream of E. Phillips Avenue. The proposed alternative includes improved inlet configuration at the upstream side of the culvert to increase capacity and reduce clogging.

WATER QUALITY ALTERNATIVES

Retrofit Existing Ponds

There are no identified alternatives for retrofit of existing ponds on this tributary.

Vegetated Rundowns

Two opportunities for vegetated rundowns were identified on publicly owned land along the tributary.

Wetland Improvements

There are no identified alternatives for wetland improvements on this tributary.

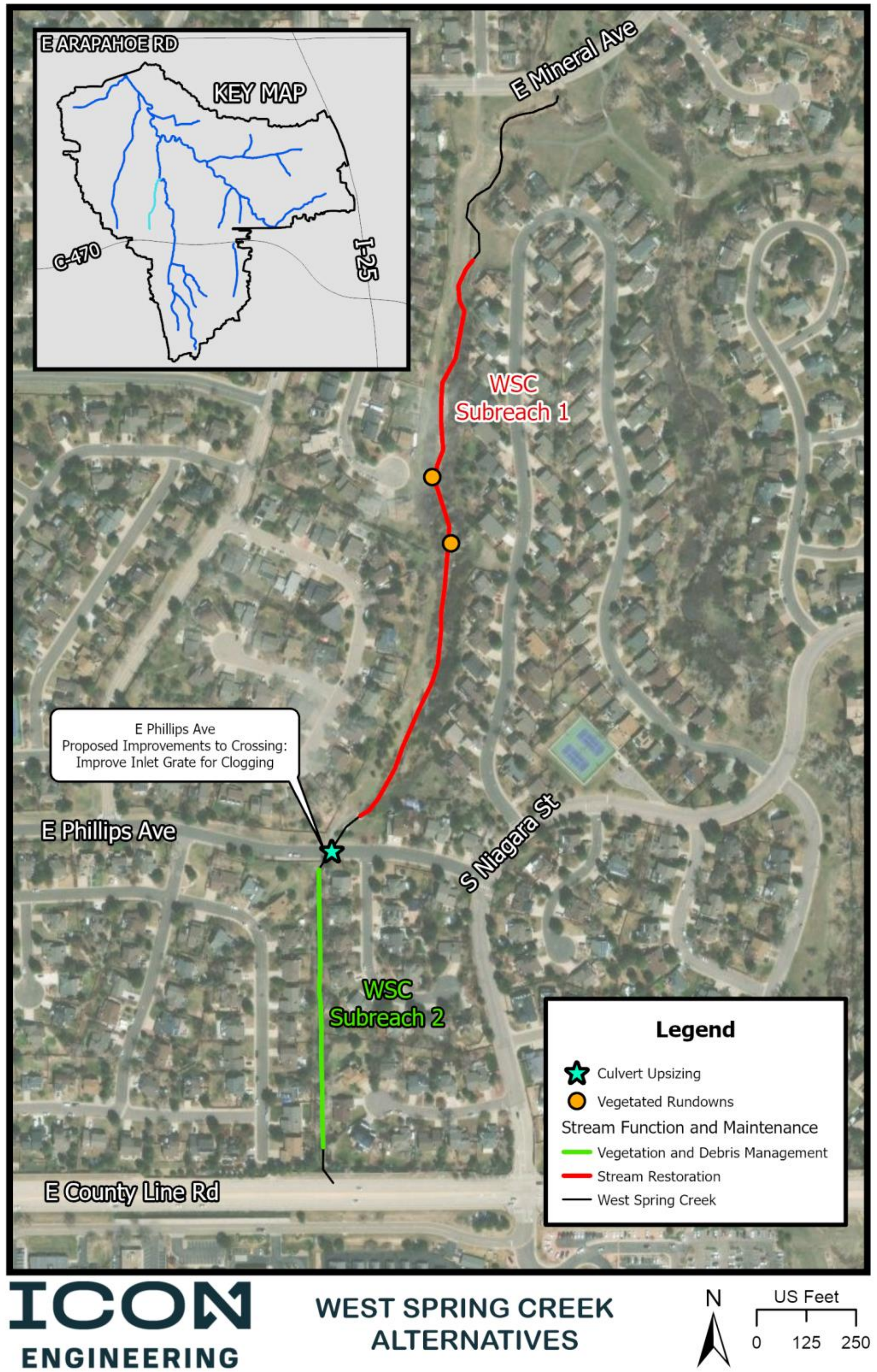


Figure 5-12: West Spring Creek Alternatives

WILLOW CREEK EAST TRIBUTARY

DESCRIPTION

Willow Creek East Tributary extends from the confluence with Willow Creek upstream to Panorama Pond, just east of S. Yosemite St. The tributary has a natural channel bottom with manicured grass overbanks. Problems identified along this tributary include erosion, degraded drop structures, outfall deterioration, and overtopped crossings.

STREAM FUNCTION AND MAINTENANCE ALTERNATIVES

Vegetation and Debris Management

There are no identified alternatives for vegetation and debris management on this tributary.

Stream Rehabilitation

Four reaches of stream rehabilitation were identified on this tributary. Rehabilitation along this reach includes outfall repairs, channel erosion, and grade control structure maintenance.

Stream Restoration

One reach of Willow Creek East Tributary was identified as a stream restoration alternative. Public comments and field visits noted that the existing grade control structure at the downstream end of the tributary has failed, and that vegetation management is needed. A SEMSWA project to address these concerns is currently in the design stage; however, no conceptual design costs were available at the time of this study.

FLOODING ALTERNATIVES

A flooding alternative was identified at S. Yosemite Street. Panorama Pond does not currently have capacity to contain the 100-year inflow volume without contributing flows to Yosemite Street via the concrete notch in the pond embankment. The proposed alternative improves flooding on S. Yosemite Street by increasing the pond embankment height and outlet configuration to prevent overtopping.

WATER QUALITY ALTERNATIVES

Retrofit Existing Ponds

There are no identified alternatives for retrofit of existing ponds for water quality purposes on this tributary. See “Flooding Alternatives” above for other proposed improvements to Panorama Pond.

Vegetated Rundowns

Five opportunities for vegetated rundowns were identified on publicly owned land along the tributary.

Wetland Improvements

There are no identified alternatives for wetland improvements on this tributary.

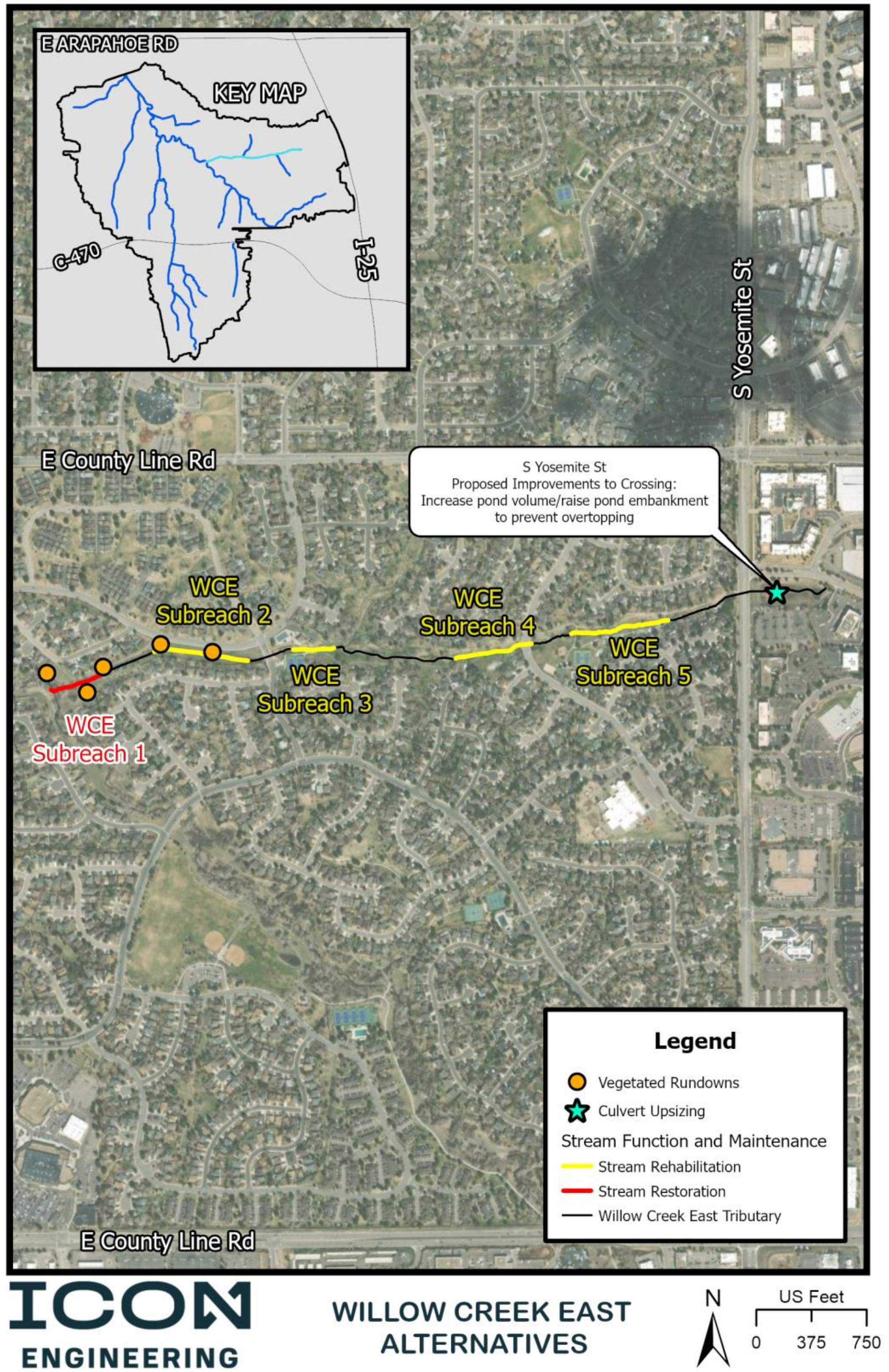


Figure 5-13: Willow Creek East Tributary Alternatives

5.3 RECOMMENDED PLAN

The Recommended Plan identifies the preferred alternatives for addressing each of the identified problems within the study area. The preferred alternatives were selected with input from the project stakeholders and sponsors. As noted in Section 5.2, the Recommended Plan alternatives focus on problem description and provide generalized solutions at a level of detail intended to inform short and long-term project planning.

5.3.1 ALTERNATIVES TO RECOMMENDED PLAN

5.3.1.1 STREAM FUNCTION AND MAINTENANCE

All Vegetation and Debris Management, Stream Rehabilitation, and Stream Restoration reaches that were identified in the Alternatives Development phase were included in the Recommended Plan. Portions of reaches that overlapped with areas of identified wetland improvements within Englewood Dam Open Space were reduced in size to avoid overlapping preferred alternatives with similar goals. Similarly, the recommended Stream Function and Maintenance alternatives were reduced to exclude crossing structure maintenance at locations where a new, upsized crossing is proposed.

5.3.1.2 FLOODING

All proposed Flooding alternatives were included in the Recommended Plan.

5.3.1.3 WATER QUALITY

1. Existing Pond Retrofits

Due to their centralized nature and large treatment area, retrofit of existing in-line detention facilities was determined to provide a greater potential for water quality uplift at a lower cost than multiple vegetated rundowns treating a comparable treatment area. When selecting preferred alternatives, vegetated rundown alternatives upstream of existing pond retrofits were therefore removed from the Recommended Plan. The Recommended Plan also retains the Spring Creek Detention Basin retrofit and removes the upstream pond retrofit alternatives at Spring Creek East Edgewood and Spring Creek East Altair Park as the Spring Creek Detention Basin has adequate capacity to provide comprehensive water quality treatment to the entire upstream area.

2. Vegetated Rundowns

As noted in the section above, vegetated rundown alternatives were removed from the Recommended Plan where the treatment area overlapped with a proposed pond retrofit alternative. The Recommended Plan also only includes vegetated rundowns in locations of piped storm outfalls greater than 18” diameter and with commercial or multi-family residential tributary land uses as these locations will provide the greatest water quality uplift potential.

3. Wetland Improvements

All proposed wetland improvement alternatives were included in the Recommended Plan.

5.3.2 RECOMMENDED PLAN SCORING TABLES

The Recommended Plan is presented in the Recommended Plan Exhibit (Figure 5-14) and summarized in Table 5-6 below. The Recommended Plan Tables (Tables 5-7 through 5-19) detail the preferred alternatives at a “project-level” scale. Refer to Section 5.2.3 for discussion of the rubric and project scoring methodology.

Table 5-6: Recommended Plan Cost Summary

Tributary	Stream Function and Maintenance Cost	Flooding Cost	Water Quality Cost	Total Cost
Acres Green	$3,050,000	$20,000	$0	$3,070,000
Fox Hill Park	$1,392,500	$580,000	$517,000	$2,489,500
Homestead	$1,450,000	$0	$110,000	$1,560,000
Homestead Farms	$115,500	$915,000	$195,000	$1,225,500
Jamison	$117,500	$0	$0	$117,500
Kettle	$60,000	$1,840,000	$0	$1,900,000
Phillips	$52,500	$0	$0	$52,500
Spring Creek	$3,597,500	$0	$236,500	$3,834,000
Spring Creek East Altair Park	$1,500,000	$0	$0	$1,500,000
Spring Creek East Edgewood	$363,000	$0	$0	$363,000
Trenton Outfall	$295,000	$0	$0	$295,000
West Spring Creek	$3,575,000	$20,000	$0	$3,595,000
Willow Creek East	$2,990,000	$250,000	$135,000	$3,375,000
Totals	**$18,558,500**	**$3,625,000**	**$1,193,500**	**$23,377,000**

Figure 5-14: Recommended Plan Exhibit 1

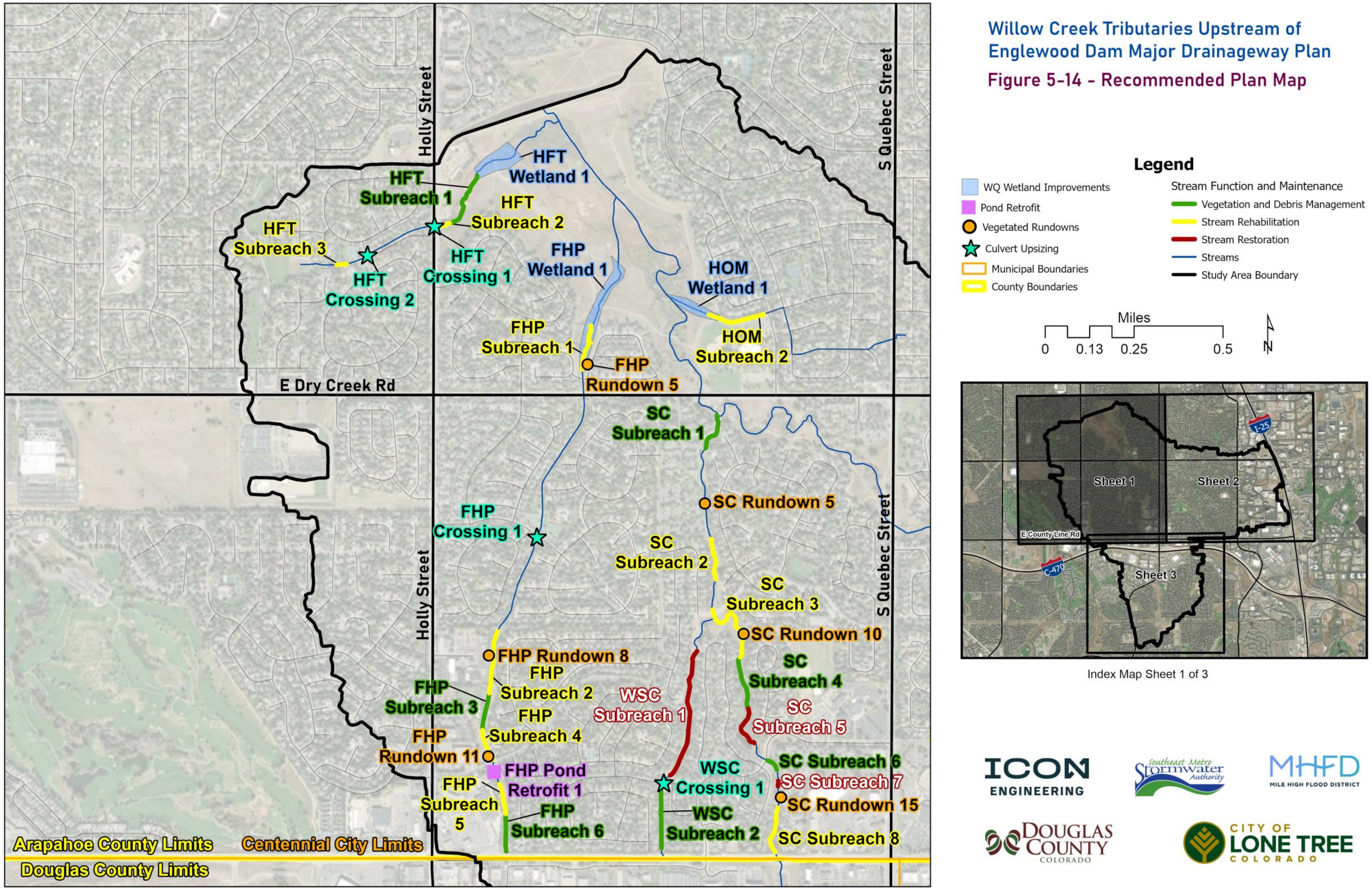


Figure 5-14 (cont.): Recommended Plan Exhibit 2

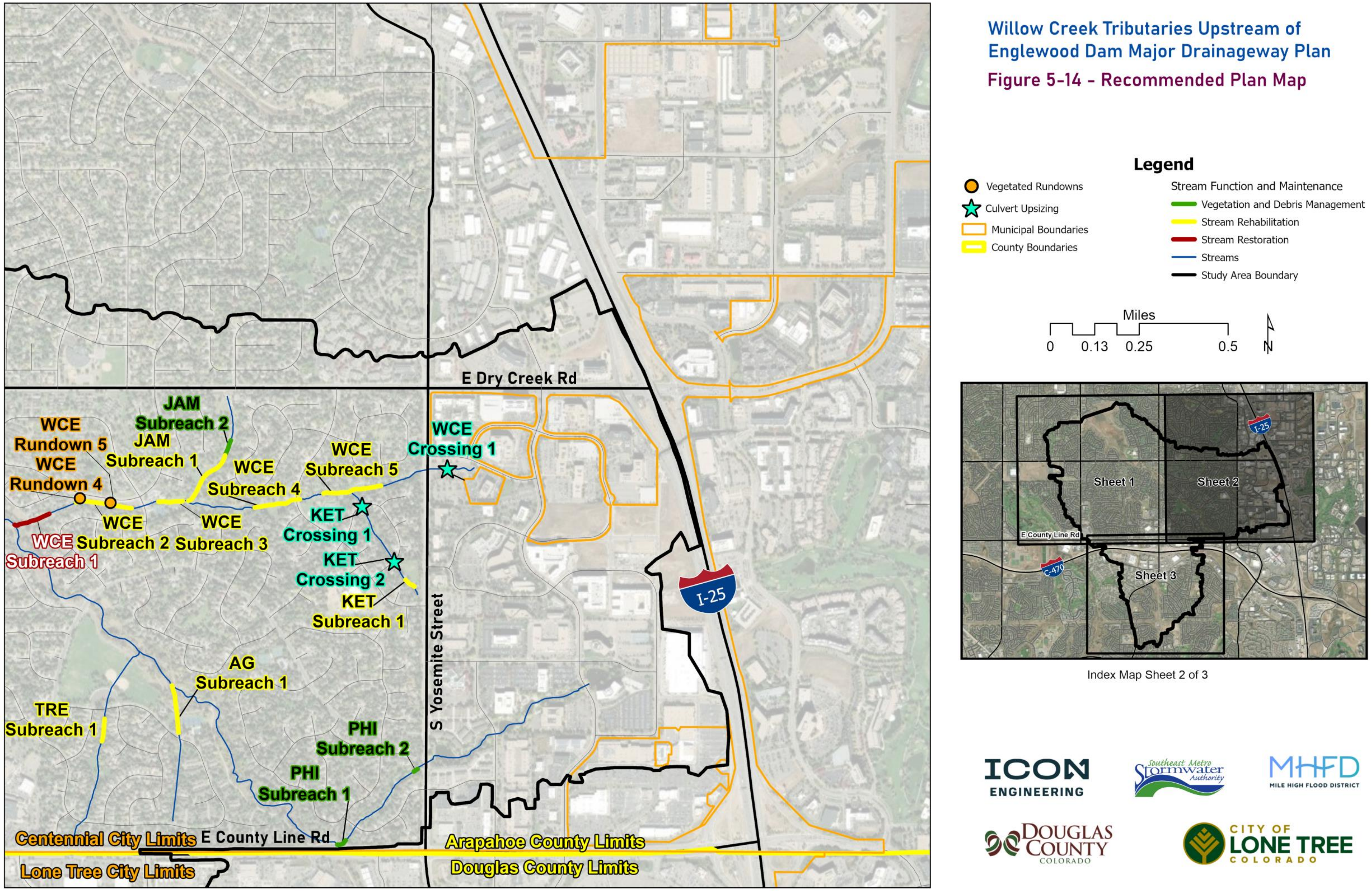
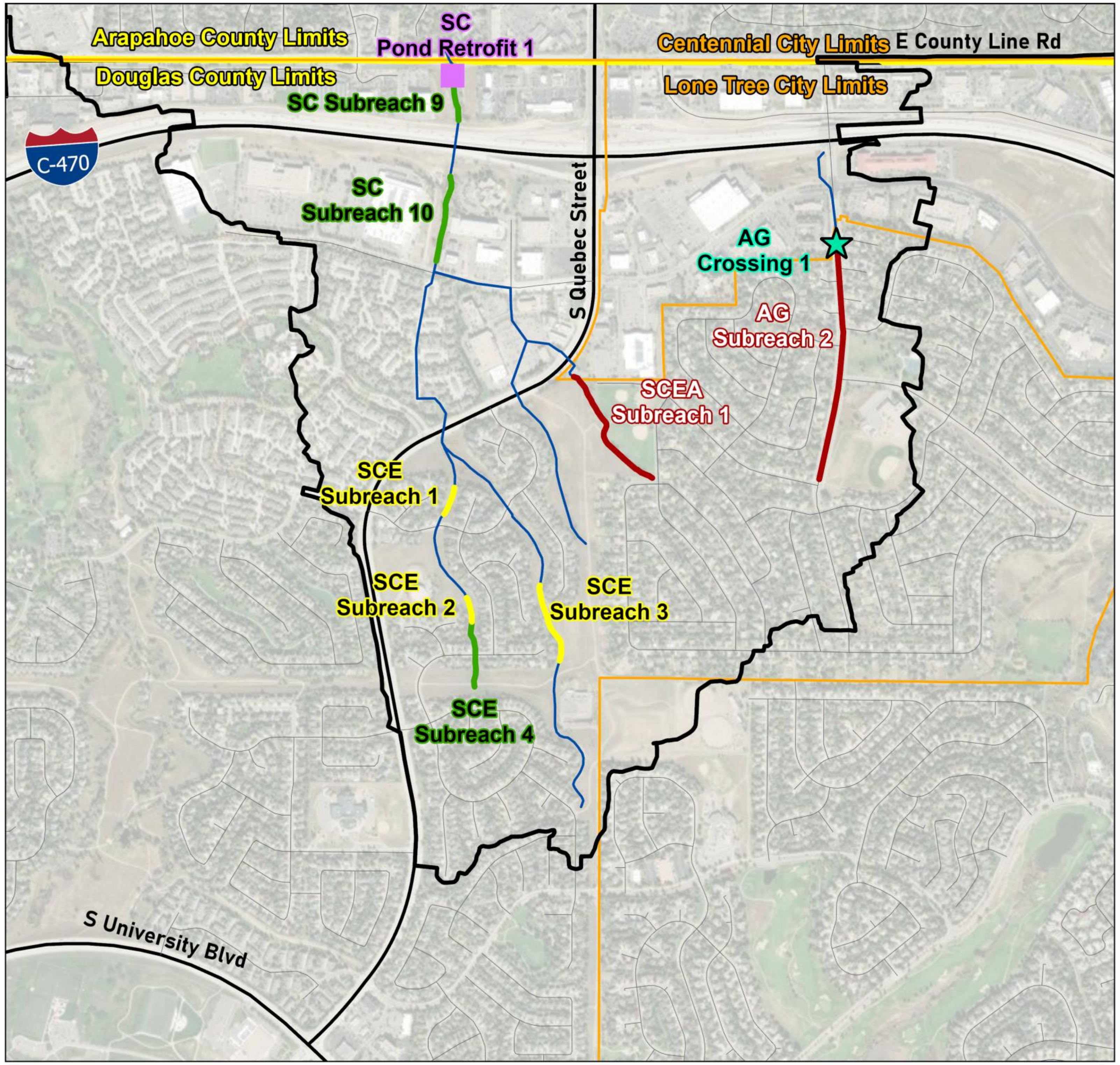


Figure 5-14 (cont.): Recommended Plan Exhibit 3



Willow Creek Tributaries Upstream of Englewood Dam Major Drainageway Plan

Figure 5-14 - Recommended Plan Map

Legend

- Pond Retrofit
- Culvert Upsizing
- County Boundaries
- Municipal Boundaries

Stream Function and Maintenance

- Vegetation and Debris Management
- Stream Rehabilitation
- Stream Restoration
- Streams
- Study Area Boundary

Miles: 0 0.13 0.25 0.5 N

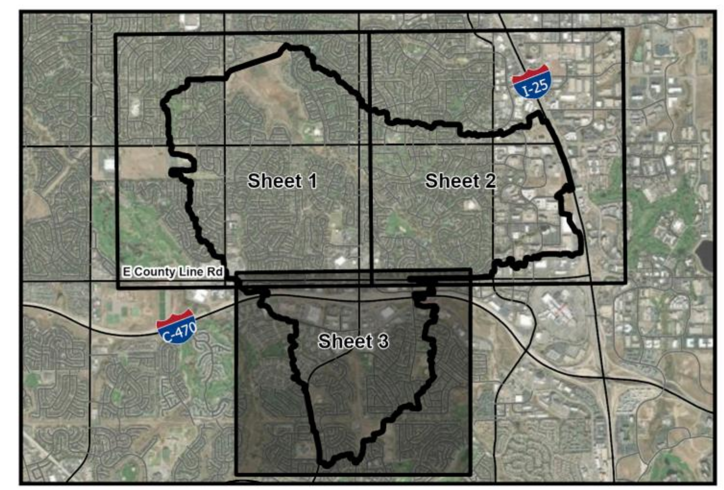


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Table 5-7: Acres Green Tributary Recommended Plan Scoring Table

Project Information						Metric (Weight)									Total Possible Score	Cumulative Weighted Score	Percentage Score
Project Category	Project Type	Project ID	Project Description	Cost Estimate	Jurisdiction	Complexity (11)	Project Cost (12)	Maintenance Efficiency (9)	Comprehensive Water Quality (8)	WQCV/and EURV Provided (8)	Stream Health (10)	Flood Capacity (10)	Public Safety (13)	Environmental (8)			
Stream Function and Maintenance	Stream Rehabilitation	AG Subreach 1	Address channel erosion, outfall repair, vegetation management, and grade control structure replacement	$650,000	City of Centennial (SEMSWA, SSPRD, HOA)	3	2	4	2	0	3	3	4	3	405	245	60%
	Stream Restoration	AG Subreach 2*	Address vegetation management, channel erosion, and pedestrian safety	$2,400,000	Douglas County (SSPRD)	3	1	4	2	0	5	3	5	2	405	258	64%
Flooding	Culvert Upsizing	AG Crossing 1	Improve inlet grate to reduce clogging	$20,000	Douglas County	5	5	5	0	0	4	5	5	2	365	331	91%

* AG Subreach 2 cost estimate was generated by assuming a cost per linear foot of $1,200 for the entire length of the project (outside the limits of the SEMSWA AMD).

Table 5-8: Fox Hill Park Tributary Recommended Plan Scoring Table

Project Information						Metric (Weight)									Total Possible Score	Cumulative Weighted Score	Percentage Score
Project Category	Project Type	Project ID	Project Description	Cost Estimate	Jurisdiction	Complexity (11)	Project Cost (12)	Maintenance Efficiency (9)	Comprehensive Water Quality (8)	WQCV/and EURV Provided (8)	Stream Health (10)	Flood Capacity (10)	Public Safety (13)	Environmental (8)			
Stream Function and Maintenance	Vegetation and Debris Management	FHP Subreach 3	Vegetation management	$17,500	City of Centennial (SEMSWA, SSPRD)	5	5	5	0	0	3	2	3	4	365	281	77%
		FHP Subreach 6	Vegetation management	$70,000	City of Centennial (SEMSWA)	4	4	5	0	0	3	2	3	4	365	258	71%
	Stream Rehabilitation	FHP Subreach 1	Address erosion, outfall repair, and grade control structure replacement	$260,000	City of Centennial (SEMSWA, SSPRD)	3	3	4	2	0	3	3	4	3	405	257	63%
		FHP Subreach 2	Address erosion, outfall repair, vegetation management, and grade control structure replacement	$505,000	City of Centennial (SEMSWA, SSPRD)	4	2	3	2	0	4	3	4	3	405	257	63%
		FHP Subreach 4	Address erosion, outfall repair, and grade control structure replacement	$390,000	City of Centennial (SEMSWA, SSPRD)	4	3	4	2	0	4	3	4	3	405	278	69%
		FHP Subreach 5	Address erosion, outfall repair, and vegetation management	$150,000	City of Centennial (SEMSWA)	4	3	4	2	0	4	3	4	3	405	278	69%
Flooding	Culvert Upsizing	FHP Crossing 1	4' x 8' RCBC with safety grate	$580,000	City of Centennial (SEMSWA)	3	2	5	0	0	4	5	4	2	365	260	71%
Water Quality	Pond Retrofit	FHP Pond Retrofit 1	Provide new water quality outlet structure	$70,000	City of Centennial (SEMSWA)	4	4	1	5	4	2	2	2	4	445	271	61%
	Vegetated Rundowns	FHP Rundown 5	Install vegetated rundown or trash/sediment collection device	$62,500	City of Centennial (SEMSWA, SSPRD)	3	4	3	4	3	3	0	0	5	330	234	71%
		FHP Rundown 8	Install vegetated rundown or trash/sediment collection device	$62,500	City of Centennial (SEMSWA, SSPRD)	4	4	2	4	4	4	0	0	5	330	254	77%
		FHP Rundown 11	Install vegetated rundown or trash/sediment collection device	$52,000	City of Centennial (SEMSWA, SSPRD)	4	4	2	3	4	4	0	0	5	330	246	75%
	Wetland Improvements	FHP Wetland 1	Wetland enhancement and creation	$270,000	City of Centennial (SEMSWA, SSPRD)	2	3	2	4	2	3	2	0	4	380	206	54%

Table 5-9: Homestead Tributary Recommended Plan Scoring Table

Project Information						Metric (Weight)									Total Possible Score	Cumulative Weighted Score	Percentage Score
						Complexity (11)	Project Cost (12)	Maintenance Efficiency (9)	Comprehensive Water Quality (8)	WQCV/and EURV Provided (8)	Stream Health (10)	Flood Capacity (10)	Public Safety (13)	Environmental (8)			
Project Category	Project Type	Project ID	Project Description	Cost Estimate	Jurisdiction												
Stream Function and Maintenance	Stream Rehabilitation	HOM Subreach 2	Address channel erosion and grade control structure replacement.	$1,450,000	City of Centennial (SEMSWA, SSPRD, HOA)	4	1	4	2	0	3	3	4	3	405	244	60%
Water Quality	Wetland Improvements	HOM Wetland 1	Wetland enhancement and creation	$110,000	City of Centennial (SEMSWA, SSPRD)	2	3	2	4	2	3	2	0	4	380	206	54%

Table 5-10: Homestead Farms Tributary Recommended Plan Scoring Table

Project Information						Metric (Weight)									Total Possible Score	Cumulative Weighted Score	Percentage Score
Project Category	Project Type	Project ID	Project Description	Cost Estimate	Jurisdiction	Complexity (11)	Project Cost (12)	Maintenance Efficiency (9)	Comprehensive Water Quality (8)	WQCV/and EURV Provided (8)	Stream Health (10)	Flood Capacity (10)	Public Safety (13)	Environmental (8)			
Stream Function and Maintenance	Vegetation and Debris Management	HFT Subreach 1	Vegetation management	$17,500	City of Centennial (SEMSWA, SSPRD)	5	5	5	0	0	3	2	3	4	365	281	77%
	Stream Rehabilitation	HFT Subreach 2	Outfall repair	$23,000	City of Centennial (SEMSWA, SSPRD)	4	5	4	2	0	3	3	4	3	405	292	72%
		HFT Subreach 3	Address channel erosion and outfall repair	$75,000	City of Centennial (SEMSWA, HOA)	4	4	4	2	0	3	3	4	3	405	280	69%
Flooding	Culvert Upsizing	HFT Crossing 1	60" RCP with safety grate	$585,000	City of Centennial (SEMSWA)	3	2	5	0	0	3	5	5	2	365	263	72%
		HFT Crossing 2	43" x 68" HERCP with safety grate	$330,000	City of Centennial (SEMSWA)	4	3	5	0	0	3	5	4	2	365	273	75%
Water Quality	Wetland Improvements	HFT Wetland 1	Wetland enhancement and creation	$195,000	City of Centennial (SEMSWA, SSPRD)	2	3	2	4	2	3	2	0	4	380	206	54%

Table 5-11: Jamison Tributary Recommended Plan Scoring Table

Project Information						Metric (Weight)									Total Possible Score	Cumulative Weighted Score	Percentage Score
Project Category	Project Type	Project ID	Project Description	Cost Estimate	Jurisdiction	Complexity (11)	Project Cost (12)	Maintenance Efficiency (9)	Comprehensive Water Quality (8)	WQCV/and EURV Provided (8)	Stream Health (10)	Flood Capacity (10)	Public Safety (13)	Environmental (8)			
Stream Function and Maintenance	Vegetation and Debris Management	JAM Subreach 2	Vegetation management	$17,500	City of Centennial (SEMSWA, HOA)	4	5	5	0	0	3	2	3	4	365	270	74%
	Stream Rehabilitation	JAM Subreach 1*	Outfall repair, upgrade adjacent storm sewer, and channel stabilization	$100,000	City of Centennial (SEMSWA, HOA)	4	3	3	2	0	3	3	4	3	405	271	64%

* JAM Subreach 1 cost estimate and description was sourced from the 30% design for this project. Design performed outside of the scope of this MDP.

Table 5-12: Kettle Tributary Recommended Plan Scoring Table

Project Information						Metric (Weight)									Total Possible Score	Cumulative Weighted Score	Percentage Score
Project Category	Project Type	Project ID	Project Description	Cost Estimate	Jurisdiction	Complexity (11)	Project Cost (12)	Maintenance Efficiency (9)	Comprehensive Water Quality (8)	WQCV/and EURV Provided (8)	Stream Health (10)	Flood Capacity (10)	Public Safety (13)	Environmental (8)			
Stream Function and Maintenance	Stream Rehabilitation	KET Subreach 1	Address channel erosion	$60,000	City of Centennial (SEMSWA, HOA)	4	4	4	2	0	3	3	4	3	405	280	69%
Flooding	Culvert Upsizing	KET Crossing1	4’ x 8’ RCBC with safety grate	$1,450,000	City of Centennial (SEMSWA)	4	1	5	0	0	3	5	4	2	365	249	68%
		KET Crossing 2	34” x 53” HERCP with safety grate	$390,000	City of Centennial (SEMSWA)	4	3	5	0	0	3	5	4	2	365	273	75%

Table 5-13: Phillips Tributary Recommended Plan Scoring Table

Project Information						Metric (Weight)									Total Possible Score	Cumulative Weighted Score	Percentage Score
						Complexity (11)	Project Cost (12)	Maintenance Efficiency (9)	Comprehensive Water Quality (8)	WQCV/and EURV Provided (8)	Stream Health (10)	Flood Capacity (10)	Public Safety (13)	Environmental (8)			
Project Category	Project Type	Project ID	Project Description	Cost Estimate	Jurisdiction												
Stream Function and Maintenance	Vegetation and Debris Management	PHI Subreach 1	Vegetation management	$35,000	City of Centennial (SEMSWA, SSPRD, HOA)	4	4	5	0	0	3	2	3	4	365	258	71%
		PHI Subreach 2	Vegetation management	$17,500	City of Centennial (SEMSWA, HOA)	5	5	5	0	0	3	2	3	4	365	281	77%

Table 5-14: Spring Creek Recommended Plan Scoring Table

Project Information						Metric (Weight)									Total Possible Score	Cumulative Weighted Score	Percentage Score
Project Category	Project Type	Project ID	Project Description	Cost Estimate	Jurisdiction	Complexity (11)	Project Cost (12)	Maintenance Efficiency (9)	Comprehensive Water Quality (8)	WQCV/and EURV Provided (8)	Stream Health (10)	Flood Capacity (10)	Public Safety (13)	Environmental (8)			
Stream Function and Maintenance	Vegetation and Debris Management	SC Subreach 1	Vegetation management	$35,000	City of Centennial (SEMSWA, SSPRD)	5	4	5	0	0	3	2	3	4	365	269	74%
		SC Subreach 4	Vegetation management	$140,000	City of Centennial (SEMSWA, SSPRD)	4	3	5	0	0	3	2	3	4	365	246	67%
		SC Subreach 6	Vegetation management	$17,500	City of Centennial (SEMSWA, HOA)	5	5	5	0	0	3	2	3	4	365	281	77%
		SC Subreach 9	Vegetation and debris management	$125,000	Douglas County (HRMD)	5	3	5	0	0	3	2	4	4	365	270	74%
		SC Subreach 10	Vegetation and debris management	$210,000	Douglas County (HRMD)	5	3	5	0	0	3	2	4	4	365	270	74%
	Stream Rehabilitation	SC Subreach 2	Address erosion, vegetation management, and grade control structure replacement	$950,000	City of Centennial (SEMSWA, SSPRD)	3	2	3	2	0	3	3	4	3	405	236	58%
		SC Subreach 3	Address erosion, outfall repair, vegetation management, and grade control structure replacement	$975,000	City of Centennial (SEMSWA, SSPRD)	3	2	4	2	0	3	3	4	3	405	245	60%
		SC Subreach 8	Address erosion, outfall repair, vegetation management, and grade control structure replacement	$460,000	City of Centennial (SEMSWA, SSPRD, HOA)	3	3	3	2	0	3	3	4	3	405	248	61%
	Stream Restoration	SC Subreach 5	Address vegetation management and channel erosion	$310,000	City of Centennial (SEMSWA, SSPRD)	2	3	3	2	0	4	3	4	2	405	239	59%
		SC Subreach 7	Grade control structure replacement	$375,000	City of Centennial (SEMSWA, SSPRD)	2	3	3	1	0	4	3	4	2	405	231	57%

Table 5-14 (cont.): Spring Creek Recommended Plan Scoring Table

Project Information						Metric (Weight)									Total Possible Score	Cumulative Weighted Score	Percentage Score
Project Category	Project Type	Project ID	Project Description	Cost Estimate	Jurisdiction	Complexity (11)	Project Cost (12)	Maintenance Efficiency (9)	Comprehensive Water Quality (8)	WQCV/and EURV Provided (8)	Stream Health (10)	Flood Capacity (10)	Public Safety (13)	Environmental (8)			
Water Quality	Pond Retrofit	SC Pond Retrofit 1	Provide new water quality outlet structure	$70,000	Douglas County (HRMD)	2	3	1	5	5	3	3	2	4	445	265	60%
	Vegetated Rundowns	SC Rundown 5	Install vegetated rundown or trash/sediment collection device	$52,000	City of Centennial (SEMSWA, SSPRD)	2	4	2	3	3	3	0	0	5	330	206	62%
		SC Rundown 10	Install vegetated rundown or trash/sediment collection device	$52,000	City of Centennial (SEMSWA, SSPRD)	3	4	3	3	4	3	0	0	5	330	234	71%
		SC Rundown 15	Install vegetated rundown or trash/sediment collection device	$62,500	City of Centennial (SEMSWA, SSPRD)	3	4	3	4	4	3	0	0	5	330	242	73%

Table 5-15: Spring Creek East – Altair Park Tributary Recommended Plan Scoring Table

Project Information						Metric (Weight)									Total Possible Score	Cumulative Weighted Score	Percentage Score
Project Category	Project Type	Project ID	Project Description	Cost Estimate	Jurisdiction	Complexity (11)	Project Cost (12)	Maintenance Efficiency (9)	Comprehensive Water Quality (8)	WQCV/and EURV Provided (8)	Stream Health (10)	Flood Capacity (10)	Public Safety (13)	Environmental (8)			
Stream Function and Maintenance	Stream Restoration	SCEA Subreach 1*	Address channel erosion and vegetation management	$1,500,000	Douglas County (SSPRD, HRMD)	3	1	4	2	0	5	3	4	2	405	245	60%

*SCEA Subreach 1 cost estimate was generated by assuming a cost per linear foot of $1,200 for the entire length of the project (outside the limits of the SEMSWA AMD).

Table 5-16: Spring Creek East - Edgewood Tributary Recommended Plan Scoring Table

Project Information						Metric (Weight)									Total Possible Score	Cumulative Weighted Score	Percentage Score
Project Category	Project Type	Project ID	Project Description	Cost Estimate	Jurisdiction	Complexity (11)	Project Cost (12)	Maintenance Efficiency (9)	Comprehensive Water Quality (8)	WQCV/and EURV Provided (8)	Stream Health (10)	Flood Capacity (10)	Public Safety (13)	Environmental (8)			
Stream Function and Maintenance	Vegetation and Debris Management	SCE Subreach 4	Vegetation management	$53,000	Douglas County (HRMD)	5	4	5	0	0	3	2	3	4	365	269	74%
	Stream Rehabilitation	SCE Subreach 1	Address outfall repair and grade control structure replacement	$130,000	Douglas County (HRMD)	4	3	4	2	0	4	3	4	3	405	278	69%
		SCE Subreach 2	Address channel erosion	$60,000	Douglas County (HRMD)	3	4	3	2	0	3	3	4	3	405	260	64%
		SCE Subreach 3	Address channel erosion	$120,000	Douglas County (HRMD)	4	3	4	2	0	4	3	4	3	405	278	69%

Table 5-17: Trenton Outfall Tributary Recommended Plan Scoring Table

Project Information						Metric (Weight)									Total Possible Score	Cumulative Weighted Score	Percentage Score
Project Category	Project Type	Project ID	Project Description	Cost Estimate	Jurisdiction	Complexity (11)	Project Cost (12)	Maintenance Efficiency (9)	Comprehensive Water Quality (8)	WQCV/and EURV Provided (8)	Stream Health (10)	Flood Capacity (10)	Public Safety (13)	Environmental (8)			
Stream Function and Maintenance	Stream Rehabilitation	TRE Subreach 1	Grade control structure replacement	$295,000	City of Centennial (SEMSWA, HOA)	4	3	4	1	0	3	3	4	3	405	260	64%

Table 5-18: West Spring Creek Recommended Plan Scoring Table

Project Information						Metric (Weight)									Total Possible Score	Cumulative Weighted Score	Percentage Score
Project Category	Project Type	Project ID	Project Description	Cost Estimate	Jurisdiction	Complexity (11)	Project Cost (12)	Maintenance Efficiency (9)	Comprehensive Water Quality (8)	WQCV/and EURV Provided (8)	Stream Health (10)	Flood Capacity (10)	Public Safety (13)	Environmental (8)			
Stream Function and Maintenance	Vegetation and Debris Management	WSC Subreach 2	Address outfall repair and channel erosion	$76,000	City of Centennial (SEMSWA, Private)	3	4	2	2	0	4	3	4	3	405	261	64%
	Stream Restoration	WSC Subreach 1*	Includes channel grading and stabilization, utility protection, and retaining wall repairs	$3,500,000	City of Centennial (SEMSWA, SSPRD)	3	1	4	2	0	5	3	4	2	405	257	60%
Flooding	Culvert Upsizing	WSC Crossing 1	Improve culvert inlet configuration	$20,000	City of Centennial (SEMSWA)	5	5	5	0	0	4	5	4	2	365	318	87%

* WSC Subreach 1 cost estimate and description was sourced from the 30% design for this project. Design performed by others outside of the scope of this MDP.

Table 5-19: Willow Creek East Tributary Recommended Plan Scoring Table

Project Information						Metric (Weight)									Total Possible Score	Cumulative Weighted Score	Percentage Score
Project Category	Project Type	Project ID	Project Description	Cost Estimate	Jurisdiction	Complexity (11)	Project Cost (12)	Maintenance Efficiency (9)	Comprehensive Water Quality (8)	WQCV/and EURV Provided (8)	Stream Health (10)	Flood Capacity (10)	Public Safety (13)	Environmental (8)			
Stream Function and Maintenance	Stream Rehabilitation	WCE Subreach 2	Grade control structure replacement	$780,000	City of Centennial (SEMSWA, SSPRD)	3	2	4	1	0	3	3	4	3	405	237	59%
		WCE Subreach 3	Address channel erosion and grade control structure replacement	$375,000	City of Centennial (SEMSWA, HOA)	3	3	4	2	0	3	3	4	3	405	257	63%
		WCE Subreach 4	Address outfall repair, crossing maintenance, channel erosion, and grade control structure replacement	$885,000	City of Centennial (SEMSWA, HOA)	3	2	4	2	0	3	3	4	3	405	245	60%
		WCE Subreach 5	Address outfall repair and grade control structure replacement	$200,000	City of Centennial (SEMSWA, HOA)	3	3	3	2	0	3	3	4	3	405	248	61%
	Stream Restoration	WCE Subreach 1	Address outfall repair and grade control structure replacement	$750,000	City of Centennial (SEMSWA, SSPRD)	2	2	3	2	0	4	3	4	2	405	227	56%
Flooding	Culvert Upsizing	WCE Crossing 1	Increase pond volume/raise embankment to prevent overtopping	$250,000	City of Centennial (SEMSWA)	2	3	5	0	0	3	5	5	2	365	264	72%
Water Quality	Vegetated Rundowns	WCE Rundown 4	Install vegetated rundown or trash/sediment collection device	$83,000	City of Centennial (SEMSWA, SSPRD)	3	4	3	4	3	3	0	0	5	330	234	71%
		WCE Rundown 5	Install vegetated rundown or trash/sediment collection device	$52,000	City of Centennial (SEMSWA, SSPRD)	3	4	3	3	3	3	0	0	5	330	226	68%

5.3.3 PROJECT PRIORITIZATION

A system for prioritization of the preferred alternatives included in the Recommended Plan is offered as part of this study. The project prioritization presented with this MDP may serve as a starting point for stakeholders to conceptualize the relative attractiveness of each project and begin long-term planning and funding allocation. The project sponsors have indicated that their own in-house prioritization methodologies will also be used to compare the preferred alternatives in this MDP to those developed by other master plans. Therefore, the prioritization schedule presented in this MDP does not reflect final rank-ordering nor does it attempt to reflect a chronological ordering for project implementation.

