



WEST TOLL GATE CREEK TRIBUTARIES

Major Drainageway Plan
September 2024

DRAFT

1525 Raleigh St. Suite 400
Denver, CO 80204





September 19, 2024

Mr. Colin Haggerty, PE, PMP
Watershed Manager
Mile High Flood District
12575 W Bayaud Avenue
Lakewood, CO 80228

**Re: West Toll Gate Tributaries Major Drainageway Plan
Agreement No. 23-01.01
Olsson Project No. 022-02231**

Dear Mr. Haggerty:

Olsson is pleased to submit the final hydrology report for the West Toll Gate Tributaries. This report documents the baseline hydrology development process.

The updated hydrology report was prepared with the cooperation of MHFD, the City of Aurora, and SEMSWA. The information from this study provides the project sponsors with design flows to be used for the next phases of the study and also for future construction and development projects in the watershed.

We appreciate the opportunity to work with you on this project and look forward to developing alternatives to solve problems within the watershed.

Sincerely,

A handwritten signature in blue ink, reading "Amy M. Gabor". The signature is fluid and cursive, with the first name "Amy" being more prominent.

Amy M. Gabor, PE, CFM, LEED® AP
Project Manager

CC: Brik Zivkovich, Mile High Flood District
Bruce Rindahl, Mile High Flood District
Jessica Traynor, Southeast Metro Stormwater Authority
Tarah Hamlyn, Southeast Metro Stormwater Authority
Tiffany Clark, Southeast Metro Stormwater Authority
Sam Scorza, City of Aurora
Encl.

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ABBREVIATIONS INDEX

Aurora – City of Aurora
Ave – Avenue
Blvd – Boulevard
BMP – Best Management Practice
CDOT – Colorado Department of Transportation
Centennial – City of Centennial
CMP – corrugated metal pipe
CUHP– Colorado Urban Hydrograph Procedure
DRCOG – Denver Regional Council of Governments
D/S - Downstream
E – East
EGL – energy grade line
EPA – Environmental Protection Agency
EURV – excess urban runoff volume
EX – existing
FEMA – Federal Emergency Management Agency
FHAD – Flood Hazard Area Delineation
FIRM – Flood Insurance Rate Map
FTR – future
HSG – hydrologic soils group
I/Imp. – Imperviousness
LiDAR – light detection and ranging
MDP – Major Drainageway Plan
MHFD – Mile High Flood District
N – North
NLCD – National Land Cover Database

No. – Number
NOAA – National Oceanic and Atmospheric Administration
NRCS – Natural Resources Conservation Service
O&M – operations and maintenance
Rd – Road
RCBC – reinforced concrete box culvert
RCP – reinforced concrete pipe
S – South
SEO – State Engineer's Office
SEMSWA – Southeast Metro Stormwater Authority
SSP – smooth steel pipe
St – Street
SWMM – Storm Water Management Model
U/S – upstream
USACE – United States Army Corps of Engineers
USDCM – Urban Storm Drainage Criteria Manual
W – West
WQCV – water quality capture volume
WSE – water surface elevation
% – percent
ac – acre
AF/ac-ft – acre-feet
cfs – cubic feet per second
ft or ' – foot/feet
in or " – inch/inches
mi – mile

1.0 INTRODUCTION

1.1 Authorization

Olsson was retained to complete a Major Drainageway Plan (MDP) for selected tributaries of West Toll Gate Creek, co-sponsored by the Mile High Flood District (MHFD), City of Aurora, and Southeast Metro Stormwater Authority (SEMSWA). Tributaries selected include Helena Circle Tributary, Woodrim Tributary, Cheery Creek Spillway, Meadowood Creek, Mission Viejo Tributary, Los Ninos Tributary, Summer Valley Ranch Tributary, Summer Lake Tributary, Marina Park Tributary, Tower Road Tributary, Smoky Ridge Tributary, Himalaya Tributary, and Park View Tributary. Agreement Regarding Major Drainageway Plan for the West Toll Gate Creek Tributaries (Agreement No. 23-01.01) was executed on January 12, 2023. Two amendments were executed for the study on September 5, 2023 and January 8, 2024 to further investigate the percent impervious values used in the hydrology.

1.2 Purpose and Scope

The purpose of this study was to update the hydrology, evaluate existing conditions in the channels, and develop alternatives to alleviate potential issues in the channels. The selected alternative will provide a guide for project sponsors to use for future construction projects for the tributaries of West Toll Gate Creek. The watershed is almost fully developed and the MDP will be used both to identify and rectify potential flooding hazards along the West Toll Gate Creek tributaries, as well as provide guidance to the project sponsors for future improvements.