The prioritization presented herein is based upon the "cumulative weighted score". The cumulative weighted score and rubric scoring methodology are discussed in Section 5.2.3 and presented in the Recommended Plan Tables (Table 5-7 through 5-19). The cumulative weighted score takes into account the goals of the project sponsors and stakeholders as it is based upon the metrics and metric weighting approved by the sponsors in the evaluation rubric used for this study. The Recommended Plan projects were separated into three groupings based on the project categories of Stream Function and Maintenance, Flooding, and Water Quality. The preferred alternatives were then classified as "low", "medium", or "high" priority. Projects with cumulative weighted scores above the 75th percentile were assigned "high" priority. Similarly, projects with cumulative weighted scores below the 25th percentile were classified as a "low" priority. Tables 5-20 through 5-22 summarize the prioritization schedule for each project category within the Recommended Plan

Table 5-20: Recommended Plan Project Prioritization - Stream Function and Maintenance

Project Type	Project ID	Project Description	Priority
Stream Rehabilitation	HFT Subreach 2	Outfall repair	High
Vegetation and Debris Management	FHP Subreach 3	Vegetation management	High
Vegetation and Debris Management	HFT Subreach 1	Vegetation management	High
Vegetation and Debris Management	PHI Subreach 2	Vegetation management	High
Vegetation and Debris Management	SC Subreach 6	Vegetation management	High
Stream Rehabilitation	HFT Subreach 3	Address channel erosion and outfall repair	High
Stream Rehabilitation	KET Subreach 1	Address channel erosion	High
Stream Rehabilitation	FHP Subreach 4	Address erosion, outfall repair, and grade control structure replacement	High
Stream Rehabilitation	FHP Subreach 5	Address erosion, outfall repair, and vegetation management	High
Stream Rehabilitation	SCE Subreach 1	Address outfall repair and grade control structure replacement	High
Stream Rehabilitation	SCE Subreach 3	Address channel erosion	High
Stream Rehabilitation	JAM Subreach 1	Outfall repair	Medium
Vegetation and Debris Management	SC Subreach 10	Vegetation and debris management	Medium
Vegetation and Debris Management	SC Subreach 9	Vegetation and debris management	Medium
Vegetation and Debris Management	JAM Subreach 2	Vegetation management	Medium
Vegetation and Debris Management	SCE Subreach 4	Vegetation management	Medium
Vegetation and Debris Management	SC Subreach 1	Vegetation management	Medium
Vegetation and Debris Management	WSC Subreach 2	Address outfall repair and channel erosion	Medium
Stream Rehabilitation	TRE Subreach 1	Grade control structure replacement	Medium
Stream Rehabilitation	SCE Subreach 2	Address channel erosion	Medium
Vegetation and Debris Management	FHP Subreach 6	Vegetation management	Medium
Vegetation and Debris Management	PHI Subreach 1	Vegetation management	Medium
Stream Restoration	AG Subreach 2	Address vegetation management, channel erosion, and pedestrian safety	Medium
Stream Restoration	WSC Subreach 1	Address channel erosion, outfall repair, and grade control structure replacement	Medium

Table 5-20 (cont.): Recommended Plan Project Prioritization - Stream Function and Maintenance

Project Type	Project ID	Project Description	Priority
Stream Rehabilitation	FHP Subreach 2	Address erosion, outfall repair, vegetation management, and grade control structure replacement	Medium
Stream Rehabilitation	WCE Subreach 3	Address channel erosion and grade control structure replacement	Medium
Stream Rehabilitation	FHP Subreach 1	Address erosion, outfall repair, and grade control structure replacement	Medium
Stream Rehabilitation	SC Subreach 8	Address erosion, outfall repair, vegetation management, and grade control structure replacement	Medium
Stream Rehabilitation	WCE Subreach 5	Address outfall repair and grade control structure replacement	Medium
Vegetation and Debris Management	SC Subreach 4	Vegetation management	Medium
Stream Restoration	SCEA Subreach 1	Address channel erosion and vegetation management	Medium
Stream Rehabilitation	SC Subreach 3	Address erosion, outfall repair, vegetation management, and grade control structure replacement	Medium
Stream Rehabilitation	WCE Subreach 4	Address outfall repair, crossing maintenance, channel erosion, and grade control structure replacement	Medium
Stream Rehabilitation	AG Subreach 1	Address channel erosion, outfall repair, vegetation management, and grade control structure replacement	Medium
Stream Rehabilitation	HOM Subreach 2	Address channel erosion and grade control structure replacement	Medium
Stream Restoration	SC Subreach 5	Address vegetation management and channel erosion	Low
Stream Rehabilitation	WCE Subreach 2	Grade control structure replacement	Low
Stream Rehabilitation	SC Subreach 2	Address erosion, vegetation management, and grade control structure replacement	Low
Stream Restoration	SC Subreach 7	Grade control structure replacement	Low
Stream Restoration	WCE Subreach 1	Address outfall repair and grade control structure replacement	Low

Table 5-21: Recommended Plan Project Prioritization - Flooding

Project Type	Project ID	Project Description	Priority
Culvert Upsizing	AG Crossing 1	Improve inlet grate to reduce clogging	High
Culvert Upsizing	WSC Crossing 1	Improve culvert inlet configuration	High
Culvert Upsizing	HFT Crossing 2	43" x 68" HERCP with safety grate	Medium
Culvert Upsizing	KET Crossing 2	34” x 53” HERCP with safety grate	Medium
Culvert Upsizing	WCE Crossing 1	Increase pond volume/raise embankment to prevent overtopping	Low
Culvert Upsizing	HFT Crossing 1	60" RCP with safety grate	Low
Culvert Upsizing	FHP Crossing 1	4' x 8' RCBC with safety grate	Low
Culvert Upsizing	KET Crossing 1	4’ x 8’ RCBC with safety grate	Low

Table 5-22: Recommended Plan Project Prioritization - Water Quality

Project Type	Project ID	Project Description	Priority
Pond Retrofit	FHP Pond Retrofit 1	Provide new water quality outlet structure	High
Pond Retrofit	SC Pond Retrofit 1	Provide new water quality outlet structure	High
Vegetated Rundown	FHP Rundown 8	Install vegetated rundown or trash/sediment collection device	Medium
Vegetated Rundown	FHP Rundown 11	Install vegetated rundown or trash/sediment collection device	Medium
Vegetated Rundown	SC Rundown 15	Install vegetated rundown or trash/sediment collection device	Medium
Vegetated Rundown	FHP Rundown 5	Install vegetated rundown or trash/sediment collection device	Medium
Vegetated Rundown	SC Rundown 10	Install vegetated rundown or trash/sediment collection device	Medium
Vegetated Rundown	WCE Rundown 4	Install vegetated rundown or trash/sediment collection device	Medium
Vegetated Rundown	WCE Rundown 5	Install vegetated rundown or trash/sediment collection device	Medium
Vegetated Rundown	SC Rundown 5	Install vegetated rundown or trash/sediment collection device	Medium
Wetland Improvements	FHP Wetland 1	Wetland enhancement and creation	Low
Wetland Improvements	HOM Wetland 1	Wetland enhancement and creation	Low
Wetland Improvements	HFT Wetland 1	Wetland enhancement and creation	Low

6.0 REFERENCES

1. ICON Engineering Inc. (2025), FHAD, Willow Creek Tributaries Upstream of Englewood Dam.
2. FEMA (2020), Flood Insurance Study, Arapahoe County, Colorado and Incorporated Areas. Revised September 4, 2020.
3. United States Department of Agriculture, Natural Resources Conservation Service, Web Soil Survey. https://websoilsurvey.sc.egov.usda.gov/
4. Urban Drainage and Flood Control District (2016) Urban Storm Drainage Criteria Manual, Volume 1 and 2.
5. CH2M Hill (2010), Willow Creek FHAD 2010.
6. CH2M Hill (2010), Willow Creek, Little Dry Creek, and Greenwood Gulch Outfall Systems Planning Study.
7. Modrick, T. (2015), CARFFG System Design and Theoretical Background. National Weather Service, Hydrologic Research Center. Presentation. September 15, 2015.
8. Shamir, E. (2018), CARFFG System Design and Theoretical Background: GIS and Threshold Runoff. National Weather Service, Hydrologic Research Center, San Diego, CA. Presentation. Last modified August 30, 2018.
9. Enginuity Engineering Solutions, Adaptive Management Dashboard Applications. Adaptive Management Dashboard Applications (arcgis.com)
10. Mile High Flood District (2023), MHFD Bid Pricing Database November 2023.
11. Mile High Flood District and Enginuity Engineering Solutions (2022), MHFD Proposed Actions Costing Tool V23.07.a (Components Costing Tool)

APPENDIX A - PROJECT CORRESPONDENCE

MAJOR DRAINAGEWAY PLAN
MEETING MATERIALS

Tributaries of Willow Creek MDP
Alternatives Scoping Meeting

November 16, 2022 | 11:00 AM

MINUTES

1. Attendees

a. Jon Villines (MHFD)
b. Jeff Battiste (MHFD)
c. Jessica Traynor (SEMSWA)
d. Cynthia Love (SEMSWA)
e. Tiffany Clark (SEMSWA)
f. Nicole Harwell (SEMSWA)
g. Jon Nelson (SEMSWA)
h. Craig Jacobson (ICON)
i. Jeremy Deischer (ICON)
j. James Duvall (ICON)
k. Shuangshuang Fan (ICON)

2. Project Deliverables

a. The team discussed how the alternatives analysis would be delivered.
    i. MHFD indicated that good digital deliverables (e.g. problems data set and recommended actions) will be preferred but that this project would likely not follow the online-only approach as guidance is still in development.
        1. MHFD said that they would be ok if the report contained the main information, and the rest was included online.
        2. ICON indicated that they would be open to beta testing the online approach if it is determined that it should be included in the scope.
    ii. SEMSWA said that they would like a hybrid approach and require the key deliverables in a standard report format. A detailed GIS deliverable and interactive map is also a desired deliverable. It was also noted that master plans can often become outdated fairly quickly, so it is important to consider how the analysis can be updated as new information becomes available.
    iii. Both MHFD and SEMSWA agree that the most important thing is to have a good digital deliverable that gives users a lot of flexibility and allows for future transition to online.
b. MHFD requested that ICON set up a meeting to further discuss online deliverables and view examples of what is being developed through the Confluence web portal.
    i. In general, future deliverables aim to describe the underlying problem (the why) and focus less on the specific prescription of solutions.

3. Goals for Alternatives Analysis

a. The team reviewed and confirmed that the previously identified alternative goals are still relevant.
    i. Identify maintenance needs
    ii. Improve water quality on a watershed scale
    iii. Engage active neighborhood
    iv. Identify capital improvement projects to reduce 100-yr floodplain
b. ICON asked if converting riparian corridors from mowed blue grass to other wetland-type vegetation should be explored as part of this project phase.
    i. SEMSWA commented that South Suburban Parks and Recreation District (SSPRD) is responsible for maintenance and that alternate vegetation would not be a priority at the moment
    ii. SEMSWA did ask that a high-level analysis for an alternative vegetation option be included as a starting point for future consideration if SSPRD does decide that a lower irrigation and lower maintenance option would be attractive. This analysis does not have to include costing.
c. MHFD indicated that a rapid geomorphic assessment (RGA) has been done by Engenuity for Spring Creek, West Spring Creek, Fox Hill Creek, Willow Creek East, and Phillips tributary.
    i. MHFD recommended that the scope include time for ICON to become familiar with the previous Enginuity stream assessment (Adaptive Management Dashboard) and how the data can be utilized as a tool in recommending alternatives and developing maintenance plans. The Adaptive Management Dashboard should be seen as a living record and updates that come from the Willow Creek Tributaries MDP should be incorporated back into the dashboard.
d. ICON asked if fluvial hazard mapping would be a product that the stakeholders would like as part of the alternatives analysis.
    i. MHFD and SEMSWA noted that they would be open to the mapping if there is a reach that needs it; however, the watershed is nearly fully developed with narrow/defined stream corridors so there may not be many benefits in this watershed.
    ii. The MHFD stream management corridors, and watershed scale, may provide additional information for use instead of developing FHZ mapping.

4. Discuss Key Areas / Ongoing Projects within Watershed

a. ICON noted that the MDP alternatives analysis will extend beyond the FHAD limits and look at the entire watershed using the 2d hydraulic models and SWMM models developed in the hydrology study.
b. In general, there are limited opportunities for new detention (full spectrum or otherwise) and proposed alternatives will likely focus on existing basins, road crossings/safety, stream function, and other water quality opportunities.
c. The team reviewed PDFs for each tributary within the project area and discussed items that should be highlighted for analysis during the next phase.
    i. SEMSWA will send the link (see below) to the online PDF review to their maintenance staff so that they can add comments on specific known maintenance issues.
        1. Mural Web Map for Willow Creek Tributaries MDP

   ii. Homestead Farm and Homestead Tributary
      1. No issues were identified
   iii. Fox Hill Park Tributary
      1. ICON mentioned that the detention basin west of Holly Street can overflow up into the roadway.
      2. The crossing at Dry Creek Road can present safety issues during high flows.
   iv. Spring Creek
      1. ICON will follow up with maintenance to determine where previous emergency repairs have been conducted along West Spring Creek. These locations will be analyzed for possible improvements.
      2. The team noted that sculpted drop structures were constructed on West Spring Creek in a previous Olsson project.
      3. The detention facility south of 470 may provide opportunities for water quality retrofit.
   v. Acres Green and Trenton Outfall
      1. ICON asked if daylighting Trenton Outfall where it is currently piped at an existing park should be explored further. SEMSWA indicated that SSPRD is generally not in favor of the redevelopment of existing parks and that there are currently not and known plans for work on the park.
      2. It was noted that within Lone Tree/Douglas County, the upper Acres Green channel is located in the median of a divided roadway.
   vi. Phillips Tributary
      1. SEMSWA mentioned there may be some erosion around the banks of the private retention ponds east of Yosemite St.
      2. It was noted that the culvert crossing under Yosemite St. was lined in a previous project.
   vii. Willow Creek East, Kettle Tributary, and Jamison Tributary
      1. SEMSWA indicated that a higher berm for Panorama Pond is being considered to accommodate higher receiving flows in the future/built-out condition as the District (Jones District) develops.
      2. MHFD mentioned that they have performed retrofitting (trickle channel) and maintenance work in the Panorama Pond.
      3. MHFD indicated that as part of the Willow Creek project, they are going to take a look at the area upstream of the confluence with Willow Creek East.
      4. In the Jamison Tributary, it was noted that there may be capacity issues at the Dry Creek Road crossing. No CIPs are currently identified for Jamison or Kettle Tributary.

5. Next Steps

a. Scope Alternatives Phase
   i. ICON will develop the scope and fee for the MPD alternatives analysis.
   ii. MHFD noted that the scope should be limited to the alternatives phase, with future phases being handled by separate scopes as progress continues.
b. ICON will reach out to additional stakeholders as work on the alternatives begins.
   i. Arapahoe County
   ii. Douglas County

   iii. Lone Tree
   iv. South Gate Water Sanitation District
   v. South Suburban Parks and Recreation
c. Work on the MDP is currently expected to begin in January 2023.
d. For the MDP and alternatives analysis, the team will plan monthly meetings to discuss progress and findings.

6. Action Items

a. ICON to develop the scope and fee for the MDP alternatives phase.
b. ICON will meet with MHFD to discuss online deliverables.
c. Comments on known issues will be collected from SEMSWA maintenance staff.

Minutes prepared by: ICON Engineering 11/17/22

MINUTES

Willow Creek Tributaries MDP

Kickoff Meeting

Virtual | November 8, 2023 | 2:00PM

Attendees:

MHFD – Jeff Battiste, Jen Winters, Jon Villines

SEMSWA – Tiffany Clark, Jon Nelson

ICON – Craig Jacobson, James Duvall, Jackson Winterrowd

Douglas County – Brad Robenstein

City of Lone Tree – Jacob James

SSPRD - None

Southgate – Katherine Henske (Burns & McDonnell)

Arapahoe County – Chuck Haskins

1. General Items

a. Progress Meetings
   1. ICON suggested that the December progress meeting be skipped due to the Thanksgiving and Christmas holidays. The next progress meeting is targeted for early/mid-January. ICON will send out a poll to determine the best day of week and time for the recurring calendar invite. At this time, Wednesdays at 2pm are agreeable for most members of the group.
   2. The team discussed that progress meetings will be held virtually. All are also welcome to join in person at ICON's office.

b. Two Additional Stakeholder/Neighborhood Engagement Meetings
   1. SEMSWA noted that there are some very active neighborhoods in the study area that we will want to engage before the alternatives development phase.
   2. Douglas County believes there will be little interest from the neighborhoods in their jurisdiction within the study area.
   3. ICON will help coordinate one stakeholder/neighborhood meeting before alternative development and one after to engage the communities. Meetings will be hosted at a public venue with the location determined in future discussions.
   4. SEMSWA noted that at the post-alternatives development community meeting, clear expectations should be set that the planned improvements are not guaranteed to be constructed and are conceptual.
   5. MHFD recommends that the MDP include the FHAD during community outreach as engagement is not currently planned for the FHAD phase. ICON suggested that floodplain changes can be shown at the first community meeting, provided that the FHAD timeline for final approved delineation aligns with the MDP schedule. ICON also noted that from the initial FHAD delineation efforts, there is not significant floodplain conflict with insurable structures that would be negatively received by the community.
   6. Jon Villines will touch base with Brooke Seymour to confirm what extent of community outreach is needed for FHAD projects.

c. Schedule
   1. The draft timeline for MDP alternatives development is November 2023 to May 2024.
   2. The team discussed that the end of January or early February could be targeted for the initial community meeting, prior to alternatives development.

d. Scope
   1. The current partial scope includes the SEMSWA tributary area with Douglas County and Lone Tree contribution being added in 2024. ICON reiterated that the timing of the funding will not impact workflow or approach and work will begin on Problem ID watershed-wide (SEMSWA, Douglas County, and Lone Tree).

e. Website for Public Outreach
   1. MHFD directed ICON to set up a project website.
   2. The team discussed a website that can then link users to the StoryMap.
   3. ICON indicated that it may be possible to go ahead and set up and publish the Introduction section of the StoryMap to provide project background to the community. Other sections of the StoryMap that are still in development can be hidden and not published until the end of the alternatives development phase.
   4. SEMSWA requested that on the website, ICON include a way for constituents to add their concerns to incorporate into problem ID. The team discussed a Survey Monkey link or an email as options for receiving feedback.
   5. SEMSWA, ICON, and MHFD will review past project websites for other feedback options.

2. Problem Identification

a. Stream Health, Function, and Resiliency
   1. ICON will incorporate GIS data from the Adaptive Management Dashboard (AMD) as well as existing locality notes and field supplemented data to analyze stream health. The team agreed with ICON's suggested approach.
   2. MHFD noted that Earthviews.com can be used to access all the fisheye camera footage and photography for the reaches in the study area.
   3. The team authorized ICON to collect field data for the tributaries in Douglas County and Lone Tree that are not in the AMD database.
   4. The team confirmed that stream function, and all other relevant key metrics, shall be evaluated along the same tributaries that were studied for the baseline hydrology effort.

b. Flooding (Streets, Floodplain, Floodway, Houses/Buildings)
   1. To study flooding, ICON will utilize the FHAD HEC-RAS models and generate 2D models for the reaches outside of the FHAD extents. Flooding problem identification will also incorporate locality notes on known issues and past flooding. The team agreed with ICON's suggested approach.
   2. ICON asked about including pedestrian bridges and trail crossings on all streams for evaluation in the master plan. SEMSWA and MHFD are not interested in pedestrian bridge analysis. ICON will follow up with SSPRD to determine their interest.
   3. The project stakeholders agreed that the roadway overtopping criteria applied in this analysis shall correspond to the relevant municipality throughout the study area (i.e., use SEMSWA criteria in SEMSWA boundary).

c. Water Quality
   1. ICON will utilize GIS data to identify water quality deficiencies and opportunities. Following the meeting, ICON requested the latest storm infrastructure GIS data from Douglas County, Lone Tree, and SEMSWA.
   2. SEMSWA noted that there is no typical water quality strategy for a study area that is as developed as Willow Creek. SEMSWA suggested that the best methodology is to be creative in suggesting opportunities. ICON confirmed that this study will look for water quality opportunities in all relevant tributary watersheds (FHAD and non-FHAD reaches)

d. Maintenance Needs
   1. ICON will incorporate GIS data, photos and videos from the Adaptive Management Dashboard, and locality notes on known issues to identify maintenance problems. The team agreed with ICON's suggested approach.

2. ICON will send out the watershed Mural map (interactive PDF) for SSPRD staff to add their notes on known problems in the watershed. This feedback has already been received from SEMSWA in November 2022. ICON will incorporate this input into the Problem ID and alternatives development.

e. Health & Safety, Community Connection, and Equity
   1. This topic was not discussed in detail at this meeting. ICON suggested that all Stakeholders come to the next progress meeting with input related to Community Connection and Equity goals & directives within their respective organizations.

f. Utilities and Other Infrastructure
   1. Southgate Water & Sanitation District (represented by Katherine Henske, Burns & McDonnell) shared 2 PDF exhibits of their master planned projects within the MDP study area, see attached.
   2. Katherine noted that the Jones line upsizing project may represent the most overlap with the master plan on Willow Creek East. ICON requested that B&M share the GIS data from the exhibits as well as any additional detail available regarding the schedule for the planned water and sanitary improvements.
   3. ICON will coordinate further with Southgate in Spring 2024, once the alternatives development phase is completed. The Southgate improvements will be incorporated into the alternatives development to highlight any projects that may represent a cost savings (and therefore an advancement in SEMSWA's CIP priority rankings) by having channel improvements constructed at the same time.

3. Alternatives Development

a. ICON clarified that the current MDP scope brings the project through the alternatives development phase. Following alternatives development, there will be additional public engagement prior to conceptual design development and cost estimating.

4. StoryMap and Report

a. ICON noted that in past discussions, it was suggested that the report not include a discussion regarding Problem ID and alternatives development in Douglas County and Lone Tree. Rather, the Douglas County and Lone Tree deliverables will be provided in StoryMap format only.

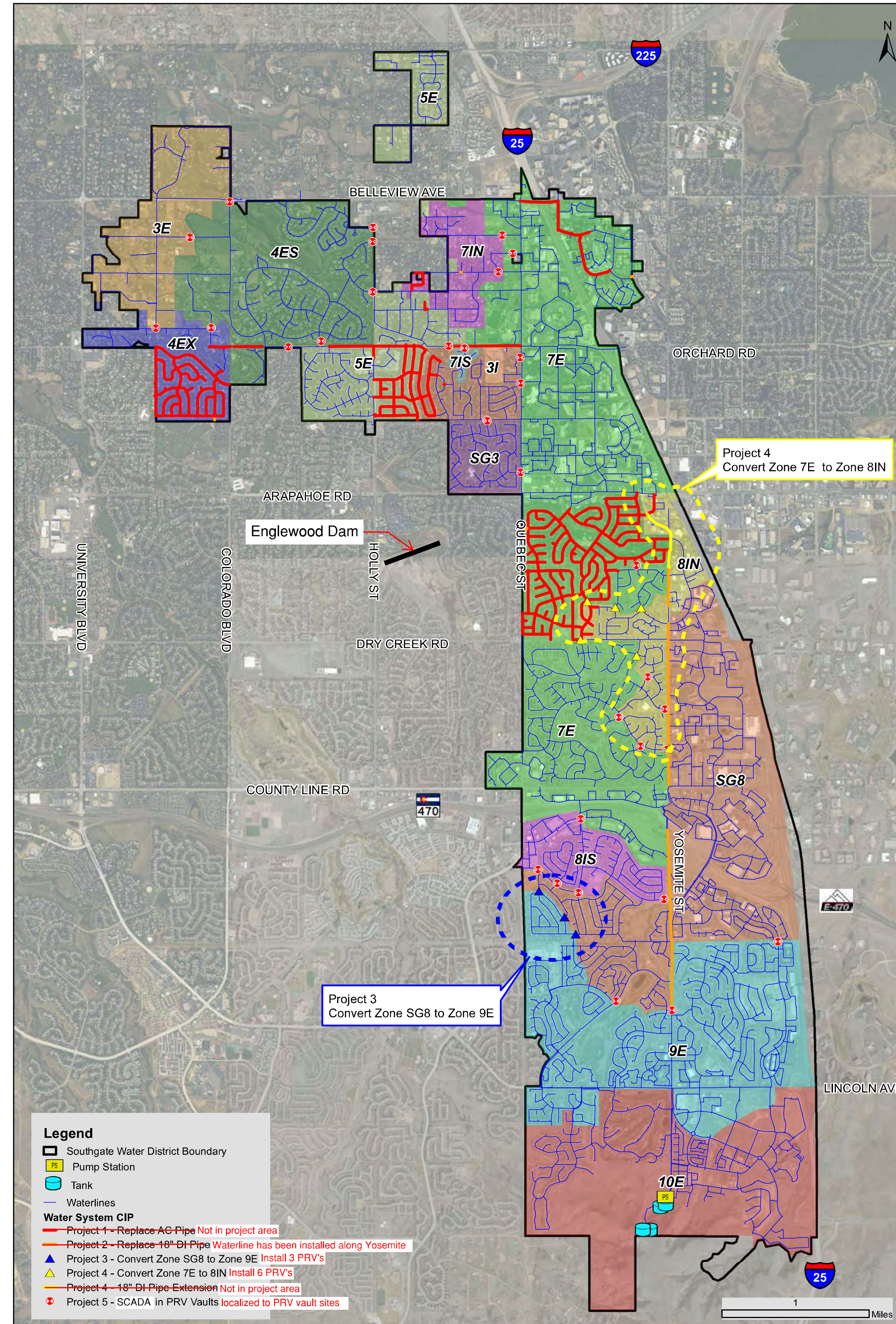
b. ICON will start setting up the StoryMap deliverable. ICON will host the StoryMap and transfer it to MHFD for hosting following project completion/delivery.

- END OF MEETING MINUTES -

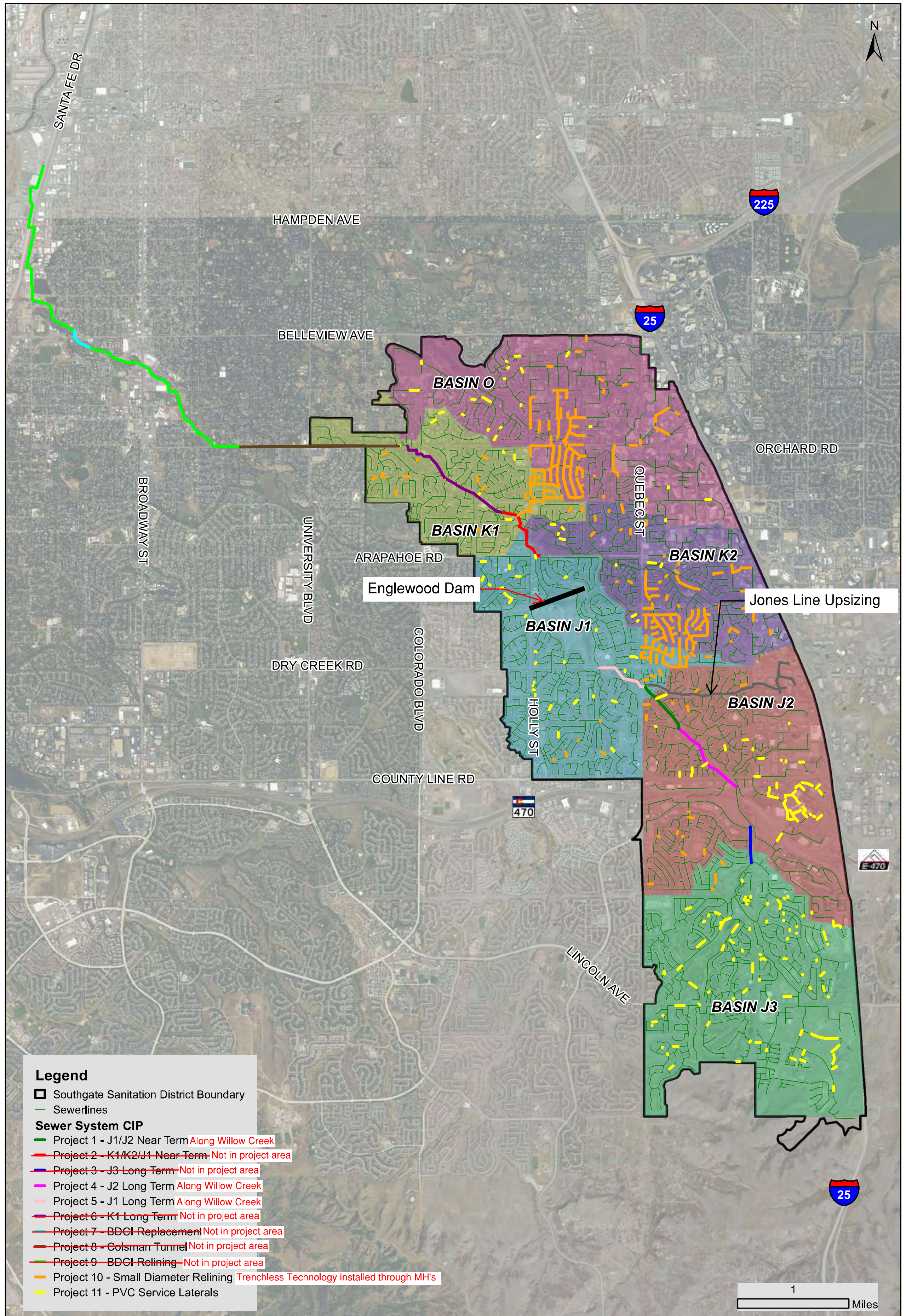
To the best of my knowledge, these minutes are a factual account of the business conducted, the discussions that took place, and the decisions that were reached at the subject meeting. Please direct any exceptions to these minutes in writing to the undersigned within ten (10) days of the issue date appearing herein. Failure to do so will constitute acceptance of these minutes as statements of fact in which you concur.

Minutes prepared by: Jackson Winterrowd | 11/15/2023

ICON Engineering Inc



SOUTHGATE WATER DISTRICT
WATER SYSTEM CAPITAL IMPROVEMENTS
Figure 10-1



PROVIDENCE INFRASTRUCTURE CONSULTANTS

SOUTHGATE SANITATION DISTRICT
SEWER SYSTEM CAPITAL IMPROVEMENTS

Figure 11-1

Southgate WATER & SANITATION DISTRICTS

11-9

MEETING MINUTES

Willow Creek Tributaries MDP

Progress Meeting

Virtual | January 17, 2024 | 2:00PM

Attendees:

MHFD – Jen Winters, Jon Villines

SEMSWA – Jessica Traynor

Douglas County – Brad Robenstein

SSPRD – Melissa Reese-Thacker, Joe Odrzywolski

ICON – Craig Jacobson, James Duvall, Jackson Winterrowd

1. **General Items**
   a. ICON submitted the FHAD Step 4 – Final Review on 1/11/2024. The FHAD is under review by MHFD.
      1. ICON will share the FHAD report and workmaps with SEMSWA and Douglas County; however, SEMSWA and Douglas County indicated that they would not be conducting a technical review of the hydraulic models or detailed output tables.
   b. ICON briefly reviewed the 2024 scope & budget contributions for the MDP.
      1. ICON is currently partially scoped through Alternatives Development, not including Alternative Selection or the final report deliverables. Per conversations in 2023, MHFD, SEMSWA, Douglas County, and the City of Lone Tree will provide the remainder of the Alternatives Development scope in 2024.
         1. Following the meeting, ICON will provide MHFD with a detailed cost breakdown.
      2. MHFD will invoice Douglas County and the City of Lone Tree directly for their contributions rather than going through a formal IGA.

2. **Problem Identification Status Update**
   a. ICON provided a progress report for the 5 key Problem Identification categories as detailed below. The discussion included description of the metrics and input data utilized for each category and a walkthrough of the GIS maps that have been prepared to visualize the analysis.
   b. Water Quality
      1. ICON used GIS points for existing detention and water quality ponds to symbolize subbasins that currently have some level of water quality treatment.
      2. The presented GIS map for Problem Identification will evolve during the Alternatives Development phase to include potential locations where regional inline detention and local water quality treatments (e.g. retrofits of outlet structures or replacing concrete rundowns with vegetated swales) could be implemented.
   c. Flooding
      1. All roadway crossings within the study area have been symbolized by whether the crossing has 100-year capacity.
         1. ICON used the 1D FHAD model to analyze crossings within the FHAD study limits and 2D models to analyze the crossings outside of the FHAD extents.
         2. The Crossings – Problem ID layer will be updated to show whether the crossing meets SEMSWA/Selected design criteria.
            a. SEMSWA criteria states that for collector roads, no overtopping is allowed for the 10-year event and that there may be a maximum of 12” depth in the gutter flowline for the 100-year event. No overtopping is allowed for arterial roadways.

2. FHAD 100-year Floodplain and Floodway
    1. ICON noted that the FHAD floodplains and floodways will be finalized after one more FHAD submittal (Step 5).
    2. MHFD agreed that showing the preliminary FHAD floodplains (as submitted with Step 4) would be good information to present at public meetings as part of FHAD outreach. ICON stated that as the 100-year FHAD models have previously been reviewed, only minor changes are anticipated to come out of the Step 4 review. No insurable structures are shown in the 100-year floodplain.
3. 2D 100-year Floodplains
    1. ICON has developed 2-Dimensional HEC-RAS models (lower resolution than the 1D FHAD HEC-RAS models) for all non-FHAD tributaries primarily for the purpose of evaluating crossing capacities.
    2. The team agreed that due to the unofficial nature of the 2D floodplains, being that they have not been formally reviewed to the same extent as the 1D FHAD floodplains, the 2D floodplains will not be provided as a digital deliverable for this study.
        a. ICON will provide cleaned up 2D floodplains to the project stakeholders for informational purposes only.

d. Stream Function
1. ICON is utilizing the active management dashboard's "Stream Conditions", "Erosion Hazards", and "Headcuts" GIS layers to identify stream health problems within the study area.
2. ICON noted that this data will be further organized into one "Stream Function" polyline layer and one "Erosion Points" point layer for the Problem ID maps. ICON is working through the data and there will be more mapping progress to show at the next progress meeting.

e. Maintenance
1. ICON is utilizing the active management dashboard's "Point of Interest", "Grade Control", "Outfalls", and "Crossing Inspection" GIS layers along with the provided SEMSWA and SSPRD maintenance comments to identify maintenance issues within the study area.
2. ICON noted that this data will be further organized into "General Maintenance" and "Vegetation Management" layers for the Problem ID maps. ICON is working through the data and there will be more mapping progress to show at the next progress meeting.

f. Social Vulnerability
1. ICON asked about how stakeholders would like to incorporate social vulnerability into the master planning effort.
    1. MHFD mentioned they have a standard social vulnerability dataset, developed in coordination with Michael Baker, that is based on a FEMA template. Jon noted that MHFD's GIS team will be able to send ICON these layers for incorporation.
    2. ICON noted that this data may best be suited for helping to rank the priority of alternatives during the Alternatives Development and Alternatives Selection phases.
    3. SEMSWA requested that ICON prepare a study area map with the clipped census data to show at the next internal progress meeting.

3. Project Website

a. ICON shared the progress of the public website which can be found at the following link: https://www.iconeng.com/project/willow-creek-tributaries/index.html
1. The project stakeholders requested that ICON keep track of public survey response comments. ICON will provide a summary of comments to the stakeholders.
2. Prior to the public meeting, the public website will include a link to the ESRI StoryMap once the StoryMap is developed.
3. SEMSWA requested that their contact information on the public website reference their general office contact information.
4. MHFD will add the public website link to their website with the other ongoing FHAD & MDP studies.

4. Public Meeting

a. Location

1. Melissa (SSPRD) offered to host the public meeting at South Suburban Sports Complex on County Line Road.
2. MHFD suggested that the room should have capacity for 100+ people as there has been large turnouts in the past at this venue.
3. Joe (SSPRD) confirmed that the South Suburban Sports Complex has a room that should be big enough for this project and they have hosted these types of meetings in the past.

b. Time & Date
1. ICON suggested that the middle of March be targeted for the public meeting date. This should give ample time to wrap up the Problem ID phase and engage the public. ICON proposed the following schedule for the 8 weeks leading up to the public meeting:
    1. Approximately 2 weeks for ICON complete the Problem Identification phase.
    2. Approximately 2 weeks for ICON to publish an ESRI StoryMap and develop any needed materials.
    3. Approximately 2 weeks for MHFD to develop and send out the public meeting notifications.
    4. Approximately 2 weeks after the mailers are sent out to give the community time to plan and for word to spread.
2. MHFD and SEMSWA indicated that the meeting time should be after work hours during the work week. ICON suggested a starting time of 6:30pm.

c. Notifications
1. ICON asked how the stakeholders usually coordinate the notification mailers and who in the study area should be included.
2. MHFD responded that they will ask their GIS team how notifications have been performed in the past. MHFD noted that they can either apply a buffer from the centerline of the tributaries or invite all residents within the study area.
3. Douglas County mentioned that it may be best to limit the notifications to the stream corridors to minimize comments on local drainage concerns not involving the Willow Creek tributaries.
4. SEMSWA noted that they have in-house social media capabilities which can be utilized to share the public meeting information through multiple online avenues.

d. Meeting Format
1. The team discussed the preferred format of the public meeting and suggested needed materials and visual aids that should be prepared.
2. MHFD noted that a printout map could be provided along with sticky notes for residents to place comments spatially.
3. SEMSWA noted that at past public meetings, laptops have been provided at the venue for attendees to add comments to online maps.

5. Action Items

a. ICON
1. Share the FHAD Step 4 submittal with SEMSWA and Douglas County.
2. Update website contact information according to the notes in Section 3, above.
3. Invite Jon Nelson and Nicole Harwell to the future progress meetings as they are both listed as Willow Creek CIP managers.
4. Invite Joe Odrzywolski to future progress meetings.
5. Prepare draft public meeting presentation materials to show at the next internal progress meeting.
6. Provide SSPRD (Joe Odrzywolski) with potential dates for a public meeting.

b. SSPRD
1. Check availability of the public meeting room at the South Suburban Sports Complex for the middle of March

c. MHFD

1. Coordinate with GIS team regarding how notifications letters have been distributed for previous projects.
2. Coordinate with GIS team to send ICON the social vulnerability dataset.
3. Add the Willow Creek Tributaries MDP website link on the MHFD website.

- END OF MEETING MINUTES -

To the best of my knowledge, these minutes are a factual account of the business conducted, the discussions that took place, and the decisions that were reached at the subject meeting. Please direct any exceptions to these minutes in writing to the undersigned within ten (10) days of the issue date appearing herein. Failure to do so will constitute acceptance of these minutes as statements of fact in which you concur.

Minutes prepared by: Jackson Winterrowd | 01/24/2024

ICON Engineering Inc

MEETING MINUTES

Willow Creek Tributaries MDP

Progress Meeting

Virtual | February 14, 2024 | 2:00PM

Attendees:

MHFD – Jen Winters, Jon Villines, Jeff Battiste

SEMSWA – Jessica Traynor, Tiffany Clark

Douglas County – Brad Robenstein

SSPRD – Melissa Reese-Thacker

ICON –James Duvall, Jackson Winterrowd

Lone Tree – Jacob James

Southgate Water and Sanitation District – Katherine Henske

1. Public Meeting Coordination

a. Time and Date
    1. Based on the responses to the poll sent out by ICON, Thursday April 4th, 2024, at 6:30pm is the most favorable time and date for the public meeting at the South Suburban Sports Complex on County Line Rd.
    2. ICON will coordinate further with SSPRD to book the Sports Complex.

b. Public Meeting Notifications
    1. The team discussed who should be invited to the public meeting.
        1. MHFD mentioned that with FHAD's, they will typically send notifications to properties that touch the existing or future 1% Annual Chance floodplain.
        2. The team decided that only residents within a buffer of the tributaries will receive physical mailers.
        3. SEMSWA added that they can coordinate with CenCON (HOA group) so that they can reach out to the relevant HOA's.
        4. SEMSWA also noted that they can post in the Nextdoor platform to communicate with neighborhoods in the study area.
        5. MHFD sent an email shortly after the meeting stating that they can handle the physical mailing of the public meeting notifications. MHFD outsources the mailing and will pull together a list of all property owners and addresses along the streams.
    2. The team discussed what information should be included in the public meeting notification letter.
        1. SEMSWA noted that there should be a map of the tributaries and a couple sentences about the venue, date, time, and a description of what the project team expects from the attendees as far as interaction and comments.
        2. MHFD added that they usually make postcard-sized mailers but that there is no standard formats or sizing. Following the meeting, Jen will speak with Brooke Seymour and provide ICON with examples of past mailers.
    3. The team discussed the timing of the public meeting notification letters.
        1. It was agreed that the mailer should be sent 2 weeks prior to the meeting date in order to provide residents ample time to prepare (March 21, 2024).
        2. In MHFD's email shortly after the meeting, it was noted that the mailers should be provided to MHFD by ICON at least 1 week prior to the desired mailing date (March 14,

2024). This will allow sufficient time for MHFD to coordinate with the company doing the mailing.

c. Public Meeting Format
   1. The team agreed that a short, 10-15 minute, presentation followed by an open house is an effective format for this type of meeting.
   2. The introduction should introduce the FHAD and MDP and explain to attendees how to interact with the exhibits and leave comments.
   3. SEMSWA mentioned that the quick introduction presentation should include representative pictures and keep it high level.

d. Public Meeting Materials
   1. ICON suggested that the following materials be created as exhibits for the public meeting:
      1. A static map for each problem identification category
      2. Static hydrology and hydraulics maps
      3. An interactive online (Felt) map of the study area
   2. The static maps will be a place for residents to attach sticky notes with their own comments regarding drainageway problems and alternatives analysis.
   3. The hydrology and hydraulics maps are to provide background about the Baseline Hydrology and FHAD studies that were precursors to this MDP.
   4. The Felt map gives the residents an opportunity to place electronic comments at the meeting. Additionally, a link to this map will be sent out with the mailers to be available for residents that can't attend.
   5. The team agreed that static maps with sticky notes, hydrology and hydraulics maps, and online Felt maps will be sufficient materials for the public meeting.

2. Story Map and Website

a. Story Map [Willow Creek Tributaries Major Drainageway Plan (arcgis.com)]
   1. ICON has been progressing the Story Map deliverable to cover project information through the Problem Identification phase of the MDP.
   2. ICON noted that the format of the Story Map follows a traditional hardcopy MDP report format regarding section headings. The text provided in each section is meant to be a brief synopsis of the material provided in the Baseline Hydrology and FHAD reports.
   3. The team viewed a draft version of the Story Map and provided initial comments.
      1. In the "Flooding" section, MHFD and SEMSWA confirmed that the floodway should not be shown on the map. Additionally, it was requested that ICON add a note in the paragraph above the map stating that no structures are in the DRAFT 1% Annual Chance Floodplain.
      2. MHFD, SEMSWA, and SSPRD commented that for the "Flooding" and "Maintenance Needs" maps, pedestrian bridges should be represented on the map for reference only. ICON will remove pedestrian bridges from the Crossing Capacity and Crossing Physical Condition layers and replace with a point layer.
   4. ICON showed the CDC Social Vulnerability Index as a potential visualization for the "Equity" problem identification category.
      1. MHFD has decided not to use the Michael Baker Social Vulnerability dataset.
      2. ICON reviewed the clipped dataset and noted that the entire study area is not at a very high vulnerability state based on the "overall score" metric in the dataset. ICON noted that the lowest scoring census tract in the study area is above the 75th percentile in terms of vulnerability.
      3. MHFD noted that the overall metric is used to compare the vulnerability of one census tract to another in response to the same magnitude of disaster.
      4. MHFD asked if the data could be used to compare tracts statewide or nationwide. ICON reviewed the metadata and revealed that the SVI data is individual to each state.
      5. MHFD recommended that the SVI data not be shown in the Story Map as there is little difference in vulnerability and it may send an unfavorable message to residents if one area is symbolized as at higher risk than others.
      6. The team agreed that the best way to use the SVI is to incorporate this dataset into the alternatives phase. The Equity category will be removed from problem identification.

b. Project Website [Willow Creek Tributaries FHAD & MDP (iconeng.com)]
   1. ICON has updated the contact information and the meetings tab since the last MDP progress meeting.
   2. ICON will update the website to include a link to the Story Map, once approved.

3. Action Items

a. ICON
   1. Create draft public meeting notification letters to show at next month's progress meeting.
   2. Create draft public meeting materials to show at next month's progress meeting.
   3. Update the Story Map and provide the team with the link.

b. SEMSWA
   1. Coordinate with CenCON to notify the relevant HOA's of the public meeting.

c. MHFD
   1. Provide ICON with examples of notification mailers.
   2. Jen will check-in with Hung-Teng regarding the status of the FHAD review by MHFD.

d. All
   1. Review and provide comments on Story Map.

- END OF MEETING MINUTES -

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Minutes prepared by: Jackson Winterrowd | 02/16/2024

ICON Engineering Inc

MEETING MINUTES

Willow Creek Tributaries MDP

Progress Meeting
Virtual | March 13, 2024 | 2:00PM

Attendees:

MHFD – Jen Winters, Jeff Battiste

SEMSWA – Jessica Traynor

Lone Tree – Jacob James

Southgate Water and Sanitation District – Katherine Henske

ICON – Craig Jacobson, Jackson Winterrowd

1. **Public Meeting Coordination**
   a. Public Meeting Time and Date
      1. Set for April 4th from 6:30pm to 8:30pm at South Suburban Sports Complex – 4810 E County Line Rd, Highlands Ranch
   b. Mailer Notifications
      1. ICON sent a finalized mailer notification to MHFD for coordination with their contractor who does the physical mailing.
      2. Approximately 1900 homes will be invited to the public meeting via mailer notifications within the next few weeks.
      3. ICON asked about HOA coordination and social media postings in addition to the mailers. SEMSWA will coordinate with the HOA's and social media from here on out.
   c. Public Meeting Roles and Responsibilities
      1. Expected attendance from the project team at the public meeting is anywhere from 7 to 11 people. Known project team attendees are listed below. ICON will reach out to the remainder of the project team to confirm the number of attendees.
         1. ICON – Craig Jacobson, James Duvall, Jackson Winterrowd
         2. MHFD – Jen Winters, Jeff Battiste
         3. SEMSWA – Jessica Traynor and will coordinate internally with SEMSWA to determine if there is interest from others in joining the meeting.
         4. Lone Tree – Jacob James or another Lone Tree representative
         5. Douglas County – Brad Robenstein was not present at the March progress meeting. ICON will follow up with Brad to confirm Douglas County attendance.
      2. Public Meeting Agenda
         1. Project team will arrive to the venue around 5:45pm to set up the room and materials.
         2. Doors will open at 6:30pm to the public.
         3. ICON will give a brief presentation beginning at 6:45pm that will last no longer than 15 minutes.
            a. The presentation will be kept at a high level for an introduction to the study.
            b. There are no standard templates used for public meeting presentations. ICON will create the presentation and send it out for feedback at least one week prior to the public meeting.
            c. SEMSWA noted that the presentation should emphasize that the goal of the meeting is to gather feedback from the public and that ICON should provide descriptive instructions on how to do so. It was also mentioned that the first slide of the presentation should be a study area map instead of an introduction slide. An introduction slide can be used as the second slide if need be.
            d. Introductions for project sponsors and stakeholders will be given by an ICON speaker to minimize the number of people presenting.
         4. At no later than 7:00pm, the meeting will break into the open house format.
      3. Open House Stations
         1. There will be 6 stations, each with a different map(s) that will be placed around the room. Attendees will be able to place sticky notes on the maps to leave comments on known issues in the watershed.
         2. Each station will be manned by a project team member to start the open house session. This can be flexible if there is little attendance at the public meeting or seems overbearing.
         3. ICON will suggest station assignments to team members prior to the public meeting.
      4. Equipment
         1. ICON will check with SSPRD to confirm that the room will be equipped with a projector, screen, tables, chairs, and microphone.
         2. 7 easels (or stands) will be required to display the static maps at all the stations. ICON has 4 easels but will need help obtaining the remaining 3 from the project team.
         3. It was not discussed during the March public meeting, but ICON will provide 3 laptops for the public meeting to have the public website, Storymap, Felt Map, and Google survey available.

2. **Public Meeting Materials**
   a. Website - Willow Creek Tributaries FHAD & MDP (iconeng.com)
      1. The public website was updated since the last progress meeting to include the public meeting details, felt map, and past meeting minutes.
   b. StoryMap - Willow Creek Tributaries Major Drainageway Plan (arcgis.com)
      1. The StoryMap has not been updated since the last progress meeting. However, ICON requested that the team communicate any comments on the StoryMap as soon as possible.
      2. ICON will update the header picture of the StoryMap to be brighter.
      3. The StoryMap will be linked on the public website prior to the public meeting.
   c. Felt Map - Willow Creek Tributaries Public Input Map — Felt
      1. The Felt Map is intended for the public to place electronic comments spatially on an online map. The functionality of the felt map is very simple and will be demonstrated at the public meeting.
      2. The Felt Map is linked to the public website and is currently live for comments.
   d. Static PDF Maps (boards)
      1. There will be 7 static maps printed out for the 6 total stations at the public meeting. The 6 stations are outlined below.
         1. Hydraulics – Effective and Draft floodplains
         2. Hydrology
         3. Flooding
         4. Stream Function
         5. Maintenance Needs
         6. Water Quality
      2. Each static map is an enlarged version of the interactive StoryMap maps that have been printed out and labeled to be easily digestible. Each map will be printed in color on a 34"x44" roll plot and displayed on the easels.
      3. ICON will provide 8.5" x 11" pictures for the "Stream Function" and "Maintenance Needs" maps to provide further context to what the symbology on the map is representing.

3. Action Items

a. ICON
   1. Create a draft public meeting presentation and send to project team for feedback at least one week prior to the public meeting.
   2. Confirm public meeting attendance from the remainder of the project team.
   3. Assign open house stations to project team members.
   4. Update all materials necessary for the public meeting (Storymap, Website, Static maps and pictures).
   5. Confirm if a projector, screen, tables, chairs, and microphone will be provided in the meeting room.

b. SEMSWA
   1. Coordinate with CenCON/HOAs and SEMSWA social media team for public meeting notifications.

c. MHFD
   1. Remain the point of contact for the public meeting mailer coordination with the mailing contractor.

d. All
   1. Review and provide comments on the Storymap.
   2. Check if your respective organization can lend easels or boards for use at the public meeting. There is currently a need for 3 easels and boards.

- END OF MEETING MINUTES -

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Minutes prepared by: Jackson Winterrowd | 03/18/2024

ICON Engineering Inc

MEETING MINUTES

Willow Creek Tributaries MDP

Public Meeting

South Suburban Sports Complex | April 4, 2024 | 6:30PM

Attendees:

MHFD – Jen Winters

SEMSWA – Jessica Traynor, Tiffany Clark

Lone Tree – Jacob James

Douglas County – Brad Robenstein

ICON – Craig Jacobson, James Duvall, Jackson Winterrowd

SSPRD – Melissa Reese-Thacker

9 attendees from the public

1. Presentation (6:45pm-7:00pm)

a. PowerPoint attached

2. Open House (7:00pm-8:30pm)

a. Map stations with comments from the public attendees attached
b. No input on the Google Form
c. One comment on Felt Map - Willow Creek Tributaries Public Input Map — Felt

- END OF MEETING MINUTES -

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Minutes prepared by: Jackson Winterrowd | 04/10/2024

ICON Engineering Inc

7000 S. Yosemite Street, Suite 120 | Centennial, CO 80112 | (303) 221-0802 | iconeng.com

MEETING MINUTES

Willow Creek Tributaries MDP

Progress Meeting
Virtual | May 8, 2024 | 2:00PM

Attendees:

MHFD – Jen Winters

SEMSWA – Jessica Traynor

Douglas County – Brad Robenstein

SSPRD – Melissa Reese-Thacker

ICON – Craig Jacobson, James Duvall, Jackson Winterrowd

1. **Public Meeting Recap**
   a. Attendance
      1. There were 9 residents that attended the public meeting on April 4th at the South Suburban Sports Complex.
   b. Public Input
      1. Attendees placed notes on the static maps at each station.
      2. There have been no new responses to the Google Form survey on the project website since the public meeting.
      3. Felt Map
         1. One comment was placed on the Felt Map during the public meeting.
         2. All meeting comments were added to the Felt Map for future reference (Willow Creek Tributaries Public Input Map – Felt).
      4. Public Meeting Follow-ups
         1. SEMSWA noted that a resident, located on Willow Creek East near the confluence with Willow Creek main stem, let them know about a grouted riprap drop that has failed. This resident is also concerned with general vegetation management strategies along Willow Creek East.
            a. This drop structure was identified on the existing conditions Maintenance Needs map.
            b. ICON noted that there is an ongoing project in this area to address these concerns. At the next MDP progress meeting, ICON will provide a project status report from the team performing the design at the confluence.
         2. MHFD added that a resident called them with concerns about the concrete energy dissipation structure and debris accumulation on Willow Creek, just downstream of the confluence with Willow Creek East. The Willow Creek main stem is not part of this study.
         3. SSPRD mentioned an area on Fox Hill Park Tributary in the Willow Spring Open Space that has opened into a makeshift swimming hole. This was also a comment received during the public meeting. ICON will walk this reach of Fox Hill Park to assess the conditions of this area and include it on the problem identification map.
            a. Melissa noted that there is ongoing discussion about a potential restoration project with Ducks Unlimited in Willow Spring Open Space.
      5. Public Meeting Lessons Learned
         1. The project team discussed the attendance at the meeting. It was determined that adequate notice and messaging was provided and that attendance can vary greatly based on each project and neighborhood.

         2. For the second public meeting, a virtual option should be provided to supplement the in-person meeting.

2. **Alternatives Development**
   a. The team agreed that a more general approach should be taken for alternatives development. MHFD and SEMSWA noted that they are steering away from conceptual designs in master plans as the designs often do not get used.
      1. SEMSWA would prefer that the master plan provide cost estimating, general feasibility, and base design requirements.
   b. Stream Function
      1. ICON will present Stream Function by reach to identify sections of channel where a project could be targeted in the future.
      2. These reaches will also consider Maintenance Needs (see additional information in Section C below)
         1. MHFD and SEMSWA noted that if a reach is classified as "good" or stable, then there is no need to think about systematic overhauls of the tributary.
   c. Maintenance Needs
      1. ICON will group maintenance points by reach to obtain the overall severity level and type of maintenance needed.
      2. Alternatives will be identified as maintenance-level and capital improvement-level (CIP) projects.
         1. CIP projects will be classified as having a large scope and cost that requires longer term planning, whereas maintenance projects will be projects with a relatively smaller footprint and cost.
   d. Flooding
      1. ICON will utilize hydraulic modeling to upsize existing culverts that do not currently meet SEMSWA criteria.
      2. ICON asked if trail inundation areas should be considered. SSPRD mentioned that there are some areas, particularly within Willow Spring Open Space, that are frequently inundated. SSPRD will check with their maintenance crews to locate these areas.
   e. Water Quality
      1. Regional Water Quality
         1. ICON will identify existing ponds to retrofit for Water Quality and EURV benefit.
            a. SEMSWA noted that this should be a high-level, planning design rather than specific design of an outlet structure or pond. Alternatives development will focus on confirming if there is enough space within the topography for the WQCV and EURV.
            b. SEMSWA mentioned a previous study that showed potential WQCV and EURV increases for each pond on a map.
            c. ICON noted that analysis of existing ponds could also include consideration of adequate space for maintenance improvements such as access roads and forebays.
      2. Point Source Water Quality
         1. ICON will identify opportunities for point treatment applications to outfalls and rundowns.
            a. SEMSWA and MHFD will check if they have any updated typical design references for water quality treatments at the end of pipes before entering the open channels.
            b. MHFD mentioned potentially bringing in their water quality specialist for this portion of the alternatives development.
   f. Ranking Alternatives
      1. The current scope is for a qualitative ranking system.
      2. SEMSWA noted that a quantitative ranking system (i.e. assigning a score) would be more useful. SEMSWA has a rubric for ranking alternatives that they suggest being incorporated into this study.
         1. Use of the SEMSWA rubric will help compare alternatives developed with this study with master plans from other watersheds.

2. ICON will use this as a starting point for ranking the alternatives but may modify some fields based on applicability to this study.
3. SEMSWA will send the rubric to ICON.

g. Cost Estimating
   1. SEMSWA and MHFD need costs associated with the recommended alternatives to put into their respective CIP plans.
   2. MHFD indicated that they have developed a new costing spreadsheet. MHFD will confirm if the spreadsheet can be shared to us before it is published online.
   3. SEMSWA noted that for a prior master plan, a cost per linear foot was developed for three kinds of stream projects. Jessica will send over this master plan for ICON to reference when developing cost estimates.

3. Schedule/Scope/Budget Updates

a. Tentative schedule
   1. July/August 2024 – Alternatives Development Completion
      1. Approximately 1 month total for review and revisions
   2. End of 2024 - Final Master Plan Completion
b. Scope
   1. ICON is currently scoped through alternatives. A new scope will be needed for cost estimating and the final report.
c. Deliverables
   1. The deliverables of the Alternatives Analysis phase will be the StoryMap and hard-copy report updated through the alternatives section.
   2. Final deliverables for the master plan will be a GIS geodatabase and hard-copy report. The Storymap will not continue to be hosted/maintained after the geodatabase is incorporated in MHFD's Confluence program.
d. Team Update
   1. Jessica will be taking on a reduced role throughout the summer. ICON will give her at least 2 weeks' notice before we expect to have a deliverable for review.

4. Action Items

a. ICON
   1. Progress the alternatives development phase and show examples at the next progress meeting.
   2. Walk the stretch of Fox Hill Park tributary in Willow Creek Open Space to look at the swimming hole.
b. MHFD
   1. Inquire about MHFD references for formalized pipe end treatment recommendations to enhance water quality.
   2. Share the new/draft standard cost estimating spreadsheet with the team.
c. SEMSWA
   1. Inquire about SEMSWA references for formalized pipe end treatment recommendations to enhance water quality.
   2. Send ICON the past master plan example with EURV map and cost per linear foot for stream projects.
   3. Send ICON the standardized SEMSWA rubric for ranking alternatives.
d. SSPRD
   1. Check in with maintenance crews to specify areas of frequent trail inundation within the Willow Spring Open Space.

- END OF MEETING MINUTES -

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Minutes prepared by: Jackson Winterrowd | 05/20/2024

ICON Engineering Inc

MEETING MINUTES

Willow Creek Tributaries MDP

Progress Meeting
Virtual | June 5, 2024 | 2:00PM

Attendees:

MHFD – Jen Winters, Jeff Battiste

SEMSWA – Jessica Traynor, Jon Nelson

Lone Tree – Jacob James

SSPRD – Melissa Reese-Thacker

ICON – Craig Jacobson, James Duvall, Jackson Winterrowd

1. Alternatives Development

a. Flooding
   i. Safety Grates
      1. With the formal guidance now available for safety grates at culvert openings from MHFD, ICON asked if safety grate recommendations should be included for all crossings in the study area that are applicable or only the culverts that are proposed to be upsized.
      2. ICON will add a statement in the report stating that safety grates should be considered in the final design of the proposed culverts. Safety grate sizing will not be included with the conceptual designs of this study.
      3. ICON will include the cost of safety grates in the cost estimates for the proposed culverts.
      4. ICON asked specifically about the culvert along Fox Hill Park Tributary at the upstream side of Dry Creek Road.
         a. SSPRD noted that this area has not been noted as a previous problem area or marked as high priority for upsizing for a pedestrian crossing. There is an existing underpass at Dry Creek Road along Willow Creek for trail users.
         b. SSPRD indicated that they could be interested in at looking at trail options if the City conducts a culvert/bridge replacement in the future.

b. Stream Function and Maintenance
   i. Combine Stream Function and Maintenance Reaches
      1. ICON initially proposed to evaluate the “Maintenance Needs” and “Stream Function” alternatives at a reach scale, consistent with the Adaptive Management Dashboard reach lenghts. However, the AMD reaches are too long to be representative of their classification and did not effectively isolate where projects were needed.
      2. ICON has refined the “Maintenance Needs” and “Stream Function” reaches to reflect groupings of problem points and removed segments where no action is needed.
      3. Grouping the maintenance projects in this fashion also allows for more accurate cost estimating for projects by not overestimated the project length.
      4. The alternatives report will still look at the streams in the study area on a higher level reach-by-reach basis; however, the final master plan will provide more detailed information about each individual maintenance project.
   ii. SSPRD noted that the tributary to upper Spring Creek East along Altair Park just upstream of Quebec Street is a high priority problem area for their staff.
      1. Altair Park is slated for future upgrades. SSPRD is interested in grass swales and water quality improvements related to the MS4 permit.

c. Water Quality
   i. ICON will calculate the required WQCV, EURV, and 100-yr detention volumes and determine if adequate space exists for proposed WQCV, EURV, and 100-yr detention volumes at the following facilities.
      1. The four existing in-line ponds that do not currently provide water quality treatment. These ponds are the Spring Creek C-470 pond, Spring Creek South pond, Sam’s Club pond, and Fox Hill Park near King Soopers pond.
      2. Six potential locations for new in-line detention facilities.
         a. ICON review each of these proposed locations on a map with the project team.
         b. The team mentioned that a site would need to be located on public land in order to be feasible as a new detention facility. SSPRD and SEMSWA also noted that a suitable site should have an existing drainage easement (or be able to easily acquire one) and is not currently being used as a public amenity (e.g. playground) other than open space. Otherwise, the team had no concerns or opposition to the locations presented.
         c. ICON will add “Land use”, “Owner”, and “Easement” fields to the alternatives GIS.
         d. The team agreed that within the scope that we have, evaluating these 10 ponds will be sufficient. ICON will not review other ponds within the study area.
   ii. The team reviewed the example drainage map provided in the Cherry Creek Southwest Master Plan.
      1. ICON will provide a similar map containing the WQCV, EURV, 100-yr detention volume, and physical volume available for each pond of interest.
   iii. In addition to ponds and pond retrofits, the team discussed potential end of pipe treatments for water quality benefits.
      1. ICON asked if the project team has any preferred details for disconnected rundowns or end of pipe treatments to enhance water quality.
      2. ICON showed typical details from the Lee Gulch Master Plan as examples.
      3. SEMSWA will talk with their environmental group to gather more information. Jon voiced support for looking into passive and low-maintenance E.O.P. treatments. He noted that even though there might not be space within the drainage easement for ponding of the entire WQCV, there are still attractive water quality benefits.
      4. MHFD has no formal details but suggested that ICON reference the Lyons Master Plan for examples. MHFD will also bring on their water quality specialist for upcoming meetings.
      5. This master plan will not provide site-specific design for E.O.P. treatments. The team suggested ICON include an appendix with preferred examples of disconnected rundowns for reference.
      6. ICON will create a SharePoint link for the project team to compile details.
      7. Similar to the proposed detention facilities, it was noted that proposed E.O.P. treatments would also need to be located on public property/easements in order to be implemented.
   iv. Acres Green Concrete Lined Channel
      1. SSPRD noted that the concrete lined channel in the Acres Green Drive median is a high priority problem area for their staff and could benefit from a stream project to enhance water quality.
         a. Further coordination with Douglas County would be necessary, but SSPRD is open to the possibilities of a restoration project within the median.

2. Deliverables

a. Confluence Geodatabases
   i. ICON will estimate the effort required to get the Master Plan data into the Confluence Geodatabases.
   ii. MHFD mentioned that this task could potentially be pushed to 2025, if needed.

b. Cost Estimating
   i. ICON will use multiple methods to estimate costs for the alternatives. This will provide information that can be used for comparison purposes.
   ii. The team discussed the MHFD cost estimating spreadsheet as one methodology.
      1. ICON will utilize the MHFD spreadsheet for point fixes such as culverts and ponds; however, this study will not be producing the level of design required to use the spreadsheet for effectively costing stream projects.

2. Jen offered that ICON could reach out to Jeff Sickles for any questions related to the spreadsheet tool.

iii. The team discussed the SEMSWA cost per linear foot as another methodology to be applied to stream maintenance and CIP projects.

1. The SEMSWA cost per linear-foot data can be matched with the with Problem ID "Level of Maintenance" category developed for this study.

a. SEMSWA noted that the cost per linear-feet data was developed from a recent Dove Creek project

iv. Additionally, ICON will cost stream maintenance projects using a formula to translate the number of maintenance points within a specific reach/channel segment.

v. MHFD and SEMSWA noted that the SEMSWA cost per linear-foot method should be used primarily, with the other methods used to confirm the estimates. The cost estimates should also not be over-analyzed as they are intended to be used for comparison and high-level planning purposes.

c. ICON will utilize the SEMSWA rubric for ranking of the proposed alternatives

i. ICON proposed to use the rubric to compare projects within each category (Maintenance & Stream Function, Flooding, and Water Quality) rather than across all categories.

ii. SEMSWA noted that the rubric is very comprehensive and that some criteria can be removed if not applicable.

3. Action items

a. ICON

i. Add Candice Owens from MHFD to the monthly progress meetings as we talk more about water quality.

ii. Create a Share Point link for the project team to compile rundown and end of pipe treatment details.

iii. Provide updated scope through project completion to MHFD.

b. MHFD, SEMSWA

i. Add any preferred rundown or end of pipe details to the Share Point link for the team's reference.

- END OF MEETING MINUTES -

To the best of my knowledge, these minutes are a factual account of the business conducted, the discussions that took place, and the decisions that were reached at the subject meeting. Please direct any exceptions to these minutes in writing to the undersigned within ten (10) days of the issue date appearing herein. Failure to do so will constitute acceptance of these minutes as statements of fact in which you concur.

Minutes prepared by: Jackson Winterrowd | 06/10/2024

ICON Engineering Inc

ICON

MEETING MINUTES

Willow Creek Tributaries MDP

Progress Meeting

Virtual | July 3, 2024 | 2:00PM

Attendees:

MHFD – Jen Winters, Candice Owen

SEMSWA – Jon Nelson

SSPRD – Melissa Reese-Thacker

Douglas County – Brad Robenstein

ICON – Craig Jacobson, James Duvall, Jackson Winterrowd

1. Alternatives Development

a. Alternatives Report

i. The MDP report and Story Map will be written through Section 6: Alternatives

ii. Section 6 will include an introduction to document all methodology and assumptions for how the alternatives were identified, cost estimated, and scored on the rubric.

iii. Section 6 will present the alternatives at the tributary scale. ICON will provide Summary Sheets for each tributary as a deliverable.

1. An example summary sheet for Fox Hill Park tributary was discussed in the meeting. The FHP summary sheet is attached to these meeting minutes.
2. There will be one summary sheet for each tributary in the study area included in the report.
3. Each summary sheet includes a description of each type of alternative present on the tributary, an exhibit displaying each alternative on the tributary, and the rubric.

iv. The final selected plan (Section 7) will present the recommendations at the sub-reach scale. Rubric scores will be provided for each alternative along with additional description on the problems and solutions in that specific sub-reach.

b. Cost Estimating

i. ICON reminded the team that during the last progress meeting, the team discussed a number of cost estimating methods would be tested on Fox Hill Park. These methods include: MHFD Cost Components Calculator excel spreadsheet, SEMSWA's cost per linear foot data, and summing the problem points per sub-reach.

ii. ICON suggested that a combination of all three methods be used to provide cost estimates for each alternative. The suggested cost methodology includes using the MHFD Cost Component calculator for Culverts and Grade Control Structures. The remaining alternatives were cost estimated by summing the individual problem points within each sub-reach. The SEMSWA cost per linear foot data will be used to cost Vegetation Management and Erosion Control points. All other points were cost using MHFD Bid Tabs.

c. Rubric

i. ICON asked the project team if scoring each alternative on the rubric should be a group effort where everyone can provide input.

1. MHFD and SEMSWA agreed that ICON should attempt scoring the rubric first and then the project stakeholders will review rubric scoring during the review of Section 6.

d. Water Quality Rundowns

i. ICON confirmed with SEMSWA and MHFD that rundowns are an agreeable solution to add water quality benefit, even though they may not provide formal WQCV treatment.

ii. Jon Nelson confirmed that maintenance will be primarily done by SEMSWA.

iii. ICON requested guidance from the project team on which rundown details are the most favorable for their inclusion in the report. Rundowns details and photos are compiled at the following link: Rundown Typical Details - OneDrive (sharepoint.com).
iv. ICON asked MHFD and SEMSWA to share any past rundown construction costs that ICON can incorporate into the cost estimates.
v. MHFD asked how the rundowns are being prioritized against each other. ICON noted that for now, the rundowns are being scored all the same in the rubric. Additional guidance on optimized rundown locations is not currently available. ICON will work with MHFD to determine attributes that can be used to further prioritize individual rundown locations in the recommended plan. ICON noted that rundowns could potentially be prioritized by outfall size, tributary area and land use, or by proximity to other proposed alternatives.

e. Pond Retrofits
   i. MHFD mentioned that there is a current study looking at retrofits on existing detention facilities and that there could be overlap with the MDP. ICON mentioned if the MHFD study yields relevant findings prior to the alternatives report completion, that information can be incorporated.
f. New Wetlands and Wetland Enhancement
   i. ICON asked MHFD and SEMSWA to share any available information regarding cost estimating the proposed wetland improvements areas.

2. Schedule

a. Alternatives Development – Report and Story Map Deliverables: Mid-August
b. Recommended Plan: End of August
c. Public Meeting (if needed): End of September
   i. The team considered if the second public meeting would be beneficial given the lack of attendance at the first public meeting and the nature of the study (no houses in the FHAD floodplain, MDP not prescribing specific projects, etc.).
   ii. MHFD mentioned that because the first public meeting covered FHAD outreach, it would be acceptable to forego the second public meeting if the other project stakeholders are agreeable.
   iii. SEMSWA noted that they hold public outreach meetings for specific CIP projects anyway. Presenting the MDP alternatives may make it seem like these projects will be implemented and confuse the public.
   iv. If the team decides to have the public meeting, an all-virtual meeting format could be utilized.
   v. MHFD posed an option that in-lieu of a second public meeting, notifications could be sent out for the public to review the Alternatives report online and provide comments and ask questions digitally.
   vi. The team will regroup on this topic at the next progress meeting for a final decision
d. Selected Plan: End of the Year 2024

3. Action items

a. ICON
   i. Complete a draft of the “Introduction and Methodology” section of the alternatives report prior to the next progress meeting.
   ii. Complete alternatives analysis for all tributaries, including summary pages, to present at the next progress meeting.
b. MHFD and SEMWA
   i. Look through the SharePoint link for water quality rundowns and provide input on the preferred conceptual details to include in the alternatives report and if any changes should be made to the details.
      1. Rundown Typical Details - OneDrive (sharepoint.com)
   ii. If available, provide past rundown and wetland project costs for incorporation into the alternative cost estimates.

- END OF MEETING MINUTES -

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Minutes prepared by: Jackson Winterrowd | 07/08/2024
ICON Engineering Inc

FOX HILL PARK TRIBUTARY

DESCRIPTION

Fox Hill Park Tributary extends from the Englewood Dam upstream to County Line Rd within the study area. There are problems such as culvert overtopping, erosion, degraded drop structures, outfall deterioration, and vegetation overgrowth present on this tributary.

STREAM FUNCTION AND MAINTENANCE

Adaptive Stream Management

Vegetation management is required in 2 places along the upstream portion of the tributary.

Stream Reclamation and Rehabilitation

Outfall structure, erosion, and grade control structure maintenance are required on this tributary.

Stream Restoration

No full stream restoration projects are required on this tributary.

FLOODING

The E Kettle Ave culvert will require upsizing to convey the 100-yr storm event without overtopping.

WATER QUALITY

Retrofit Existing Ponds

The existing Detention Pond just upstream of E Otero Ave can be retrofitted for the WQCV.

Proposed New Ponds

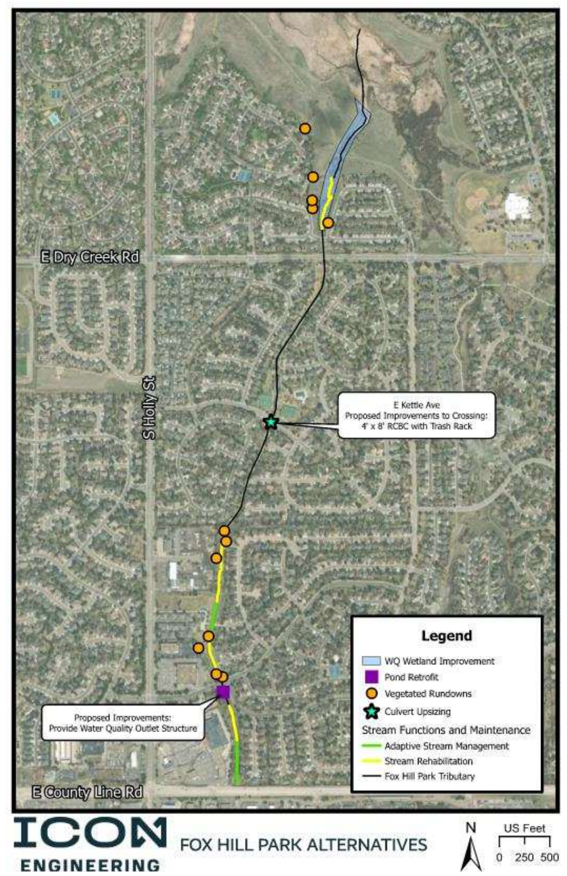
There are no feasible new regional water quality opportunities on this tributary.

Rundowns

There are opportunities for vegetated rundowns on publicly owned land along the tributary in the Englewood Dam Open Space and further upstream near the commercial developments.

Wetland Improvements

There is also an opportunity for wetland improvements to promote water quality in the Dam Open Space.



FOX HILL PARK ALTERNATIVES RUBRIC

Project Category	Project Type	Complexity	Project Cost	Maintenance Efficiency	Comprehensive Water Quality	WQCV/and EURV Provided	Stream Health	Flood Capacity	Public Safety	Environmental	Total Possible Score	Total Score	Percentage Score
Weight		11	12	9	8	8	10	10	13	8			
Stream Function and Maintenance	Adaptive Stream Management	5	4.5	5	0	0	3	2	3	4	365	275	75%
	Stream Rehabilitation	4	2.75	3.75	2	0	3.75	3	4	3	405	270.25	67%
	Stream Restoration	-	-	-	-	-	-	-	-	-	-	-	-
Flooding	Culvert Upsizing	3	2	5	0	0	4	5	5	2	365	273	75%
Water Quality	Pond Retrofit	2	4	1	5	4	2	2	2	3	445	241	54%
	Rundowns	4	4	2	3	3	3.6	0	0	5	330	233.83	71%
	Wetland Improvements	2	3	2	4	2	3	0	2	4	395	212	54%

ICON

MEETING MINUTES

Willow Creek Tributaries MDP

Progress Meeting

Virtual | July 31, 2024 | 2:00PM

Attendees:

MHFD – Jen Winters

SEMSWA – Jon Nelson, Jessica Traynor

Douglas County – Brad Robenstein

ICON – Craig Jacobson, James Duvall, Jackson Winterrowd

1. **Alternatives Development**
    a. ICON is progressing the methodology section and summary alternatives pages for each tributary for Section 5: Alternatives Analysis.
    b. ICON shared the vision for the alternatives section of the StoryMap
        i. The Storymap zooms to each tributary as the user scrolls through the Alternatives section. Each tributary is accompanied by a short description of the alternatives, a legend, and clickable features for the alternatives with relevant information.
            1. SEMSWA noted that the pond ownership field should reflect private or public ownership instead of the parcel owner. This field should be based on easements not property ownership. ICON will email SEMSWA's GIS team for the easement layer.
            2. SEMSWA also noted that fields with numerical values should have the units included.
2. **Recommended Plan**
    a. ICON noted that the Recommended Plan will look very similar to the alternatives because there are only a few problem areas that could have different potential solutions. The team discussed the areas that were identified as having multiple solutions or a preferred solution:
        i. Rundowns
            1. ICON suggested to pair down the number of rundown locations in the recommended plan as to only include 12"-36" outfall sizes.
            2. SEMSWA suggested that we should only include rundowns that are over 18-inch diameter. Additionally, SEMSWA suggested that land use be a factor in pairing down the recommended rundown locations as more developed land uses will provide the most potential for water quality benefit.. ICON will only include rundowns with Commercial land use and medium/large tributary areas as well as Multi-Family land use with a large tributary area.
        ii. Retrofit of C-470 pond
            1. The alternatives show that the C-470 pond on Spring Creek can be retrofitted for both the WQCV and EURV.
            2. Upstream of the C-470 pond, there are 2 other detention ponds that can be retrofitted and multiple rundown opportunities. Retrofit of the C-470 pond is more cost effective and provides greater water quality benefit than the point source solutions. Therefore, water quality alternatives upstream of the C-470 pond will be removed from the recommended plan.
        iii. Acres Green Drive
            1. The Acres Green Drive channel within the road median can be restored as a piped/boxed solution, a native channel (potentially paired with adjacent traffic lane removal for additional flow conveyance), or a spot fix solution to address localized infrastructure repairs.

            2. ICON will reach out to SSPRD to get their opinions on their goals for this drainageway so that the recommended plan aligns with their vision and needs.
    b. SEMSWA mentioned that costs should only be provided for selected alternatives.
    c. Report and StoryMap
        i. The recommended plan will be a short text section in the report detailing the selected alternatives along with a map of the entire study depicting the recommended plan.
        ii. The recommended plan StoryMap section will include an interactive map of the plan.
        iii. SEMSWA requested that a table be added to the recommended plan to summarize the rubric scoring for each alternative.
        iv. MHFD noted that ICON should continue to write the report in the E-Plan format instead of the newer tech memo format, as all of the previous report sections follow the E-Plan.
3. **Schedule**
    a. August Progress Meeting – Cancelled
        i. The team agreed to cancel the next progress meeting on August 28th. ICON will use the time to finish Section 5 of the MDP report and the StoryMap.
    b. Draft Submittal of the Recommended Plan – Early September
        i. The team agreed to combine the Alternatives and Recommended Plan deliverables as they will be very similar. This will make for only one review instead of two from the project sponsors.
    c. September Progress Meeting
        i. This meeting will serve as a comment review session for the Alternatives report submitted in early September.
    d. Public Meeting 2 - Cancelled
        i. SEMSWA noted that a second public meeting is not necessary because it could potentially confuse the attendees by implying that these alternatives are going to be constructed. SEMSWA also noted the lack of attendance at the last public meeting.
        ii. MHFD added that they covered the FHAD and MDP outreach requirements at the last public meeting and are agreeable to not having a meeting prior to conceptual design/final plan.
        iii. ICON could send the report and StoryMap to the 9 attendees of the last public meeting via email and ask if for input. ICON noted that the project website is continually being updated with new project deliverables and meeting records for the public to reference.
    e. Future Steps – October through end of 2024
        i. ICON is currently scoped through the Conceptual Design phase.
        ii. The team noted that with the new master plan intent of being more high-level, this master plan may be able to conclude after the Alternatives/Recommended Plan phase. The project sponsors will review the Alternatives report and decide on next steps after their review.
4. **Other**
    a. Jen Winters noted that the FHAD will be reviewed by Katie Kirsten for any final comments from MHFD.
5. **Action Items**
    a. ICON
        i. Reach out to SEMSWA's GIS team for the easement layer to evaluate pond retrofit feasibility.
        ii. Reach out to Melissa to gauge SSPRD's vision for the Acres Green Drive channel.

- END OF MEETING MINUTES -

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Minutes prepared by: Jackson Winterrowd | 08/05/2024

ICON Engineering Inc

MINUTES

Willow Creek Tributaries MDP

Progress Meeting

Virtual | October 23, 2024 | 2:00PM

Attendees:

MHFD – Jen Winters

SEMSWA – Jon Nelson

Douglas County – Brad Robenstein

Lone Tree – Duncan Rady

ICON – Craig Jacobson, James Duvall, Jackson Winterrowd

1. Report Section 5 Feedback

a. Alternatives and Recommended Plan Report Comments

i. General Feedback

1. The project team noted that the report is well written and generally serves the purpose of the MDP intent through the recommended plan.

ii. MHFD

1. ICON received comments from MHFD on 10/18/2024. Most of the comments were regarding report content and formatting.
2. There was a comment received about potentially changing the name of the "Adaptive Stream Management" reaches because it is confusing with the Adaptive Management Dashboard and is a term that can mean different things. ICON will change the terminology to "Vegetation and Debris Management" to be more clearly defined.
3. There was also a comment to aggregate the recommended plan scores into one table for a summary reference. ICON suggested that projects in the same category can be compared against each other as to not try to compare unlike projects on the same rubric. This will play into the next phase of the MDP with the project prioritization (see more in section 2ii below).

iii. SEMSWA

1. ICON received comments from SEMSWA on 10/23/24. ICON will review the comments and schedule a meeting with the reviewers if necessary.

iv. Cost Estimates

1. ICON inquired about any initial gut feelings of the recommended plan project costs from the project team. The project team thought that the cost estimates looked reasonable at our level of design. Jon reminded the group that these cost estimates are for planning purposes and shouldn't be taken as a firm projection of project costs. ICON will include language in the next iteration of the report about cost estimates outside of the SEMSWA limits since the AMD didn't cover Douglas County.

2. Next Steps

a. Progress the MDP Recommended Plan

i. Address comments from the project team

1. There may be some outstanding comments from Tiffany (SEMSWA), Candice (MHFD), and Melissa (SSPRD). ICON will review the additional comments as they come in and will reach out with any questions.

ii. Prioritization

1. The next phase of the MDP will include project prioritization and a breakdown of jurisdictional funding.

2. ICON will provide lists of the recommended plan projects ranked by priority to the project team for review when available.

iii. Project Scale Splash Sheets

1. For the stream projects that are the highest priority, a separate splash page will be included in an Appendix with additional detail about the project reach. Additional details will include a blown-up map view, cost estimate breakdown, and information on the problem points along the reach.
2. Project splash sheets will not include any flooding (culvert) or water quality projects because these projects have more clarity on the proposed project which leaves little uncertainty on the estimated project cost and scope.

iv. Conceptual designs

1. The team agreed that 10-15% conceptual designs for West Spring Creek, Acres Green, and Altair Park are out of scope for the purposes of this MDP. Additional details will be provided for these reaches in the project scale splash sheets because they are going to be high priority stream reaches.

b. FHAD comments

i. ICON is meeting with MHFD in the next week or two to discuss the Step 4 FHAD submittal comments.

c. StoryMap

i. MHFD noted that the StoryMap will go offline after the MDP data is in confluence. It will be used as a tool for the project team's review and public outreach. ICON will continue to update the StoryMap for all phases of the MDP. Confluence deliverables will come later.

d. Public outreach

i. ICON will continue to update the project website and StoryMap as a form of project outreach in place of a second public meeting.

3. Schedule

a. FHAD

i. The schedule will be determined based on the results of the meeting with MHFD on the FHAD comments.

b. MDP

i. By the end of 2024 or the beginning of 2025 for MDP re-submittal still seems obtainable and should be the goal for submitting the MDP report.

ii. Jen mentioned that if the FHAD takes longer, there is no problem with separating the FHAD and MDP from each other.

4. Action Items

a. ICON

i. Look out for outstanding MDP draft report comments as they come in.

ii. Incorporate feedback from the project team into the MDP report.

iii. Progress the recommended plan with project prioritization, a jurisdictional funding breakdown, and StoryMap.

- END OF MEETING MINUTES -

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Minutes prepared by: Jackson Winterrowd | 10/24/2024

ICON Engineering Inc

MINUTES

Willow Creek Tributaries MDP

Progress Meeting

Virtual | November 20, 2024 | 2:00PM

Attendees:

MHFD – Jen Winters

SEMSWA – Jessica Traynor

Douglas County – Brad Robenstein

SSPRD – Melissa Reese-Thacker

Lone Tree – Duncan Rady

ICON – Craig Jacobson, James Duvall, Jackson Winterrowd

1. **Review MDP Comments**
   a. MHFD
      i. The project team discussed all MDP related comments from MHFD in the previous monthly progress meeting (10/23/2024). Since that October meeting, ICON met with Hung-Teng and Katie from MHFD to discuss comments related to the FHAD report and hydraulic modeling.
      ii. Jen noted that Jon Villines should be added to the project team table in the MDP report but not in the FHAD report.
   b. SEMSWA
      i. ICON will add a table to the cover of the MDP report listing the tributaries that are included in the study and also noting the tributaries that were studied in the FHAD .
      ii. ICON will ensure that each instance of “main stem” in the report is consistently spelled as two words.
      iii. For Figures 2-2, 2-3, and 3- 4, ICON will adjust the zoom level, text size, and legend according to the comments received. Jurisdictional hatching will only be included on Figure 2-2 as it will clash with the hatching already in Figures 2-3 and 3-4.
      iv. The impervious values used for this study stem from Table 6-3 in the 2016 USDCM. ICON will include a note specifying this source below Table 3-4.
      v. ICON clarified that Fox Hill Park Tributary was included in the FHAD, and that West Spring Creek was not.
      vi. A comment was received regarding a potential pond at the confluence of Spring Creek and West Spring Creek. ICON explained that a pond at this location was explored but ultimately not included in the Alternatives and Recommended Plan due to size constraints with the WQCV, EURV, and 100-year ponding volume.
      vii. ICON will consistently refer to Trenton Outfall as “Trenton Outfall Tributary” throughout the MDP report and all figures.
      viii. For the upstream-most portion of West Spring Creek, ICON will update the alternative to from a “Stream Rehabilitation” reach to a “Vegetation and Debris Management” reach. ICON will provide a description of the identified problems in the reach and reflect the access issues on the alternative splash sheet.
      ix. Per Jon Nelson, the Stream Restoration alternative on West Spring Creek is currently under design for construction in 2026 or 2027. ICON will keep the reach in the Alternatives and Recommended Plan and update the cost estimate to reflect actual costs generated by the design project team (Kimley Horn). ICON will include a note about the source of the cost estimate for this reach. ICON will reach out to Molly at SEMSWA for additional information.

      x. ICON will reach out to Britni Kahler at SEMSWA for clarification on the comment regarding the downstream drop structures on Willow Creek East.
      xi. ICON will move the rubric scoring table out of Appendix I and add additional text to the report body clarifying the scoring methodology.
      xii. The “Swimming Hole” identified at the downstream end of Fox Hill Park Tributary was suspected to be located on the Willow Creek main stem. Melissa confirmed that the swimming hole is on the main stem and should not be included as it is outside of the scope of this MDP. Melissa noted that SSPRD is coordinating with Ducks Unlimited on potential projects within the Englewood Dam Open Space. ICON will follow up with Melissa following the meeting to discuss if there is additional information on the design of these wetland areas that should be included in the MDP.
   c. General
      i. ICON will provide responses to every comment in a comment response matrix to be included with the final MDP submittal.

2. **Project Prioritization**
   a. ICON will provide three Recommended Plan tables corresponding to the Stream Function and Maintenance, Water Quality, and Flooding projects. These tables will include an associated “high”, “medium”, or “low” priority ranking for each selected alternative.
      i. SEMSWA mentioned that the project prioritization ultimately will not be used by their organization. SEMSWA has an in-house ranking system that they use to compare recommended projects across master plans.

3. **Project Detail Sheets**
   a. The project team decided that the project detail sheets are not necessary to meet the intent of the MDP and will not be included with this study.