The following tasks were completed as part of the major drainageway plan:

- Collected existing information, including a previous FHAD and MDP, development drainage studies, and drainage improvement as-built plans
- Solicited input from project sponsors
- Obtained base mapping, structure surveys, and GIS information from MHFD, SEMSWA, and City of Aurora
- Set up and maintained a project website linked to MHFD’s website
- Determined subwatershed boundaries and parameters in accordance with MHFD criteria
- Developed existing conditions baseline hydrology using the Colorado Urban Hydrograph Procedure (CUHP) 2005, version 2.0.1 and the Environmental Protection Agency Stormwater Management Model (EPA SWMM) 5.2, version 5.2.3
- Reconciled the hydrology with previous studies
- Completed a report documenting the baseline hydrology

1.3 Planning Process

The effective hydrology of the West Toll Gate Creek watershed was completed as part of the *West Toll Gate Creek Major Drainageway Plan*, prepared by Michael Baker Jr., Inc. and Enginuity Engineering Solutions in December 2012 (2012 MDP). The *Flood Hazard Area Delineation, West Toll Gate Creek* was completed, also by Michael Baker Jr. Inc. and Enginuity Engineering Solutions, in November 2013 (2013 FHAD). The 2012 MDP and 2013 FHAD were focused on West Toll Gate Creek itself and

Unnamed Creek. While the 2012 MDP hydrology included the tributaries, the tributaries themselves were not studied in detail.

Meadowood Creek was studied as part of the *Quincy Creek, Shop Creek, and Meadowood Creek Outfall Systems Plan*, prepared by Michael Baker International in October 2017 (2017 OSP). This study included updated hydrology along Meadowood Creek.

The majority of West Toll Gate tributaries have no FEMA-floodplain designations. Only Cherry Creek Spillway and Meadowood Creek have a FEMA-floodplain designation. Cherry Creek Spillway has a Zone AE floodplain extending from South Chambers Road down to the confluence with West Toll Gate Creek. Meadowood Creek has FEMA-designated Zone A and Zone AE floodplains.

The baseline hydrology developed for this study represents an updated analysis using CUHP 2005, version 2.0.1 and EPA SWMM, version 5.2.3. Further information regarding the hydrologic modeling process is included in Section 3.0.

A kickoff meeting was held on September 7, 2023 to discuss the project goals, hydrologic analysis, and areas of concern with MHFD. A meeting to discuss the hydrology review comments was held on June 20, 2024. Minutes from the meetings are included in Appendix A.

MHFD, City of Aurora, and SEMWSA reviewed the draft baseline hydrology and returned comments in June 2024. The comments were incorporated into this final report. Summaries of the key review comments and responses for the draft hydrology are supplemented in the meeting minutes for the June 20, 2024 meeting, included in Appendix A.

1.4 Mapping and Surveys

MHFD provided 1-foot (ft) interval 2020 LiDAR mapping for the entire West Toll Gate Creek watershed. The LiDAR mapping is referenced to the NAVD 88 vertical datum and the NAD 83 horizontal datum. Additional shapefiles and Geographic Information System (GIS) layers were provided by MHFD, City of Aurora, and SEMSWA.

1.5 Data Collection

Drainage studies and as-built plans were collected from MHFD and SEMSWA. The Arapahoe County, Colorado and Incorporated Areas FIS and Flood Insurance Rate Maps (FIRMs) were obtained from the Federal Emergency Management Agency (FEMA). The main studies and plans that were reviewed in the preparation of this report are shown in Table 1. A list of all studies reviewed in the preparation of this report is shown in Section 7.

Table 1 – Data Collected

Title	Date	Author
Upper Toll Gate Creek Basin: Outfall Planning Study	August 1990	Kiowa Engineering Corporation
Quincy Reservoir Watershed: Outfall Systems Planning Alternatives Evaluation Report Phase A	October 1998	Turner Collie & Braden, Inc.
Quincy Reservoir Watershed: Outfall Systems Planning Alternatives Evaluation Report Phase B	September 1999	Turner Collie & Braden, Inc.
Toll Gate Creek Watershed Hydrology Report	August 2006	Kiowa Engineering Corporation
West Toll Gate Creek: Major Drainageway Plan	December 2012	Michael Baker Jr., Inc. and Enginuity Engineering Solutions
Flood Hazard Area Delineation, West Toll Gate Creek	November 2013	Michael Baker Jr., Inc. and Enginuity Engineering Solutions
City of Aurora Channel Stabilization Study Summary Report	September 2016	Stantec Consulting Services, Inc.
Quincy Creek, Shop Creek, and Meadowood Creek Outfall Systems Plan	October 2017	Michael Baker International

1.6 Acknowledgements

The MDP was prepared with the cooperation of MHFD, City of Aurora, and SEMSWA. The representatives who were involved with this study are listed in Table 2.