4. **Action Items**
   a. ICON
      i. Address all MDP comments.
      ii. Follow up with Britni and Molly at SEMSWA for clarification on MDP report comments.
      iii. Final MDP report submittal slated for December 2024

- END OF MEETING MINUTES -

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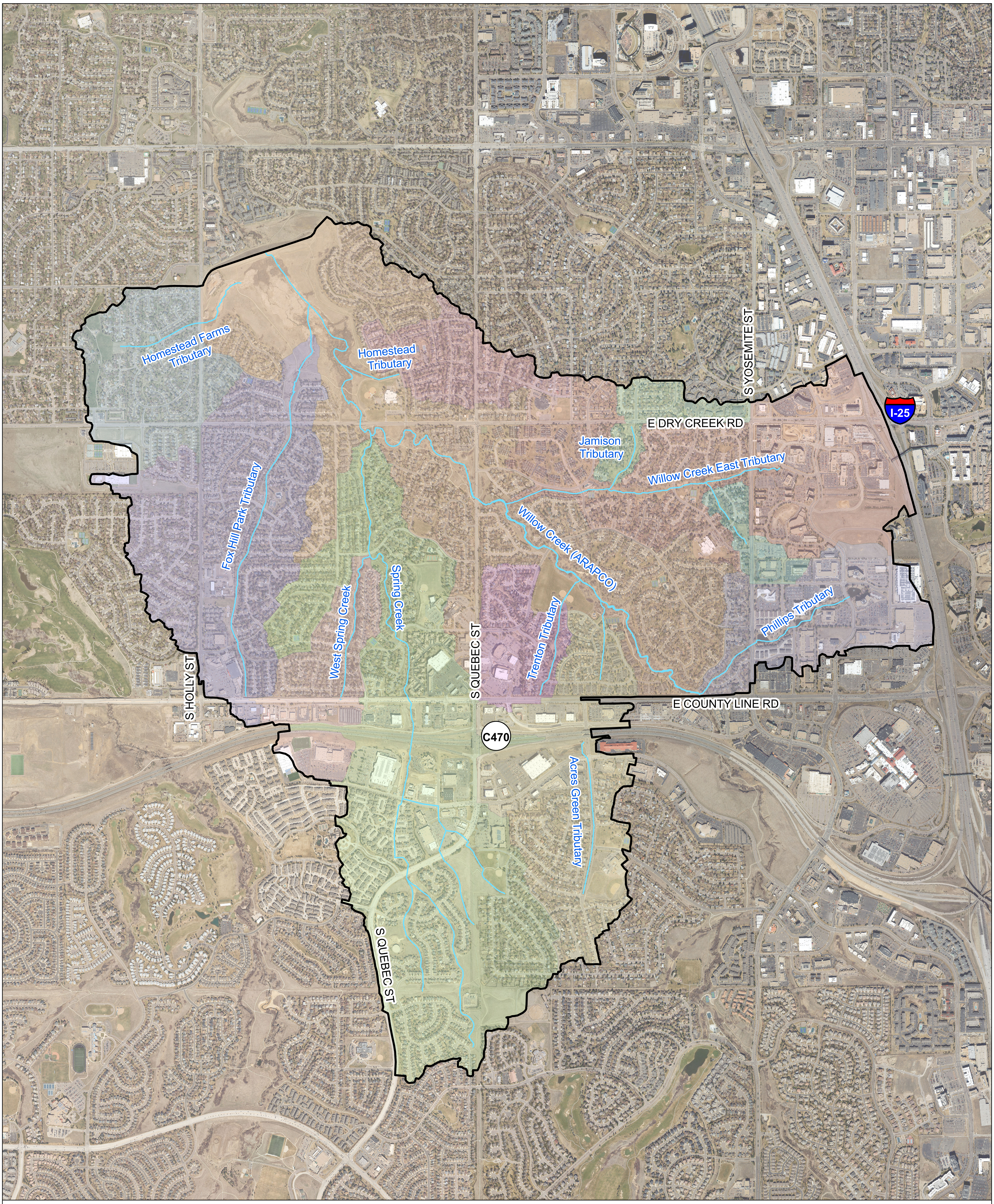
Minutes prepared by: Jackson Winterrowd | 11/22/2024

ICON Engineering Inc

APPENDIX B - HYDROLOGIC ANALYSIS



Tributaries of Willow Creek MDP - Interactive Map

ICON ENGINEERING

MHFD MILE HIGH FLOOD DISTRICT

Southeast Metro Stormwater Authority

0 0.25 0.5 1 Miles

N S E W

Interactive Figures (Select Below)

Study Area Map	Major Roads	ON	OFF
Existing Soils Map	Local Roads	ON	OFF
Existing Land Use	1-ft Contours	ON	OFF
Existing SWMM Routing	10-ft Contours & Labels	ON	OFF
	Subwatershed & Labels	ON	OFF

Subbasin Name / Area (Ac.) / Imperv. Ex % Fut % — Subwatershed Label

SWMM Junctions
SWMM Dividers
SWMM Outfalls
SWMM Storage
SWMM Conduits
Study Area
Drainageway
Subwatershed

Soil Type	Land Use	
A	5 - 10%	50 - 60%
B	10 - 20%	60 -70%
C	20 - 30%	70 - 80%
D	30 - 40%	80 - 90%
Water	40 - 50%	90 - 100%

To Export the Hydrology Map to PDF:

1. Select Export Map... from the File menu.
2. In the Export Map dialog box, name the file and navigate to desired directory to save the file.
3. Set the save as type: to "PDF (*.pdf)."
4. In the Options group, on the General tab, set the Resolution and Output Image Quality. It is recommended that the Resolution = 300 dpi and the Output Image Quality = Normal to preserve the print quality.
5. On the Format tab, check Compress Vector Graphics.
6. Set Picture Symbol: to "Vectorize layers with bitmap markers/fills"
7.Check Embed All Document Fonts.
8. On the Advanced tab, set Layers and Attributes: to Export PDF Layers Only.
Important: "Export to PDF Layers Only" or "Export PDF Layers and Feature Attributes" must be selected in order to provide Map Controls.
9. Click Save

CUHP Rainfall Distribution

2-Year	
1-hr Point Rainfall = 0.84	
Time (min)	Depth (in)
0:05	0.02
0:10	0.03
0:15	0.07
0:20	0.13
0:25	0.21
0:30	0.12
0:35	0.05
0:40	0.04
0:45	0.03
0:50	0.03
0:55	0.03
1:00	0.03
1:05	0.03
1:10	0.02
1:15	0.02
1:20	0.02
1:25	0.02
1:30	0.02
1:35	0.02
1:40	0.02
1:45	0.02
1:50	0.02
1:55	0.01
2:00	0.01

5-Year	
1-hr Point Rainfall = 1.10	
Time (min)	Depth (in)
0:05	0.02
0:10	0.04
0:15	0.10
0:20	0.17
0:25	0.28
0:30	0.14
0:35	0.06
0:40	0.05
0:45	0.04
0:50	0.04
0:55	0.03
1:00	0.03
1:05	0.03
1:10	0.03
1:15	0.03
1:20	0.02
1:25	0.02
1:30	0.02
1:35	0.02
1:40	0.02
1:45	0.02
1:50	0.02
1:55	0.02
2:00	0.01

10-Year	
1-hr Point Rainfall = 1.34	
Time (min)	Depth (in)
0:05	0.03
0:10	0.05
0:15	0.11
0:20	0.20
0:25	0.34
0:30	0.16
0:35	0.08
0:40	0.06
0:45	0.05
0:50	0.04
0:55	0.04
1:00	0.04
1:05	0.04
1:10	0.04
1:15	0.04
1:20	0.03
1:25	0.03
1:30	0.03
1:35	0.03
1:40	0.03
1:45	0.03
1:50	0.03
1:55	0.02
2:00	0.02

25-Year	
1-hr Point Rainfall = 1.69	
Time (min)	Depth (in)
0:05	0.02
0:10	0.06
0:15	0.08
0:20	0.14
0:25	0.25
0:30	0.42
0:35	0.20
0:40	0.14
0:45	0.08
0:50	0.08
0:55	0.05
1:00	0.05
1:05	0.05
1:10	0.04
1:15	0.04
1:20	0.03
1:25	0.03
1:30	0.02
1:35	0.02
1:40	0.02
1:45	0.02
1:50	0.02
1:55	0.02
2:00	0.02

50-Year	
1-hr Point Rainfall = 1.99	
Time (min)	Depth (in)
0:05	0.03
0:10	0.07
0:15	0.10
0:20	0.16
0:25	0.30
0:30	0.50
0:35	0.24
0:40	0.16
0:45	0.10
0:50	0.10
0:55	0.06
1:00	0.06
1:05	0.06
1:10	0.05
1:15	0.05
1:20	0.04
1:25	0.04
1:30	0.03
1:35	0.03
1:40	0.03
1:45	0.03
1:50	0.03
1:55	0.03
2:00	0.03

100-Year	
1-hr Point Rainfall = 2.30	
Time (min)	Depth (in)
0:05	0.02
0:10	0.07
0:15	0.11
0:20	0.18
0:25	0.32
0:30	0.57
0:35	0.32
0:40	0.18
0:45	0.14
0:50	0.11
0:55	0.09
1:00	0.09
1:05	0.09
1:10	0.05
1:15	0.05
1:20	0.03
1:25	0.03
1:30	0.03
1:35	0.03
1:40	0.03
1:45	0.03
1:50	0.03
1:55	0.03
2:00	0.03

500-Year	
1-hr Point Rainfall = 3.10	
Time (min)	Depth (in)
0:05	0.03
0:10	0.09
0:15	0.14
0:20	0.25
0:25	0.43
0:30	0.77
0:35	0.43
0:40	0.25
0:45	0.19
0:50	0.15
0:55	0.12
1:00	0.12
1:05	0.12
1:10	0.06
1:15	0.06
1:20	0.04
1:25	0.04
1:30	0.04
1:35	0.04
1:40	0.04
1:45	0.04
1:50	0.04
1:55	0.04
2:00	0.04

Future CUHP Input

Subcatchment Name	EPA SWMM Target Node	Raingage	Area (Ac.)	Length to Centroid (ft.)	Length (ft.)	Slope (ft/ft)	Percent Imperviousness	Depression Storage (in) Pervious	Depression Storage (in) Impervious	Hortons's Infiltration Parameters Initial Rate (in/hr)	Hortons's Infiltration Parameters Decay Coefficient (1/seconds)	Hortons's Infiltration Parameters Final Rate (in/hr)
ACR_B005	ACR_B005	WCT	19.71	1040.30	1835.85	0.034	45.5	0.35	0.05	3.00	0.0018	0.50
ACR_B010	ACR_B010	WCT	11.49	873.82	1766.62	0.0223	75.0	0.35	0.05	3.00	0.0018	0.50
ACR_B015	ACR_B015	WCT	12.45	818.21	2019.28	0.0317	71.2	0.35	0.05	3.00	0.0018	0.50
ACR_B020	ACR_B020	WCT	22.57	1030.32	2130.69	0.0083	75.0	0.35	0.10	3.00	0.0018	0.50
ACR_B025	ACR_B025	WCT	21.37	842.54	2108.17	0.0186	87.3	0.35	0.10	3.00	0.0018	0.50
ACR_B030	ACR_B030	WCT	33.29	1654.26	2571.18	0.0237	79.3	0.35	0.10	3.00	0.0018	0.50
ACR_B035	ACR_B035	WCT	25.04	1044.31	1993.94	0.0329	69.5	0.35	0.10	3.00	0.0018	0.50
ACR_B040	ACR_B040	WCT	36.29	1078.40	2515.83	0.0342	45.1	0.35	0.05	3.00	0.0018	0.50
ACR_B045	ACR_B045	WCT	33.96	441.76	1669.35	0.0338	45.7	0.35	0.05	3.00	0.0018	0.50
ACR_B050	ACR_B050	WCT	28.09	484.85	1551.54	0.0415	49.5	0.35	0.05	3.00	0.0018	0.50
ACR_B055	ACR_B055	WCT	29.27	1258.49	2132.53	0.0298	45.0	0.35	0.05	3.00	0.0018	0.50
DFA_B005	DFA_B005	WCT	156.12	1458.94	4214.57	0.0125	18.5	0.40	0.05	3.00	0.0018	0.50
DFA_B010	DFA_B010	WCT	21.01	1009.84	1806.20	0.0361	44.7	0.35	0.05	3.00	0.0018	0.50
DFA_B015	DFA_B015	WCT	37.20	732.37	1537.48	0.0396	44.6	0.35	0.05	3.00	0.0018	0.50
DFA_B020	DFA_B020	WCT	17.33	1247.83	2407.41	0.0263	47.8	0.35	0.05	3.00	0.0018	0.50
DFA_B021	DFA_B021	WCT	35.15	1450.20	3444.57	0.0292	50.9	0.35	0.05	3.00	0.0018	0.50
DFA_B025	DFA_B025	WCT	22.95	365.76	1131.05	0.0408	49.0	0.35	0.05	3.00	0.0018	0.50
DFA_B030	DFA_B030	WCT	23.74	1503.44	2360.94	0.0353	45.0	0.35	0.05	3.00	0.0018	0.50
DFA_B035	DFA_B035	WCT	12.59	367.06	988.25	0.0361	33.8	0.35	0.05	3.00	0.0018	0.50
DFA_B040	DFA_B040	WCT	35.58	961.10	2268.03	0.0385	33.4	0.35	0.05	3.00	0.0018	0.50
DFA_B041	DFA_B041	WCT	28.38	937.28	1542.59	0.0431	35.6	0.35	0.05	3.00	0.0018	0.50
DFA_B042	DFA_B042	WCT	6.80	501.54	1027.01	0.0356	48.8	0.35	0.05	3.00	0.0018	0.50
DFA_B043	DFA_B043	WCT	17.43	394.91	1212.12	0.0286	86.6	0.35	0.05	3.02	0.0018	0.51
DFA_B045	DFA_B045	WCT	27.16	1002.61	2196.83	0.0414	36.0	0.35	0.05	3.00	0.0018	0.50
DFA_B046	DFA_B046	WCT	22.97	1002.48	2085.31	0.0372	40.2	0.35	0.05	3.00	0.0018	0.50
DFA_B050	DFA_B050	WCT	53.60	764.83	1721.38	0.0343	31.0	0.35	0.05	3.00	0.0018	0.50
DFA_B051	DFA_B051	WCT	15.46	416.65	1433.85	0.0434	45.2	0.35	0.05	3.00	0.0018	0.50
DFA_B055	DFA_B055	WCT	42.40	794.77	2015.27	0.0417	45.0	0.35	0.05	3.00	0.0018	0.50
DFA_B060	DFA_B060	WCT	25.68	1191.68	1486.25	0.0285	14.5	0.40	0.05	3.00	0.0018	0.50
DFA_B061	DFA_B061	WCT	14.17	957.57	1788.31	0.0243	45.0	0.35	0.05	3.00	0.0018	0.50
DFA_B065	DFA_B065	WCT	22.63	1021.93	1792.02	0.0148	40.1	0.40	0.05	3.03	0.0018	0.50
DFA_B100	DFA_B100	WCT	6.81	588.91	961.11	0.0262	45.0	0.35	0.05	3.00	0.0018	0.50
DFA_B105	DFA_B105	WCT	11.01	318.78	1047.95	0.0421	45.0	0.35	0.05	3.00	0.0018	0.50
FHP_B005	FHP_B005	WCT	15.72	753.01	1581.61	0.0117	15.5	0.35	0.05	3.00	0.0018	0.50
FHP_B010	FHP_B010	WCT	13.75	805.39	1960.13	0.0326	48.0	0.35	0.05	3.00	0.0018	0.50
FHP_B015	FHP_B015	WCT	4.50	345.12	618.19	0.0358	75.0	0.35	0.05	3.00	0.0018	0.50
FHP_B020	FHP_B020	WCT	6.18	189.50	957.24	0.0103	75.0	0.35	0.05	3.00	0.0018	0.50
FHP_B025	FHP_B025	WCT	8.02	596.05	1836.48	0.033	67.5	0.35	0.05	3.00	0.0018	0.50
FHP_B030	FHP_B030	WCT	59.11	926.57	2438.39	0.0354	51.1	0.35	0.05	3.00	0.0018	0.50
FHP_B035	FHP_B035	WCT	5.19	623.02	1281.11	0.0308	29.3	0.35	0.05	3.00	0.0018	0.50
FHP_B040	FHP_B040	WCT	23.73	1028.75	1741.84	0.0335	37.6	0.35	0.05	3.00	0.0018	0.50
FHP_B045	FHP_B045	WCT	8.14	548.47	1338.72	0.0254	71.2	0.35	0.05	3.00	0.0018	0.50
FHP_B050	FHP_B050	WCT	6.82	414.56	1020.51	0.0291	45.0	0.35	0.05	3.00	0.0018	0.50

Future CUHP Input

Subcatchment Name	EPA SWMM Target Node	Raingage	Area (Ac.)	Length to Centroid (ft.)	Length (ft.)	Slope (ft/ft)	Percent Imperviousness	Depression Storage (in)		Hortons's Infiltration Parameters		
								Pervious	Impervious	Initial Rate (in/hr)	Decay Coefficient (1/seconds)	Final Rate (in/hr)
FHP_B055	FHP_B055	WCT	6.27	548.06	1127.76	0.0267	44.2	0.35	0.05	3.00	0.0018	0.50
FHP_B060	FHP_B060	WCT	23.16	787.42	1657.97	0.0223	46.5	0.35	0.05	3.00	0.0018	0.50
FHP_B065	FHP_B065	WCT	35.94	1039.23	2191.53	0.0176	44.7	0.35	0.05	3.00	0.0018	0.50
FHP_B070	FHP_B070	WCT	31.77	935.94	2188.38	0.0184	45.0	0.35	0.05	3.00	0.0018	0.50
FHP_B075	FHP_B075	WCT	6.63	1303.78	2563.03	0.0277	45.6	0.35	0.05	3.00	0.0018	0.50
FHP_B080	FHP_B080	WCT	27.51	618.66	1938.22	0.0304	42.8	0.35	0.05	3.00	0.0018	0.50
FHP_B085	FHP_B085	WCT	33.29	893.84	2253.34	0.0345	60.4	0.35	0.10	3.00	0.0018	0.50
FHP_B090	FHP_B090	WCT	18.25	443.41	1135.72	0.0377	44.9	0.35	0.05	3.00	0.0018	0.50
FHP_B095	FHP_B095	WCT	19.45	791.78	1444.90	0.0265	69.6	0.35	0.10	3.00	0.0018	0.50
FHP_B100	FHP_B100	WCT	14.09	627.67	1354.66	0.0364	45.0	0.35	0.05	3.00	0.0018	0.50
FHP_B105	FHP_B105	WCT	5.62	163.19	534.96	0.0176	75.2	0.35	0.10	3.00	0.0018	0.50
HFT_B005	HFT_B005	WCT	29.98	1078.57	2032.77	0.0354	45.0	0.35	0.05	3.00	0.0018	0.50
HFT_B010	HFT_B010	WCT	55.63	999.96	2454.72	0.0269	35.0	0.35	0.05	3.00	0.0018	0.50
HFT_B015	HFT_B015	WCT	42.19	1231.35	3069.17	0.0331	45.0	0.35	0.05	3.00	0.0018	0.50
HFT_B020	HFT_B020	WCT	16.18	1430.26	2332.60	0.0279	45.0	0.35	0.05	3.00	0.0018	0.50
HFT_B025	HFT_B025	WCT	20.38	1372.38	1940.15	0.0238	52.9	0.35	0.05	3.00	0.0018	0.50
HFT_B030	HFT_B030	WCT	5.40	544.79	863.18	0.024	75.0	0.35	0.05	3.00	0.0018	0.50
HOM_B005	HOM_B005	WCT	10.33	372.42	1055.53	0.0167	45.0	0.35	0.05	3.00	0.0018	0.50
HOM_B010	HOM_B010	WCT	32.38	857.69	2064.91	0.0428	45.6	0.35	0.05	3.00	0.0018	0.50
HOM_B015	HOM_B015	WCT	24.49	1134.31	2253.69	0.034	45.0	0.35	0.05	3.00	0.0018	0.50
HOM_B020	HOM_B020	WCT	30.34	958.53	2454.06	0.0284	45.0	0.35	0.05	3.00	0.0018	0.50
JAM_B005	JAM_B005	WCT	17.62	685.10	1401.25	0.0355	34.2	0.35	0.05	3.00	0.0018	0.50
JAM_B010	JAM_B010	WCT	35.35	813.48	2510.97	0.0209	56.0	0.35	0.05	3.00	0.0018	0.50
KET_B005	KET_B005	WCT	16.55	551.11	1396.05	0.035	44.9	0.35	0.05	3.00	0.0018	0.50
KET_B010	KET_B010	WCT	19.32	566.80	1431.86	0.0348	91.0	0.35	0.10	3.00	0.0018	0.50
PHI_B100	PHI_B100	WCT	16.90	695.90	1367.05	0.036	44.7	0.35	0.05	3.00	0.0018	0.50
PHI_B105	PHI_B105	WCT	16.19	1252.41	2135.63	0.0252	45.0	0.35	0.05	3.00	0.0018	0.50
PHI_B110	PHI_B110	WCT	35.24	684.79	1773.59	0.0301	78.8	0.35	0.10	3.06	0.0018	0.52
PHI_B115	PHI_B115	WCT	100.88	1180.72	2655.81	0.0405	81.5	0.35	0.10	3.54	0.0015	0.64
SPC_B005	SPC_B005	WCT	24.29	910.02	1952.26	0.0258	50.1	0.35	0.05	3.00	0.0018	0.50
SPC_B010	SPC_B010	WCT	28.37	550.51	2074.85	0.0329	40.4	0.35	0.05	3.00	0.0018	0.50
SPC_B015	SPC_B015	WCT	40.17	1302.16	2538.54	0.0357	43.9	0.35	0.05	3.00	0.0018	0.50
SPC_B020	SPC_B020	WCT	18.19	1118.43	2638.39	0.0329	46.9	0.35	0.05	3.00	0.0018	0.50
SPC_B025	SPC_B025	WCT	41.11	1243.12	2911.96	0.0246	51.4	0.35	0.05	3.45	0.0016	0.61
SPC_B030	SPC_B030	WCT	54.04	643.22	2125.36	0.036	63.4	0.35	0.10	3.05	0.0018	0.51
SPC_B035	SPC_B035	WCT	29.05	430.47	1597.35	0.0332	78.1	0.35	0.10	3.00	0.0018	0.50
SPC_B036	SPC_B036	WCT	24.57	560.40	2510.84	0.013	95.0	0.35	0.05	3.00	0.0018	0.50
SPC_B040	SPC_B040	WCT	58.63	478.52	2204.12	0.04	77.4	0.35	0.10	3.00	0.0018	0.50
SPC_B045	SPC_B045	WCT	56.97	600.07	1837.86	0.0311	50.7	0.35	0.05	3.00	0.0018	0.50
SPC_B046	SPC_B046	WCT	15.68	450.23	1139.63	0.0316	45.0	0.35	0.05	3.00	0.0018	0.50
SPC_B050	SPC_B050	WCT	8.07	601.60	1060.53	0.0336	34.6	0.35	0.05	3.00	0.0018	0.50
SPC_B055	SPC_B055	WCT	16.75	423.33	1359.15	0.0355	28.7	0.35	0.05	3.00	0.0018	0.50
SPC_B060	SPC_B060	WCT	22.31	754.58	1871.86	0.0431	27.8	0.35	0.05	3.00	0.0018	0.50

Future CUHP Input

								Depression Storage (in)		Hortons's Infiltration Parameters		
Subcatchment Name	EPA SWMM Target Node	Raingage	Area (Ac.)	Length to Centroid (ft.)	Length (ft.)	Slope (ft/ft)	Percent Imperviousness	Pervious	Impervious	Initial Rate (in/hr)	Decay Coefficient (1/seconds)	Final Rate (in/hr)
SPC_B065	SPC_B065	WCT	23.15	712.30	1792.42	0.0471	23.8	0.35	0.05	3.00	0.0018	0.50
SPC_B070	SPC_B070	WCT	40.23	847.46	1975.59	0.0415	28.1	0.35	0.05	3.00	0.0018	0.50
SPC_B080	SPC_B080	WCT	22.07	1049.42	2098.49	0.0318	44.6	0.35	0.05	3.00	0.0018	0.50
SPC_B085	SPC_B085	WCT	19.54	907.32	1653.03	0.0303	44.8	0.35	0.05	3.00	0.0018	0.50
SPC_B090	SPC_B090	WCT	9.89	938.65	2025.67	0.0252	29.8	0.35	0.05	3.00	0.0018	0.50
SPC_B095	SPC_B095	WCT	42.42	915.60	2173.88	0.0289	47.0	0.35	0.10	3.00	0.0018	0.50
SPC_B100	SPC_B100	WCT	32.62	831.55	2295.28	0.0394	45.0	0.35	0.05	3.00	0.0018	0.50
SPC_B105	SPC_B105	WCT	27.26	926.15	2677.45	0.0382	25.5	0.35	0.05	3.00	0.0018	0.50
SPC_B110	SPC_B110	WCT	25.65	750.06	2060.35	0.0356	41.4	0.35	0.05	3.00	0.0018	0.50
TRE_B005	TRE_B005	WCT	28.56	1342.01	2011.51	0.0251	42.3	0.35	0.05	3.00	0.0018	0.50
TRE_B010	TRE_B010	WCT	31.97	1068.85	1893.51	0.033	70.2	0.35	0.10	3.00	0.0018	0.50
TRE_B015	TRE_B015	WCT	18.00	446.98	1242.82	0.0382	33.5	0.35	0.05	3.00	0.0018	0.50
TRE_B020	TRE_B020	WCT	5.41	198.88	737.58	0.0254	57.6	0.35	0.05	3.00	0.0018	0.50
TRE_B025	TRE_B025	WCT	3.32	485.88	917.10	0.0214	75.0	0.35	0.05	3.00	0.0018	0.50
WCE_B005	WCE_B005	WCT	8.42	947.17	2268.78	0.0324	28.4	0.35	0.05	3.00	0.0018	0.50
WCE_B010	WCE_B010	WCT	13.60	523.70	1334.00	0.0339	45.0	0.35	0.05	3.00	0.0018	0.50
WCE_B015	WCE_B015	WCT	28.51	1253.78	1845.39	0.0267	43.9	0.35	0.05	3.00	0.0018	0.50
WCE_B020	WCE_B020	WCT	18.47	638.61	1541.51	0.0375	45.0	0.35	0.05	3.00	0.0018	0.50
WCE_B025	WCE_B025	WCT	12.46	693.21	1500.27	0.0365	43.7	0.35	0.05	3.00	0.0018	0.50
WCE_B029	WCE_B029	WCT	13.23	726.13	1657.71	0.039	34.0	0.35	0.05	3.00	0.0018	0.50
WCE_B030	WCE_B030	WCT	25.55	1139.94	2135.03	0.025	36.7	0.35	0.05	3.00	0.0018	0.50
WCE_B035	WCE_B035	WCT	22.11	908.99	2346.05	0.0265	44.8	0.35	0.05	3.00	0.0018	0.50
WCE_B040	WCE_B040	WCT	3.23	530.18	1337.74	0.0343	43.7	0.35	0.05	3.00	0.0018	0.50
WCE_B045	WCE_B045	WCT	26.98	1068.45	2276.54	0.0359	48.0	0.35	0.05	3.00	0.0018	0.50
WCE_B050	WCE_B050	WCT	14.39	733.60	2147.58	0.0253	26.8	0.35	0.05	3.00	0.0018	0.50
WCE_B055	WCE_B055	WCT	20.04	682.11	1779.82	0.0343	43.0	0.35	0.05	3.00	0.0018	0.50
WCE_B056	WCE_B056	WCT	3.19	402.50	1017.00	0.0406	56.0	0.35	0.05	3.00	0.0018	0.50
WCE_B060	WCE_B060	WCT	9.28	507.12	989.40	0.0285	88.1	0.35	0.10	3.00	0.0018	0.50
WCE_B065	WCE_B065	WCT	19.32	454.11	1048.37	0.0459	85.9	0.35	0.10	3.00	0.0018	0.50
WCE_B070	WCE_B070	WCT	14.54	714.39	1554.31	0.0337	80.6	0.35	0.10	3.49	0.0015	0.62
WCE_B075	WCE_B075	WCT	10.93	693.22	1566.95	0.0348	94.8	0.35	0.10	3.00	0.0018	0.50
WCE_B080	WCE_B080	WCT	13.06	473.04	1316.78	0.0348	94.9	0.35	0.10	3.56	0.0015	0.64
WCE_B085	WCE_B085	WCT	6.06	571.76	1183.99	0.0386	94.9	0.35	0.10	3.00	0.0018	0.50
WCE_B090	WCE_B090	WCT	44.84	1270.90	2861.97	0.0281	83.3	0.35	0.10	3.44	0.0016	0.61
WCE_B095	WCE_B095	WCT	6.78	545.26	1266.48	0.0216	95.0	0.35	0.10	3.00	0.0018	0.50
WCE_B100	WCE_B100	WCT	27.07	921.83	2466.81	0.0191	90.7	0.35	0.10	3.00	0.0018	0.50
WCE_B105	WCE_B105	WCT	25.44	823.17	1763.10	0.0331	92.2	0.35	0.10	3.00	0.0018	0.50
WCE_B110	WCE_B110	WCT	18.53	631.64	2022.95	0.0168	91.1	0.35	0.05	3.00	0.0018	0.50
WSC_B005	WSC_B005	WCT	42.28	1392.22	2808.54	0.0361	38.0	0.35	0.05	3.00	0.0018	0.50
WSC_B010	WSC_B010	WCT	9.63	452.69	1156.85	0.0325	44.8	0.35	0.05	3.00	0.0018	0.50
WSC_B015	WSC_B015	WCT	16.57	514.85	1569.92	0.0229	45.0	0.35	0.05	3.00	0.0018	0.50
WSC_B020	WSC_B020	WCT	22.62	823.69	1516.79	0.0235	76.9	0.35	0.10	3.00	0.0018	0.50
WSC_B025	WSC_B025	WCT	25.44	722.30	1192.27	0.0246	77.6	0.35	0.10	3.00	0.0018	0.50

Annual / WQ CUHP Input

Subcatchment Name	EPA SWMM Target Node	Raingage	Area (Ac.)	Length to Centroid (ft.)	Length (ft.)	Slope (ft/ft)	Percent Imperviousness	Depression Storage (in) Pervious	Depression Storage (in) Impervious	Hortons's Infiltration Parameters Initial Rate (in/hr)	Hortons's Infiltration Parameters Decay Coefficient (1/seconds)	Hortons's Infiltration Parameters Final Rate (in/hr)
ACR_B005	ACR_B005	WCT	19.71	1040.30	1835.85	0.034	45.5	0.35	0.05	0.75	0.0007	0.60
ACR_B010	ACR_B010	WCT	11.49	873.82	1766.62	0.0223	75.0	0.35	0.05	0.40	0.0007	0.32
ACR_B015	ACR_B015	WCT	12.45	818.21	2019.28	0.0317	71.2	0.35	0.05	0.48	0.0007	0.38
ACR_B020	ACR_B020	WCT	22.57	1030.32	2130.69	0.0083	75.0	0.35	0.10	0.71	0.0007	0.56
ACR_B025	ACR_B025	WCT	21.37	842.54	2108.17	0.0186	87.3	0.35	0.10	0.74	0.0007	0.59
ACR_B030	ACR_B030	WCT	33.29	1654.26	2571.18	0.0237	79.3	0.35	0.10	0.79	0.0007	0.63
ACR_B035	ACR_B035	WCT	24.91	1044.31	1993.94	0.0329	69.5	0.35	0.10	0.77	0.0007	0.62
ACR_B040	ACR_B040	WCT	36.29	1078.40	2515.83	0.0342	45.1	0.35	0.05	1.05	0.0007	0.84
ACR_B045	ACR_B045	WCT	34.10	441.76	1669.35	0.0338	45.7	0.35	0.05	1.17	0.0007	0.94
ACR_B050	ACR_B050	WCT	28.09	484.85	1551.54	0.0415	49.5	0.35	0.05	1.19	0.0007	0.95
ACR_B055	ACR_B055	WCT	29.27	1258.49	2132.53	0.0298	45.0	0.35	0.05	0.76	0.0007	0.61
DFA_B005	DFA_B005	WCT	156.12	1458.94	4214.57	0.0125	18.5	0.40	0.05	1.51	0.0007	1.20
DFA_B010	DFA_B010	WCT	21.01	1009.84	1806.20	0.0361	44.7	0.35	0.05	0.85	0.0007	0.68
DFA_B015	DFA_B015	WCT	37.20	732.37	1537.48	0.0396	44.6	0.35	0.05	1.22	0.0007	0.98
DFA_B020	DFA_B020	WCT	17.33	1247.83	2407.41	0.0263	47.8	0.35	0.05	0.73	0.0007	0.58
DFA_B021	DFA_B021	WCT	35.15	1450.20	3444.57	0.0292	50.9	0.35	0.05	0.94	0.0007	0.75
DFA_B025	DFA_B025	WCT	22.95	365.76	1131.05	0.0408	49.0	0.35	0.05	1.02	0.0007	0.82
DFA_B030	DFA_B030	WCT	23.74	1503.44	2360.94	0.0353	45.0	0.35	0.05	0.84	0.0007	0.67
DFA_B035	DFA_B035	WCT	12.59	367.06	988.25	0.0361	33.8	0.35	0.05	0.89	0.0007	0.71
DFA_B040	DFA_B040	WCT	35.58	961.10	2268.03	0.0385	33.4	0.35	0.05	1.06	0.0007	0.84
DFA_B041	DFA_B041	WCT	28.38	937.28	1542.59	0.0431	35.6	0.35	0.05	1.09	0.0007	0.87
DFA_B042	DFA_B042	WCT	6.80	501.54	1027.01	0.0356	48.8	0.35	0.05	0.42	0.0007	0.34
DFA_B043	DFA_B043	WCT	17.43	394.91	1212.12	0.0286	86.6	0.35	0.05	0.89	0.0007	0.71
DFA_B045	DFA_B045	WCT	27.16	1002.61	2196.83	0.0414	36.0	0.35	0.05	0.83	0.0007	0.67
DFA_B046	DFA_B046	WCT	22.97	1002.48	2085.31	0.0372	40.2	0.35	0.05	0.82	0.0007	0.66
DFA_B050	DFA_B050	WCT	53.60	764.83	1721.38	0.0343	31.0	0.35	0.05	1.32	0.0007	1.05
DFA_B051	DFA_B051	WCT	15.46	416.65	1433.85	0.0434	45.2	0.35	0.05	0.51	0.0007	0.41
DFA_B055	DFA_B055	WCT	42.40	794.77	2015.27	0.0417	45.0	0.35	0.05	1.19	0.0007	0.95
DFA_B060	DFA_B060	WCT	25.68	1191.68	1486.25	0.0285	14.5	0.40	0.05	0.85	0.0007	0.68
DFA_B061	DFA_B061	WCT	14.17	957.57	1788.31	0.0243	45.0	0.35	0.05	0.65	0.0007	0.52
DFA_B065	DFA_B065	WCT	22.63	1021.93	1792.02	0.0148	40.1	0.40	0.05	0.90	0.0007	0.72
DFA_B100	DFA_B100	WCT	6.81	588.91	961.11	0.0262	45.0	0.35	0.05	0.33	0.0007	0.26
DFA_B105	DFA_B105	WCT	11.01	318.78	1047.95	0.0421	45.0	0.35	0.05	0.60	0.0007	0.48
FHP_B005	FHP_B005	WCT	15.72	753.01	1581.61	0.0117	15.5	0.35	0.05	0.60	0.0007	0.48
FHP_B010	FHP_B010	WCT	13.75	805.39	1960.13	0.0326	48.0	0.35	0.05	0.60	0.0007	0.48
FHP_B015	FHP_B015	WCT	4.50	345.12	618.19	0.0358	75.0	0.35	0.05	0.38	0.0007	0.30
FHP_B020	FHP_B020	WCT	6.18	189.50	957.24	0.0103	75.0	0.35	0.05	0.48	0.0007	0.39
FHP_B025	FHP_B025	WCT	8.02	596.05	1836.48	0.033	67.5	0.35	0.05	0.47	0.0007	0.37
FHP_B030	FHP_B030	WCT	59.11	926.57	2438.39	0.0354	51.1	0.35	0.05	1.33	0.0007	1.06
FHP_B035	FHP_B035	WCT	5.19	623.02	1281.11	0.0308	29.3	0.35	0.05	0.48	0.0007	0.39
FHP_B040	FHP_B040	WCT	23.73	1028.75	1741.84	0.0335	37.6	0.35	0.05	0.80	0.0007	0.64
FHP_B045	FHP_B045	WCT	8.14	548.47	1338.72	0.0254	71.2	0.35	0.05	0.52	0.0007	0.41
FHP_B050	FHP_B050	WCT	6.82	414.56	1020.51	0.0291	45.0	0.35	0.05	0.47	0.007	0.38

Annual / WQ CUHP Input

Subcatchment Name	EPA SWMM Target Node	Raingage	Area (Ac.)	Length to Centroid (ft.)	Length (ft.)	Slope (ft/ft)	Percent Imperviousness	Depression Storage (in)		Hortons's Infiltration Parameters		
								Pervious	Impervious	Initial Rate (in/hr)	Decay Coefficient (1/seconds)	Final Rate (in/hr)
FHP_B055	FHP_B055	WCT	6.27	175.04	1127.76	0.0267	44.2	0.35	0.05	0.53	0.007	0.42
FHP_B060	FHP_B060	WCT	23.16	787.42	1657.97	0.0223	46.5	0.35	0.05	0.88	0.0007	0.70
FHP_B065	FHP_B065	WCT	35.94	1039.23	2191.53	0.0176	44.7	0.35	0.05	1.09	0.0007	0.87
FHP_B070	FHP_B070	WCT	31.77	935.94	2188.38	0.0184	45.0	0.35	0.05	1.07	0.0007	0.86
FHP_B075	FHP_B075	WCT	6.63	1303.78	2563.03	0.0277	45.6	0.35	0.05	0.46	0.0007	0.37
FHP_B080	FHP_B080	WCT	27.51	618.66	1938.22	0.0304	42.8	0.35	0.05	0.97	0.0007	0.77
FHP_B085	FHP_B085	WCT	33.29	893.84	2253.34	0.0345	60.4	0.35	0.10	1.01	0.0007	0.80
FHP_B090	FHP_B090	WCT	18.25	443.41	1135.72	0.0377	44.9	0.35	0.05	0.90	0.0007	0.72
FHP_B095	FHP_B095	WCT	19.45	791.78	1444.90	0.0265	69.6	0.35	0.10	0.69	0.0007	0.64
FHP_B100	FHP_B100	WCT	14.09	627.67	1354.66	0.0364	45.0	0.35	0.05	0.67	0.0007	0.54
FHP_B105	FHP_B105	WCT	5.62	163.19	534.96	0.0176	75.2	0.35	0.10	0.64	0.0007	0.51
HFT_B005	HFT_B005	WCT	29.98	1078.57	2032.77	0.0354	45.0	0.35	0.05	1.00	0.0007	0.80
HFT_B010	HFT_B010	WCT	55.63	999.96	2454.72	0.0269	35.0	0.35	0.05	1.29	0.0007	1.04
HFT_B015	HFT_B015	WCT	42.19	1231.35	3069.17	0.0331	45.0	0.35	0.05	1.14	0.0007	0.91
HFT_B020	HFT_B020	WCT	16.18	1430.26	2332.60	0.0279	45.0	0.35	0.05	0.60	0.0007	0.48
HFT_B025	HFT_B025	WCT	20.38	1372.38	1940.15	0.0238	52.9	0.35	0.05	0.67	0.0007	0.54
HFT_B030	HFT_B030	WCT	5.40	544.79	863.18	0.024	75.0	0.35	0.05	0.50	0.0007	0.40
HOM_B005	HOM_B005	WCT	10.33	372.42	1055.53	0.0167	45.0	0.35	0.05	0.61	0.0007	0.49
HOM_B010	HOM_B010	WCT	32.38	857.69	2064.91	0.0428	45.6	0.35	0.05	1.16	0.0007	0.93
HOM_B015	HOM_B015	WCT	24.49	1134.31	2253.69	0.034	45.0	0.35	0.05	0.74	0.0007	0.60
HOM_B020	HOM_B020	WCT	30.34	958.53	2454.06	0.0284	45.0	0.35	0.05	0.99	0.0007	0.79
JAM_B005	JAM_B005	WCT	17.62	685.10	1401.25	0.0355	34.2	0.35	0.05	0.78	0.0007	0.62
JAM_B010	JAM_B010	WCT	35.35	813.48	2510.97	0.0209	56.0	0.35	0.05	1.09	0.0007	0.87
KET_B005	KET_B005	WCT	16.55	551.11	1396.05	0.035	44.9	0.35	0.05	0.77	0.0007	0.62
KET_B010	KET_B010	WCT	19.32	566.80	1431.86	0.0348	91.0	0.35	0.10	0.71	0.0007	0.57
PHI_B100	PHI_B100	WCT	16.90	695.90	1367.05	0.036	44.7	0.35	0.05	0.59	0.0007	0.47
PHI_B105	PHI_B105	WCT	16.19	1252.41	2135.63	0.0252	45.0	0.35	0.05	0.45	0.0007	0.36
PHI_B110	PHI_B110	WCT	35.24	684.79	1773.59	0.0301	78.8	0.35	0.10	1.17	0.0007	0.94
PHI_B115	PHI_B115	WCT	100.88	1180.72	2655.81	0.0405	81.5	0.35	0.10	1.41	0.0007	1.13
SPC_B005	SPC_B005	WCT	24.29	910.02	1952.26	0.0258	50.1	0.35	0.05	0.97	0.0007	0.78
SPC_B010	SPC_B010	WCT	28.37	550.51	2074.85	0.0329	40.4	0.35	0.05	0.98	0.0007	0.78
SPC_B015	SPC_B015	WCT	40.17	1302.16	2538.54	0.0357	43.9	0.35	0.05	1.08	0.0007	0.86
SPC_B020	SPC_B020	WCT	18.19	1118.43	2638.39	0.0329	46.9	0.35	0.05	0.67	0.0007	0.54
SPC_B025	SPC_B025	WCT	41.11	1243.12	2911.96	0.0246	51.4	0.35	0.05	1.08	0.0007	0.88
SPC_B030	SPC_B030	WCT	54.04	643.22	2125.36	0.036	63.4	0.35	0.10	1.34	0.0007	1.07
SPC_B035	SPC_B035	WCT	29.05	430.47	1597.35	0.0332	78.1	0.35	0.10	1.07	0.0007	0.85
SPC_B036	SPC_B036	WCT	24.57	560.40	2510.84	0.013	95.0	0.35	0.05	0.93	0.0007	0.74
SPC_B040	SPC_B040	WCT	58.63	478.52	2204.12	0.04	77.4	0.35	0.10	1.15	0.0007	0.92
SPC_B045	SPC_B045	WCT	56.97	600.07	1837.86	0.0311	50.7	0.35	0.05	1.37	0.0007	1.09
SPC_B046	SPC_B046	WCT	15.68	450.23	1139.63	0.0316	45.0	0.35	0.05	0.76	0.0007	0.61
SPC_B050	SPC_B050	WCT	8.07	1060.53	1060.53	0.0336	34.6	0.35	0.05	0.36	0.0007	0.29
SPC_B055	SPC_B055	WCT	16.75	423.33	1359.15	0.0355	28.7	0.35	0.05	0.61	0.0007	0.49
SPC_B060	SPC_B060	WCT	22.31	754.58	1871.86	0.0431	27.8	0.35	0.05	0.80	0.0007	0.64

Annual / WQ CUHP Input

Subcatchment Name	EPA SWMM Target Node	Raingage	Area (Ac.)	Length to Centroid (ft.)	Length (ft.)	Slope (ft/ft)	Percent Imperviousness	Depression Storage (in) Pervious	Depression Storage (in) Impervious	Hortons's Infiltration Parameters Initial Rate (in/hr)	Decay Coefficient (1/seconds)	Final Rate (in/hr)
SPC_B065	SPC_B065	WCT	23.15	712.30	1792.42	0.0471	23.8	0.35	0.05	0.75	0.0007	0.60
SPC_B070	SPC_B070	WCT	40.23	847.46	1975.59	0.0415	28.1	0.35	0.05	1.26	0.0007	1.01
SPC_B080	SPC_B080	WCT	22.07	1049.42	2098.49	0.0318	44.6	0.35	0.05	1.08	0.0007	0.86
SPC_B085	SPC_B085	WCT	19.54	907.32	1653.03	0.0303	44.8	0.35	0.05	0.74	0.0007	0.59
SPC_B090	SPC_B090	WCT	9.89	938.65	2025.67	0.0252	29.8	0.35	0.05	0.58	0.0007	0.46
SPC_B095	SPC_B095	WCT	42.42	915.60	2173.88	0.0289	47.0	0.35	0.10	1.10	0.0007	0.88
SPC_B100	SPC_B100	WCT	32.62	831.55	2295.28	0.0394	45.0	0.35	0.05	0.87	0.0007	0.70
SPC_B105	SPC_B105	WCT	27.26	926.15	2677.45	0.0382	25.5	0.35	0.05	0.55	0.0007	0.44
SPC_B110	SPC_B110	WCT	25.65	750.06	2060.35	0.0356	41.4	0.35	0.05	0.75	0.0007	0.60
TRE_B005	TRE_B005	WCT	28.56	1342.01	2011.51	0.0251	42.3	0.35	0.05	0.62	0.0007	0.49
TRE_B010	TRE_B010	WCT	31.97	1068.85	1893.51	0.033	70.2	0.35	0.10	1.02	0.0007	0.82
TRE_B015	TRE_B015	WCT	18.00	446.98	1242.82	0.0382	33.5	0.35	0.05	0.77	0.0007	0.61
TRE_B020	TRE_B020	WCT	5.41	198.88	737.58	0.0254	57.6	0.35	0.05	0.40	0.0007	0.32
TRE_B025	TRE_B025	WCT	3.32	485.88	917.10	0.0214	75.0	0.35	0.05	0.36	0.0007	0.29
WCE_B005	WCE_B005	WCT	8.42	947.17	2268.78	0.0324	28.4	0.35	0.05	0.71	0.0007	0.57
WCE_B010	WCE_B010	WCT	13.60	523.70	1334.00	0.0339	45.0	0.35	0.05	0.61	0.0007	0.49
WCE_B015	WCE_B015	WCT	28.51	1253.78	1845.39	0.0267	43.9	0.35	0.05	0.85	0.0007	0.68
WCE_B020	WCE_B020	WCT	18.47	638.61	1541.51	0.0375	45.0	0.35	0.05	0.95	0.0007	0.76
WCE_B025	WCE_B025	WCT	12.46	693.21	1500.27	0.0365	43.7	0.35	0.05	0.61	0.0007	0.49
WCE_B029	WCE_B029	WCT	13.23	726.13	1657.71	0.039	34.0	0.35	0.05	0.70	0.0007	0.56
WCE_B030	WCE_B030	WCT	25.55	1139.94	2135.03	0.025	36.7	0.35	0.05	0.70	0.0007	0.56
WCE_B035	WCE_B035	WCT	22.11	908.99	2346.05	0.0265	44.8	0.35	0.05	0.77	0.0007	0.61
WCE_B040	WCE_B040	WCT	3.23	530.18	1337.74	0.0343	43.7	0.35	0.05	0.39	0.0007	0.31
WCE_B045	WCE_B045	WCT	26.98	1068.45	2276.54	0.0359	48.0	0.35	0.05	0.87	0.0007	0.70
WCE_B050	WCE_B050	WCT	14.39	733.60	2147.58	0.0253	26.8	0.35	0.05	0.59	0.0007	0.47
WCE_B055	WCE_B055	WCT	20.04	682.11	1779.82	0.0343	43.0	0.35	0.05	0.75	0.0007	0.60
WCE_B056	WCE_B056	WCT	3.19	402.50	1017.00	0.0406	56.0	0.35	0.05	0.40	0.0007	0.32
WCE_B060	WCE_B060	WCT	9.28	507.12	989.40	0.0285	88.1	0.35	0.10	0.59	0.0007	0.47
WCE_B065	WCE_B065	WCT	19.32	454.11	1048.37	0.0459	85.9	0.35	0.10	0.73	0.0007	0.58
WCE_B070	WCE_B070	WCT	14.54	714.39	1554.31	0.0337	80.6	0.35	0.10	1.08	0.0007	0.86
WCE_B075	WCE_B075	WCT	10.93	693.22	1566.95	0.0348	94.8	0.35	0.10	0.55	0.0007	0.44
WCE_B080	WCE_B080	WCT	13.06	473.04	1316.78	0.0348	94.9	0.35	0.10	1.05	0.0007	0.84
WCE_B085	WCE_B085	WCT	6.06	571.76	1183.99	0.0386	94.9	0.35	0.10	0.57	0.0007	0.46
WCE_B090	WCE_B090	WCT	44.84	1270.90	2861.97	0.0281	83.3	0.35	0.10	1.15	0.0007	0.92
WCE_B095	WCE_B095	WCT	6.78	545.26	1266.48	0.0216	95.0	0.35	0.10	0.47	0.0007	0.38
WCE_B100	WCE_B100	WCT	27.07	921.83	2466.81	0.0191	90.7	0.35	0.10	0.92	0.0007	0.74
WCE_B105	WCE_B105	WCT	25.44	823.17	1763.10	0.0331	92.2	0.35	0.10	0.99	0.0007	0.79
WCE_B110	WCE_B110	WCT	18.53	631.64	2022.95	0.0168	91.1	0.35	0.05	0.72	0.0007	0.57
WSC_B005	WSC_B005	WCT	42.28	1392.22	2808.54	0.0361	38.0	0.35	0.05	1.03	0.0007	0.83
WSC_B010	WSC_B010	WCT	9.63	452.69	1156.85	0.0325	44.8	0.35	0.05	0.65	0.0007	0.52
WSC_B015	WSC_B015	WCT	16.57	514.85	1569.92	0.0229	45.0	0.35	0.05	0.75	0.0007	0.60
WSC_B020	WSC_B020	WCT	22.62	823.69	1516.79	0.0235	76.9	0.35	0.10	1.09	0.0007	0.87
WSC_B025	WSC_B025	WCT	25.44	722.30	1192.27	0.0246	77.6	0.35	0.10	1.03	0.0007	0.83

Detention Basin Rating Curves

Sam's Club Detention Basin (ACR_S100)				
Elevation (ft)	Depth (ft)	Surface Area (ft^2)	Storage (Ac-ft.)	Discharge (cfs.)
5739.00	0.0	0	0.00	0.0
5739.50	0.5	--	--	0.0
5740.00	1.0	3,736	0.03	0.1
5740.50	1.5	--	--	0.3
5741.00	2.0	14,506	0.22	0.4
5741.50	2.5	--	--	0.6
5742.00	3.0	25,105	0.67	0.9
5742.50	3.5	--	--	1.1
5743.00	4.0	39,455	1.41	1.4
5743.50	4.5	--	--	1.7
5744.00	5.0	50,060	2.43	2.0
5744.50	5.5	--	--	2.3
5745.00	6.0	57,979	3.67	2.6
5745.50	6.5	--	--	3.0
5746.00	7.0	64,800	5.08	3.4
5746.50	7.5	--	--	3.8
5747.00	8.0	71,971	6.65	4.1
5747.50	8.5	--	--	4.6
5747.87	8.9	--	--	4.8
5748.00	9.0	78,052	8.37	7.4
5748.50	9.5	--	--	31.2
5749.00	10.0	78,052	10.16	67.0
5749.50	10.5	--	--	79.6
5750.00	11.0	78,052	11.96	90.4
5750.50	11.5	--	--	191.9
5751.00	12.0	78,052	13.75	368.8
5751.50	12.5	--	--	594.5
5752.00	13.0	78,052	15.54	859.8

-- Values interpolated by SWMM

Spring Creek Detention Basin (SPC_S100)				
Elevation (ft)	Depth (ft)	Surface Area (ft^2)	Storage (Ac-ft.)	Discharge (cfs.)
5705.17	0.0	0	0.00	0.0
5705.50	0.3	--	--	1.4
5706.00	0.8	--	--	7.1
5706.50	1.3	--	--	16.7
5707.00	1.8	--	--	29.6
5707.50	2.3	--	--	34.8
5708.00	2.8	--	--	55.1
5708.50	3.3	--	--	69.8
5709.00	3.8	--	--	81.9
5709.50	4.3	--	--	92.4
5710.00	4.8	7,386	0.00	101.8
5710.50	5.3	--	--	110.4
5711.00	5.8	18,869	0.29	118.4
5711.50	6.3	--	--	125.9
5712.00	6.8	26,607	0.81	133.0
5712.50	7.3	--	--	139.7
5713.00	7.8	31,986	1.48	146.1
5713.50	8.3	--	--	152.2
5714.00	8.8	35,764	2.26	158.1
5714.50	9.3	--	--	163.8
5715.00	9.8	38,981	3.12	169.3
5715.50	10.3	--	--	174.6
5716.00	10.8	42,001	4.05	179.8
5716.50	11.3	--	--	184.8
5717.00	11.8	45,120	5.05	189.7
5717.50	12.3	--	--	194.5
5718.00	12.8	48,163	6.12	199.1
5718.50	13.3	--	--	203.7
5719.00	13.8	51,098	7.26	208.1
5719.50	14.3	--	--	212.5
5720.00	14.8	53,951	8.46	216.7
5720.50	15.3	--	--	257.7
5721.00	15.8	56,725	9.73	329.0
5721.50	16.3	--	--	420.1
5722.00	16.8	59,546	11.07	488.4
5722.50	17.3	--	--	522.4
5723.00	17.8	62,566	12.47	541.7
5723.50	18.3	--	--	550.1
5724.00	18.8	66,070	13.94	558.5
5724.50	19.3	--	--	566.7
5725.00	19.8	70,632	15.51	574.9
5725.50	20.3	--	--	582.9
5726.00	20.8	76,494	17.20	590.8
5726.50	21.3	--	--	598.6
5727.00	21.8	90,522	19.12	606.2
5727.50	22.3	--	--	613.8
5728.00	22.8	102,624	21.33	621.3
5728.50	23.3	--	--	628.8
5729.00	23.8	112,373	23.80	636.1
5729.50	24.3	--	--	643.3
5730.00	24.8	121,115	26.48	650.5
5730.50	25.3	--	--	657.6
5731.00	25.8	129,600	29.36	664.6
5731.50	26.3	--	--	671.5
5732.00	26.8	139,312	32.44	678.4
5732.50	27.3	--	--	685.2
5733.00	27.8	155,128	35.82	691.9

-- Values interpolated by SWMM

-- Values interpolated by SWMM

Detention Basin Rating Curves

Yosemite Pond (PHI_S100)				
Elevation (ft)	Depth (ft)	Surface Area (ft^2)	Storage (Ac-ft.)	Discharge (cfs.)
5754.00	0.0	29,962	0.00	0.0
5754.83	0.8	--	--	0.1
5755.00	1.0	35,438	0.75	0.9
5755.50	1.5	--	--	7.5
5756.00	2.0	39,056	1.60	19.6
5756.50	2.5	--	--	36.5
5757.00	3.0	42,247	2.54	58.0
5757.50	3.5	--	--	83.8
5758.00	4.0	45,338	3.54	117.1
5758.50	4.5	--	--	131.4
5759.00	5.0	48,540	4.62	144.3
5759.50	5.5	--	--	156.2
5760.00	6.0	52,081	5.77	167.2
5760.50	6.5	--	--	177.6
5761.00	7.0	56,096	7.02	187.3
5761.50	7.5	--	--	196.6
5762.00	8.0	56,096	8.30	205.5
5762.30	8.3	--	--	205.5
5762.50	8.5	--	--	223.3
5763.00	9.0	56,096	9.59	283.1
5763.50	9.5	--	--	366.8
5764.00	10.0	56,096	10.88	468.2
5764.50	10.5	--	--	584.4
5765.00	11.0	56,097	12.17	713.6

-- Values interpolated by SWMM

Akron Pond (PHI_S200)				
Elevation (ft)	Depth (ft)	Surface Area (ft^2)	Storage (Ac-ft.)	Discharge (cfs.)
5778.0	0.0	17,058	0.00	0.0
5778.5	0.5	--	--	30.3
5779.0	1.0	22,803	0.46	171.6
5779.5	1.5	--	--	315.2
5780.0	2.0	26,142	1.02	360.0
5780.5	2.5	--	--	384.0
5781.0	3.0	29,483	1.66	408.0
5781.5	3.5	--	--	432.0
5782.0	4.0	29,483	2.33	456.0

-- Values interpolated by SWMM

Panorama Pond (WCE_S100)				
Elevation (ft)	Depth (ft)	Surface Area (ft^2)	Storage (Ac-ft.)	Discharge (cfs.)
5741.00	0.0	111	0.00	0.0
5741.60	0.6	--	--	0.0
5742.00	1.0	1,050	0.00	0.7
5742.50	1.5	--	--	1.6
5743.00	2.0	13,112	0.00	2.9
5743.50	2.5	--	--	4.3
5744.00	3.0	33,024	0.00	6.1
5744.50	3.5	--	--	7.9
5745.00	4.0	45,406	0.00	9.9
5745.50	4.5	--	--	12.0
5746.00	5.0	56,427	0.00	14.3
5746.50	5.5	--	--	16.7
5747.00	6.0	63,137	0.48	19.3
5747.11	6.1	--	--	19.8
5747.50	6.5	--	--	27.3
5748.00	7.0	67,009	1.49	28.0
5748.50	7.5	--	--	28.0
5749.00	8.0	70,679	1.58	28.0
5749.50	8.5	--	--	28.0
5750.00	9.0	74,633	1.67	28.0
5750.50	9.5	--	--	28.0
5751.00	10.0	78,986	1.76	28.0
5751.14	10.1	--	--	29.0
5751.50	10.5	--	--	51.4
5752.00	11.0	83,855	1.87	114.4
5752.50	11.5	--	--	149.2
5753.00	12.0	89,051	1.98	169.6
5753.50	12.5	--	--	173.3
5754.00	13.0	93,985	2.10	177.0
5754.48	13.5	--	--	180.4
5754.50	13.5	96,323	1.09	182.3
5755.00	14.0	98,661	2.21	281.5
5755.50	14.5	--	--	455.2
5756.00	15.0	98,661	3.36	678.0

-- Values interpolated by SWMM

Future Conditions Peak Flow (cfs)

Node	Junction Type	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
ACR_B005	JUNCTION	7.2	10.9	15.2	24.7	31.0	38.4	55.7
ACR_B010	JUNCTION	7.7	10.4	13.1	18.5	22.4	26.9	37.5
ACR_B015	JUNCTION	8.2	11.3	14.3	20.3	24.7	29.8	41.8
ACR_B020	JUNCTION	13.3	18.3	23.2	33.7	40.9	49.1	68.7
ACR_B025	JUNCTION	18.7	25.1	30.9	42.3	50.8	60.5	83.3
ACR_B030	JUNCTION	23.0	31.4	39.4	55.8	67.5	80.9	112.5
ACR_B035	JUNCTION	17.2	24.2	31.2	45.0	55.0	66.7	93.8
ACR_B040	JUNCTION	14.2	21.6	30.2	48.6	61.1	75.7	110.0
ACR_B045	JUNCTION	19.8	30.1	42.3	65.6	82.7	103.1	149.0
ACR_B050	JUNCTION	17.9	26.6	36.7	55.8	69.9	86.8	124.7
ACR_B055	JUNCTION	10.4	15.9	22.1	36.0	45.3	56.1	81.5
ACR_J005	JUNCTION	98.6	142.0	189.6	289.1	358.5	439.6	649.7
ACR_J010	JUNCTION	84.0	121.0	161.7	246.0	305.2	374.5	557.0
ACR_J035	JUNCTION	76.1	110.3	148.0	226.0	280.8	345.1	516.5
ACR_J045	DIVIDER	76.1	110.3	148.1	226.0	280.8	345.2	521.9
ACR_J050	JUNCTION	76.1	110.3	148.1	226.0	280.8	345.2	521.9
ACR_J055	DIVIDER	44.9	68.0	95.1	151.0	190.2	236.6	345.9
ACR_J060	JUNCTION	0.0	0.0	0.0	0.0	0.0	0.0	10.0
ACR_J065	JUNCTION	44.0	66.9	93.9	149.2	188.2	234.4	354.9
ACR_J070	JUNCTION	0.0	0.0	0.0	0.0	0.0	0.0	11.6
ACR_J075	DIVIDER	44.0	66.9	93.9	149.2	188.2	234.4	341.1
ACR_J080	JUNCTION	26.2	39.6	55.1	87.3	109.7	136.4	198.0
ACR_J085	JUNCTION	10.4	15.9	22.1	36.0	45.3	56.1	81.5
ACR_J200	DIVIDER	2.6	3.4	4.2	22.0	50.2	75.8	172.9
ACR_J204	JUNCTION	14.2	21.6	30.2	48.5	61.1	75.7	110.0
ACR_J205	JUNCTION	14.2	21.6	30.2	48.5	61.1	75.7	110.0
ACR_J210	JUNCTION	14.2	21.6	30.2	48.5	61.1	75.7	110.0
ACR_J215	JUNCTION	14.2	21.6	30.2	48.5	61.1	75.7	110.0
ACR_J220	JUNCTION	14.2	21.6	30.2	48.5	61.1	75.7	110.0
ACR_J225	JUNCTION	14.2	21.6	30.2	48.5	61.1	75.7	110.0
ACR_J230	DIVIDER	14.2	21.6	30.2	48.5	61.1	75.7	110.0
ACR_J235	JUNCTION	14.2	21.6	30.2	48.5	61.1	75.7	110.0
ACR_J240	JUNCTION	14.2	21.6	30.2	48.5	61.1	75.7	110.0
ACR_J245	JUNCTION	14.2	21.6	30.2	48.5	61.1	75.7	110.0
ACR_J250	JUNCTION	14.2	21.6	30.2	48.6	61.1	75.7	110.0
ACR_O005	OUTFALL	98.5	141.8	189.4	289.0	358.4	439.5	647.8
ACR_O010	OUTFALL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ACR_S100	STORAGE	54.0	76.4	99.8	148.2	182.4	222.0	314.7
DFA_B005	OUTFALL	15.5	25.8	49.9	107.9	144.8	190.8	292.7
DFA_B010	OUTFALL	7.8	11.9	16.7	27.0	34.0	42.1	61.2
DFA_B015	OUTFALL	19.4	29.7	42.0	65.7	82.8	103.5	149.9
DFA_B020	OUTFALL	5.4	8.1	11.0	18.0	22.5	27.9	40.3
DFA_B021	OUTFALL	13.1	19.3	26.1	41.6	51.9	63.9	91.9
DFA_B025	OUTFALL	15.9	23.7	32.9	49.7	62.4	77.6	111.1
DFA_B030	OUTFALL	7.4	11.2	15.6	25.7	32.3	40.0	58.2

Node	Junction Type	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
DFA_B035	OUTFALL	4.3	7.1	10.7	18.0	23.2	29.3	43.5
DFA_B040	OUTFALL	9.1	15.2	22.7	39.9	51.3	64.5	95.7
DFA_B041	OUTFALL	8.9	14.4	21.4	36.3	46.3	58.3	86.1
DFA_B042	JUNCTION	3.1	4.6	6.4	9.9	12.4	15.4	22.2
DFA_B043	JUNCTION	22.4	29.5	36.6	49.1	58.8	68.2	93.5
DFA_B045	OUTFALL	7.3	11.9	17.5	30.2	38.6	48.3	71.3
DFA_B046	OUTFALL	7.1	11.1	15.9	26.7	33.9	42.2	61.8
DFA_B050	OUTFALL	16.2	27.4	42.3	73.0	94.5	119.9	178.7
DFA_B051	OUTFALL	7.9	12.0	16.8	26.3	33.2	41.4	60.0
DFA_B055	OUTFALL	21.2	32.2	45.4	71.3	89.9	112.0	162.5
DFA_B060	OUTFALL	1.9	3.4	7.3	16.7	22.7	30.1	46.6
DFA_B061	OUTFALL	4.5	6.8	9.5	15.6	19.6	24.3	35.3
DFA_B065	OUTFALL	6.0	8.7	12.9	22.6	29.0	36.3	53.7
DFA_B100	OUTFALL	2.5	3.8	5.3	8.6	10.8	13.4	19.5
DFA_B105	OUTFALL	6.0	9.1	12.9	20.0	25.2	31.5	45.6
DFA_J005	JUNCTION	25.5	34.0	42.3	57.8	69.7	83.4	115.2
DFA_J010	JUNCTION	22.4	29.5	36.6	49.1	58.8	68.2	93.5
DFA_O005	OUTFALL	25.1	33.6	41.9	57.2	69.1	82.9	115.0
FHP_B005	JUNCTION	1.1	2.4	4.4	9.2	12.2	16.1	24.5
FHP_B010	JUNCTION	5.2	7.7	10.6	17.0	21.3	26.3	38.0
FHP_B015	JUNCTION	4.4	6.0	7.5	10.4	12.5	15.2	21.1
FHP_B020	JUNCTION	5.9	8.0	10.0	13.8	16.6	20.2	28.0
FHP_B025	JUNCTION	4.9	6.8	8.7	12.6	15.4	18.6	26.2
FHP_B030	JUNCTION	34.7	51.1	70.1	106.7	133.3	164.7	236.7
FHP_B035	JUNCTION	0.8	1.3	2.0	3.7	4.8	6.2	9.3
FHP_B040	JUNCTION	6.8	10.9	15.9	27.2	34.6	43.2	63.6
FHP_B045	JUNCTION	5.9	8.1	10.3	14.5	17.7	21.4	29.9
FHP_B050	JUNCTION	2.8	4.3	6.0	9.6	12.0	15.0	21.8
FHP_B055	JUNCTION	2.1	3.2	4.5	7.5	9.4	11.6	16.9
FHP_B060	JUNCTION	9.8	14.8	20.6	32.5	40.9	50.7	73.5
FHP_B065	JUNCTION	13.1	20.0	27.9	45.4	57.1	70.8	102.9
FHP_B070	JUNCTION	11.7	17.9	24.9	40.4	50.9	63.0	91.5
FHP_B075	JUNCTION	1.3	2.0	2.7	4.6	5.8	7.3	10.7
FHP_B080	JUNCTION	11.6	17.9	25.5	40.8	51.7	64.5	94.0
FHP_B085	JUNCTION	20.8	30.0	40.0	59.5	73.6	90.1	128.2
FHP_B090	JUNCTION	9.9	15.1	21.3	33.2	41.9	52.3	75.8
FHP_B095	JUNCTION	14.6	20.4	26.3	37.8	46.2	56.1	78.8
FHP_B100	JUNCTION	6.0	9.2	12.9	20.4	25.8	32.0	46.6
FHP_B105	JUNCTION	6.3	8.5	11.0	15.5	18.9	22.1	30.9
FHP_J005	JUNCTION	148.7	223.5	306.7	495.6	626.9	780.3	1200.0
FHP_J010	JUNCTION	139.4	209.2	287.4	463.9	586.5	728.9	1126.6
FHP_J015	DIVIDER	135.2	203.4	279.9	452.5	572.2	711.3	1032.8
FHP_J020	JUNCTION	112.0	167.2	229.5	368.6	462.7	571.7	827.6
FHP_J030	JUNCTION	105.0	155.8	212.8	339.0	424.6	523.5	755.8
FHP_J035	JUNCTION	59.9	88.7	120.2	189.1	235.2	288.9	415.9

Future Conditions Peak Flow (cfs)

Node	Junction Type	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
FHP_J040	JUNCTION	50.3	73.2	97.8	150.5	185.9	227.3	325.4
FHP_J045	JUNCTION	26.1	35.9	45.7	64.9	78.7	95.0	132.3
FHP_J050	JUNCTION	20.1	26.8	32.8	44.6	53.0	63.0	85.7
FHP_J055	JUNCTION	6.3	7.5	7.5	7.5	7.5	7.5	7.5
FHP_J060	JUNCTION	6.3	7.5	7.5	7.5	7.5	7.5	7.5
FHP_J065	DIVIDER	6.3	8.5	11.0	15.5	18.9	22.1	30.9
FHP_J100	JUNCTION	46.0	67.1	85.7	90.6	93.1	96.0	99.1
FHP_J105	JUNCTION	43.3	62.2	80.9	85.6	88.0	91.0	93.6
FHP_J110	JUNCTION	40.6	58.3	75.3	76.1	76.1	76.1	76.1
FHP_J115	JUNCTION	37.6	55.3	72.6	73.0	73.0	73.0	73.0
FHP_J120	DIVIDER	37.6	55.3	72.1	92.9	106.6	122.4	159.8
FHP_J125	DIVIDER	28.0	41.3	58.1	78.9	92.6	108.4	145.8
FHP_J130	DIVIDER	12.9	19.2	27.0	44.4	56.0	69.4	101.0
FHP_J135	DIVIDER	12.9	19.7	27.5	44.7	56.3	69.7	101.3
FHP_J140	JUNCTION	4.0	4.0	4.0	4.0	4.0	4.0	4.0
FHP_J145	DIVIDER	13.0	19.7	27.5	44.8	56.3	69.7	101.3
FHP_J150	DIVIDER	13.1	20.0	27.9	45.4	57.1	70.8	102.9
FHP_J160	JUNCTION	9.8	14.0	14.0	14.0	14.0	14.0	14.0
FHP_J165	DIVIDER	9.8	14.8	20.6	32.5	40.9	50.7	73.5
FHP_J200	DIVIDER	2.9	5.0	12.8	65.8	102.6	145.0	244.7
FHP_J205	DIVIDER	5.9	8.1	15.8	68.8	105.6	148.1	247.8
FHP_J210	DIVIDER	2.8	4.3	6.0	9.6	12.0	15.0	21.8
FHP_J215	JUNCTION	0.0	0.7	6.4	55.4	89.0	127.9	219.3
FHP_O005	OUTFALL	148.9	224.6	309.8	503.4	637.0	794.3	1220.1
HFT_B005	JUNCTION	11.9	18.1	25.3	40.6	51.0	63.3	92.1
HFT_B010	JUNCTION	16.2	26.5	39.4	67.8	86.8	109.0	161.2
HFT_B015	JUNCTION	15.3	23.4	32.6	53.0	66.7	82.6	120.0
HFT_B020	JUNCTION	4.3	6.6	9.1	15.1	19.0	23.7	34.5
HFT_B025	JUNCTION	8.1	11.8	15.8	24.9	31.1	38.0	54.6
HFT_B030	JUNCTION	4.3	5.8	7.2	10.1	12.2	14.7	20.5
HFT_J005	JUNCTION	27.7	44.1	64.0	107.9	137.4	171.8	252.6
HFT_J010	JUNCTION	16.2	26.5	39.4	67.8	86.8	109.0	161.2
HFT_J100	DIVIDER	31.8	47.3	64.5	100.8	110.3	123.0	133.8
HFT_J101	JUNCTION	0.0	4.0	21.2	62.1	85.1	114.0	182.8
HFT_J105	JUNCTION	27.6	40.8	55.6	85.9	91.3	99.3	99.3
HFT_J110	DIVIDER	15.3	23.4	32.6	53.0	66.7	82.9	140.7
HFT_J115	DIVIDER	15.3	23.4	32.6	53.0	66.7	82.6	120.0
HFT_J120	JUNCTION	12.3	17.5	23.0	34.8	43.0	51.0	51.0
HFT_J125	JUNCTION	12.3	17.5	23.0	34.8	43.0	51.0	51.0
HFT_J130	JUNCTION	12.3	17.5	23.0	34.8	43.0	51.0	51.0
HFT_J135	JUNCTION	12.3	17.5	23.0	34.8	43.0	51.0	51.0
HFT_J140	JUNCTION	12.3	17.5	23.0	34.8	43.0	51.0	51.0
HFT_J145	DIVIDER	12.3	17.5	23.0	34.8	43.0	52.4	74.6
HFT_J150	JUNCTION	4.2	5.7	7.2	10.1	12.2	14.7	20.5
HFT_J155	JUNCTION	4.2	5.8	7.2	10.1	12.2	14.7	20.5

Node	Junction Type	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
HFT_J160	JUNCTION	4.2	5.8	7.2	10.1	12.2	14.7	20.5
HFT_J165	JUNCTION	4.3	5.8	7.2	10.1	12.2	14.7	20.5
HFT_J170	JUNCTION	4.3	5.8	7.2	10.1	12.2	14.7	20.5
HFT_O005	OUTFALL	31.8	46.3	46.9	46.9	46.9	46.9	46.9
HFT_O010	OUTFALL	27.7	47.9	85.1	169.9	222.3	285.5	433.0
HOM_B005	JUNCTION	4.6	6.9	9.7	15.4	19.4	24.1	35.1
HOM_B010	JUNCTION	14.8	22.5	31.5	49.7	62.6	77.9	113.0
HOM_B015	JUNCTION	8.5	13.0	18.1	29.6	37.2	46.1	66.9
HOM_B020	JUNCTION	11.3	17.2	24.1	39.0	49.1	60.8	88.3
HOM_J005	JUNCTION	38.0	61.2	80.8	128.2	146.6	158.5	204.1
HOM_J010	JUNCTION	34.0	55.0	72.1	114.2	127.6	134.9	169.8
HOM_J015	JUNCTION	34.1	56.1	72.5	114.4	128.0	135.2	170.3
HOM_J020	JUNCTION	34.1	50.1	50.2	50.2	50.2	50.2	50.2
HOM_J025	DIVIDER	34.1	52.6	72.5	115.6	128.0	135.2	170.3
HOM_J030	DIVIDER	34.1	52.6	72.5	112.7	120.0	135.3	170.3
HOM_J035	JUNCTION	19.8	30.5	42.2	63.9	63.2	62.6	61.8
HOM_J040	JUNCTION	19.9	30.7	42.2	62.1	62.1	62.1	62.1
HOM_J045	DIVIDER	19.9	30.7	42.2	68.5	86.3	106.9	156.8
HOM_J050	JUNCTION	11.3	17.7	24.1	39.0	49.1	60.8	80.0
HOM_J055	JUNCTION	11.3	17.8	24.1	39.0	49.1	60.8	80.0
HOM_J060	JUNCTION	11.3	17.8	24.1	39.0	49.1	60.8	80.1
HOM_J065	DIVIDER	11.3	17.8	24.1	39.0	49.1	60.8	91.2
HOM_J070	DIVIDER	11.3	18.0	24.1	39.0	49.1	60.8	92.2
HOM_J075	DIVIDER	11.3	18.1	24.1	39.0	49.1	60.8	88.3
HOM_J080	JUNCTION	11.3	16.6	16.5	16.1	16.2	16.1	16.1
HOM_J085	JUNCTION	11.3	16.1	16.1	16.1	16.1	16.1	16.1
HOM_J090	DIVIDER	11.3	17.2	24.1	39.0	49.1	60.8	88.3
HOM_O005	OUTFALL	37.7	60.3	79.7	122.3	145.1	157.5	203.3
HOM_O010	OUTFALL	0.0	0.0	0.0	11.1	28.9	49.5	99.4
JAM_B005	JUNCTION	4.9	8.0	12.0	20.8	26.7	33.5	49.6
JAM_B010	JUNCTION	19.6	28.2	37.7	56.7	70.4	86.3	123.3
JAM_J005	JUNCTION	19.5	28.2	37.7	56.7	70.4	86.3	123.3
JAM_J010	JUNCTION	19.6	28.2	37.7	56.7	70.4	86.3	123.3
JAM_J015	JUNCTION	19.6	28.2	37.7	56.7	70.4	86.3	123.3
KET_B005	JUNCTION	7.6	11.6	16.3	25.7	32.5	40.4	58.8
KET_B010	JUNCTION	23.6	31.1	38.0	51.0	60.9	71.8	98.0
KET_J005	DIVIDER	31.0	42.6	55.6	76.4	93.0	112.0	156.5
KET_J010	DIVIDER	23.5	31.1	39.7	50.8	60.7	71.7	97.9
KET_J011	JUNCTION	23.5	31.1	35.7	35.7	35.7	35.7	35.7
KET_J015	DIVIDER	23.5	31.1	38.0	50.8	60.7	71.7	98.0
KET_J020	JUNCTION	23.5	31.1	38.0	50.9	60.8	71.7	98.0
KET_J025	JUNCTION	23.5	31.1	38.0	50.9	60.8	71.7	98.0
KET_J030	JUNCTION	23.5	31.1	38.0	50.9	60.8	71.7	98.0
KET_J035	DIVIDER	23.5	31.1	38.0	50.9	60.8	71.8	98.0
KET_J040	JUNCTION	23.6	31.1	38.0	51.0	60.9	71.8	98.0

Future Conditions Peak Flow (cfs)

Node	Junction Type	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
PHI_B100	JUNCTION	7.3	11.1	15.6	24.8	31.3	38.9	56.6
PHI_B105	JUNCTION	4.6	7.0	9.7	16.0	20.2	25.1	36.5
PHI_B110	JUNCTION	36.7	49.6	62.4	86.4	104.5	125.3	173.5
PHI_B115	JUNCTION	113.8	152.5	189.3	263.6	319.5	378.1	524.4
PHI_J010	JUNCTION	82.9	126.3	154.6	211.4	243.5	302.4	574.4
PHI_J015	JUNCTION	77.6	117.7	142.4	191.6	219.0	272.9	527.7
PHI_J020	JUNCTION	112.6	150.8	187.1	259.1	313.6	357.3	445.8
PHI_O005	OUTFALL	82.9	126.3	154.5	211.4	243.5	302.4	574.3
PHI_S100	STORAGE	149.0	200.3	249.4	344.9	417.3	478.2	603.1
PHI_S200	STORAGE	113.8	152.5	189.3	263.6	319.5	378.1	524.4
SPC_B005	JUNCTION	10.9	16.1	22.0	34.3	42.8	52.8	76.2
SPC_B010	JUNCTION	11.3	17.8	25.6	41.6	52.8	66.2	96.8
SPC_B015	JUNCTION	14.6	22.4	31.5	51.3	64.7	80.3	116.8
SPC_B020	JUNCTION	5.8	8.8	12.1	19.7	24.7	30.6	44.3
SPC_B025	JUNCTION	17.0	23.6	32.5	52.6	66.2	82.0	118.9
SPC_B030	JUNCTION	46.0	65.0	86.1	125.1	154.6	188.2	265.3
SPC_B035	JUNCTION	32.9	44.4	56.7	79.2	96.1	112.7	156.4
SPC_B036	JUNCTION	26.9	34.9	42.0	55.3	65.5	77.6	105.4
SPC_B040	JUNCTION	70.7	96.2	123.8	173.4	210.6	245.9	341.0
SPC_B045	JUNCTION	38.9	57.5	79.2	119.8	149.6	185.5	265.6
SPC_B046	JUNCTION	7.9	12.1	17.1	26.7	33.6	42.0	60.8
SPC_B050	JUNCTION	2.0	3.3	4.9	8.6	11.0	13.8	20.4
SPC_B055	JUNCTION	4.0	7.0	11.0	19.7	25.6	32.4	48.5
SPC_B060	JUNCTION	4.2	7.5	11.7	21.5	28.0	35.6	53.4
SPC_B065	JUNCTION	3.9	7.2	11.6	21.9	28.6	36.4	54.7
SPC_B070	JUNCTION	8.8	15.6	24.3	44.4	57.6	73.1	109.6
SPC_B080	JUNCTION	7.6	11.6	16.3	26.6	33.5	41.5	60.3
SPC_B085	JUNCTION	7.4	11.3	15.8	25.5	32.0	39.7	57.7
SPC_B090	JUNCTION	1.3	2.2	3.4	6.3	8.2	10.6	15.8
SPC_B095	JUNCTION	18.9	29.0	40.9	65.0	81.9	101.8	147.8
SPC_B100	JUNCTION	14.1	21.5	30.2	47.9	60.4	75.1	109.2
SPC_B105	JUNCTION	4.0	7.1	11.3	21.2	27.7	35.7	53.5
SPC_B110	JUNCTION	9.5	14.7	21.1	34.4	43.5	54.3	79.4
SPC_J005	JUNCTION	274.8	363.6	459.5	809.9	1013.3	1211.8	1622.9
SPC_J010	JUNCTION	266.4	350.6	441.1	788.4	982.5	1169.1	1554.4
SPC_J015	JUNCTION	257.6	335.9	419.4	763.2	944.5	1115.7	1529.0
SPC_J020	DIVIDER	238.2	305.6	376.8	706.6	865.8	1009.1	1284.2
SPC_J025	JUNCTION	179.0	218.1	257.2	575.7	677.6	756.7	912.2
SPC_J030	JUNCTION	165.1	200.3	232.4	539.3	625.2	686.8	802.3
SPC_J035	JUNCTION	146.4	179.0	209.2	493.8	560.7	614.1	691.9
SPC_J040	DIVIDER	147.1	225.4	321.0	544.9	695.1	869.4	1245.8
SPC_J045	JUNCTION	107.6	172.0	251.9	438.2	561.4	707.0	1029.1
SPC_J050	JUNCTION	107.6	172.0	251.9	438.2	561.4	707.0	1029.1
SPC_J055	JUNCTION	107.6	172.0	251.9	438.2	561.4	707.0	1029.1
SPC_J060	JUNCTION	41.0	68.5	103.6	187.1	242.0	308.1	458.7

Node	Junction Type	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
SPC_J065	JUNCTION	41.0	68.5	103.6	187.1	242.0	300.1	300.2
SPC_J070	JUNCTION	41.0	68.5	103.6	187.1	242.0	300.1	300.2
SPC_J075	JUNCTION	41.0	68.5	103.6	187.1	242.0	300.1	300.2
SPC_J080	JUNCTION	41.0	68.5	103.6	187.1	242.0	300.1	300.3
SPC_J085	JUNCTION	41.0	68.5	103.6	187.1	242.0	300.1	300.3
SPC_J090	DIVIDER	41.0	68.5	103.6	187.1	242.0	308.5	459.4
SPC_J095	JUNCTION	35.7	60.0	91.2	165.7	214.7	274.0	300.0
SPC_J100	JUNCTION	35.7	60.0	91.2	165.7	214.7	274.0	300.0
SPC_J105	JUNCTION	35.7	60.0	91.2	165.7	214.7	274.0	300.0
SPC_J110	DIVIDER	35.7	60.0	91.2	165.7	214.7	274.0	408.8
SPC_J115	DIVIDER	26.2	45.3	70.1	129.1	167.6	213.9	320.7
SPC_J120	JUNCTION	26.2	45.3	70.2	129.1	167.8	214.0	320.8
SPC_J125	JUNCTION	7.5	13.6	22.0	42.0	55.0	70.8	106.8
SPC_J130	JUNCTION	3.9	7.2	11.6	21.9	28.6	36.4	54.7
SPC_J135	JUNCTION	15.5	25.8	38.9	69.2	89.3	112.8	168.0
SPC_J140	JUNCTION	7.6	11.6	16.3	26.6	33.5	41.5	60.3
SPC_J150	JUNCTION	9.7	15.2	21.9	38.0	48.6	61.5	90.6
SPC_J155	JUNCTION	9.7	15.2	21.9	38.0	48.6	61.5	90.6
SPC_J160	JUNCTION	9.7	15.2	21.9	38.0	48.6	61.5	90.6
SPC_J165	JUNCTION	8.0	12.5	17.7	30.3	38.6	48.7	71.5
SPC_J170	JUNCTION	7.4	11.3	15.8	25.5	32.0	39.7	57.7
SPC_J200	JUNCTION	42.1	66.6	96.1	162.5	206.9	258.7	377.9
SPC_J205	JUNCTION	42.1	66.6	96.1	162.5	206.9	258.7	377.9
SPC_J210	JUNCTION	42.1	66.6	96.1	162.5	206.9	258.7	377.9
SPC_J215	JUNCTION	42.1	66.6	96.1	162.5	206.9	258.7	377.9
SPC_J220	JUNCTION	42.1	66.6	96.1	162.5	206.9	258.7	377.9
SPC_J225	JUNCTION	25.7	41.1	59.7	101.9	129.9	162.6	212.6
SPC_J230	JUNCTION	25.7	41.1	59.7	101.9	129.9	162.6	213.3
SPC_J235	JUNCTION	13.3	20.6	29.0	47.2	59.6	73.9	88.6
SPC_J240	DIVIDER	13.3	20.6	29.0	47.2	59.6	73.9	108.7
SPC_J245	JUNCTION	13.3	20.6	29.0	47.2	59.6	73.9	84.0
SPC_J250	DIVIDER	13.3	20.6	29.0	47.2	59.6	73.9	107.7
SPC_J255	JUNCTION	14.1	21.5	30.2	47.9	60.4	75.1	109.2
SPC_J260	JUNCTION	12.6	20.8	31.0	54.8	70.5	88.9	136.6
SPC_J265	DIVIDER	12.6	20.8	31.0	54.8	70.5	88.9	131.6
SPC_J270	JUNCTION	9.5	14.7	21.1	34.4	43.5	54.3	79.4
SPC_J275	JUNCTION	9.5	14.7	21.1	34.4	43.5	54.3	79.4
SPC_J300	JUNCTION	14.6	22.4	31.5	51.3	64.7	74.0	74.1
SPC_J305	JUNCTION	14.6	22.4	31.5	51.3	64.7	74.0	74.1
SPC_J310	DIVIDER	14.6	22.4	31.5	51.3	64.7	80.3	116.8
SPC_J400	JUNCTION	7.9	12.1	17.1	26.7	33.6	42.0	60.8
SPC_J405	JUNCTION	7.9	12.1	17.1	26.7	33.6	42.0	60.8
SPC_J410	JUNCTION	7.9	12.1	17.1	26.7	33.6	42.0	60.8
SPC_O005	OUTFALL	274.7	363.4	459.3	809.5	1012.9	1211.4	1621.0
SPC_S100	STORAGE	199.5	290.1	399.5	656.3	830.4	1034.9	1494.7

Future Conditions Peak Flow (cfs)

Node	Junction Type	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
TRE_B005	JUNCTION	8.8	13.7	19.3	32.1	40.6	50.4	73.6
TRE_B010	JUNCTION	24.4	34.1	43.9	62.9	76.8	93.2	130.8
TRE_B015	JUNCTION	5.9	9.8	14.9	25.1	32.3	40.9	60.7
TRE_B020	JUNCTION	4.1	5.9	7.8	11.4	14.1	17.4	24.7
TRE_B025	JUNCTION	2.3	3.1	3.8	5.4	6.5	7.9	11.0
TRE_J005	JUNCTION	11.2	17.6	24.9	40.9	51.7	64.6	94.4
TRE_J010	DIVIDER	11.2	17.6	24.9	40.9	51.7	64.6	94.5
TRE_J015	JUNCTION	11.2	17.6	24.9	40.9	51.7	64.6	94.5
TRE_J020	DIVIDER	11.2	17.6	24.9	40.9	51.7	64.6	94.5
TRE_J025	JUNCTION	11.2	17.6	24.9	30.0	30.0	30.0	30.0
TRE_J030	DIVIDER	11.2	17.6	24.9	40.9	51.7	64.6	94.5
TRE_J035	JUNCTION	6.2	8.8	11.5	16.6	20.4	25.0	35.3
TRE_J040	JUNCTION	2.3	3.1	3.8	5.4	6.5	7.9	11.0
TRE_J045	DIVIDER	2.3	3.1	3.8	5.4	6.5	7.9	11.0
TRE_J200	JUNCTION	33.0	47.3	62.6	93.5	115.7	141.8	145.1
TRE_J205	DIVIDER	33.0	47.3	62.6	93.5	115.7	141.8	201.3
TRE_J210	JUNCTION	24.4	34.0	43.8	62.8	76.8	93.1	105.1
TRE_J215	JUNCTION	24.4	34.1	43.9	62.9	76.8	93.2	105.0
TRE_J220	JUNCTION	24.4	34.1	43.9	62.9	76.8	93.2	105.0
TRE_J225	DIVIDER	24.4	34.1	43.9	62.9	76.8	93.2	130.8
TRE_O005	OUTFALL	11.2	17.6	24.9	40.9	51.7	64.6	94.4
TRE_O010	OUTFALL	33.0	47.3	62.6	93.5	115.7	141.8	201.2
WCE_B005	JUNCTION	0.9	1.6	2.6	4.9	6.4	8.2	12.3
WCE_B010	JUNCTION	6.1	9.3	13.0	20.5	25.9	32.2	46.8
WCE_B015	JUNCTION	10.0	15.3	21.4	35.1	44.2	54.8	79.8
WCE_B020	JUNCTION	8.2	12.5	17.6	27.8	35.1	43.7	63.5
WCE_B025	JUNCTION	4.6	7.0	9.9	16.0	20.2	25.1	36.5
WCE_B029	JUNCTION	3.1	5.1	7.6	13.4	17.3	21.7	32.2
WCE_B030	JUNCTION	6.2	9.9	14.5	25.2	32.2	40.4	59.5
WCE_B035	JUNCTION	7.5	11.5	16.0	26.3	33.1	40.9	59.5
WCE_B040	JUNCTION	0.9	1.3	1.8	3.1	3.9	4.8	7.0
WCE_B045	JUNCTION	11.1	16.6	22.9	36.3	45.4	56.1	81.1
WCE_B050	JUNCTION	2.0	3.4	5.3	10.1	13.2	17.1	25.7
WCE_B055	JUNCTION	7.8	12.1	17.1	27.6	34.9	43.4	63.4
WCE_B056	JUNCTION	1.6	2.3	3.0	4.6	5.7	6.9	9.9
WCE_B060	JUNCTION	10.1	13.4	16.4	22.1	26.4	31.7	43.4
WCE_B065	JUNCTION	25.4	34.2	43.0	58.3	69.9	81.0	111.3
WCE_B070	JUNCTION	12.7	17.0	21.2	29.7	35.9	43.3	60.2
WCE_B075	JUNCTION	11.2	14.8	17.9	24.0	28.5	33.8	46.1
WCE_B080	JUNCTION	16.3	21.2	25.7	34.3	40.8	48.1	65.4
WCE_B085	JUNCTION	6.2	8.1	9.8	13.2	15.7	18.6	25.3
WCE_B090	JUNCTION	38.8	51.9	64.5	89.8	108.4	129.8	179.8
WCE_B095	JUNCTION	6.5	8.5	10.4	13.9	16.5	19.6	26.8
WCE_B100	JUNCTION	24.9	33.1	40.6	55.0	65.8	78.1	107.1
WCE_B105	JUNCTION	28.9	38.2	46.6	62.2	74.1	88.1	120.3

Node	Junction Type	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
WCE_B110	JUNCTION	19.0	24.8	30.0	40.0	47.6	56.6	77.2
WCE_J005	JUNCTION	161.8	221.8	287.4	472.4	605.6	745.4	1215.7
WCE_J010	JUNCTION	153.8	213.2	277.9	460.6	592.3	730.2	1196.5
WCE_J015	JUNCTION	143.6	197.0	254.6	429.7	549.2	672.1	1123.9
WCE_J020	JUNCTION	140.7	192.1	247.3	418.3	533.5	651.5	1095.8
WCE_J025	JUNCTION	106.6	138.9	173.6	315.7	393.6	475.9	857.7
WCE_J030	JUNCTION	94.9	121.3	159.2	282.9	349.2	430.3	783.4
WCE_J035	JUNCTION	93.2	118.1	154.9	273.3	337.6	414.9	758.8
WCE_J040	JUNCTION	85.7	106.4	146.1	251.6	315.0	385.6	708.0
WCE_J045	JUNCTION	55.9	78.5	127.6	206.6	233.9	328.6	605.3
WCE_J064	JUNCTION	139.9	185.8	228.4	307.3	381.0	440.1	596.1
WCE_J065	JUNCTION	117.4	155.5	190.9	258.5	265.1	265.1	265.1
WCE_J070	JUNCTION	117.4	155.5	190.9	258.5	265.1	265.1	265.1
WCE_J075	JUNCTION	117.4	155.5	190.9	258.5	265.1	265.2	265.1
WCE_J080	JUNCTION	117.4	155.5	190.9	258.5	265.1	265.5	265.7
WCE_J085	DIVIDER	117.4	155.6	190.9	258.5	324.8	371.3	502.0
WCE_J090	JUNCTION	117.4	155.6	190.9	258.6	300.3	302.3	302.3
WCE_J095	DIVIDER	117.4	155.6	190.9	258.6	308.0	371.5	502.0
WCE_J100	JUNCTION	78.6	103.8	126.5	169.2	200.1	241.9	323.6
WCE_J105	JUNCTION	72.2	95.3	116.2	140.1	140.1	140.1	140.1
WCE_J110	JUNCTION	72.2	95.3	116.2	140.1	140.1	140.1	140.1
WCE_J115	DIVIDER	72.2	95.3	116.2	156.0	184.1	223.5	297.6
WCE_J120	JUNCTION	43.9	57.8	70.4	94.9	112.0	132.3	182.1
WCE_J125	DIVIDER	43.9	57.8	70.4	94.9	112.0	132.3	182.1
WCE_J130	JUNCTION	43.9	57.8	70.4	94.9	112.0	130.0	130.0
WCE_J135	DIVIDER	43.9	57.8	70.5	94.9	112.0	132.6	182.4
WCE_J140	JUNCTION	19.0	24.8	30.0	40.0	42.0	42.0	42.0
WCE_J145	JUNCTION	19.0	24.8	30.0	40.0	42.0	42.0	42.0
WCE_J150	JUNCTION	19.0	24.8	30.0	40.0	42.0	42.0	42.0
WCE_J155	JUNCTION	19.0	24.8	30.0	40.0	42.0	42.0	42.0
WCE_J160	JUNCTION	19.0	24.8	30.0	40.0	42.0	42.0	42.0
WCE_J165	JUNCTION	19.0	24.8	30.0	40.0	42.0	42.0	42.0
WCE_J170	DIVIDER	19.0	24.8	30.0	40.0	47.6	56.6	77.2
WCE_J180	DIVIDER	28.9	38.2	46.6	62.2	74.1	88.1	120.3
WCE_J200	JUNCTION	7.3	7.2	7.2	7.3	7.2	7.2	7.3
WCE_J205	JUNCTION	7.6	7.6	7.5	7.6	7.6	7.5	7.6
WCE_J210	JUNCTION	7.8	7.8	7.8	7.9	7.8	7.8	7.8
WCE_J215	JUNCTION	7.7	7.7	7.7	7.7	7.7	7.7	7.7
WCE_J220	DIVIDER	15.5	23.8	33.5	54.6	69.0	85.7	124.6
WCE_J225	DIVIDER	15.5	23.8	33.5	54.7	69.0	85.7	124.6
WCE_J230	JUNCTION	10.0	15.3	21.4	35.1	44.2	54.8	79.8
WCE_J300	JUNCTION	10.1	13.4	16.4	22.1	26.4	31.7	43.4
WCE_J400	JUNCTION	16.3	21.2	25.7	34.2	37.0	37.0	37.1
WCE_J405	JUNCTION	16.3	21.3	25.7	34.2	37.0	37.0	37.0
WCE_J410	DIVIDER	16.3	21.2	25.7	34.3	40.8	48.1	65.4

Future Conditions Peak Flow (cfs)

Node	Junction Type	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
WCE_J415	JUNCTION	16.6	21.9	26.7	36.2	46.5	61.9	98.1
WCE_J420	JUNCTION	6.2	8.1	9.8	13.2	15.7	18.6	25.3
WCE_O005	OUTFALL	169.3	237.4	312.4	511.0	659.8	818.5	1312.3
WCE_S100	STORAGE	168.4	223.7	274.9	369.7	453.0	519.6	692.1
WSC_B005	JUNCTION	11.6	18.6	26.9	46.0	58.6	73.3	107.7
WSC_B010	JUNCTION	4.2	6.4	9.0	14.2	17.9	22.3	32.4
WSC_B015	JUNCTION	7.0	10.7	15.0	23.8	30.0	37.4	54.3
WSC_B020	JUNCTION	19.5	26.7	33.7	47.2	57.2	69.1	96.0
WSC_B025	JUNCTION	25.5	34.8	43.8	60.6	73.5	88.5	122.8
WSC_J005	JUNCTION	66.0	96.2	128.9	195.9	244.1	295.6	391.8
WSC_J010	JUNCTION	55.7	78.9	103.5	151.7	187.4	223.3	286.0
WSC_J015	JUNCTION	48.8	68.3	88.6	128.0	157.5	186.0	231.7
WSC_J020	JUNCTION	48.8	68.3	88.6	128.0	157.5	186.0	231.7
WSC_J025	JUNCTION	45.0	62.4	80.1	114.1	139.9	164.1	199.9
WSC_J030	JUNCTION	25.5	34.7	43.8	60.6	73.5	82.1	82.1
WSC_J035	JUNCTION	25.5	34.7	43.8	60.6	73.5	82.1	82.1
WSC_J040	JUNCTION	25.5	34.7	43.8	60.7	73.5	82.1	82.1
WSC_J045	JUNCTION	25.5	34.7	43.8	60.7	73.5	82.1	82.1
WSC_J050	DIVIDER	25.5	34.8	43.8	60.6	73.5	88.5	122.8
WSC_J100	JUNCTION	7.0	10.7	15.0	23.8	30.0	37.4	54.3

Future Conditions Total Node Inflow (Ac-ft.)