Table 2 – Project Participants

Name	Representing	Assignment
Colin Haggerty	MHFD	Watershed Manager
Derek Clark	MHFD	Project Sponsor
Brik Zivkovich	MHFD	Project Advisor - Hydrology
Bruce Rindahl	MHFD	Project Advisor - Hydrology
Craig Pearl	City of Aurora	Project Sponsor
Sam Scorza	City of Aurora	Project Sponsor
Tiffany Clark	SEMSWA	Project Sponsor
Tarah Hamlyn	SEMSWA	Project Sponsor
Jessica Traynor	SEMSWA	Project Sponsor
Amy Gabor	Olsson	Project Manager
Kiersten Rasmussen	Olsson	Assistant Engineer

2.0 STUDY AREA DESCRIPTION

2.1 Project Area

Watershed and Drainageway Description

The total area of West Toll Gate Creek watershed is approximately 23.4 square miles, with approximately 7.89 square miles encompassing the tributaries of interest. The overall West Toll Gate Creek watershed extends from north of Smoky Hill Road and west of E-470 to the north to its confluence with East Toll Gate Creek, north of Alameda Parkway and west of Airport Boulevard. It is bound to the west by Smoky Hill Road and I-225. Descriptions for each tributary are provide below:

Helena Circle Tributary – Helena Circle Tributary is approximately 0.3 square miles, extending from the intersection of E Arkansas Drive and E Florida Avenue to the east to its confluence with West Toll Gate Creek east of S Idalia Street. This tributary is primarily piped underground until it outfalls to West Toll Gate Creek. Helena Circle Tributary is located in the City of Aurora as shown on Figure 1. Tributary slopes generally range from 0.5 to 2 percent (%) with the lowest and highest watershed elevations being 5466 and 5619, respectively.

Woodrim Tributary – Woodrim Tributary is approximately 0.6 square miles, extending from the intersection of S Blackhawk Street and E Iliff Avenue to the northeast to its confluence with West Toll Gate Creek at E Mexico Drive. This tributary has a combination of underground storm drain system and vegetated open channel. Woodrim Tributary is located in the City of Aurora as shown on Figure 1. Tributary slopes generally range from 0.4 to 3 percent (%) with the lowest and highest watershed elevations being 5481 and 5635, respectively.

Cherry Creek Spillway – Cherry Creek Spillway is approximately 2.2 square miles downstream of the Cherry Creek Reservoir, extending from the intersection of S Parker Road and E Hampden Avenue to the north to its confluence with West Toll Gate Creek near Horseshoe Park. This tributary contains concrete and grass-lined open channels including the spillway for the Cherry Creek Reservoir. Cherry Creek Spillway is located in the City of Aurora as shown on Figure 1. Tributary slopes generally range from 0.2 to 2 percent (%) with the lowest and highest watershed elevations being 5505 and 5698, respectively.

Meadowood Creek – Meadowood Creek is approximately 2.6 square miles, extending from E Smoky Hill Road and S Buckley Road to the north to its confluence with West Toll Gate Creek north of E Iliff Avenue. This tributary consists of a vegetated open channel extending along the middle of the entire watershed conveying flows north. Meadowood Creek is located in the City of Aurora as shown on Figure 1. Tributary slopes generally range from 0.3 to 2 percent (%) with the lowest and highest watershed elevations being 5511 and 5823, respectively.

Mission Viejo Tributary – Mission Viejo Tributary is approximately 0.1 square miles, extending from S Mission Parkway to the north to its confluence with Meadowood Creek at E Hampden Avenue. This tributary conveys flows within underground storm drain system that outlets into a vegetated open channel. Mission Viejo is located in the City of Aurora as shown on Figure 1. Tributary slopes generally range from 1 to 2 percent (%) with the lowest and highest watershed elevations being 5649 and 5722, respectively.