Node	Junction Type	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
ACR_B005	JUNCTION	0.6	0.9	1.2	1.9	2.4	3.0	4.4
ACR_B010	JUNCTION	0.6	0.8	1.1	1.4	1.7	2.1	2.9
ACR_B015	JUNCTION	0.6	0.9	1.1	1.5	1.8	2.2	3.1
ACR_B020	JUNCTION	1.1	1.6	2.0	2.8	3.4	4.0	5.6
ACR_B025	JUNCTION	1.3	1.7	2.2	2.9	3.4	4.1	5.6
ACR_B030	JUNCTION	1.8	2.5	3.1	4.2	5.1	6.1	8.5
ACR_B035	JUNCTION	1.2	1.6	2.1	2.9	3.6	4.3	6.1
ACR_B040	JUNCTION	1.1	1.6	2.3	3.5	4.4	5.5	8.0
ACR_B045	JUNCTION	1.0	1.6	2.1	3.3	4.1	5.2	7.6
ACR_B050	JUNCTION	0.9	1.4	1.9	2.8	3.5	4.4	6.4
ACR_B055	JUNCTION	0.9	1.3	1.8	2.8	3.5	4.4	6.5
ACR_J005	JUNCTION	7.7	11.0	14.5	22.0	29.0	37.1	57.4
ACR_J010	JUNCTION	6.5	9.3	12.2	18.6	24.9	31.9	50.0
ACR_J035	JUNCTION	5.9	8.4	11.1	17.2	23.0	29.8	47.0
ACR_J045	DIVIDER	5.9	8.4	11.1	17.2	23.1	29.8	47.0
ACR_J050	JUNCTION	5.9	8.4	11.1	17.2	23.1	29.8	47.0
ACR_J055	DIVIDER	3.5	5.2	6.9	11.5	16.3	21.8	35.0
ACR_J060	JUNCTION	0.0	0.0	0.0	0.0	0.0	0.0	0.1
ACR_J065	JUNCTION	2.9	4.3	5.9	8.9	11.2	13.9	20.4
ACR_J070	JUNCTION	0.0	0.0	0.0	0.0	0.0	0.0	0.1
ACR_J075	DIVIDER	2.9	4.3	5.9	8.9	11.2	13.9	20.4
ACR_J080	JUNCTION	1.8	2.7	3.7	5.6	7.1	8.8	12.8
ACR_J085	JUNCTION	0.9	1.3	1.8	2.8	3.5	4.4	6.5
ACR_J200	DIVIDER	0.7	0.9	1.1	2.7	5.1	7.9	14.5
ACR_J204	JUNCTION	1.1	1.6	2.3	3.5	4.4	5.5	8.0
ACR_J205	JUNCTION	1.1	1.6	2.3	3.5	4.4	5.5	8.0
ACR_J210	JUNCTION	1.1	1.6	2.3	3.5	4.4	5.5	8.0
ACR_J215	JUNCTION	1.1	1.6	2.3	3.5	4.4	5.5	8.0
ACR_J220	JUNCTION	1.1	1.6	2.3	3.5	4.4	5.5	8.0
ACR_J225	JUNCTION	1.1	1.6	2.3	3.5	4.4	5.5	8.0
ACR_J230	DIVIDER	1.1	1.6	2.3	3.5	4.4	5.5	8.0
ACR_J235	JUNCTION	1.1	1.6	2.3	3.5	4.4	5.5	8.0
ACR_J240	JUNCTION	1.1	1.6	2.3	3.5	4.4	5.5	8.0
ACR_J245	JUNCTION	1.1	1.6	2.3	3.5	4.4	5.5	8.0
ACR_J250	JUNCTION	1.1	1.6	2.3	3.5	4.4	5.5	8.0
ACR_O005	OUTFALL	7.7	11.0	14.5	21.9	29.0	37.1	57.4
ACR_O010	OUTFALL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ACR_S100	STORAGE	4.0	5.7	7.5	10.6	13.1	15.8	22.6
DFA_B005	OUTFALL	1.6	2.7	5.1	10.3	14.1	19.0	29.7
DFA_B010	OUTFALL	0.6	0.9	1.3	2.0	2.5	3.2	4.6
DFA_B015	OUTFALL	1.1	1.7	2.3	3.5	4.5	5.6	8.2
DFA_B020	OUTFALL	0.6	0.8	1.1	1.7	2.1	2.7	3.9
DFA_B021	OUTFALL	1.2	1.8	2.4	3.6	4.4	5.5	8.0
DFA_B025	OUTFALL	0.8	1.1	1.5	2.3	2.9	3.6	5.2
DFA_B030	OUTFALL	0.7	1.1	1.5	2.3	2.9	3.6	5.2

Node	Junction Type	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
DFA_B035	OUTFALL	0.3	0.4	0.6	1.1	1.4	1.8	2.6
DFA_B040	OUTFALL	0.8	1.2	1.8	3.0	3.9	5.0	7.5
DFA_B041	OUTFALL	0.6	1.0	1.5	2.4	3.2	4.0	6.0
DFA_B042	JUNCTION	0.2	0.3	0.5	0.7	0.9	1.1	1.5
DFA_B043	JUNCTION	1.1	1.5	1.8	2.4	2.9	3.3	4.6
DFA_B045	OUTFALL	0.6	1.0	1.4	2.3	3.0	3.9	5.8
DFA_B046	OUTFALL	0.6	0.9	1.3	2.1	2.7	3.3	5.0
DFA_B050	OUTFALL	1.0	1.7	2.6	4.4	5.7	7.3	11.1
DFA_B051	OUTFALL	0.5	0.7	1.0	1.5	1.9	2.3	3.4
DFA_B055	OUTFALL	1.3	1.9	2.6	4.1	5.1	6.4	9.4
DFA_B060	OUTFALL	0.2	0.4	0.7	1.6	2.2	3.0	4.8
DFA_B061	OUTFALL	0.4	0.6	0.9	1.4	1.7	2.1	3.1
DFA_B065	OUTFALL	0.6	0.9	1.2	2.0	2.6	3.3	4.8
DFA_B100	OUTFALL	0.2	0.3	0.4	0.7	0.8	1.0	1.5
DFA_B105	OUTFALL	0.3	0.5	0.7	1.0	1.3	1.7	2.4
DFA_J005	JUNCTION	1.3	1.8	2.3	3.1	3.7	4.4	6.2
DFA_J010	JUNCTION	1.1	1.5	1.8	2.4	2.9	3.3	4.6
DFA_O005	OUTFALL	1.3	1.8	2.3	3.1	3.7	4.4	6.2
FHP_B005	JUNCTION	0.1	0.3	0.5	1.0	1.4	1.9	3.0
FHP_B010	JUNCTION	0.4	0.7	0.9	1.4	1.7	2.1	3.1
FHP_B015	JUNCTION	0.2	0.3	0.4	0.6	0.7	0.8	1.1
FHP_B020	JUNCTION	0.3	0.5	0.6	0.8	0.9	1.1	1.6
FHP_B025	JUNCTION	0.4	0.5	0.7	0.9	1.2	1.4	2.0
FHP_B030	JUNCTION	2.1	3.0	4.1	6.0	7.5	9.3	13.5
FHP_B035	JUNCTION	0.1	0.2	0.2	0.4	0.5	0.7	1.1
FHP_B040	JUNCTION	0.6	0.9	1.3	2.1	2.7	3.4	5.1
FHP_B045	JUNCTION	0.4	0.6	0.7	1.0	1.2	1.4	2.0
FHP_B050	JUNCTION	0.2	0.3	0.4	0.7	0.8	1.0	1.5
FHP_B055	JUNCTION	0.2	0.3	0.4	0.6	0.8	0.9	1.4
FHP_B060	JUNCTION	0.7	1.1	1.5	2.2	2.8	3.5	5.2
FHP_B065	JUNCTION	1.1	1.6	2.2	3.4	4.3	5.4	7.9
FHP_B070	JUNCTION	1.0	1.4	2.0	3.0	3.8	4.8	7.0
FHP_B075	JUNCTION	0.2	0.3	0.4	0.6	0.8	1.0	1.5
FHP_B080	JUNCTION	0.8	1.2	1.7	2.6	3.3	4.1	6.0
FHP_B085	JUNCTION	1.3	1.9	2.5	3.6	4.5	5.5	7.8
FHP_B090	JUNCTION	0.5	0.8	1.1	1.7	2.2	2.8	4.1
FHP_B095	JUNCTION	0.9	1.3	1.6	2.3	2.8	3.4	4.8
FHP_B100	JUNCTION	0.4	0.6	0.9	1.3	1.7	2.1	3.1
FHP_B105	JUNCTION	0.3	0.4	0.5	0.7	0.8	1.0	1.4
FHP_J005	JUNCTION	12.2	17.8	24.1	35.9	44.8	55.2	81.3
FHP_J010	JUNCTION	11.2	16.4	22.2	33.1	41.4	51.3	75.8
FHP_J015	DIVIDER	10.8	15.9	21.6	32.2	40.5	50.0	72.7
FHP_J020	JUNCTION	8.7	12.9	17.5	26.2	32.8	40.8	59.2
FHP_J030	JUNCTION	8.0	11.8	16.0	23.7	29.6	36.5	53.1
FHP_J035	JUNCTION	4.3	6.2	8.3	12.1	15.0	18.4	26.5

Future Conditions Total Node Inflow (Ac-ft.)

Node	Junction Type	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
FHP_J040	JUNCTION	3.5	5.0	6.7	9.5	11.8	14.3	20.5
FHP_J045	JUNCTION	1.6	2.3	3.0	4.1	5.1	6.1	8.6
FHP_J050	JUNCTION	1.2	1.7	2.1	2.8	3.4	4.0	5.5
FHP_J055	JUNCTION	0.3	0.4	0.5	0.5	0.6	0.6	0.7
FHP_J060	JUNCTION	0.3	0.4	0.5	0.5	0.6	0.6	0.7
FHP_J065	DIVIDER	0.3	0.4	0.5	0.7	0.8	1.0	1.4
FHP_J100	JUNCTION	3.7	5.6	7.5	9.5	10.7	11.5	13.3
FHP_J105	JUNCTION	3.7	5.4	7.2	9.1	10.2	11.0	12.6
FHP_J110	JUNCTION	3.5	5.1	6.8	8.5	9.4	9.9	11.2
FHP_J115	JUNCTION	3.1	4.7	6.4	8.0	8.9	9.5	10.7
FHP_J120	DIVIDER	3.1	4.7	6.4	8.6	10.2	11.8	15.4
FHP_J125	DIVIDER	2.4	3.6	5.0	7.1	8.5	10.0	13.5
FHP_J130	DIVIDER	1.2	1.7	2.4	3.7	4.7	5.8	8.5
FHP_J135	DIVIDER	1.2	1.7	2.4	3.7	4.6	5.8	8.5
FHP_J140	JUNCTION	0.7	0.8	0.8	0.9	0.9	0.9	1.0
FHP_J145	DIVIDER	1.2	1.7	2.4	3.7	4.6	5.8	8.5
FHP_J150	DIVIDER	1.1	1.6	2.2	3.4	4.3	5.4	7.9
FHP_J160	JUNCTION	0.7	1.1	1.3	1.6	1.7	1.8	2.0
FHP_J165	DIVIDER	0.7	1.1	1.5	2.2	2.8	3.5	5.2
FHP_J200	DIVIDER	0.1	0.2	0.4	2.5	4.4	7.2	13.8
FHP_J205	DIVIDER	0.4	0.6	0.9	2.9	4.8	7.7	14.3
FHP_J210	DIVIDER	0.2	0.3	0.4	0.7	0.8	1.0	1.5
FHP_J215	JUNCTION	0.0	0.0	0.1	1.9	3.7	6.2	12.3
FHP_O005	OUTFALL	12.3	18.1	24.6	36.8	46.3	57.4	84.4
HFT_B005	JUNCTION	0.9	1.4	1.9	2.9	3.6	4.5	6.6
HFT_B010	JUNCTION	1.2	2.0	2.9	4.8	6.1	7.8	11.8
HFT_B015	JUNCTION	1.3	1.9	2.6	4.0	5.1	6.4	9.4
HFT_B020	JUNCTION	0.5	0.7	1.0	1.5	2.0	2.4	3.6
HFT_B025	JUNCTION	0.7	1.1	1.4	2.1	2.6	3.2	4.7
HFT_B030	JUNCTION	0.3	0.4	0.5	0.7	0.8	1.0	1.4
HFT_J005	JUNCTION	2.2	3.3	4.8	7.6	9.8	12.4	18.4
HFT_J010	JUNCTION	1.2	2.0	2.9	4.8	6.1	7.8	11.8
HFT_J100	DIVIDER	2.8	4.1	5.6	8.3	10.0	11.8	14.9
HFT_J101	JUNCTION	0.0	0.0	0.6	2.7	4.3	6.5	11.8
HFT_J105	JUNCTION	2.3	3.4	4.6	6.8	8.1	9.3	11.3
HFT_J110	DIVIDER	1.3	1.9	2.6	4.0	5.1	6.4	10.1
HFT_J115	DIVIDER	1.3	1.9	2.6	4.0	5.1	6.4	9.4
HFT_J120	JUNCTION	1.0	1.5	1.9	2.8	3.4	4.2	5.3
HFT_J125	JUNCTION	1.0	1.5	1.9	2.8	3.4	4.2	5.3
HFT_J130	JUNCTION	1.0	1.5	1.9	2.8	3.4	4.2	5.3
HFT_J135	JUNCTION	1.0	1.5	1.9	2.8	3.4	4.2	5.3
HFT_J140	JUNCTION	1.0	1.5	1.9	2.8	3.4	4.2	5.3
HFT_J145	DIVIDER	1.0	1.5	1.9	2.8	3.4	4.2	6.0
HFT_J150	JUNCTION	0.3	0.4	0.5	0.7	0.8	1.0	1.4
HFT_J155	JUNCTION	0.3	0.4	0.5	0.7	0.8	1.0	1.4

Node	Junction Type	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
HFT_J160	JUNCTION	0.3	0.4	0.5	0.7	0.8	1.0	1.4
HFT_J165	JUNCTION	0.3	0.4	0.5	0.7	0.8	1.0	1.4
HFT_J170	JUNCTION	0.3	0.4	0.5	0.7	0.8	1.0	1.4
HFT_O005	OUTFALL	2.8	4.1	5.0	5.7	6.2	6.5	7.2
HFT_O010	OUTFALL	2.2	3.4	5.3	10.3	14.1	18.9	30.2
HOM_B005	JUNCTION	0.3	0.5	0.6	1.0	1.2	1.6	2.3
HOM_B010	JUNCTION	1.0	1.5	2.0	3.1	3.9	4.9	7.2
HOM_B015	JUNCTION	0.7	1.1	1.5	2.3	3.0	3.7	5.4
HOM_B020	JUNCTION	0.9	1.4	1.9	2.9	3.7	4.6	6.7
HOM_J005	JUNCTION	3.0	4.4	6.1	9.1	11.1	12.8	16.8
HOM_J010	JUNCTION	2.6	4.0	5.5	8.2	9.9	11.2	14.5
HOM_J015	JUNCTION	2.6	4.0	5.5	8.2	9.9	11.2	14.5
HOM_J020	JUNCTION	2.6	3.9	4.8	5.5	6.0	6.3	7.0
HOM_J025	DIVIDER	2.6	4.0	5.5	8.2	9.9	11.2	14.5
HOM_J030	DIVIDER	2.6	4.0	5.5	8.2	9.7	11.2	14.5
HOM_J035	JUNCTION	1.7	2.5	3.4	5.0	5.8	6.3	7.4
HOM_J040	JUNCTION	1.7	2.5	3.4	5.0	5.8	6.3	7.4
HOM_J045	DIVIDER	1.7	2.5	3.4	5.2	6.6	8.3	12.2
HOM_J050	JUNCTION	0.9	1.4	1.9	2.9	3.7	4.6	6.6
HOM_J055	JUNCTION	0.9	1.4	1.9	2.9	3.7	4.6	6.6
HOM_J060	JUNCTION	0.9	1.4	1.9	2.9	3.7	4.6	6.6
HOM_J065	DIVIDER	0.9	1.4	1.9	2.9	3.7	4.6	6.8
HOM_J070	DIVIDER	0.9	1.4	1.9	2.9	3.7	4.6	6.8
HOM_J075	DIVIDER	0.9	1.4	1.9	2.9	3.7	4.6	6.7
HOM_J080	JUNCTION	0.9	1.3	1.6	1.9	2.0	2.1	2.3
HOM_J085	JUNCTION	0.9	1.3	1.6	1.9	2.0	2.1	2.3
HOM_J090	DIVIDER	0.9	1.4	1.9	2.9	3.7	4.6	6.7
HOM_O005	OUTFALL	3.0	4.4	6.1	9.1	11.1	12.8	16.8
HOM_O010	OUTFALL	0.0	0.0	0.0	0.2	0.8	1.9	4.8
JAM_B005	JUNCTION	0.4	0.6	0.9	1.5	1.9	2.5	3.7
JAM_B010	JUNCTION	1.4	2.0	2.6	3.8	4.7	5.7	8.2
JAM_J005	JUNCTION	1.4	2.0	2.6	3.8	4.7	5.7	8.2
JAM_J010	JUNCTION	1.4	2.0	2.6	3.8	4.7	5.7	8.2
JAM_J015	JUNCTION	1.4	2.0	2.6	3.8	4.7	5.7	8.2
KET_B005	JUNCTION	0.5	0.7	1.0	1.6	2.0	2.5	3.7
KET_B010	JUNCTION	1.2	1.6	2.0	2.7	3.2	3.7	5.2
KET_J005	DIVIDER	1.7	2.4	3.1	4.3	5.2	6.3	8.8
KET_J010	DIVIDER	1.2	1.6	2.1	2.7	3.2	3.7	5.2
KET_J011	JUNCTION	1.2	1.6	2.0	2.4	2.6	2.8	3.3
KET_J015	DIVIDER	1.2	1.6	2.0	2.7	3.2	3.7	5.2
KET_J020	JUNCTION	1.2	1.6	2.0	2.7	3.2	3.7	5.2
KET_J025	JUNCTION	1.2	1.6	2.0	2.7	3.2	3.7	5.2
KET_J030	JUNCTION	1.2	1.6	2.0	2.7	3.2	3.7	5.2
KET_J035	DIVIDER	1.2	1.6	2.0	2.7	3.2	3.7	5.2
KET_J040	JUNCTION	1.2	1.6	2.0	2.7	3.2	3.7	5.2

Future Conditions Total Node Inflow (Ac-ft.)

Node	Junction Type	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
PHI_B100	JUNCTION	0.5	0.8	1.0	1.6	2.0	2.5	3.7
PHI_B105	JUNCTION	0.5	0.7	1.0	1.5	2.0	2.4	3.6
PHI_B110	JUNCTION	1.9	2.6	3.3	4.4	5.4	6.4	8.9
PHI_B115	JUNCTION	5.5	7.5	9.5	12.7	15.3	18.3	25.5
PHI_J010	JUNCTION	7.5	10.7	14.0	19.4	23.9	28.8	40.8
PHI_J015	JUNCTION	7.1	10.0	13.0	17.8	21.9	26.3	37.1
PHI_J020	JUNCTION	5.5	7.5	9.5	12.7	15.3	18.3	25.5
PHI_O005	OUTFALL	7.5	10.7	14.0	19.4	23.9	28.8	40.8
PHI_S100	STORAGE	7.3	10.0	12.7	17.1	20.7	24.6	34.4
PHI_S200	STORAGE	5.5	7.5	9.5	12.7	15.3	18.3	25.5
SPC_B005	JUNCTION	0.8	1.2	1.6	2.4	3.1	3.8	5.5
SPC_B010	JUNCTION	0.8	1.2	1.6	2.6	3.3	4.1	6.1
SPC_B015	JUNCTION	1.2	1.8	2.5	3.8	4.8	6.0	8.8
SPC_B020	JUNCTION	0.6	0.9	1.2	1.8	2.2	2.8	4.1
SPC_B025	JUNCTION	1.4	1.9	2.6	3.9	5.0	6.2	9.1
SPC_B030	JUNCTION	2.3	3.2	4.2	6.0	7.4	9.0	12.9
SPC_B035	JUNCTION	1.5	2.1	2.7	3.7	4.4	5.2	7.4
SPC_B036	JUNCTION	1.7	2.3	2.8	3.6	4.2	4.9	6.8
SPC_B040	JUNCTION	3.0	4.2	5.4	7.3	8.9	10.6	14.8
SPC_B045	JUNCTION	2.0	2.9	3.9	5.8	7.2	8.9	13.0
SPC_B046	JUNCTION	0.5	0.7	1.0	1.5	1.9	2.4	3.5
SPC_B050	JUNCTION	0.2	0.3	0.4	0.7	0.9	1.1	1.7
SPC_B055	JUNCTION	0.3	0.5	0.8	1.3	1.7	2.3	3.4
SPC_B060	JUNCTION	0.4	0.6	1.0	1.7	2.3	3.0	4.5
SPC_B065	JUNCTION	0.3	0.6	0.9	1.7	2.3	3.0	4.6
SPC_B070	JUNCTION	0.7	1.2	1.8	3.2	4.2	5.4	8.2
SPC_B080	JUNCTION	0.7	1.0	1.4	2.1	2.7	3.3	4.9
SPC_B085	JUNCTION	0.6	0.9	1.2	1.9	2.4	2.9	4.3
SPC_B090	JUNCTION	0.2	0.3	0.5	0.8	1.0	1.3	2.0
SPC_B095	JUNCTION	1.3	1.9	2.7	4.1	5.2	6.4	9.4
SPC_B100	JUNCTION	1.0	1.5	2.0	3.1	3.9	4.9	7.2
SPC_B105	JUNCTION	0.4	0.7	1.2	2.1	2.8	3.6	5.5
SPC_B110	JUNCTION	0.7	1.1	1.5	2.4	3.0	3.8	5.6
SPC_J005	JUNCTION	26.7	39.3	53.4	79.8	100.0	124.0	181.1
SPC_J010	JUNCTION	25.9	38.1	51.6	77.3	97.0	120.3	175.8
SPC_J015	JUNCTION	25.1	36.8	50.0	74.6	93.9	116.3	169.7
SPC_J020	DIVIDER	23.4	34.4	46.3	69.0	86.8	107.4	156.5
SPC_J025	JUNCTION	19.1	27.9	38.1	56.8	71.2	88.4	129.5
SPC_J030	JUNCTION	17.7	26.0	35.3	52.8	66.3	82.2	120.3
SPC_J035	JUNCTION	15.4	22.7	31.0	46.6	58.9	73.0	107.4
SPC_J040	DIVIDER	12.2	18.4	25.6	39.6	50.3	62.9	92.7
SPC_J045	JUNCTION	9.1	14.1	20.2	32.2	41.4	52.5	77.9
SPC_J050	JUNCTION	9.1	14.1	20.2	32.2	41.4	52.5	77.9
SPC_J055	JUNCTION	9.1	14.1	20.2	32.2	41.4	52.5	77.9
SPC_J060	JUNCTION	3.8	6.1	9.0	14.9	19.4	24.7	37.1

Node	Junction Type	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
SPC_J065	JUNCTION	3.8	6.1	9.0	14.9	19.4	24.6	31.9
SPC_J070	JUNCTION	3.8	6.1	9.0	14.9	19.4	24.6	31.9
SPC_J075	JUNCTION	3.8	6.1	9.0	14.9	19.4	24.6	31.9
SPC_J080	JUNCTION	3.8	6.1	9.0	14.9	19.4	24.6	31.9
SPC_J085	JUNCTION	3.8	6.1	9.0	14.9	19.4	24.7	31.9
SPC_J090	DIVIDER	3.8	6.1	9.0	14.9	19.4	24.7	37.1
SPC_J095	JUNCTION	3.3	5.4	8.0	13.4	17.5	22.4	30.5
SPC_J100	JUNCTION	3.3	5.4	8.0	13.4	17.5	22.4	30.5
SPC_J105	JUNCTION	3.3	5.4	8.0	13.4	17.5	22.4	30.5
SPC_J110	DIVIDER	3.3	5.4	8.0	13.4	17.5	22.4	33.8
SPC_J115	DIVIDER	2.3	3.9	5.9	10.1	13.2	17.0	25.7
SPC_J120	JUNCTION	2.4	3.9	5.9	10.1	13.2	17.0	25.7
SPC_J125	JUNCTION	0.7	1.2	2.0	3.5	4.6	6.0	9.1
SPC_J130	JUNCTION	0.3	0.6	0.9	1.7	2.3	3.0	4.6
SPC_J135	JUNCTION	1.4	2.2	3.2	5.3	6.8	8.7	13.1
SPC_J140	JUNCTION	0.7	1.0	1.4	2.1	2.7	3.3	4.9
SPC_J150	JUNCTION	0.9	1.5	2.1	3.3	4.3	5.4	8.0
SPC_J155	JUNCTION	0.9	1.5	2.1	3.3	4.3	5.4	8.0
SPC_J160	JUNCTION	0.9	1.5	2.1	3.3	4.3	5.4	8.0
SPC_J165	JUNCTION	0.8	1.2	1.7	2.7	3.4	4.3	6.4
SPC_J170	JUNCTION	0.6	0.9	1.2	1.9	2.4	2.9	4.3
SPC_J200	JUNCTION	3.4	5.2	7.4	11.6	14.9	18.7	27.7
SPC_J205	JUNCTION	3.4	5.2	7.4	11.6	14.9	18.7	27.7
SPC_J210	JUNCTION	3.4	5.2	7.4	11.6	14.9	18.7	27.7
SPC_J215	JUNCTION	3.4	5.2	7.4	11.6	14.9	18.7	27.7
SPC_J220	JUNCTION	3.4	5.2	7.4	11.6	14.9	18.7	27.7
SPC_J225	JUNCTION	2.1	3.3	4.7	7.5	9.7	12.3	17.7
SPC_J230	JUNCTION	2.1	3.3	4.7	7.5	9.7	12.3	17.7
SPC_J235	JUNCTION	1.0	1.5	2.0	3.1	4.0	4.9	6.7
SPC_J240	DIVIDER	1.0	1.5	2.0	3.1	4.0	4.9	7.3
SPC_J245	JUNCTION	1.0	1.5	2.0	3.1	4.0	4.9	6.8
SPC_J250	DIVIDER	1.0	1.5	2.0	3.1	4.0	4.9	7.2
SPC_J255	JUNCTION	1.0	1.5	2.0	3.1	3.9	4.9	7.2
SPC_J260	JUNCTION	1.1	1.8	2.7	4.4	5.8	7.4	11.0
SPC_J265	DIVIDER	1.1	1.8	2.7	4.4	5.8	7.4	11.1
SPC_J270	JUNCTION	0.7	1.1	1.5	2.4	3.0	3.8	5.6
SPC_J275	JUNCTION	0.7	1.1	1.5	2.4	3.0	3.8	5.6
SPC_J300	JUNCTION	1.2	1.8	2.5	3.8	4.8	5.9	7.5
SPC_J305	JUNCTION	1.2	1.8	2.5	3.8	4.8	5.9	7.5
SPC_J310	DIVIDER	1.2	1.8	2.5	3.8	4.8	6.0	8.8
SPC_J400	JUNCTION	0.5	0.7	1.0	1.5	1.9	2.4	3.5
SPC_J405	JUNCTION	0.5	0.7	1.0	1.5	1.9	2.4	3.5
SPC_J410	JUNCTION	0.5	0.7	1.0	1.5	1.9	2.4	3.5
SPC_O005	OUTFALL	26.7	39.3	53.4	79.5	100.0	124.0	181.1
SPC_S100	STORAGE	15.4	22.8	31.0	47.0	58.9	73.0	107.4

Future Conditions Total Node Inflow (Ac-ft.)

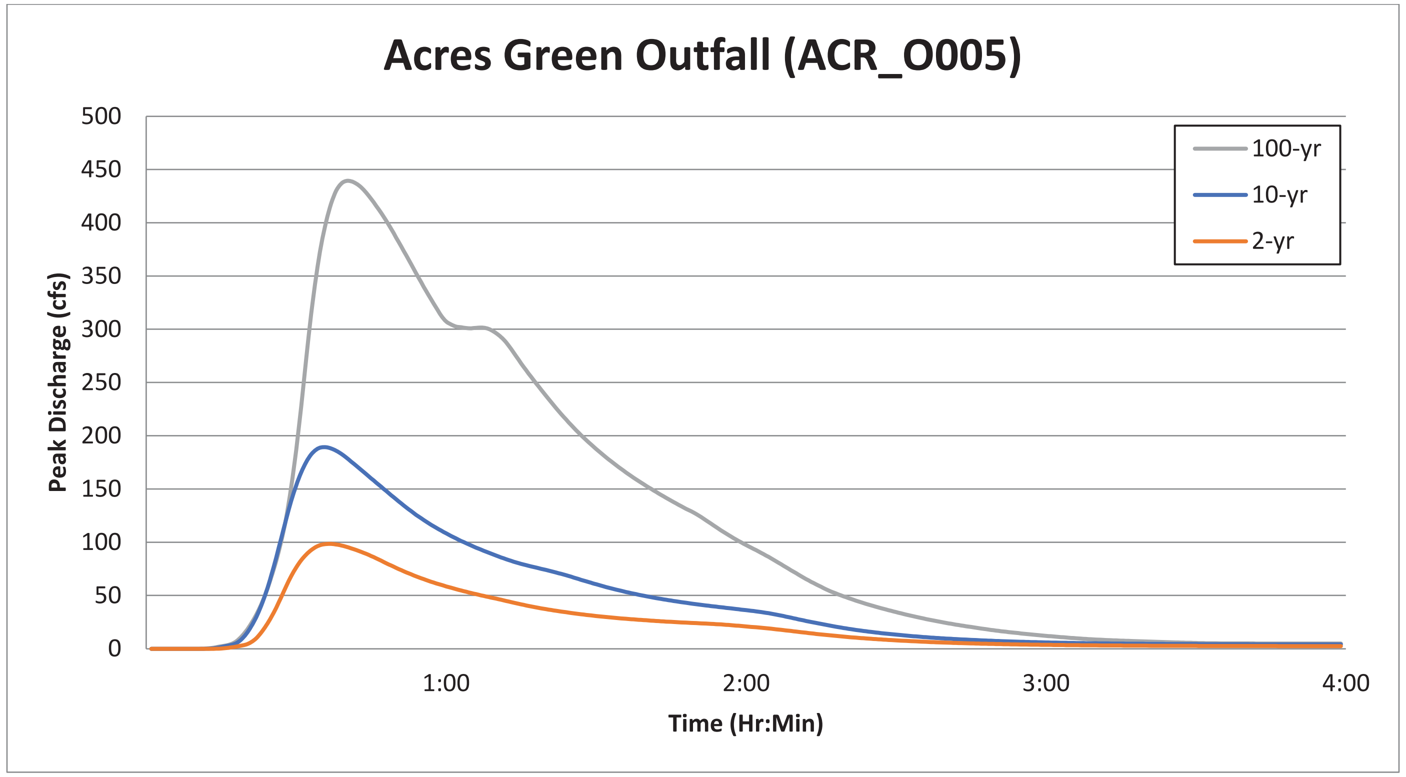
Node	Junction Type	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
TRE_B005	JUNCTION	0.8	1.2	1.7	2.7	3.4	4.2	6.3
TRE_B010	JUNCTION	1.5	2.1	2.7	3.8	4.6	5.6	7.9
TRE_B015	JUNCTION	0.4	0.6	0.9	1.5	2.0	2.5	3.8
TRE_B020	JUNCTION	0.2	0.3	0.4	0.6	0.7	0.9	1.3
TRE_B025	JUNCTION	0.2	0.2	0.3	0.4	0.5	0.6	0.8
TRE_J005	JUNCTION	0.8	1.2	1.6	2.5	3.2	4.0	5.9
TRE_J010	DIVIDER	0.8	1.2	1.6	2.5	3.2	4.0	5.9
TRE_J015	JUNCTION	0.8	1.2	1.6	2.5	3.2	4.0	5.9
TRE_J020	DIVIDER	0.8	1.2	1.6	2.5	3.2	4.0	5.9
TRE_J025	JUNCTION	0.8	1.2	1.6	2.3	2.6	2.9	3.3
TRE_J030	DIVIDER	0.8	1.2	1.6	2.5	3.2	4.0	5.9
TRE_J035	JUNCTION	0.4	0.5	0.7	1.0	1.2	1.5	2.1
TRE_J040	JUNCTION	0.2	0.2	0.3	0.4	0.5	0.6	0.8
TRE_J045	DIVIDER	0.2	0.2	0.3	0.4	0.5	0.6	0.8
TRE_J200	JUNCTION	2.3	3.3	4.4	6.4	8.0	9.8	12.8
TRE_J205	DIVIDER	2.3	3.3	4.4	6.4	8.0	9.8	14.1
TRE_J210	JUNCTION	1.5	2.1	2.7	3.8	4.6	5.5	7.5
TRE_J215	JUNCTION	1.5	2.1	2.7	3.8	4.6	5.6	7.5
TRE_J220	JUNCTION	1.5	2.1	2.7	3.8	4.6	5.6	7.5
TRE_J225	DIVIDER	1.5	2.1	2.7	3.8	4.6	5.6	7.9
TRE_O005	OUTFALL	0.8	1.2	1.6	2.5	3.2	4.0	5.9
TRE_O010	OUTFALL	2.3	3.3	4.4	6.4	8.0	9.8	14.1
WCE_B005	JUNCTION	0.1	0.2	0.4	0.7	0.9	1.1	1.7
WCE_B010	JUNCTION	0.4	0.6	0.8	1.3	1.6	2.1	3.0
WCE_B015	JUNCTION	0.8	1.3	1.7	2.7	3.4	4.3	6.3
WCE_B020	JUNCTION	0.6	0.8	1.2	1.8	2.2	2.8	4.1
WCE_B025	JUNCTION	0.4	0.5	0.8	1.2	1.5	1.9	2.7
WCE_B029	JUNCTION	0.3	0.5	0.7	1.1	1.4	1.9	2.8
WCE_B030	JUNCTION	0.6	1.0	1.4	2.2	2.9	3.7	5.4
WCE_B035	JUNCTION	0.7	1.0	1.4	2.1	2.7	3.3	4.9
WCE_B040	JUNCTION	0.1	0.1	0.2	0.3	0.4	0.5	0.7
WCE_B045	JUNCTION	0.9	1.3	1.8	2.7	3.3	4.1	6.1
WCE_B050	JUNCTION	0.2	0.4	0.6	1.1	1.5	1.9	2.9
WCE_B055	JUNCTION	0.6	0.9	1.2	1.9	2.4	3.0	4.4
WCE_B056	JUNCTION	0.1	0.2	0.2	0.3	0.4	0.5	0.7
WCE_B060	JUNCTION	0.6	0.8	1.0	1.3	1.5	1.8	2.4
WCE_B065	JUNCTION	1.1	1.5	1.9	2.6	3.1	3.7	5.0
WCE_B070	JUNCTION	0.8	1.1	1.4	1.8	2.2	2.6	3.7
WCE_B075	JUNCTION	0.7	1.0	1.2	1.5	1.8	2.2	3.0
WCE_B080	JUNCTION	0.8	1.1	1.4	1.8	2.2	2.6	3.5
WCE_B085	JUNCTION	0.4	0.5	0.7	0.9	1.0	1.2	1.6
WCE_B090	JUNCTION	2.5	3.4	4.3	5.7	6.9	8.2	11.5
WCE_B095	JUNCTION	0.4	0.6	0.7	1.0	1.1	1.3	1.8
WCE_B100	JUNCTION	1.7	2.3	2.9	3.7	4.4	5.2	7.2
WCE_B105	JUNCTION	1.6	2.2	2.7	3.5	4.2	4.9	6.8

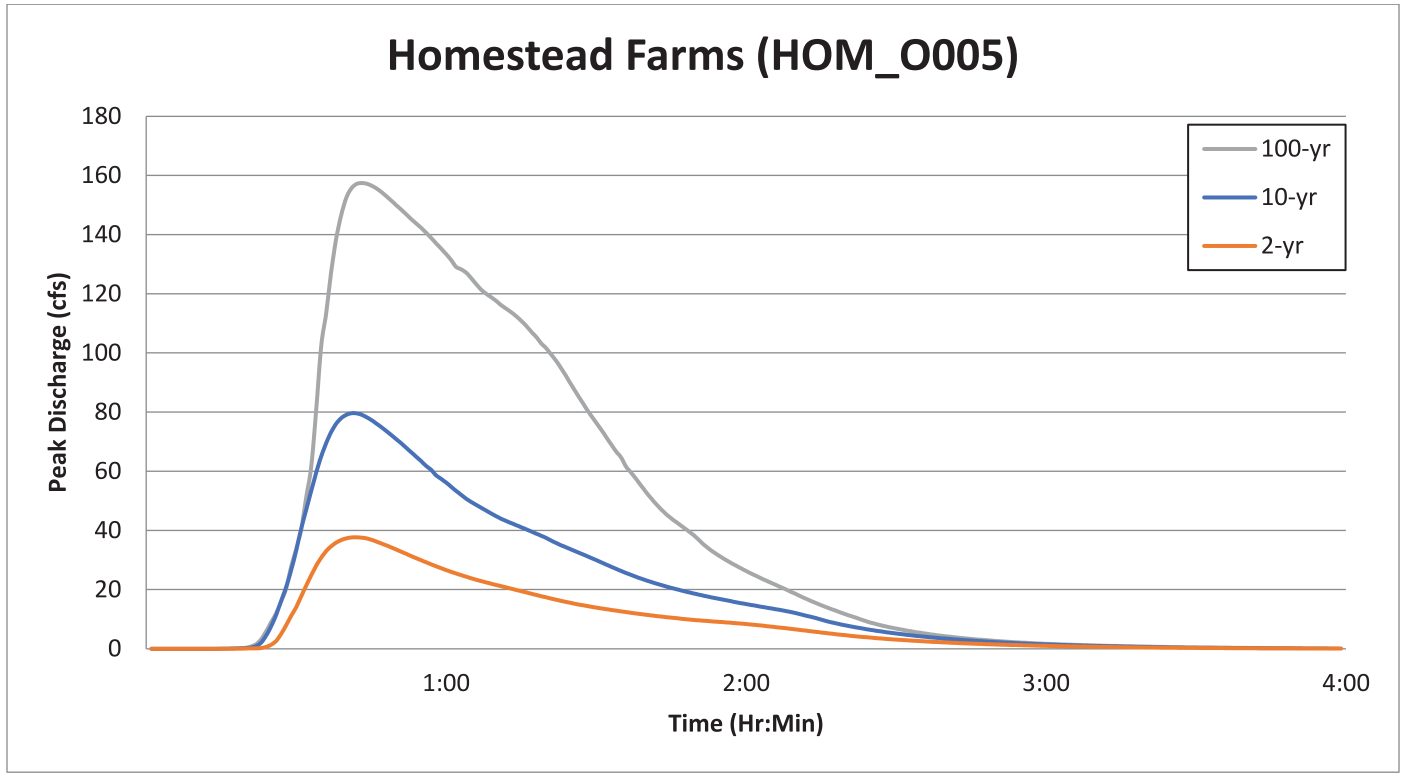
Node	Junction Type	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
WCE_B110	JUNCTION	1.2	1.6	2.0	2.6	3.1	3.7	5.0
WCE_J005	JUNCTION	18.2	25.2	33.8	48.5	60.5	73.7	105.9
WCE_J010	JUNCTION	17.2	24.0	32.2	46.6	58.3	71.2	102.8
WCE_J015	JUNCTION	16.4	22.7	30.4	43.9	54.6	66.6	96.1
WCE_J020	JUNCTION	16.2	22.3	29.8	42.7	53.4	65.1	93.3
WCE_J025	JUNCTION	13.4	18.1	23.8	33.5	41.4	50.0	71.2
WCE_J030	JUNCTION	12.5	16.7	21.9	30.5	37.7	45.4	64.4
WCE_J035	JUNCTION	12.3	16.4	21.4	29.5	36.5	43.6	61.7
WCE_J040	JUNCTION	11.9	15.6	20.3	27.7	34.1	40.8	57.4
WCE_J045	JUNCTION	10.3	13.4	17.3	23.6	29.0	34.7	48.8
WCE_J064	JUNCTION	8.6	11.6	14.6	19.1	23.2	27.2	37.4
WCE_J065	JUNCTION	7.4	10.1	12.7	16.6	19.3	21.4	25.5
WCE_J070	JUNCTION	7.4	10.1	12.7	16.6	19.3	21.4	25.5
WCE_J075	JUNCTION	7.4	10.1	12.7	16.6	19.3	21.4	25.5
WCE_J080	JUNCTION	7.4	10.1	12.7	16.6	19.3	21.4	25.5
WCE_J085	DIVIDER	7.4	10.1	12.7	16.6	20.1	23.5	32.5
WCE_J090	JUNCTION	7.4	10.1	12.7	16.6	19.8	21.9	26.3
WCE_J095	DIVIDER	7.4	10.1	12.7	16.6	19.9	23.5	32.2
WCE_J100	JUNCTION	4.9	6.7	8.3	10.8	13.0	15.3	20.9
WCE_J105	JUNCTION	4.5	6.1	7.6	9.7	11.0	12.0	14.1
WCE_J110	JUNCTION	4.5	6.1	7.6	9.7	11.0	12.0	14.1
WCE_J115	DIVIDER	4.5	6.1	7.6	9.9	11.8	13.9	19.1
WCE_J120	JUNCTION	2.9	3.9	4.9	6.4	7.6	8.9	12.2
WCE_J125	DIVIDER	2.9	3.9	4.9	6.4	7.6	8.9	12.2
WCE_J130	JUNCTION	2.9	3.9	4.9	6.4	7.6	8.9	11.1
WCE_J135	DIVIDER	2.9	3.9	4.9	6.4	7.6	8.9	12.2
WCE_J140	JUNCTION	1.2	1.6	2.0	2.6	3.1	3.4	4.1
WCE_J145	JUNCTION	1.2	1.6	2.0	2.6	3.1	3.4	4.1
WCE_J150	JUNCTION	1.2	1.6	2.0	2.6	3.1	3.4	4.1
WCE_J155	JUNCTION	1.2	1.6	2.0	2.6	3.1	3.4	4.1
WCE_J160	JUNCTION	1.2	1.6	2.0	2.6	3.1	3.4	4.1
WCE_J165	JUNCTION	1.2	1.6	2.0	2.6	3.1	3.4	4.1
WCE_J170	DIVIDER	1.2	1.6	2.0	2.6	3.1	3.7	5.0
WCE_J180	DIVIDER	1.6	2.2	2.7	3.5	4.2	4.9	6.8
WCE_J200	JUNCTION	0.9	1.1	1.2	1.2	1.3	1.3	1.4
WCE_J205	JUNCTION	0.9	1.1	1.2	1.2	1.3	1.3	1.4
WCE_J210	JUNCTION	0.9	1.1	1.2	1.2	1.3	1.3	1.4
WCE_J215	JUNCTION	0.9	1.1	1.2	1.2	1.3	1.3	1.4
WCE_J220	DIVIDER	1.2	1.9	2.6	4.0	5.1	6.3	9.3
WCE_J225	DIVIDER	1.2	1.9	2.6	4.0	5.1	6.3	9.3
WCE_J230	JUNCTION	0.8	1.3	1.7	2.7	3.4	4.3	6.3
WCE_J300	JUNCTION	0.6	0.8	1.0	1.3	1.5	1.8	2.4
WCE_J400	JUNCTION	0.8	1.1	1.4	1.8	2.2	2.4	2.9
WCE_J405	JUNCTION	0.8	1.1	1.4	1.8	2.2	2.4	2.9
WCE_J410	DIVIDER	0.8	1.1	1.4	1.8	2.2	2.6	3.5

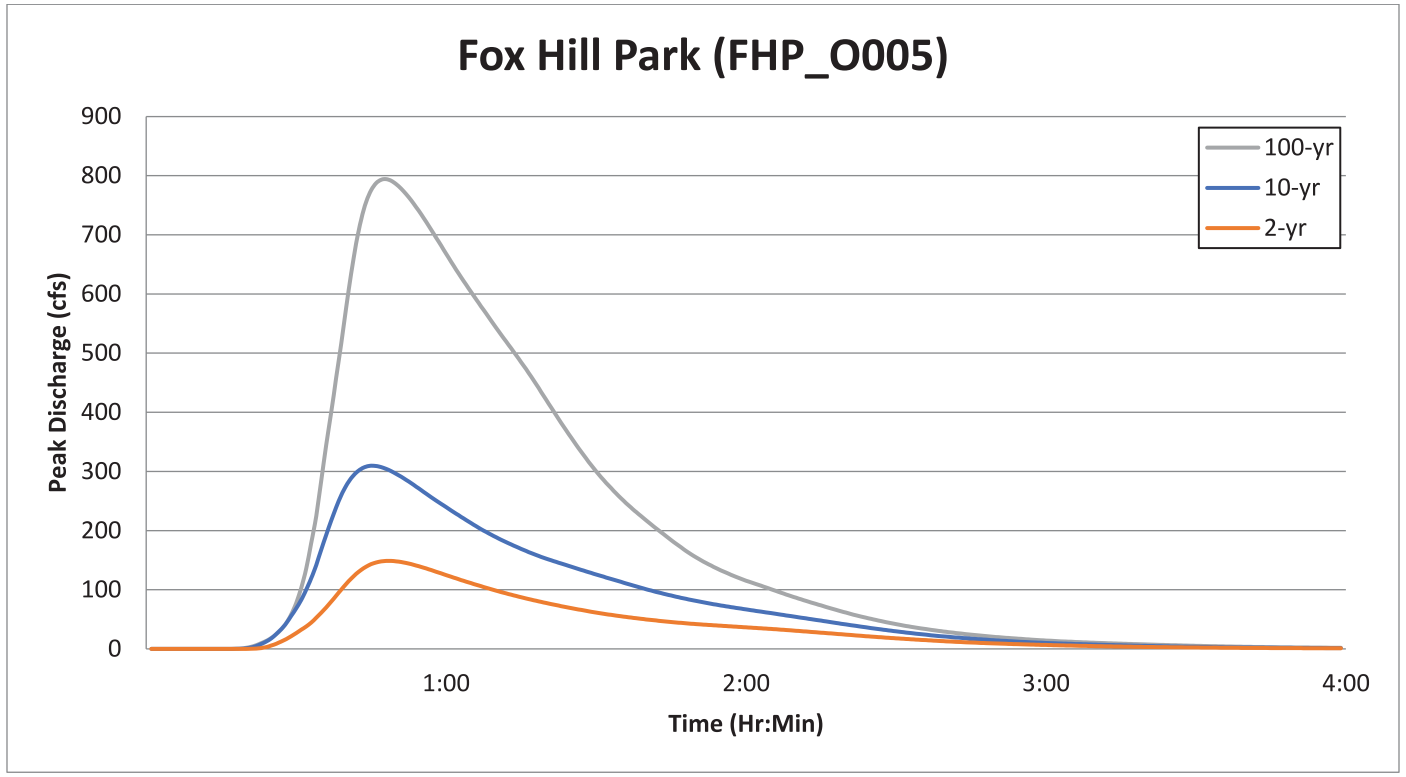
Future Conditions Total Node Inflow (Ac-ft.)