Los Ninos Tributary – Los Ninos Tributary is approximately 0.2 square miles, extending from S Chambers Road and S Chambers Way to the east to its confluence with Meadowood Creek near Mission Viejo Park. This tributary has a combination of underground storm drain systems vegetated open channel. Los Ninos is located in the City of Aurora as shown on Figure 1. Tributary slopes generally range from 0.8 to 2 percent (%) with the lowest and highest watershed elevations being 5665 and 5782, respectively.

Summer Valley Ranch Tributary – Summer Valley Ranch Tributary is approximately 0.7 square miles, extending from E Quincy Avenue and S Reservoir Road to the northwest to its confluence with West Toll Gate Creek at E Hampden Avenue. This tributary consists of grass-lined open channels. Summer Valley Ranch Tributary is located in the City of Aurora as shown on Figure 1. Tributary slopes generally range from 0.6 to 3 percent (%) with the lowest and highest watershed elevations being 5606 and 5799, respectively.

Summer Lake Tributary – Summer Lake Tributary is approximately 0.3 square miles, extending from E Quincy Avenue and S Flanders Street to the south to its confluence with West Toll Gate Creek near Quincy Reservoir. This tributary has a combination of underground and natural conveyance systems. Summer Lake Tributary is located in the City of Aurora and the City of Centennial as shown on Figure 1. Tributary slopes generally range from 0.2 to 3 percent (%) with the lowest and highest watershed elevations being 5716 and 5816, respectively.

Marina Park Tributary – Marina Park Tributary is approximately 0.4 square miles, extending from the intersection of S Tower Road and E Smoky Hill Road to the northwest to its confluence with Tower Road Tributary near Quincy Reservoir. This tributary has a combination of underground storm drain systems, concrete open channel, and vegetated open channel. Marina Park Tributary is located in the City of Aurora and the City of Centennial as shown on Figure 1. Tributary slopes generally range from 0.8 to 2 percent (%) with the lowest and highest watershed elevations being 5718 and 5836, respectively.

Tower Road Tributary – Tower Road Tributary is approximately 1.0 square miles, extending from E Smoky Hill Road and S Gibraltar Way to the northwest to its confluence with West Toll Gate Creek near Quincy Reservoir. This tributary has a combination of underground storm drain systems and vegetated open channel. Tower Road Tributary is located in the City of Aurora and the City of Centennial as shown on Figure 1. Tributary slopes generally range from 0.5 to 3 percent (%) with the lowest and highest watershed elevations being 5718 and 5945, respectively.

Smoky Ridge Tributary – Smoky Ridge Tributary is approximately 0.10 square miles, extending from Peakview Elementary to the north to its confluence with West Toll Gate Creek. This tributary is primarily piped underground until it outfalls to West Toll Gate Creek near S Flanders Street. This tributary has a combination of underground storm drain systems and vegetated open channel. Smoky Ridge Tributary is located in the City of Centennial as shown on Figure 1. Tributary slopes generally range from 0.5 to 3 percent (%) with the lowest and highest watershed elevations being 5728 and 5862, respectively.

Himalaya Tributary – Himalaya Tributary is approximately 0.01 square miles, extending from S Himalaya Street and E Bellevue Lane to the northeast to its confluence with West Toll Gate Creek at E Chenango Avenue. This tributary is conveyed primarily overland in a vegetated channel. Himalaya Tributary is located in the City of Centennial as shown on Figure 1. Tributary slopes generally range

from 0.5 to 2 percent (%) with the lowest and highest watershed elevations being 5772 and 5944, respectively.

Park View Tributary – Park View Tributary is approximately 0.1 square miles, extending from E Smoky Hill Road and S Kirk Street to the north to its confluence with West Toll Gate Creek at E Willamette Avenue. This tributary is conveyed primarily overland in vegetated and concrete open channels and detention ponds. Park View Tributary is located in the City of Centennial as shown on Figure 1. Tributary slopes generally range from 0.5 to 3 percent (%) with the lowest and highest watershed elevations being 5809 and 5944, respectively.

Reservoirs

No reservoirs are located within the tributary watersheds, although several of the tributaries release flows into Quincy Reservoir.

Existing Regional Detention Basins

A total of three detention basins were included in the baseline hydrology. The tributary watersheds include more private detention facilities that were not included in the baseline hydrology, as well as several detention ponds that were previously modeled in the 2012 MDP, but do not significantly impact peak flows. These detention ponds were removed to simplify the model. The modeled detention basins include two (2) facilities along Tower Road Tributary, and one (1) facility along the Summer Lake Tributary. These three (3) detention basins have been included in the hydrologic models. More detailed information is included in Section 3.4.