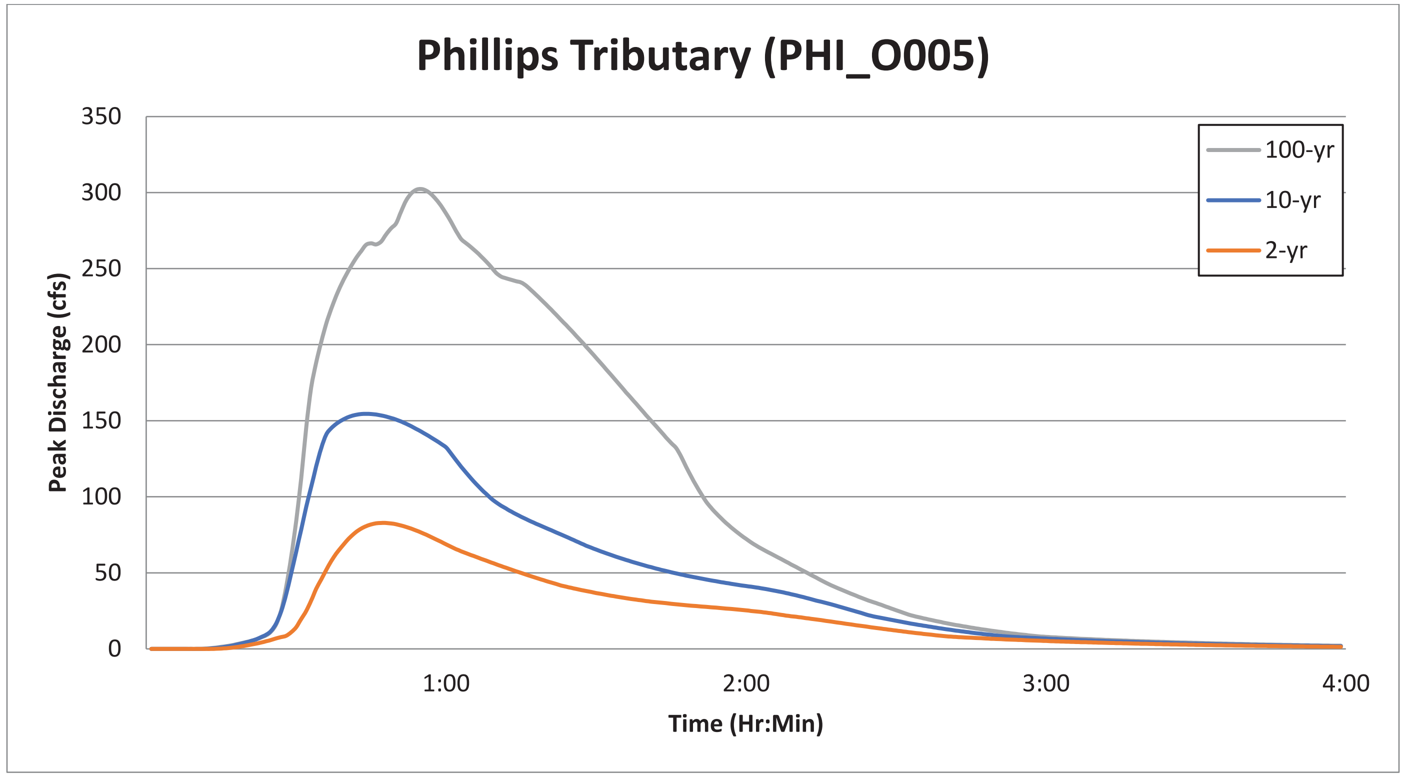
Node	Junction Type	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
WCE_J415	JUNCTION	1.1	1.5	1.9	2.4	2.9	3.5	5.2
WCE_J420	JUNCTION	0.4	0.5	0.7	0.9	1.0	1.2	1.6
WCE_O005	OUTFALL	18.4	25.9	35.0	51.3	64.1	78.6	113.5
WCE_S100	STORAGE	10.2	13.8	17.4	22.8	27.6	32.2	43.9
WSC_B005	JUNCTION	1.0	1.6	2.3	3.7	4.8	6.1	9.1
WSC_B010	JUNCTION	0.3	0.4	0.6	0.9	1.2	1.5	2.1
WSC_B015	JUNCTION	0.5	0.7	1.0	1.6	2.0	2.5	3.7
WSC_B020	JUNCTION	1.2	1.6	2.1	2.8	3.4	4.1	5.7
WSC_B025	JUNCTION	1.3	1.8	2.4	3.2	3.9	4.6	6.4
WSC_J005	JUNCTION	4.3	6.3	8.5	12.4	15.5	19.1	27.0
WSC_J010	JUNCTION	3.3	4.7	6.1	8.7	10.7	13.0	18.0
WSC_J015	JUNCTION	2.8	3.9	5.1	7.1	8.7	10.5	14.3
WSC_J020	JUNCTION	2.8	3.9	5.1	7.1	8.7	10.5	14.3
WSC_J025	JUNCTION	2.5	3.5	4.5	6.2	7.5	9.0	12.2
WSC_J030	JUNCTION	1.3	1.8	2.4	3.2	3.9	4.5	5.7
WSC_J035	JUNCTION	1.3	1.8	2.4	3.2	3.9	4.5	5.7
WSC_J040	JUNCTION	1.3	1.8	2.4	3.2	3.9	4.5	5.7
WSC_J045	JUNCTION	1.3	1.8	2.4	3.2	3.9	4.5	5.7
WSC_J050	DIVIDER	1.3	1.8	2.4	3.2	3.9	4.6	6.4
WSC_J100	JUNCTION	0.5	0.7	1.0	1.6	2.0	2.5	3.7

Future Conditions 2-, 10-, and 100-year Outfall Hydrographs

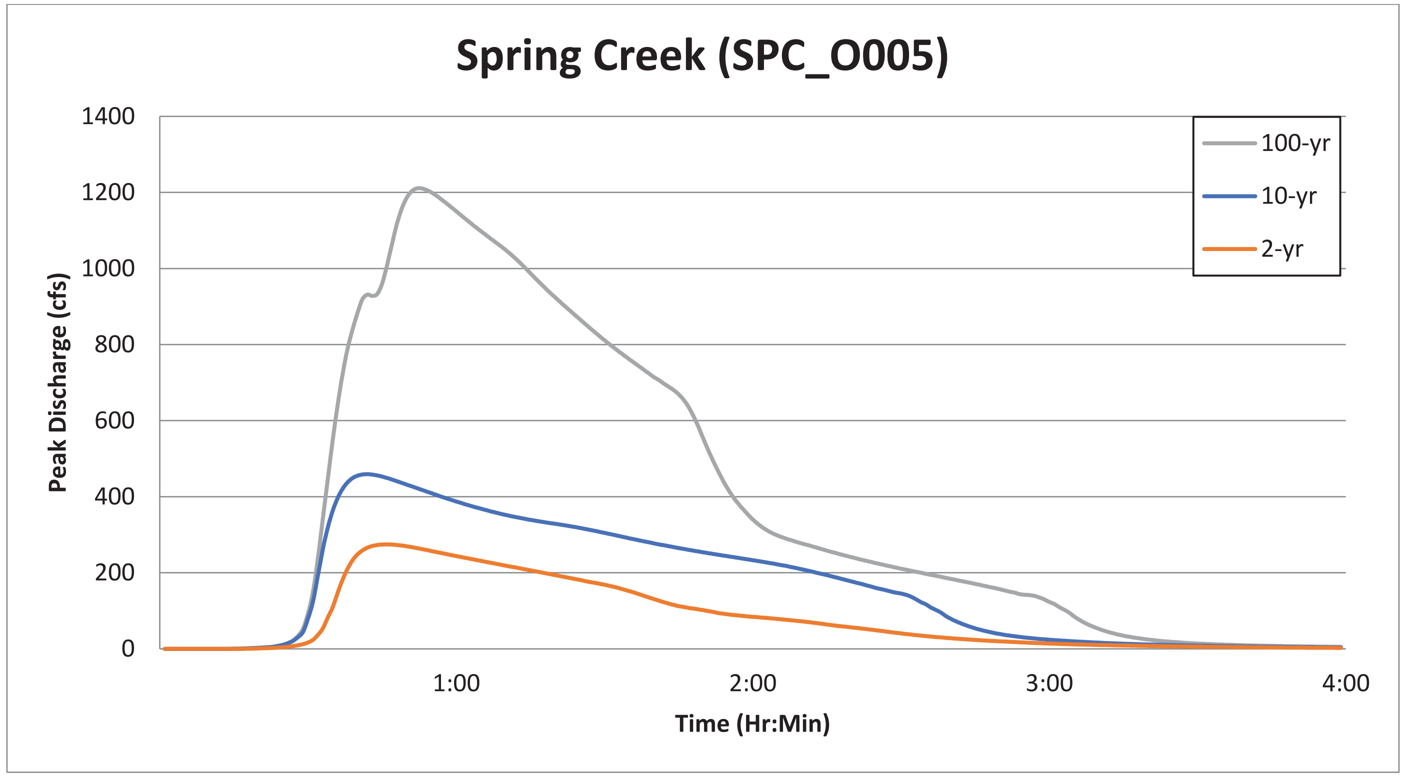


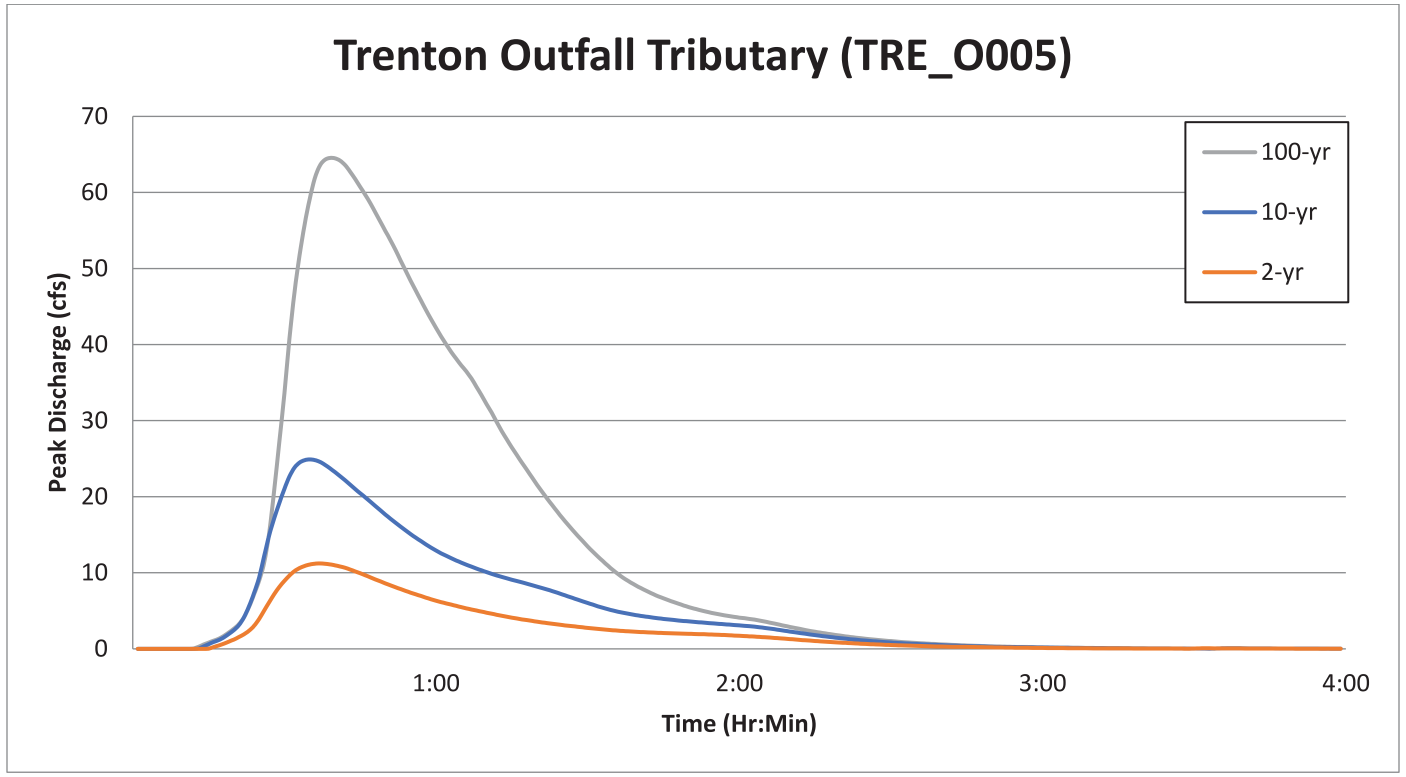


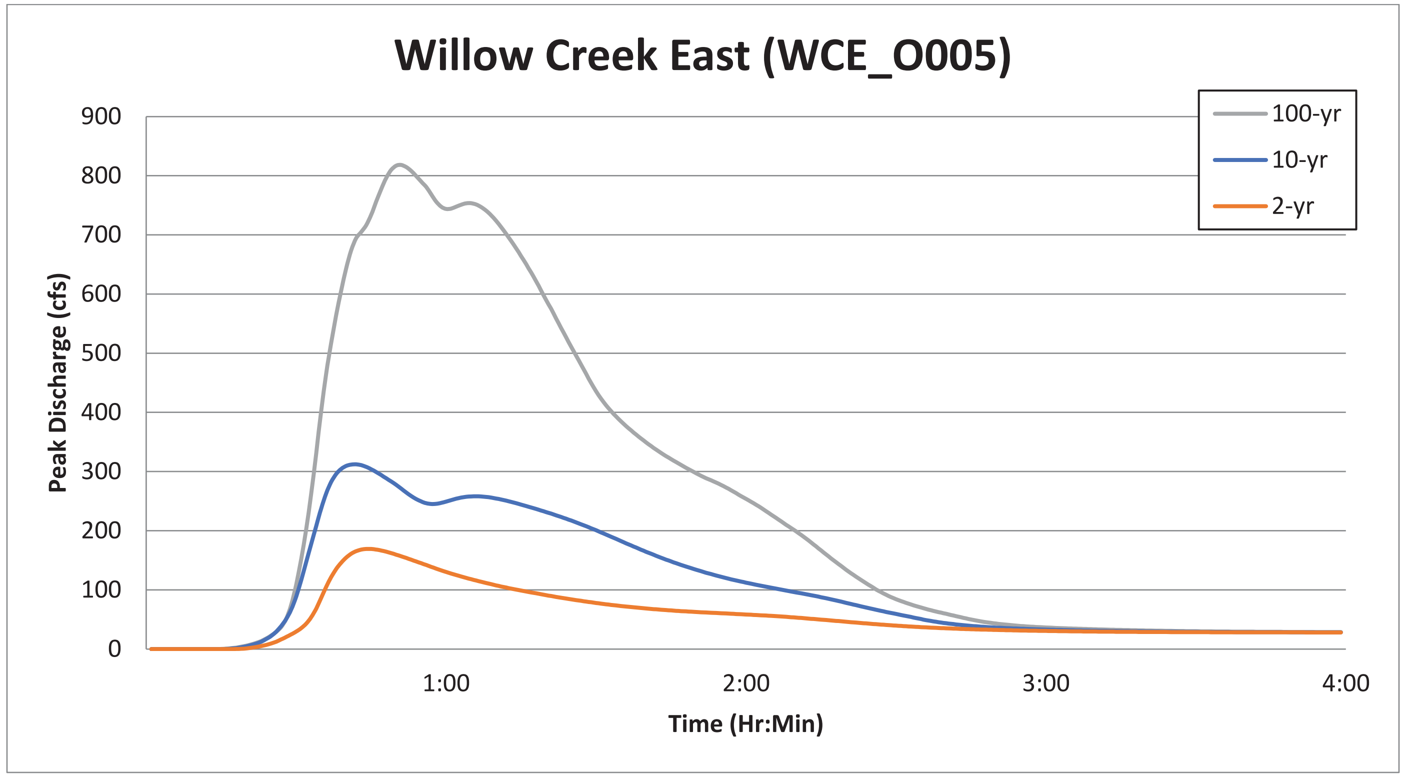




Future Conditions 2-, 10-, and 100-year Outfall Hydrographs







Threshold Runoff

Threshold runoff is defined as "the amount of *effective* rainfall of a given duration falling over a watershed that is just enough to cause *bankfull* conditions at the outlet of the draining stream." (Modrick, 2015; Shamir, 2018). Threshold runoff is an important physically-based characteristic of a watershed used by Weather Forecast Offices and River Forecast Centers, and is a prime indicator of maximal sustainable surface runoff for a given watershed (Carpenter et al., 1999). When combined with current soil moisture conditions and doppler radar, threshold runoff estimates become an essential component of the flash flood warning and flash flood guidance systems, especially in watersheds prone to flash flooding.

Threshold runoff estimates are commonly evaluated by application of the thresholdR Method or through GIS-based assessments. The thresholdR Method, developed by NOAA's National Weather Service as part of the Threshold Runoff Program that following deployment of Doppler radar in the early 1990s, is used for flash flood guidance purposes. This method defines threshold runoff as the ratio of the streamflow at bankfull conditions to the unit hydrograph peak flow in a given watershed. Bankfull flow is derived by applying Manning's flow equation for a given stream or through USGS regression equations for a two-year return frequency. The unit hydrograph peak flow is estimated through Snyder's unit hydrograph method or the geomorphologic unit hydrograph (NWS, 2001).

Initial soil moisture content (or soil moisture deficit) is the most critical factor relating the precipitation to threshold runoff because threshold runoff quantifies the saturated and unsaturated soil condition relationship to direct runoff during varying precipitation events. Several research papers and experiments studies address these hydrologic-hydraulic through experimental studies and modeling applications.

- Ajmal et al. (2015) evaluated event-based rainfall-runoff models in terms of antecedent soil moisture conditions for NRCS curve numbers and nonlinear runoff estimation methods.
- Kusumastuti et al. (2007) illustrated the effects of threshold runoff to flood frequency.
- Kampf et al. (2018) and Faulconer (2015) (master's thesis) evaluated the occurrence of runoff in hyperarid and semi-arid ephemeral streams due to rainfall intensity thresholds and illustrated the importance of runoff frequency and scale-dependence in threshold analyses in these types of watersheds.
- Hrncir et al. (2010) determined that initial soil water content is a statistically significant physical parameter influencing the rainfall-runoff relationship and runoff forming process at the catchment scale.
- Reed (2001) (presentation) and Reed et al. (2002) provided an overview of GIS applications for deriving threshold runoff values to assist in flash flood guidance, and discussed methods for determining threshold runoff estimates for application purposes.
- Curtu et al. (2014) presented ordinary differential equations to quantify the relationship between soil moisture, groundwater, and surface runoff dynamics.
- Minet et al. (2011) determined simulated runoff response in a watershed is highly sensitive to spatial variability of soil moisture within a distributed hydrologic model.
- Scaife and Band (2017) illustrated seasonal and interannual nonstationary associated with stormflow thresholds as a function of precipitation and antecedent soil moisture conditions, including recent climate dryness, ecosystem water use, and catchment geophysical properties such as vegetation-climate influences on long-term rainfall-runoff relationships.
- Schoener and Stone (2019) researched the impact of soil moisture on runoff in a semi-arid climate and determined that antecedent soil moisture, when modeled at the catchment scale, performed poorly for small runoff events compared to large discharge events that considered antecedent soil moisture conditions.
- Penna et al. 2011 evaluated soil moisture in alpine headwater streams and determined clear threshold relationships between soil water content and streamflow on hydrologic response timing.
- Other relevant research for modeling relationship of soil moisture and precipitation to storm runoff/hydrologic response are discussed in Ali et al. (2015), Williams et al. (pre-print), Zehe et al. (2005), and Zhang et al. (2011).

To summarize, threshold runoff is a one-time, physically-based calculation relating watershed characteristics (area, length, slope) to channel properties (bankfull channel width and depth) of a given drainage area, whereas flash flood guidance systems integrate the threshold runoff as a physically-based characteristic with soil moisture parameters and parameter for flood forecasting and warnings. The influence of antecedent soil water content to flow frequency is significant when compared to other hydrologic and hydraulic parameters on threshold runoff estimates.

The literature indicates much variability for threshold runoff based on watershed conditions, and unfortunately, a detailed study of this phenomena has not been conducted in the Denver region. Such a study could potentially be conducted for small watersheds in the metropolitan area using UDFCD rainfall and stream gauges. The studies with greatest applicability to the western US are summarized in Table 1. Heavily forested watersheds may have thresholds well in excess of an inch of rainfall as reported by Ali et al. (2015), which is not surprising since the forest canopy and heavy "duff" layer can store significant amounts of rain and because shallow subsurface flow may occur in many of the watersheds. The study by Kampf et al. (2018), which is based in Arizona with arid and semi-arid watersheds, reported significantly lower thresholds, on the order of 0.5 inches of precipitation over a short duration (e.g., several hours). Given differences between watersheds in Arizona and Front Range watersheds in Colorado, we would expect these values to be somewhat lower than in Colorado. The study by Carpenter et al. (1999) found threshold runoff values for short duration storms in Iowa, Oklahoma, and California that generally fell between those found by Ali et al. (2015) in the northwest and Kampf et al. (2018) in Arizona.

Absent a detailed study in Colorado, WWE supplemented the literature review with some Curve Number calculations to determine typical initial abstractions for different types of land cover. Table 2 presents these results. For herbaceous cover in good condition, the initial abstraction for Hydrologic Soil Group C is approximately 0.7 inches. The initial abstraction is very similar to the 1-hour, 1-year depth from NOAA Atlas 14 in the study area, which is 0.68 inches. If more woody vegetation is present, the initial abstraction is somewhat higher.

This literature review and calculations indicate that threshold runoff is very sensitive to site-specific conditions, including vegetative cover, hydrologic conditions, soils, antecedent moisture, and other watershed characteristics. Detailed data are not available for Colorado, but based on studies in western states and calculations, it seems reasonable to assume a threshold for runoff around the 1-year event for short duration (1- to 3- hour storms) for native grasslands. WWE found similar results in our continuous simulation modeling of the Oak Gulch watershed. UDFCD hopes to collect baseline data in the Oak Gulch watershed before the development is constructed to help verify a range of threshold runoff values for different antecedent conditions.

Table 1. Major Findings from Literature Review of Threshold Runoff

Reference	Study Area	Findings
Ali et al. 2015	Nine North-Watch catchments (US, Sweden, Canada, and Scotland); catchment area ranged from 100 to 7,400 acres	- Threshold values were highly variable between catchments - For <u>rainfall</u> events <u>without consideration for the storage deficit</u>, values ranged from 2.0 to 3.9 inches (median of 3.1 inches). - For <u>rainfall</u> events <u>with consideration for the storage deficit</u>, values ranged from 1.4 to 3.1 inches (median of 2.1 inches). - For <u>snowmelt</u> events <u>without consideration for the storage</u> deficit, values ranged from 1.0 to 7.1 inches (median of 4.7 inches) - For <u>snowmelt</u> events <u>with consideration for the storage deficit</u>, values ranged from 1.2 to 7.1 inches (median of 3.3 inches)
Carpenter et al. 1999	Three different regions evaluated with the <u>four</u> different *threshR* methods, including: - California (1,794 subbasins with areas ranging from 2 to 1,420 mi^2), - Iowa (10,878 subbasins with areas ranging from 2 to 4,500 mi^2), and - Oklahoma (15,879 subbasins with areas ranging from 2 to 7,500 mi^2)	- Threshold runoff values varied between each region with averages of 1.3 inches for Oklahoma, 0.6 inches for Iowa, and 0.4 inches for California - Manually procedure-computed threshold runoff values for Iowa and Oklahoma were 0.1 to 1.7 inches and 0.4 to 1.7 inches, respectively. - Relative frequency of threshold runoff values for the <u>four</u> methods and <u>three</u> effective rainfall durations (1-hour, 3-hour, and 6-hour) were computed for Oklahoma basins and represented in Figure 9 of the text.
Kampf et al. 2018	Study watersheds in Arizona, including one hyperarid and one semiarid watershed	- Watershed mean 60-min intensity thresholds ranged from 0.1-0.5 in/hr in hyperarid watersheds and 0.3-0.6 in/hr in semiarid watersheds. - The maximum MI_{60} threshold values increased with drainage area (around <u>0.2 in/hr in the smallest watersheds</u> up to over <u>1.0 in/hr in the largest watersheds</u>). - The choice of rain data strongly influenced threshold values; single rain gauges were only adequate for threshold prediction with watershed areas less than 0.4 mi^2, and incomplete rainfall data led to increases in thresholds with increased drainage areas.

Table 2. Estimated Initial Abstraction by NRCS Runoff Curve Numbers for Arid and Semiarid Rangelands

Land Cover Description		Hydrologic soil group C			Hydrologic soil group D			Range of I_a for Type C/D Soils
Cover Type	**Condition**	**CN**	**S (in)**	**I_a (in)**	**CN**	**S (in)**	**I_a (in)**	**I_a (in)**
Herbaceous – mixture of grass, weeds and low-growing brush, with brush the minor element	Poor	87	1.5	0.3	93	0.8	0.2	0.2 to 0.3
	Fair	81	2.3	0.5	89	1.2	0.2	0.2 to 0.5
	Good	74	3.5	0.7	85	1.8	0.4	0.4 to 0.7
Oak-Aspen – mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush	Poor	74	3.5	0.7	79	2.7	0.5	0.5 to 0.7
	Fair	57	7.5	1.5	63	5.9	1.2	1.2 to 1.5
	Good	41	14.4	2.9	48	10.8	2.2	2.2 to 2.9
Pinyon-juniper – pinyon, juniper, or both; grass understory	Poor	85	1.8	0.4	89	1.2	0.2	0.2 to 0.4
	Fair	73	3.7	0.7	80	2.5	0.5	0.5 to 0.7
	Good	61	6.4	1.3	71	4.1	0.8	0.8 to 1.3
Sage-grass – sage with grass understory	Poor	80	2.5	0.5	85	1.8	0.4	0.4 to 0.5
	Fair	63	5.9	1.2	70	4.3	0.9	0.9 to 1.2
	Good	47	11.3	2.3	55	8.2	1.6	1.6 to 2.3
Desert shrub – major plants include saltbush, greasewood, creosote bush, blackbrush, bursage, paloverde, mesquite, and cactus	Poor	85	1.8	0.4	88	1.4	0.3	0.3 to 0.4
	Fair	81	2.3	0.5	86	1.6	0.3	0.3 to 0.5
	Good	79	2.7	0.5	84	1.9	0.4	0.4 to 0.5

NOTES
1) CN represent NRCS runoff curve numbers for rangelands from Table 2-2d.
2) S represent potential maximum retention after runoff begins (inches), where S=1000/CN-10.
3) Ia represents initial abstraction (inches), where Ia = 0.2S

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Screenshots of tables from *Urban hydrology for small watersheds (TR-55)* by Cronshey (1986)

Table 2-2d Runoff curve numbers for arid and semiarid rangelands [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition [2]	A [3]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

1 Average runoff condition, and I_a, = 0.2S. For range in humid regions, use table 2-2c.
2 Poor: <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: > 70% ground cover.
3 Curve numbers for group A have been developed only for desert shrub.

Table 4-1 I_a values for runoff curve numbers

Curve number	I_a (in)	Curve number	I_a (in)
40	3.000	70	0.857
41	2.878	71	0.817
42	2.762	72	0.778
43	2.651	73	0.740
44	2.545	74	0.703
45	2.444	75	0.667
46	2.348	76	0.632
47	2.255	77	0.597
48	2.167	78	0.564
49	2.082	79	0.532
50	2.000	80	0.500
51	1.922	81	0.469
52	1.846	82	0.439
53	1.774	83	0.410
54	1.704	84	0.381
55	1.636	85	0.353
56	1.571	86	0.326
57	1.509	87	0.299
58	1.448	88	0.273
59	1.390	89	0.247
60	1.333	90	0.222
61	1.279	91	0.198
62	1.226	92	0.174
63	1.175	93	0.151
64	1.125	94	0.128
65	1.077	95	0.105
66	1.030	96	0.083
67	0.985	97	0.062
68	0.941	98	0.041
69	0.899		

APPENDIX C - HYDRAULIC ANALYSIS

REFER TO WILLOW CREEK TRIBUTARIES UPSTREAM OF ENGLEWOOD DAM FHAD REPORT 2025 FOR APPENDIX C

APPENDIX D – FLOODPLAIN AND FLOODWAY DATA TABLES

REFER TO WILLOW CREEK TRIBUTARIES
UPSTREAM OF ENGLEWOOD DAM FHAD REPORT 2025
FOR APPENDIX D

APPENDIX E – FLOOD FIGURES

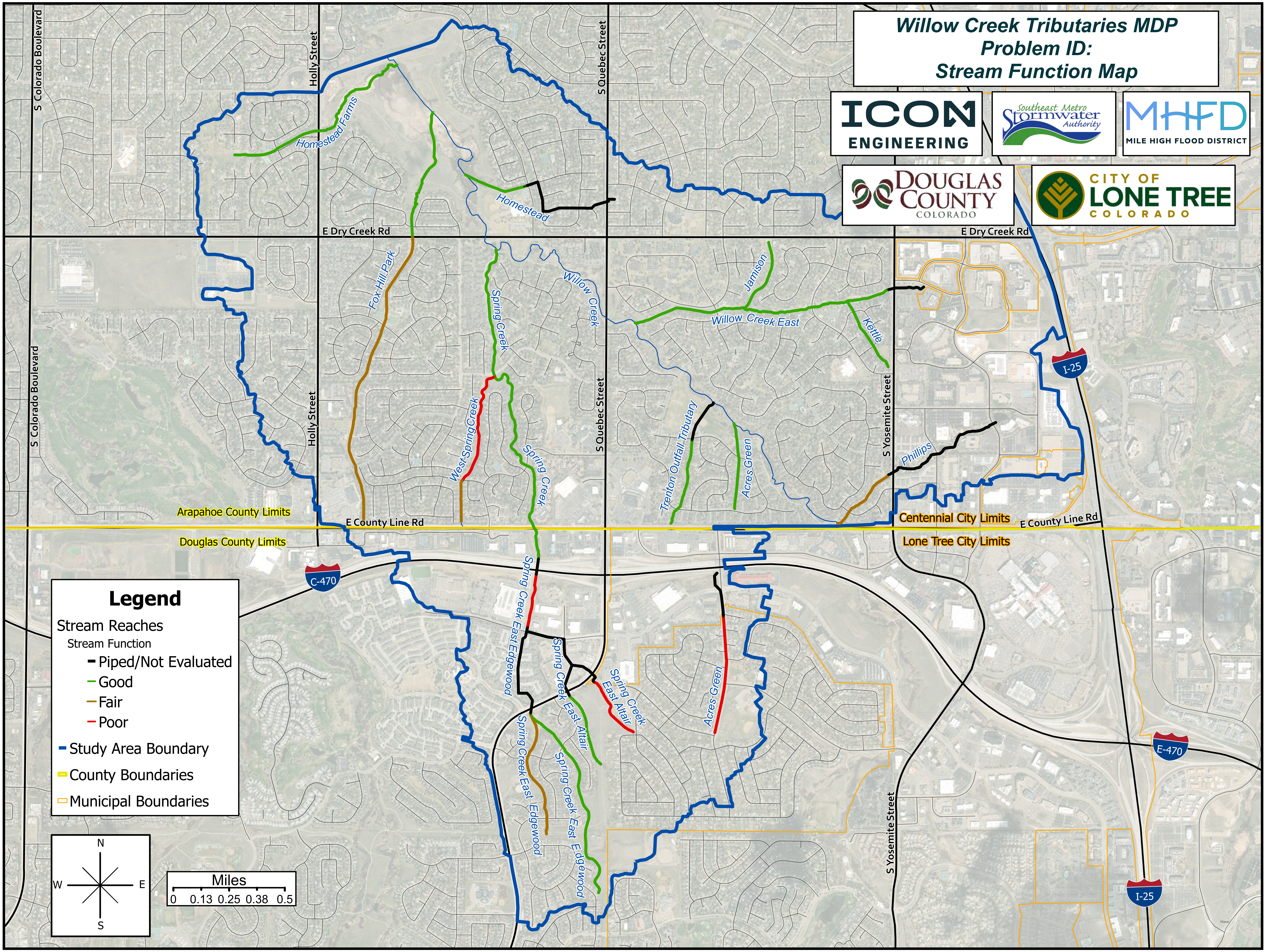
REFER TO WILLOW CREEK TRIBUTARIES UPSTREAM OF ENGLEWOOD DAM FHAD REPORT 2025 FOR APPENDIX E

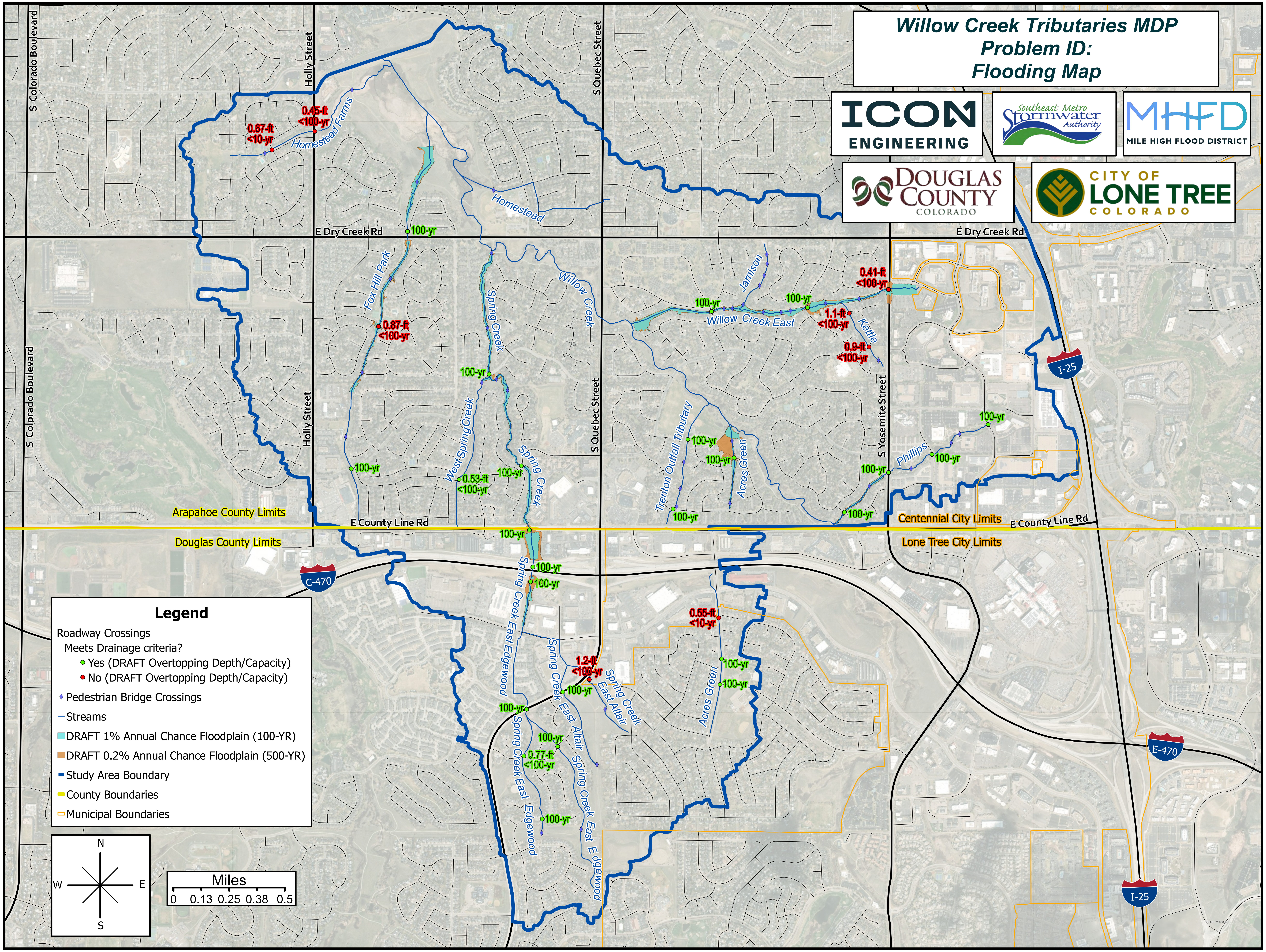
APPENDIX F – FLOOD PROFILES

REFER TO WILLOW CREEK TRIBUTARIES UPSTREAM OF ENGLEWOOD DAM FHAD REPORT 2025 FOR APPENDIX F

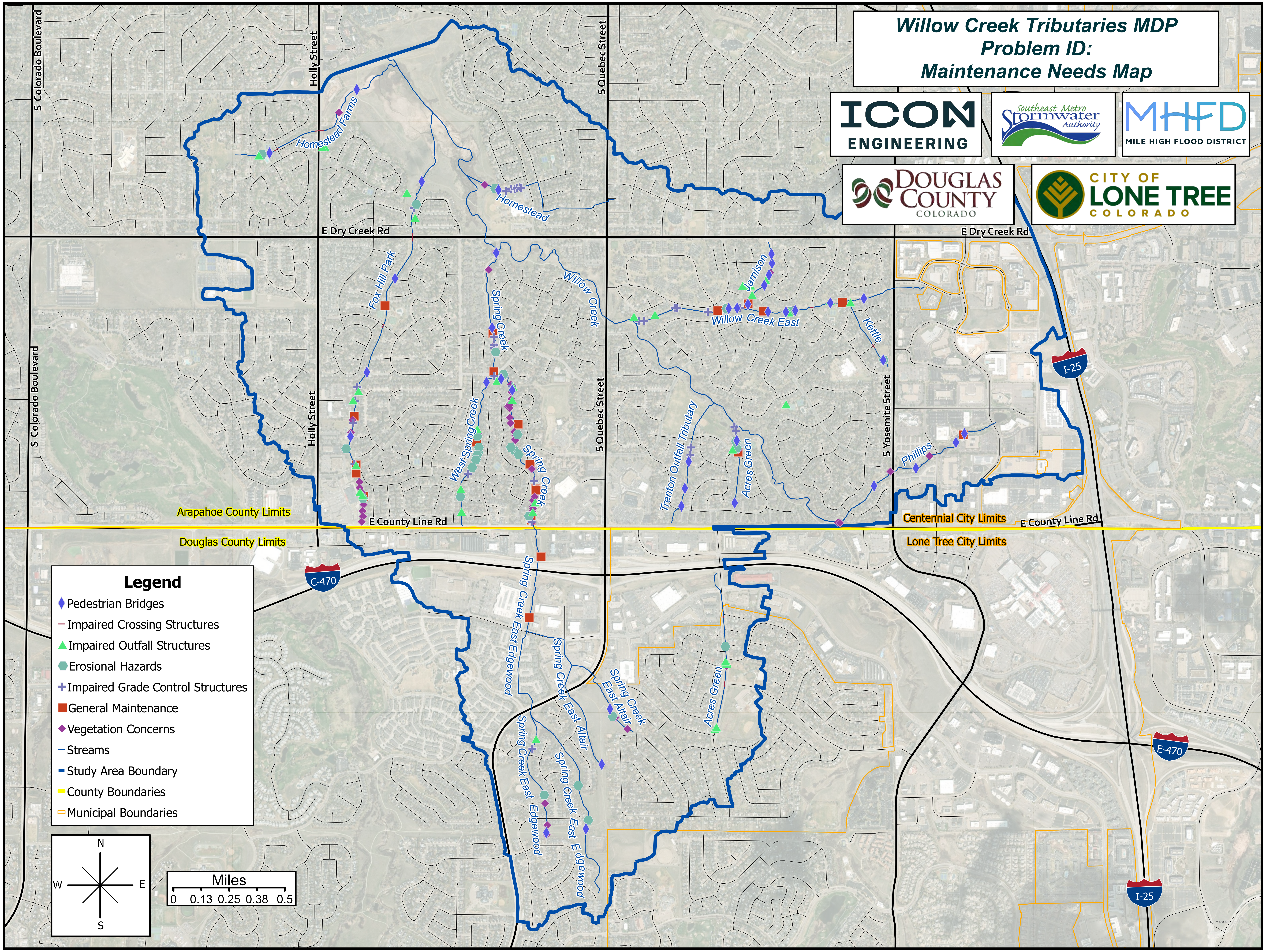
APPENDIX G – PROBLEM ID MAPS

Willow Creek Tributaries MDP
Problem ID:
Stream Function Map

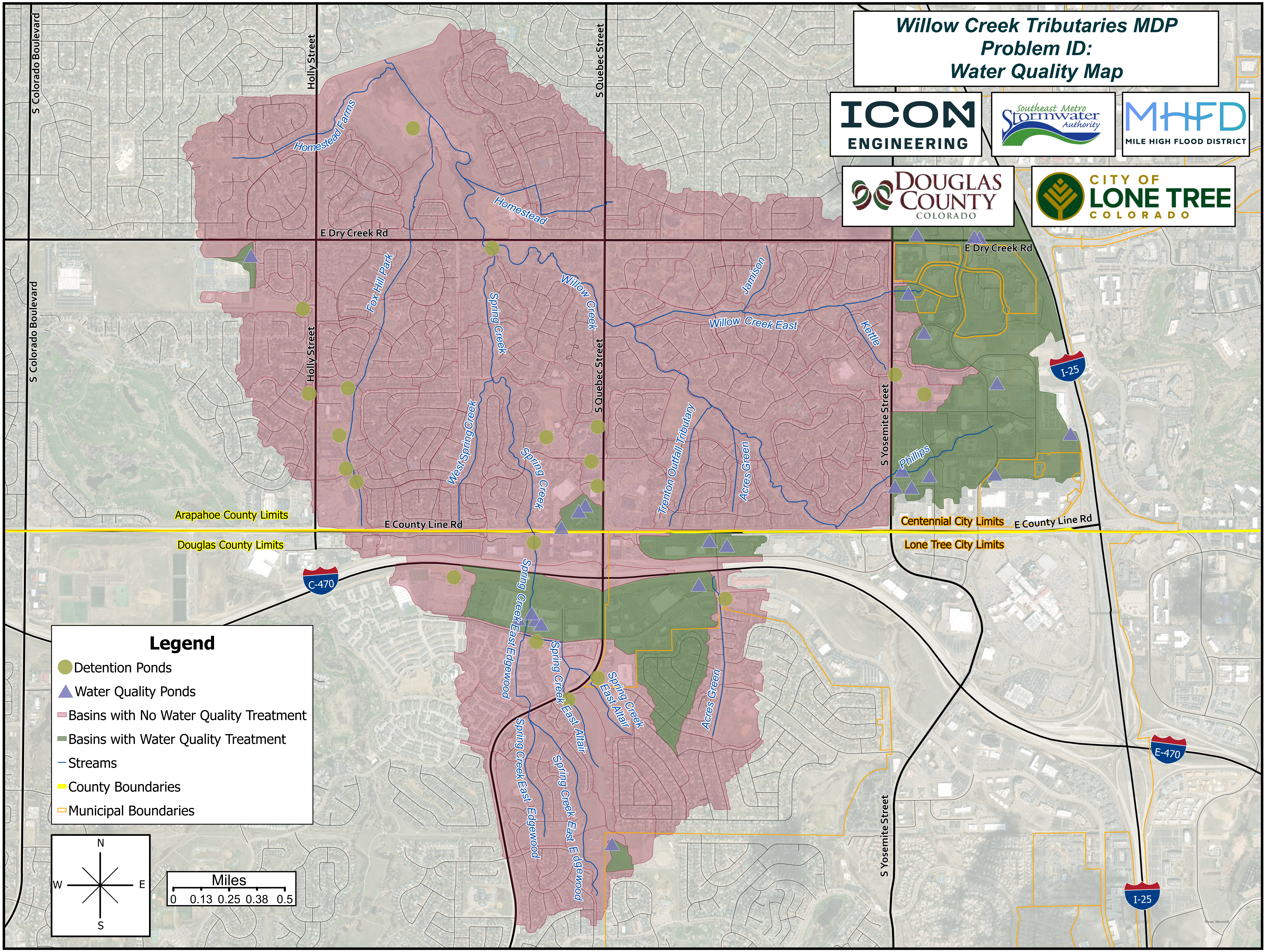




The Flooding Problem ID map included in this MDP report contains draft FHAD modeling results for informational purposes only. Refer to *Flood Hazard Area Delineation Willow Creek Tributaries Upstream of Englewood Dam, January 2025* for final crossing results and floodplain delineations.