Irrigation Ditches

No irrigation ditches cross the tributary watersheds. The High Line Canal crosses the West Toll Gate Creek watershed just north of Alameda Parkway.

Soils

Soil types were determined using the Natural Resources Conservation Service (NRCS) Web Soil Survey. Approximately half of the soils in the selected tributaries' watersheds consist of hydrologic soils group (HSG) Type B, which are generally characterized by moderate infiltration rates as defined by NRCS. Approximately 30% of the area consists of HSG Type C and D soils, which are generally characterized by low infiltration rates. The remaining 20% consists of HSG Type A soils, which are generally characterized by high infiltration rates. The soils map is included on Figures B-1A through B-1B in Appendix B.

2.2 Land Use

The watersheds are fully developed. Single-family residential is the primary land use. Other land uses include multi-family, mixed-use, commercial, and parks and open space. Existing land use was verified using aerial imagery and through site visit observations.

As the study area is fully developed, no future land use changes are anticipated. Additional discussion of land uses and corresponding percent impervious values is included in Section 3.3.

2.3 Reach Description

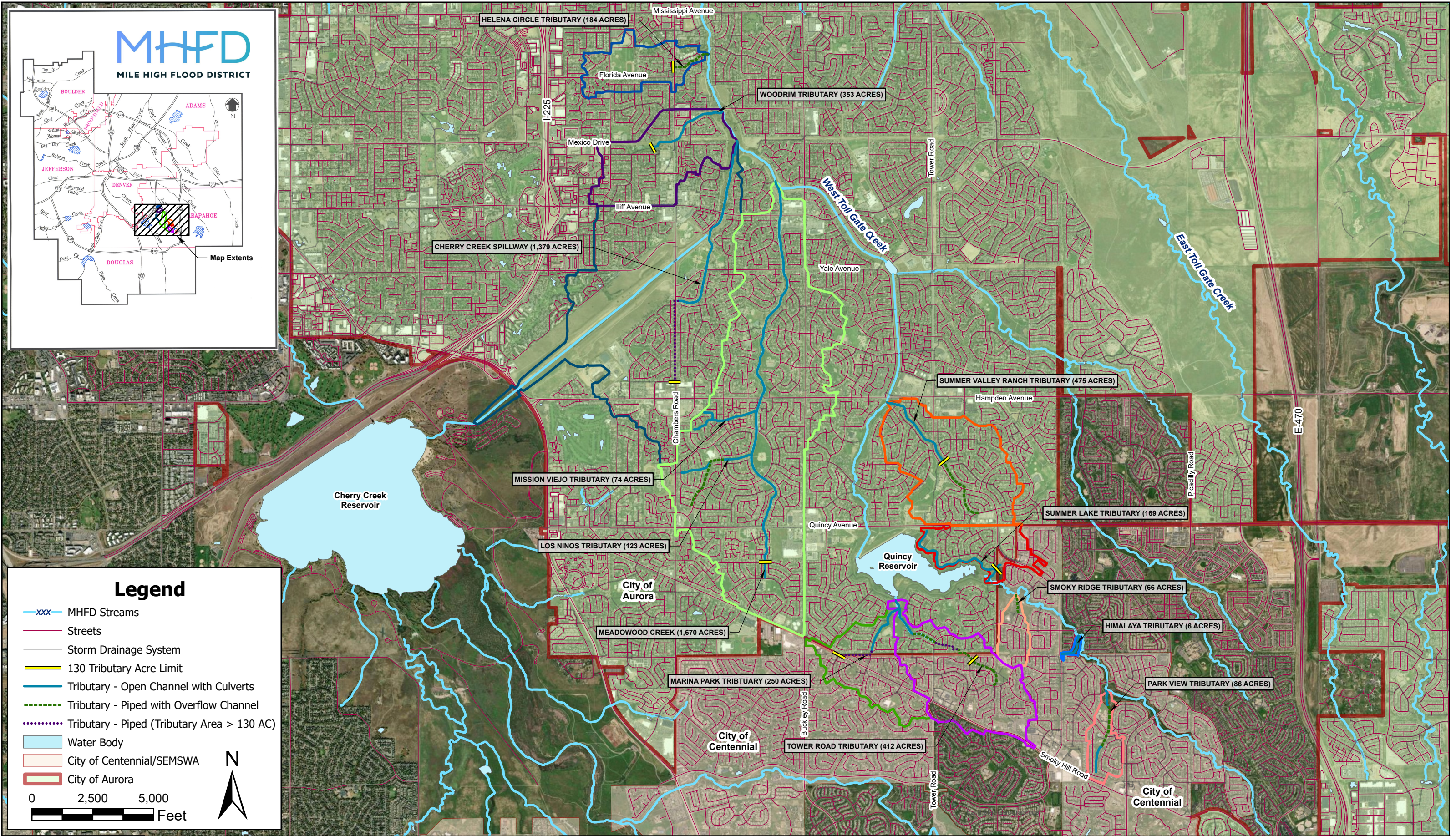
For this study, the West Toll Gate tributaries were broken out into thirteen distinct watersheds as shown on Figure 1. This section, along with Table 3, will be completed with the alternatives analysis.

2.4 Flood History

Flood history of the West Toll Gate Creek was briefly discussed as part of the *Toll Gate Creek Flood Warning Plan* prepared by the Mile High Flood District in April 2009. Overtopping of Mexico Avenue, as a result of undersized culverts, was identified as a flood hazard area at the confluence of Woodrim Tributary and West Toll Gate Creek. No other reported flooding history was found.

2.5 Environmental Assessment

This section will be completed with the alternatives analysis.



3.0 HYDROLOGIC ANALYSIS

3.1 Overview

Hydrology was developed for the baseline condition using existing infrastructure and existing land uses. Peak discharges for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year return period storms were analyzed using CUHP version 2.0.1, to generate hydrographs for each subwatershed. Hydrographs for the subwatersheds were routed using EPA SWMM, version 5.2.3, to determine peak discharge rates at select design points. The updated EPA SWMM results were compared to the 2012 MDP/2013 FHAD and 2017 OSP. The hydrology comparison is detailed in Section 3.6 and shown in Table 6.

3.2 Design Rainfall

One-hour rainfall depths from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 were input into CUHP to model the watershed hydrology for each storm event and are shown in Table 3. As no tributary drainage basins were greater than 5 square miles, no area adjustments were necessary for any of the storm events.

Table 3 - One-Hour Point Rainfall (inches)

Duration	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
1-Hour	0.87	1.14	1.39	1.77	2.08	2.41	3.28
6-Hour	1.39	1.78	2.15	2.70	3.17	3.68	5.02

3.3 Subwatershed Characteristics

A summary of the CUHP 2.0.1 model parameters can be found in Appendix B. The 2020 LiDAR mapping, structure survey information, as-built drawings, drainage studies, aerial imagery, and future land use maps were used to determine input parameters.

Subwatershed Delineation

The overall watershed boundary was delineated using 2020 LiDAR mapping and then checked for general agreement with previous studies. The 2012 MDP did not redo hydrology, but rather updated the hydrology that was prepared as part of the *Toll Gate Creek Watershed Hydrology Report*, prepared by Kiowa Engineering Corporation in August 2006 (2006 Hydrology). The subbasins in the 2006 Hydrology were based on 10-foot topography and while the overall tributary watersheds are of similar size, many of the subbasins differ as a result of using more detailed topography in this study.

Subwatershed delineation and peak flow calculations for the West Toll Gate Creek tributary watersheds were divided into 89 subwatersheds at an average size of 56.7 acres and a maximum size of 127.7 acres. Subwatershed boundaries reflect the major storm event conditions and typically do not include minor storm drain systems. Portions of Subwatershed T6 and T7 flow to storm drain systems that route flows into Piney Creek and flows in excess of the storm drain capacity will flow to Tower Road Tributary. A diversion link was used at these two locations to remove the pipe-full capacity of the storm drain system. A rating curve was used rather than a cutoff flow to ramp up to the total pipe capacity to reduce

the resulting diversion from minor storm events, since the pipe will likely not be full during minor events. The pipe capacity calculations are shown in Table B-3, in Appendix B. The subwatersheds are shown on Figures B-1A and B-1B in Appendix B.

Length, Distance to Centroid, Slope

The 2020 LiDAR data was used to determine subwatershed flow path lengths, distance to centroid values, and slopes. Private detention facilities were not included in the model. Where private detention basins were present, flow paths were determined based on the overflow path from the ponds, assuming the outlets would be clogged.