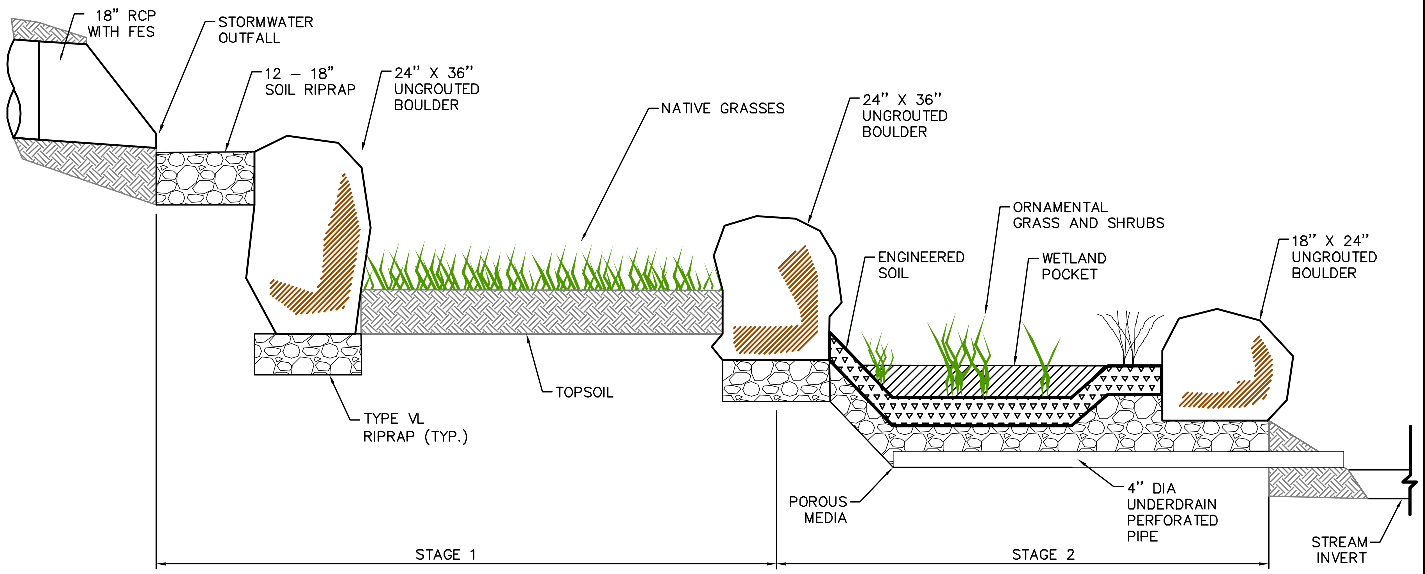


Willow Creek Tributaries MDP
Problem ID:
Maintenance Needs Map
ICON ENGINEERING
Southeast Metro Stormwater Authority
MHFD
MILE HIGH FLOOD DISTRICT
DOUGLAS COUNTY COLORADO
CITY OF LONE TREE COLORADO
S Colorado Boulevard
Holly Street
S Quebec Street
S Yosemite Street
E Dry Creek Rd
E County Line Rd
Arapahoe County Limits
Douglas County Limits
Centennial City Limits
Lone Tree City Limits
C-470
E-470
I-25
Homestead Farms
Homestead
Fox Hill Park
Spring Creek
West Spring Creek
Willow Creek
Willow Creek East
Jamison
Kettle
Trenton Outfall Tributary
Acres Green
Phillips
Spring Creek East Edgewood
Spring Creek East Altair
Legend
Pedestrian Bridges
Impaired Crossing Structures
Impaired Outfall Structures
Erosional Hazards
Impaired Grade Control Structures
General Maintenance
Vegetation Concerns
Streams
Study Area Boundary
County Boundaries
Municipal Boundaries
N
W
E
S
Miles
0 0.13 0.25 0.38 0.5

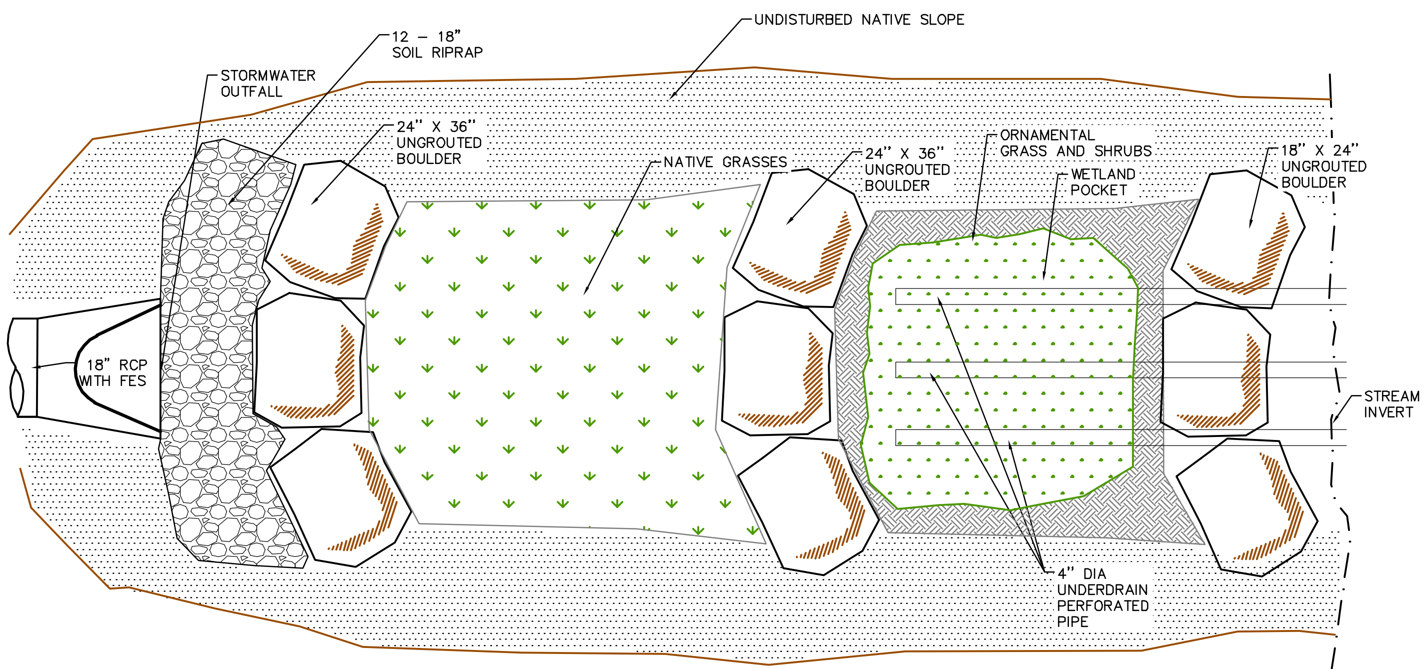

Willow Creek Tributaries MDP
Problem ID:
Water Quality Map
ICON ENGINEERING
Southeast Metro Stormwater Authority
MHFD
MILE HIGH FLOOD DISTRICT
DOUGLAS COUNTY COLORADO
CITY OF LONE TREE COLORADO
Legend
Detention Ponds
Water Quality Ponds
Basins with No Water Quality Treatment
Basins with Water Quality Treatment
Streams
County Boundaries
Municipal Boundaries
N
W
E
S
Miles
0 0.13 0.25 0.38 0.5
S Colorado Boulevard
Holly Street
S Quebec Street
S Yosemite Street
E Dry Creek Rd
E County Line Rd
I-25
C-470
E-470
Arapahoe County Limits
Douglas County Limits
Centennial City Limits
Lone Tree City Limits
Homestead Farms
Homestead
Fox Hill Park
Spring Creek
West Spring Creek
Willow Creek
Willow Creek East
Jamison
Kettle
Phillips
Trenton Outfall Tributary
Acres Green
Spring Creek East Edgewood
Spring Creek East Altair
Spring Creek East Altair
Spring Creek East Edgewood

Appendix H – Vegetated Rundown Details

For Reference Only



PROFILE



PLAN

NOTES:

A. STAGE 1 : REMOVAL OF SANDS, GRAVEL AND TRASH

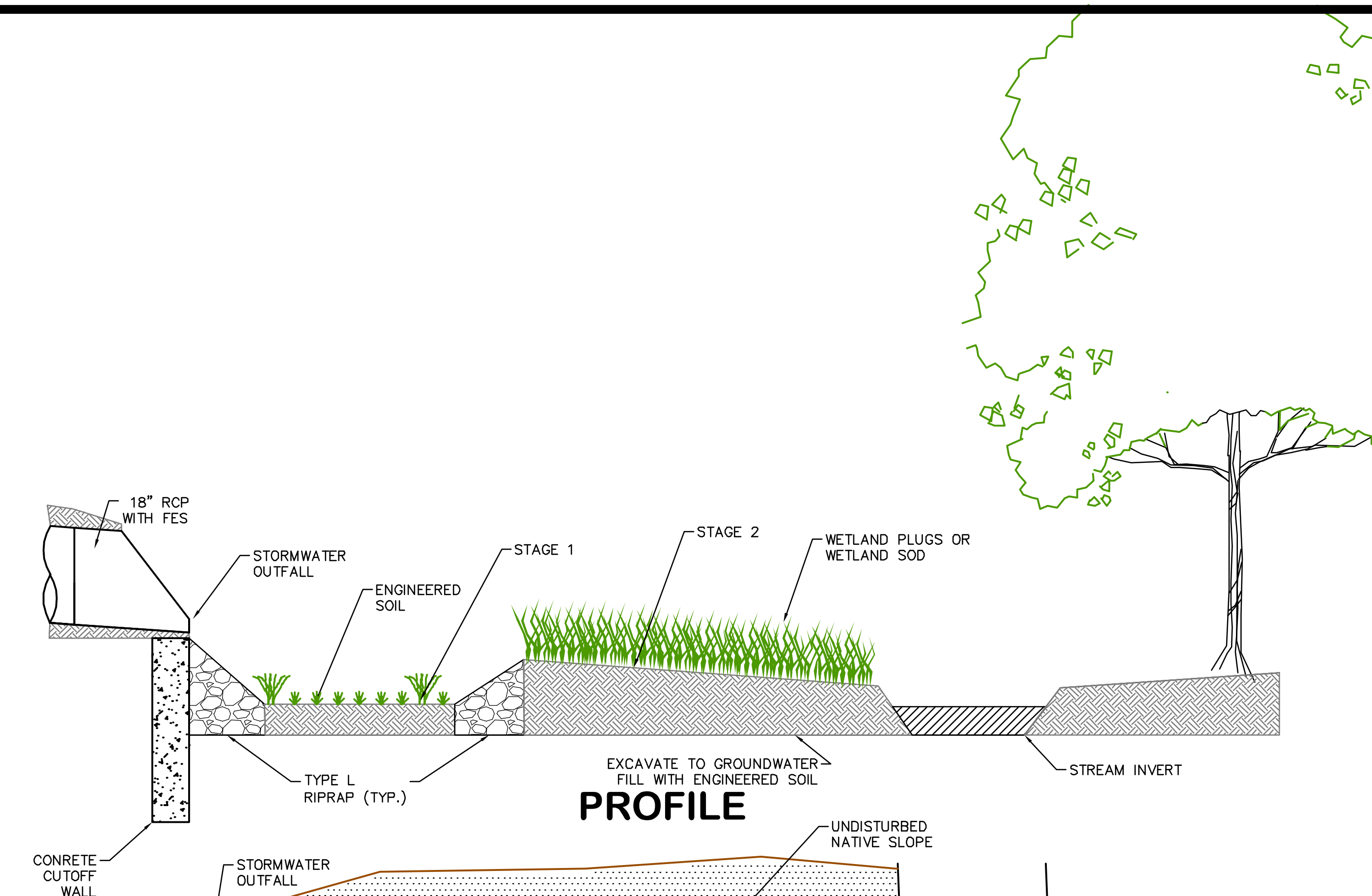
B. STAGE 2 : FILTRATION AND NUTRIENT REMOVAL

C. ENGINEERED SOIL: WELL GRADED GRANULAR SOIL WITH ORGANIC SUPPLEMENT

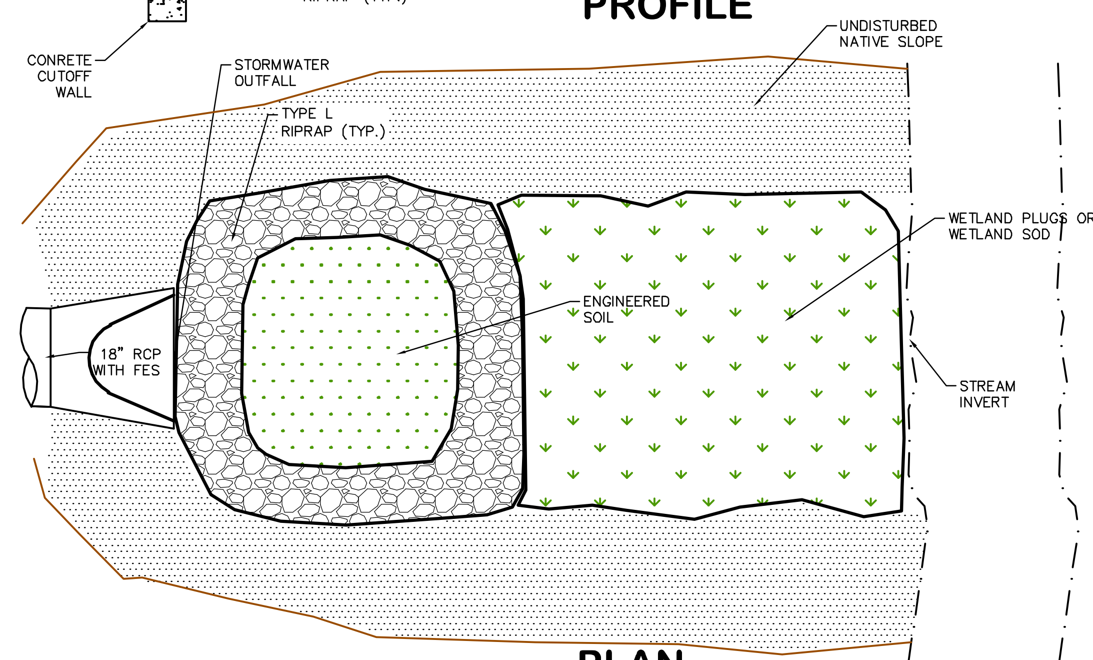
WATER QUALITY – CASCADE

ICON ENGINEERING

–OUTFALL WATER QUALITY TREATMENT CONCEPT–
WELL SUITED FOR NEAR–INVERT OUTFALLS IN TIERED STREAM BANKS



PROFILE



PLAN

NOTES:

A. STAGE 1 : REMOVAL OF SANDS, GRAVEL AND TRASH

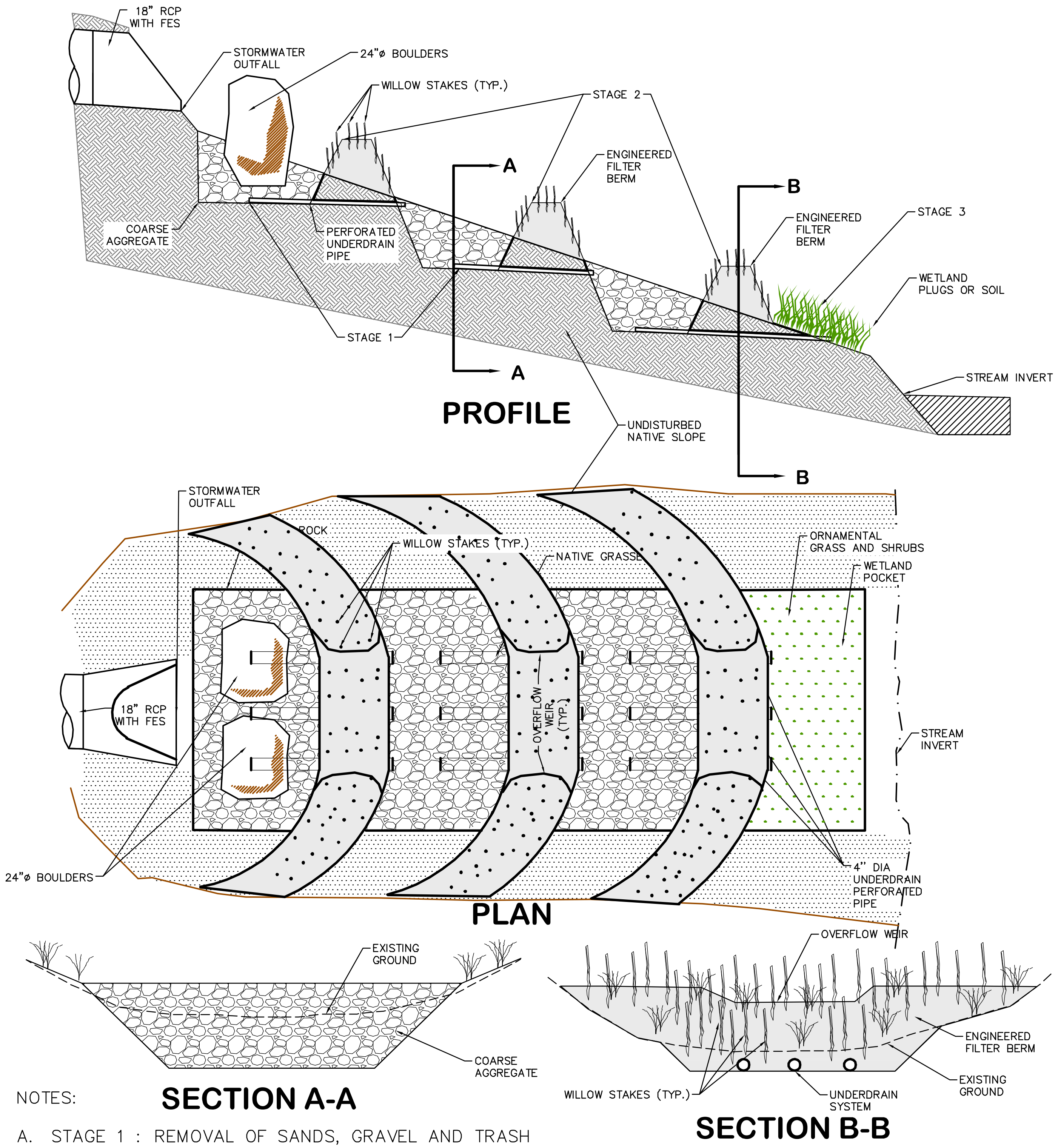
B. STAGE 2 : FILTRATION AND NUTRIENT REMOVAL

C. ENGINEERED SOIL: WELL GRADED GRANULAR SOIL WITH ORGANIC SUPPLEMENT.

WATER QUALITY – SOFT FOREBAY

ICON ENGINEERING

–OUTFALL WATER QUALITY TREATMENT CONCEPT–
WELL SUITED FOR LOW GRADE OUTFALL WITH WIDE RIPARIAN BENCH



NOTES:

A. STAGE 1 : REMOVAL OF SANDS, GRAVEL AND TRASH

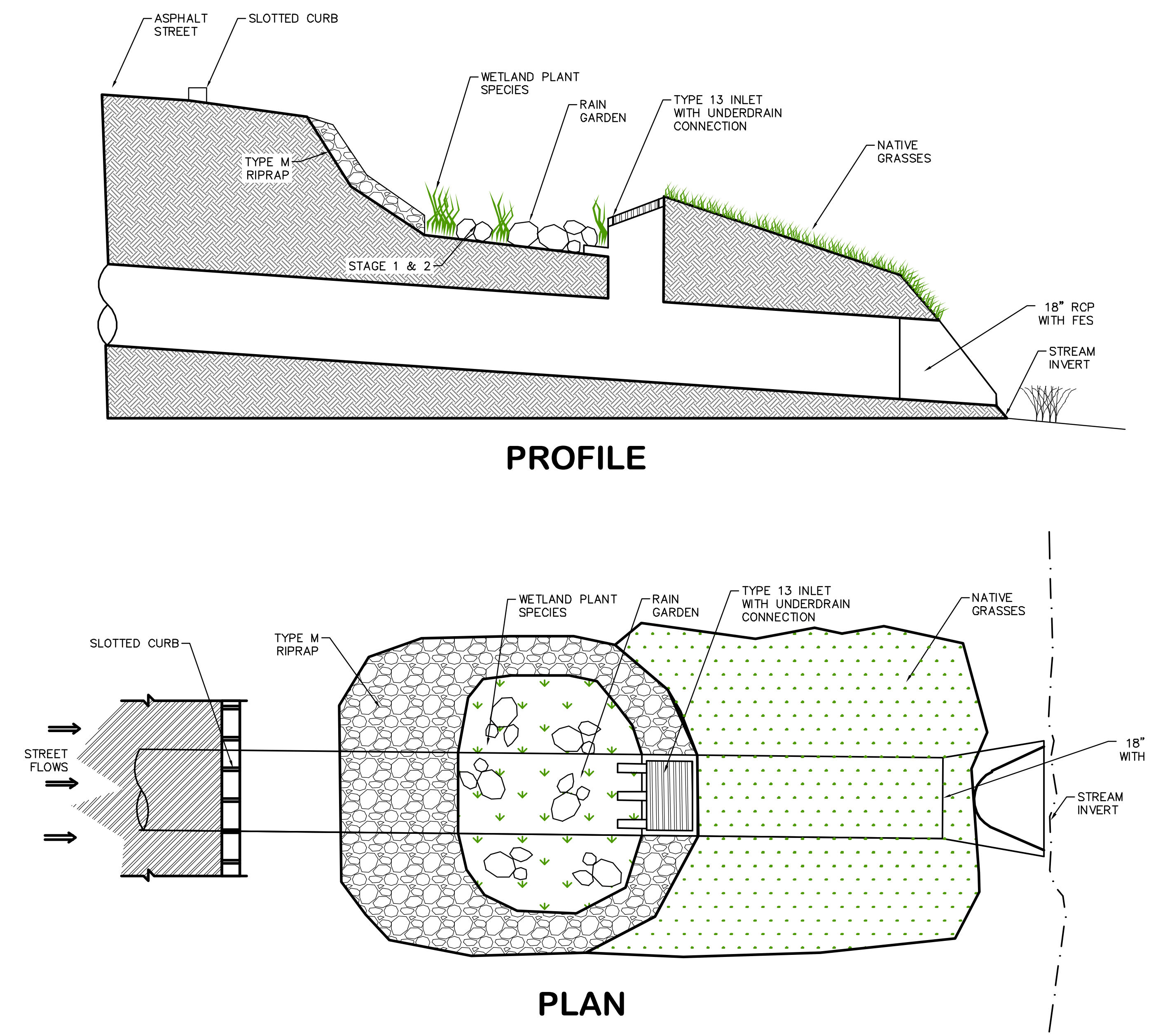
B. STAGE 2 : FILTRATION AND NUTRIENT REMOVAL

C. ENGINEERED FILTER BERM: TOPSOIL WRAPPED IN NATURAL FIBER EROSION BLANKET AND PLANTED WITH WILLOW STAKES AND GRASSES

WATER QUALITY – LIVING WALLS

ICON ENGINEERING

–OUTFALL WATER QUALITY TREATMENT CONCEPT–
WELL SUITED FOR STEEP SLOPES



NOTES:

A. STAGE 1 ; REMOVAL OF SANDS, GRAVEL AND TRASH

B. STAGE 2 : FILTRATION AND NUTRIENT REMOVAL

C. ENGINEERED SOIL: WELL GRADED GRANULAR SOIL WITH ORGANIC SUPPLEMENT.

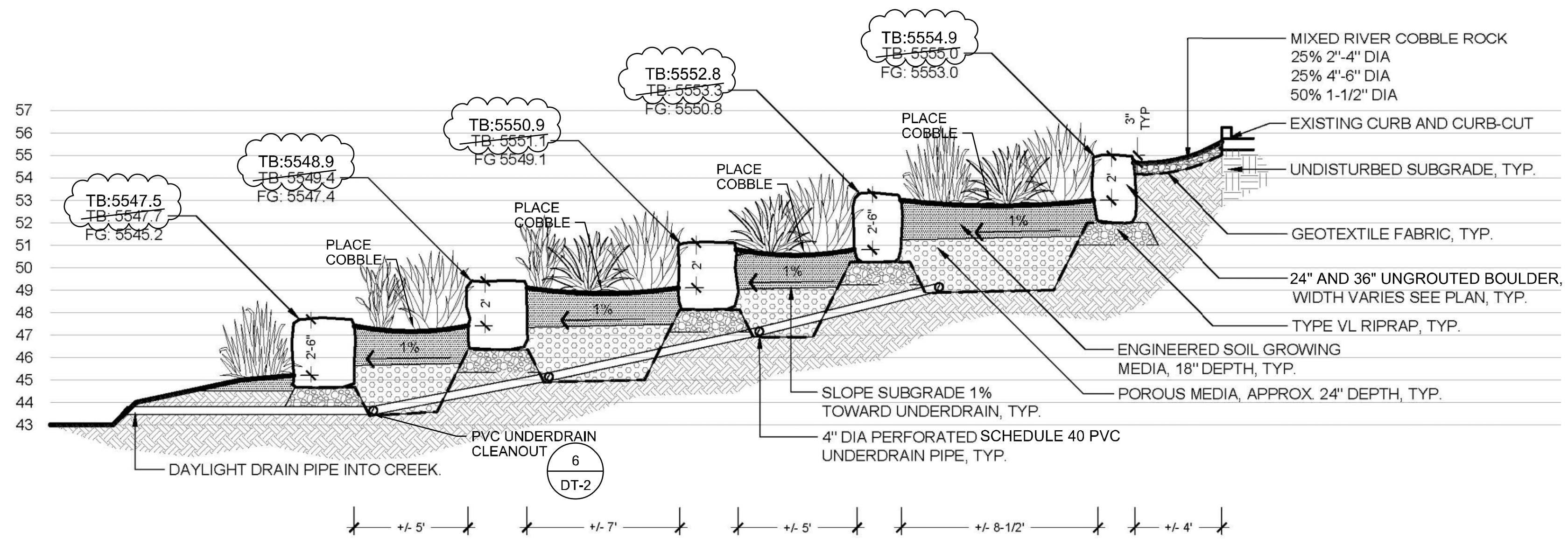
WATER QUALITY – RAIN GARDEN

ICON ENGINEERING

–OUTFALL WATER QUALITY TREATMENT CONCEPT–
WELL SUITED FOR IMPERVIOUS SURFACE RUNOFF,
REQUIRES PROXIMITY TO STORM SEWER

FOR REFERENCE ONLY - PROVIDED BY SEMSWA FOR USE IN THIS MAJOR DRIAINAGEWAY PLAN

OUTFALL 2 STORM SEWER PLAN



A OUTFALL 2 STORM SEWER PROFILE

NTS

RECORD DRAWINGS

Revisions Drawn By B SCHAFROTH Date 08/22/2016

THESE RECORD DRAWINGS HAVE BEEN PREPARED, IN PART, ON THE BASIS OF INFORMATION COMPILED BY OTHERS. THEY ARE NOT INTENDED TO REPRESENT IN DETAIL THE EXACT LOCATION, TYPE OF COMPONENT NOR MANNER OF CONSTRUCTION. THE ENGINEER WILL NOT BE RESPONSIBLE FOR ANY ERRORS OR OMISSIONS WHICH HAVE BEEN INCORPORATED INTO THE RECORD DRAWINGS.

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WILLOW CREEK CHANNEL IMPROVEMENTS

OUTFALL 2 STORM SEWER PLAN AND PROFILE

NO.	DATE	REVISION	BY	APVD
R	08/2016	RECORD DRAWINGS	BS	ML

DSGN B HEDEL | DR B SCHAFROTH | CHK M LYNCH | APVD M LYNCH

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	SEPTEMBER 2016
PROJ	661933
DWG	C-6
SHEET	12 of 21

RECORD DRAWINGS

UPLAND RESTORATION PLANT SCHEDULE

DECIDUOUS TREES	QTY	BOTANICAL NAME	COMMON NAME	CONT	CAL
MARA	3	MALUS X `RADIANT`	RADIANT CRAB APPLE	B & B	2"CAL
ULFR	3	ULMUS X `FRONTIER`	AMERICAN ELM	B & B	2"CAL

DECIDUOUS SHRUBS	QTY	BOTANICAL NAME	COMMON NAME	CONT
PEAT	4	PEROVSKIA ATRIPLICIFOLIA	RUSSIAN SAGE	5 GAL
PRBE	5	PRUNUS BESSEYI `PAWNEE BUTTES`	SAND CHERRY	5 GAL
SAPU	4	SALIX PURPUREA `NANA`	DWARF ARCTIC WILLOW	5 GAL

EVERGREEN SHRUBS	QTY	BOTANICAL NAME	COMMON NAME	CONT
JUHO	4	JUNIPERUS HORIZONTALIS `BLUE CHIP`	BLUE CHIP JUNIPER	5 GAL

ORNAMENTAL GRASS	QTY	BOTANICAL NAME	COMMON NAME	CONT
BOGR	3	BOUTELOUA GRACILIS `BLONDE AMBITION`	BLUE GRAMA	1 GAL
PAVI	6	PANICUM VIRGATUM `SHENENDOAH`	BURGUNDY SWITCH GRASS	1 GAL
SCSC	8	SCHIZACHYRIUM SCOPARIUM	LITTLE BLUESTEM GRASS	1 GAL

PERENNIALS	QTY	BOTANICAL NAME	COMMON NAME	CONT
ECPU	8	ECHINACEA PURPUREA `MAGNUS`	PURPLE CONEFLOWER	1 GAL
GAAR	5	GAILLARDIA ARISTATA	BLANKET FLOWER	1 GAL
HERE	4	HEMEROCALLIS X `RED`	RED DAYLILY	1 GAL
PEME	7	PENSTEMON MEXICALI `RED ROCKS`	RED ROCKS PENSTEMON	1 GAL
RUFU	8	RUDBECKIA FULGIDA `GOLDSTGRUM`	BLACK EYED SUSAN	1 GAL
SOGB	3	SOLIDAGO X `GOLDEN BABY`	GOLDENROD	1 GAL

GROUND COVERS	QTY	BOTANICAL NAME	COMMON NAME	CONT @
	20,380 SF	SEED	UPLAND SEED MIX	SEED
	10,900 SF	SOD	BLUEGRASS BLEND	SOD

RIPARIAN RESTORATION SCHEDULE

RIPARIAN RESTORATION - TREES	QTY	BOTANICAL NAME	COMMON NAME	CONT
PODE	40	POPULUS DELTOIDES	PLAINS COTTONWOOD	40 CI
SAAM	40	SALIX AMYGDALOIDES	PEACH-LEAVED WILLOW	40 CI

RIPARIAN RESTORATION - SHRUBS	QTY	BOTANICAL NAME	COMMON NAME	CONT
SAEX	60	SALIX EXIGUA	NARROW-LEAF WILLOW	40 CI

RIPARIAN RESTORATION - PLUGS	QTY		BOTANICAL NAME	COMMON NAME	CONT
	11,495	SF	ZONE 1: LOWER RIPARIAN AREAS & SOIL WRAPPED LIFTS (36" CENTERS)		
	588	EA	SCHOENOPLECTUS TABERNAEMONTANI	SOFT -STEM BULRUSH	10 CI
	588	EA	SCIRPUS MICROCARPUS	RED-TINGE BULRUSH	10 CI
	2,962	LF	ZONE 1.5: TRANSITION ZONE BETWEEN LOWER AND UPPER AREAS (EVERY 24")		
	686	EA	CAREX NEBRASCENSIS	NEBRASKA SEDGE	10 CI
	686	EA	ELEOCHARIS PALUSTRIS	CREEPING SPIKERUSH	10 CI
	6,588	SF	ZONE 2: UPPER RIPARIAN AREAS (36" CENTERS)		
	294	EA	CAREX NEBRASCENSIS	NEBRASKA SEDGE	10 CI
	294	EA	JUNCUS BALTICUS	BALTIC RUSH	10 CI
	294	EA	JUNCUS TORREYI	TORREY'S RUSH	10 CI

PLANT ZONE NOTES:
1. ZONE 1 AND 2 PLANTS WILL BE INSTALLED VERTICALLY THROUGH THE FABRIC OF THE SOIL LIFTS.
2. ZONE 1.5 PLANTS WILL BE INSTALLED HORIZONTALLY BETWEEN THE LIFTS DURING CONSTRUCTION.
3. WOODY PLANTS WILL BE INSTALLED IN DISCRETE POCKETS IN ZONE 2. LOCATIONS OF COTTONWOOD AND PEACHLEAF WILLOW SHOWN ON THE PLAN ARE SCHEMATIC. ALL NARROW-LEAF WILLOW WILL BE LOCATED IN THE FIELD AT THE TIME OF PLANTING. THE EXACT LOCATION WILL BE BASED ON THE FINAL GRADING AND DETERMINED AFTER GRADING IS COMPLETE.

SEED MIXES

RIPARIAN MIX

COMMON NAME	SCIENTIFIC NAME	VARIETY	PLS LBS/ACRE
FOWL MANNAGRASS	GLYCERIA STRIATA	NATIVE	5.0
BALTIC RUSH	JUNCUS BALTICUS	NATIVE	0.1
LESSER POVERTY RUSH	JUNCUS TENUIS	NATIVE	0.1
TORREY'S RUSH	JUNCUS TORREYI	NATIVE	0.1
FOWL BLUEGRASS	POA PALUSTRIS	NATIVE	1.5
PRAIRIE CORDGRASS	SPARTINA PECTINATA	NATIVE	5.0
TOTAL POUNDS PLS/ACRE			11.8

UPLAND MIX

COMMON NAME	SCIENTIFIC NAME	VARIETY	POUND/ACRE
SAND BLUESTEM	ANDROPOGON HALLII	WOODWARD	1.0
SIDEOATS GRAMA	BOUTELOUA CURTIPENDULA	BUTTE	4.0
BLUE GRAMA	BOUTELOUA GRACILIS	LOVINGTON	4.0
PRAIRIE SANDREED	CALAMOVILFA LONGIFOLIA	NATIVE	4.0
SWITCHGRASS	PANICUM VIRGATUM	BLACKWELL	4.0
WESTERN WHEATGRASS	PASCOPYRUM SMITHII	ARRIBA	8.0
YELLOW INDIANGRASS	SORGHASTRUM NUTANS	HOLT	3.0
SAND DROPSEED	SPOROBOLUS CRYPTANDRUS	NATIVE	2.0
TOTAL PLS/ACRE			30.0

SEED NOTES:
1. ZONES 1 AND 2 WILL BE SEEDED WITH THE RIPARIAN SEED MIX.
2. RIPARIAN SEED WILL BE BROADCAST AT PRESCRIBED RATE ON THE SOIL SURFACE, IMMEDIATELY BELOW THE FABRIC ENCAPSULATING THE SOIL LIFTS.

REVEGETATION PLANTING NOTES

SOIL AMENDMENTS
1. NO FERTILIZERS OR RELATED AMENDMENTS TO BE APPLIED TO AREAS <12" ABOVE NORMAL HIGH WATER ELEVATION.
2. AREAS > 12" FROM NORMAL WATER SURFACE ELEVATION SHALL BE AMENDED WITH 800 #/ACRE BIOSOL PLUS 25 #/ACRE GRANULAR HUMATE.

EROSION CONTROL
1. ALL STRAW SHALL BE 75% OVER 10 INCHES IN LENGTH AND CERTIFIED WEED FREE. .
2. HYDROMULCH OVER UPLAND SEED SHALL BE USED FROM EDGES OF FABRIC INSTALLATION UP TO LIMITS OF DISTURBANCE (2500 POUNDS VIRGIN WOOD FIBER PLUS 150 POUNDS ORGANIC TACKIFIER PER ACRE).
3. REFER TO CIVIL DRAWINGS FOR LOCATIONS AND DEPTHS OF SOIL FILLED RIP-RAP.
4. WOODY PLANT MATERIAL PLACEMENTS TO BE FIELD ADJUSTED AND APPROVED BY THE ECOLOGIST IN FIELD PRIOR TO FINAL INSTALLATION (CONTACT OWNER'S REPRESENTATIVE PRIOR TO INSTALLATION).
5. BANK PROTECTION MEASURES VARY ALONG A GIVEN CROSS-SECTION. CONTRACTOR SHALL UTILIZE THE CIVIL ENGINEER'S GRADING PLANS IN CONJUNCTION WITH THE LANDSCAPE DETAILS TO DETERMINE THE LIMITS OF BANK PROTECTION MEASURES.
6. CHECK SLOTS 6" DEEP SHALL BE INSTALLED ON 10' INTERVALS OR CONTOURS IN UPLAND SECONDARY CHANNELS OR ON SLOPES LONGER THAN 15' IN LENGTH.
7. ADJACENT SEED MIXTURES MUST OVERLAP AT LEAST THREE FEET (THREE FEET OF SEEDING WITH BOTH MIXTURES.)
8. SEED TAGS MUST SHOW JOB NAME, TOTAL POUNDS OF MIXTURE, INTENDED SEEDING AREA, ALL SCIENTIFIC NAMES OF SPECIES. SEED MUST BE WEED FREE OR ANY WEEDS PRESENT REPORTED AND PRE-APPROVED BY ECOLOGIST.

TREE AND SHRUB PLANTING
1. TREES AND SHRUBS MUST BE INSPECTED FOR HEALTH, SIZE, AND SPECIES PRIOR TO INSTALLATION. NOTIFY THE LANDSCAPE ARCHITECT, ECOLOGIST, AND/OR OWNER'S REPRESENTATIVE AT LEAST 48 HOURS PRIOR TO INSTALLATION AT SITE. NURSERY INSPECTION OF PLANTS MAY BE ARRANGED PRIOR TO SHIPPING TO SITE, IF A LOCAL NURSERY IS USED. NOTIFY THE LANDSCAPE ARCHITECT, ECOLOGIST, AND/OR OWNER'S REPRESENTATIVE AT LEAST 1 WEEK PRIOR TO SHIPPING FOR NURSERY INSPECTION.
2. ALL TREES AND SHRUBS MUST BE WATERED AND TARPED WHEN SHIPPED TO SITE. ALL TREES AND SHRUBS SHALL BE WATERED UPON ARRIVAL AND STORED IN A SHADED, MULCHED LOCATION UNTIL INSTALLATION.
3. ALL PLANTING LOCATIONS SHALL BE APPROVED IN THE FIELD AND ADJUSTED BY THE ECOLOGIST PRIOR TO INSTALLATION TO ASSURE BEST PLACEMENT (CONTACT OWNER'S REPRESENTATIVE PRIOR TO INSTALLATION).
4. MANY OF THE TREES AND SHRUBS ARE TO BE DEEP PLANTED (ROOTBALLS PLACED ON THE WATER TABLE). CONTRACTOR MUST ARRANGE TO INSTALL THESE AND THE FABRIC MULCH WITHOUT DISRUPTING EITHER FABRIC OR VEGETATION. A BACK HOE MAY BE REQUIRED FOR PROPER PLANTING.
5. ALL COTTONWOOD TREES MUST BE PROTECTED BY STAKED BEAVER CAGES AND WEBBING STRAPS, SEE DETAIL DRAWING FOR TYPICAL TREE PLANTING METHOD.

CONSTRUCTION PERIOD NOTES
1. ALL WEEDS (ANNUAL, BIENNIAL, OR PERENNIAL) ON CONSTRUCTION SITE ARE TO BE CONTROLLED BY CONTRACTOR DURING THE PERIOD OF CONSTRUCTION AND FOR THE ENTIRE WARRANTY PERIOD.
2. SPOT APPLICATION OF PRE-APPROVED HERBICIDES BY A STATE CERTIFIED WEED CONTROL SPECIALIST IS REQUIRED TO PREVENT SEEDING OR SPREAD OF WEED SPECIES. ANNUAL WEEDS MAY REQUIRE TWO OR THREE MOWING OPERATIONS DURING THE WARRANTY PERIOD TO PREVENT SEED SET.

LANDSCAPE PLANTING NOTES:

1. LANDSCAPE CONTRACTOR SHALL LOCATE ALL TREES, SHRUBS AND PLANTING BEDS ACCORDING TO LOCATIONS SHOWN ON DRAWINGS. ALL PLANTING LOCATIONS SHALL BE SUBJECT TO REVIEW AND APPROVAL BY LANDSCAPE ARCHITECT PRIOR TO THE START OF PLANTING OPERATIONS. LANDSCAPE CONTRACTOR SHALL MAKE MODIFICATIONS IN LOCATIONS AS DIRECTED BY LANDSCAPE ARCHITECT.
2. THE PLANT SCHEDULE IS FOR CONTRACTOR'S CONVENIENCE ONLY, THE CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING EXISTING CONDITIONS AND REPORTING IN WRITING TO THE LANDSCAPE ARCHITECT ANY CONFLICTS RELATIVE TO IMPLEMENTATION OF THE LANDSCAPE CONSTRUCTION DOCUMENTS. VALERIAN LLC. SHALL NOT ASSUME ANY ERRORS OR OMISSIONS IN THE PLANT SCHEDULE LISTED HEREIN. THE PLANT SYMBOLS SHOWN ON THE LANDSCAPE PLAN SHALL PREVAIL SHOULD THERE BE ANY DISCREPANCIES IN QUANTITIES BETWEEN THE PLAN AND PLANT SCHEDULE.
3. LANDSCAPE CONTRACTOR SHALL PROVIDE PLANT PROTECTION AND MAINTENANCE THROUGHOUT INSTALLATION AND UNTIL FINAL ACCEPTANCE OF LANDSCAPE INSTALLATION AS FOLLOWS:
   A) ALL PLANT MATERIAL SHALL BE PROTECTED, FROM TIME OF DIGGING TO TIME OF FINAL ACCEPTANCE, FROM INJURY, EXCESSIVE DRYING FROM WINDS, IMPROPER VENTILATION, OVER-WATERING, FREEZING, HIGH TEMPERATURES, OR ANY OTHER CONDITION DAMAGING TO PLANTS.
   B) PLANT MATERIAL SHALL BE PLANTED ON THE DAY OF DELIVERY IF POSSIBLE. ALL PLANTS NOT PLANTED ON THE DAY OF DELIVERY SHALL BE PLACED IN A TEMPORARY NURSERY AND KEPT MOIST, SHADED, AND PROTECTED FROM THE SUN AND WIND. EACH ROOTBALL SHALL BE COVERED ENTIRELY WITH MULCH. ALL PLANT MATERIALS SHALL BE INSTALLED PER THE PLAN DRAWINGS AND SPECIFICATIONS.
   C) LANDSCAPE CONTRACTOR SHALL PROVIDE PLANT MATERIALS THAT COMPLY WITH THE REQUIREMENTS OF THE MOST RECENT ANSI Z 60.1 "STANDARDS FOR NURSERY STOCK'" UNLESS OTHERWISE SPECIFIED. CALIPER OF B&B TREES SHALL BE TAKEN 6 INCHES ABOVE THE GROUND UP TO AND INCLUDING 4 INCH CALIPER SIZE, AND 12 INCHES ABOVE THE GROUND FOR LARGER SIZES.
   D) PLANTING MAINTENANCE SHALL INCLUDE WATERING, WEEDING, CULTIVATING, RESETTING PLANTS TO PROPER GRADES OR POSITION, REESTABLISHING SETTLED GRADES. HERBICIDE IS NOT RECOMMENDED FOR ONE YEAR FOLLOWING LANDSCAPE INSTALLATION.
   E) PLANT MAINTENANCE SHALL INCLUDE THOSE OPERATIONS NECESSARY TO PROPER GROWTH AND SURVIVAL OF ALL PLANT MATERIALS. CONTRACTOR SHALL PROVIDE THIS WORK IN ADDITION TO SPECIFIC WARRANTY/GUARANTEES.
4. CONTRACTOR SHALL VERIFY AND MAINTAIN ALL SETBACKS, CLEAR ZONES AND SIGHT TRIANGLES REQUIRED BY ALL LOCAL AND MUNICIPAL CODES WHERE APPLICABLE.
5. LANDSCAPE CONTRACTOR SHALL ENSURE THAT THE LANDSCAPE INSTALLATION IS COORDINATED WITH THE PLANS PREPARED BY OTHER CONSULTANTS SO THAT THE PROPOSED GRADING, STORM DRAINAGE OR OTHER PROPOSED CONSTRUCTION DOES NOT CONFLICT WITH NOR PRECLUDE INSTALLATION AND MAINTENANCE OF LANDSCAPE ELEMENTS AS DESIGNATED ON THIS PLAN.

SOD:

1. KEEP ALL EQUIPMENT, VEHICLES AND FOOT TRAFFIC OFF ALL SODDED AREAS. ALL DAMAGED MATERIALS SHALL BE REPLACED AND ALL DAMAGED AREAS RESTORED TO ORIGINAL CONDITIONS.
2. ALL SOD SHALL BE KENTUCKY BLUE GRASS SOD OUTLINED IN THE PLANT SCHEDULE OR APPROVED EQUAL. FOR SUBSTITUTION APPROVAL CONTACT THE OWNER'S REPRESENTATIVE OR LANDSCAPE ARCHITECT.
3. ALL SOD SHALL BE INSTALLED WITHIN 24 HOURS FROM THE TIME OF CUTTING ON A FIRM AND MOIST SUBGRADE. DO NOT PLANT IF SOD IS DORMANT OR THE GROUND IS FROZEN.
4. ALL SOD SHALL BE INSTALLED PARALLEL TO SLOPES TO FORM A SOLID MASS WITH TIGHTLY FITTED JOINTS. BUTT ENDS AND SIDES OF SOD STRIPS. DO NOT OVERLAP. STAGGER STRIPS TO OFFSET JOINTS IN ADJACENT COURSES.

Landscape Architecture
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Urban Design

3001 Brighton Boulevard, Suite 643
Denver, CO 80216
phone 303.347.1200
VALERIAN

NO.	DATE	REVISION	BY	APVD

DSGN BK | DR BK | CHK CK | APVD CK

CH2MHILL
9193 S JAMAICA ST
ENGLEWOOD, CO 80112

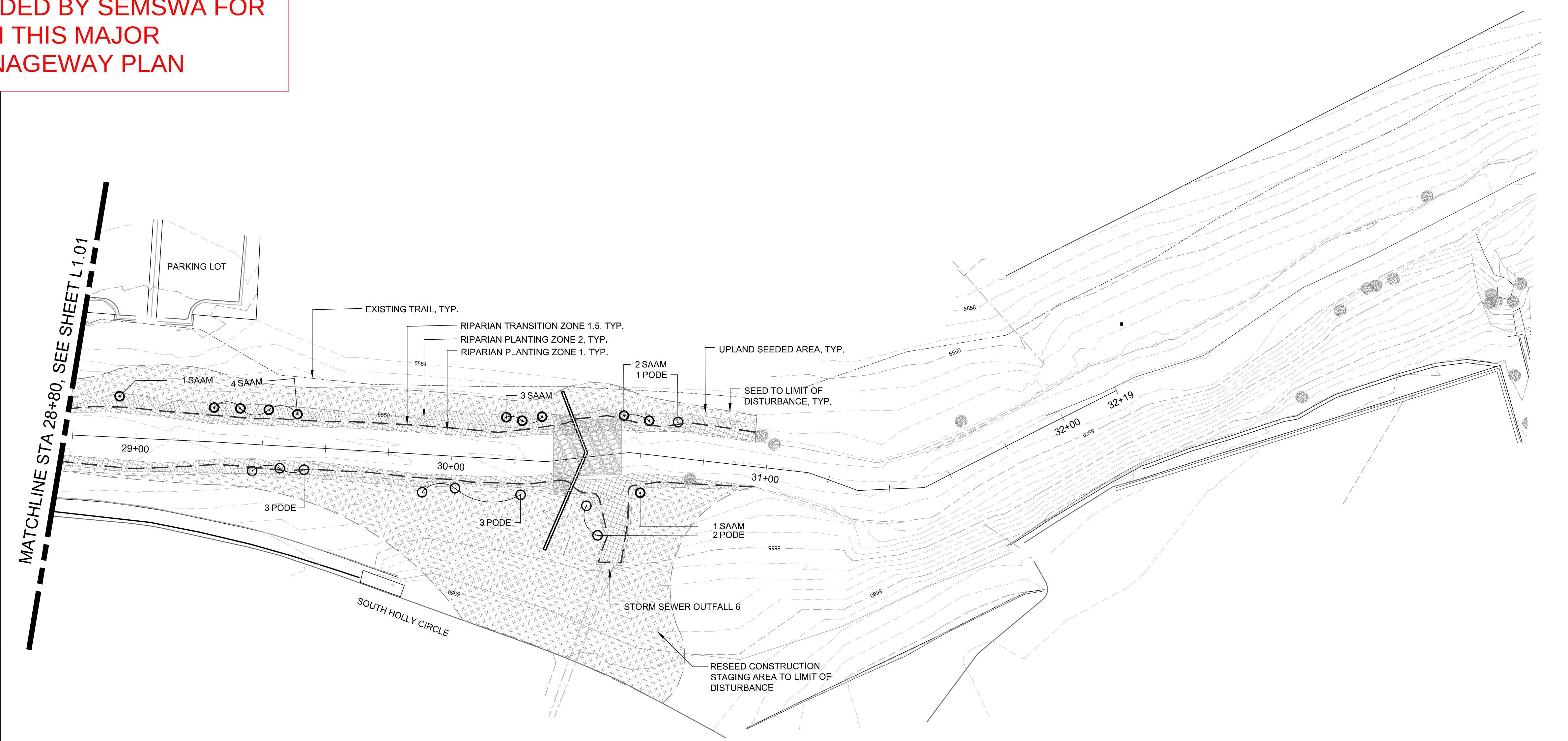
WILLOW CREEK CHANNEL IMPROVEMENTS
PLANTING SCHEDULE & NOTES

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	JUNE 2015
PROJ	661933
DWG	LS-01
SHEET	17 of 21

FILENAME: 14-015_LS-01_Landscape Notes.dwg PLOT DATE: June 25, 2015 PLOT TIME: 4:18 PM

FOR REFERENCE ONLY - PROVIDED BY SEMSWA FOR USE IN THIS MAJOR DRIAINAGEWAY PLAN



LEGEND

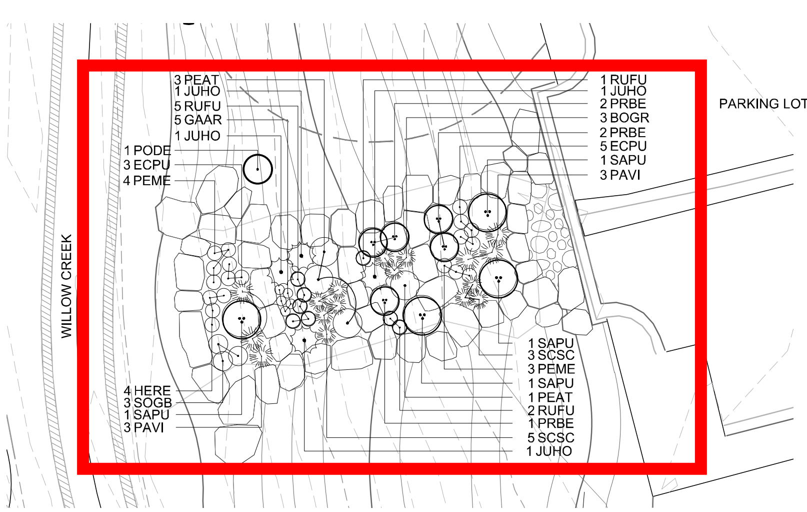
- UPLAND RESTORATION - DECIDUOUS TREE
- UPLAND RESTORATION - SHRUBS
- UPLAND RESTORATION - GRASSES
- UPLAND RESTORATION - PERENNIALS
- RIPARIAN RESTORATION - TREES
- EXISTING TREES TO REMAIN
- UPLAND SEED MIX
- SODDED AREA
- RIPARIAN PLANTING ZONE 1
- RIPARIAN PLANTING ZONE 2
- RIPARIAN TRANSITION ZONE 1.5
- SOIL WRAPPED LIFTS, SEE CIVIL PLANS

1 LS-03 PLANTING PLAN & ENLARGEMENTS - STA 19+00 TO STA 23+70

NORTH

0 20 40 60 feet

SCALE: 1" = 20'



2 LS-03 OUTFALL #2 ENLARGEMENT

0 10 20 30 feet

SCALE: 1" = 10'

NORTH

H - 5

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Urban Design
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9193 S JAMAICA ST
ENGLEWOOD, CO 80112

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WILLOW CREEK CHANNEL IMPROVEMENTS

PLANTING PLAN & ENLARGEMENTS

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	JUNE 2015
PROJ	661933
DWG	LS-03
SHEET	19 of 21

FILENAME: 14-015_LS-03_Landscape Plan.dwg PLOT DATE: June 25, 2015 PLOT TIME: 4:19 PM