Subwatersheds were generally delineated to avoid shapes with elongated tails and very narrow and long shapes. To check these two scenarios, the following equations were used:

$r = \text{Length to Centroid} / \text{Total Length}$ (if $0.1 \leq r < 0.3$, the subwatershed may have an elongated tail)
 $r = \text{Length}^2 / \text{Area}$ (if $r > 4$, the subwatershed may be very narrow and long)

If the r value of a subwatershed indicated that it may have an elongated tail, or be very narrow and long, it was checked. Many of the subwatersheds in question did not have an elongated tail and were not long and narrow in shape. The questionable r values were generally a result of more winding flow paths, which results in longer flow paths. A sensitivity analysis was performed to determine which subbasins were more sensitive to the lengths. Subbasins that resulted in higher differences when lengths had acceptable r values were further subdivided.

The tributaries of West Toll Gate Creek generally slope down toward the north. Subbasin flow path slopes ranged from 0.04 to 3.0 percent (%). The lowest and highest watershed elevations are 5466 and 5945, respectively. Slopes were estimated using the weighted slope equation from the CUHP manual:

$\text{Weighted sloped} = ((L_1S_1^{0.24} + \dots + L_nS_n^{0.24}) / (L_1 + \dots + L_n))^{4.17}$

Watershed Imperviousness

The existing land uses are discussed in Section 2.2. To determine the existing conditions percent imperviousness, the 2020 Denver Regional Council of Governments (DRCOG) planimetrics data was used. To calculate the percent impervious values using DRCOG, five planimetric datasets were obtained and assigned a percent impervious value consistent with the MHFD criteria as follows:

- Roof prints – 95%
- Edge of Pavement – 95%
- Sidewalks – 95%
- Driveways – 95%
- Parking – 95%

The following additional adjustments were made to the base DRCOG data to calculate the percent imperviousness:

1. Because the database was prepared in 2020, aerial imagery from 2020 was compared to a 2024 aerial imagery to determine areas in the watershed that developed after the database was compiled.

One area on Woodrim Tributary was updated based on aerial imagery (Subbasin W3). Mult-family housing was constructed. This area was assumed to have an imperviousness of 70%.

- 2. Areas with permanent water were delineated and assigned a value of 100% impervious.
- 3. The remaining pervious areas were split into two groups: disturbed soils (ie lawns and parks) and undisturbed soils (ie native open space areas). Disturbed soils were assigned a percent imperviousness of 20% based on MHFD criteria and assumed to include all non-impervious areas within the developed portions of the watershed. Undisturbed open space areas are primarily located near the West Toll Gate Creek confluences and along the Cherry Creek spillway and were assigned a percent imperviousness of 5%, per on MHFD criteria.

After the percent impervious values were determined using the DRCOG data, the values were spot checked for accuracy and were determined to be acceptable. Additionally, Olson completed a separate evaluation of percent impervious values using the 2021 National Land Cover Database (NLCD) and found the DRCOG data to more accurately represent the percent imperviousness. The percent impervious values are similar to the 2012 MDP study, which was based on land use designation. The overall existing percent imperviousness of the watershed is 51%. Overall existing percent imperviousness values for each tributary are shown in Table 4. The existing percent impervious values for each subbasin are shown on Figures B-1A and B-1B, in Appendix B.

Table 4 – Tributary Imperviousness

Tributary	% Imperviousness
Helena Circle Tributary	54
Woodrim Tributary	56
Cherry Creek Spillway	44
Meadowood Creek	55
Mission Viejo Tributary	59
Los Ninos Tributary	54
Summer Valley Ranch Tributary	54
Summer Lake Tributary	52
Marina Park Tributary	51
Tower Road Tributary	52
Smoky Ridge Tributary	44
Himalaya Tributary	17
Park View Tributary	46

Depression Losses

Depression losses were determined using Table 6-6 in the USDCM. A weighted average was used for the depression losses in each subbasin, based on land use designation. A pervious depression loss of 0.35 inches, which represents lawns and grass, was used for the developed portions of the watershed, and a value of 0.4, which represents open fields, was used for the open space portions of the watershed. An average of an impervious depression loss of 0.07, which represents sloped roofs, and 0.1, which represents large paved areas, was used for residential areas. A value of 0.1, which represents flat roofs and large paved areas, was used for commercial, office, and industrial areas.

Infiltration

Initial and final infiltration rates and Horton’s decay rate were determined using Table 6-7 in the USDCM and are shown in Table . A weighted average of soil type was used to determine subwatershed rates. The hydrologic soil groups are shown on Figures B-1A and B-1B, in Appendix B.

Table 5 - Horton's Equation Parameters

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

3.4 Detention

Pursuant to MHFD’s policy to recognize only regional and publicly-owned facilities, private detention basins, irrigation reservoirs, and inadvertent detention areas were not modeled. Additionally, four (4) detention basins that were included in the 2012 MDP were removed from the hydrology for this study, as described below:

- Two detention basins in the 2012 MDP were removed from the baseline hydrology model because they are primarily served by a storm drain system and the baseline hydrology generally assumed clogged storm drain systems. These two ponds included:
 - The Marina Park Tributary detention basin LBO Pond 2, located west of S Uravan Place and E Progress Place
 - The Tower Road Tributary detention basin, LBO Pond 1, located at S Yampa Circle
- Two detention basins in the 2012 MDP were removed from the baseline hydrology model to simplify the model since they had insignificant impact on peak flows. These two ponds included:
 - The Marina Park Tributary detention basin LBO Pond 3, located at the southwest corner of the intersection of E Smoky Hill Road and S Telluride Street
 - The Park View Tributary detention basin Pond 19, located south of E Berry Drive

Three (3) detention basins from the 2012 MDP were included in the baseline hydrology model, as summarized below:

- One detention basin, Pond 1, is within the Summer Lake Tributary, located at the downstream end of the Summer Lake Tributary east of Quincy Reservoir.
- Two detention basins are within the Tower Road Tributary. Smokey Ridge Pond is located at the upstream end of the Tower Road Tributary at the northwest corner of E Prentice Avenue and E Crestline Circle. Meadow Point Pond is located at the downstream end of Tower Road Tributary south of Quincy Reservoir.

According to the 2023 MDP, all of the modeled detention ponds were either MHFD maintenance eligible, publicly owned and maintained, or there is a maintenance agreement in place with the local metro district. The 2012 MDP noted that some of the dentition basins had less than 100 acres of tributary area, but were included to be consistent with the 2006 hydrologic models. Two of the three detention basins included in this study are less than 100 acres in tributary area, including the Summer

Lake Tributary detention basin and the upstream Tower Road Tributary detention basin. No more additional information was available in the 2012 MDP regarding the three modeled detention basins. Storage-discharge information for the detention basins were based on the 2012 MDP and are shown in Table B-2, in Appendix B.

3.5 Hydrograph Routing

The parameters for the EPA SWMM model conveyance elements were determined using the 2020 LiDAR data. Channel geometry was determined using the LiDAR mapping; sections could generally be defined by a trapezoidal section. For flows that are conveyed via streets, the street sections were modeled as irregular sections, separated by minor and major road type. The underground storm drain system was not modeled, except for the major storm event pipe at defined locations.

The Manning's n values for engineered conveyance elements, including engineered channels, pipe, and street, were increased 25 percent in accordance with the USDCM. Channel section Manning's n values ranged from 0.016 (concrete) to 0.05 (vegetated) in the model. Street section Manning's n values were set at 0.016, or 0.02 in the model. Concrete pipe Manning's n values were set at 0.013, or 0.016 in the model. One pipe section was changed to 0.013 in the model to avoid needing to add an overflow element.

The EPA SWMM 5.2 input parameters and 100-year future conditions output are included in Appendix B. EPA SWMM 5.2 model elements, including subwatersheds, design points and conveyance elements are shown on Figures B-1A and B-1B and a schematic of the model is shown on Figures B-2A through B-2B in Appendix B. No flow diversions were included in the analysis.

3.6 Previous Studies

The West Toll Gate Creek watershed has been included in several previous studies. The most recent hydrology studies are the 2017 OSP for Meadowood Creek and the 2012 MDP/2013 FHAD for the remainder of the included tributaries. The 2012 MDP was initially based on the previous hydrology study, the 2006 Hydrology.

In addition to these hydrology studies, outfall systems plans (OSPs) were created to analyze certain tributaries highlighted in this study. Marina Park Tributary, Tower Road Tributary, and Park View Tributary were all analyzed in the 1998/1999 *Quincy Reservoir Watershed Outfall Systems Planning Alternatives Evaluation Report* by Turner Collie & Braden Inc.

A comparison of peak flows in the 2012 MDP and 2017 OSP versus this study is shown in Table 6. In general, the peak flows are lower than the 2012 MDP, but similar to the 2017 OSP for Meadowood Creek. The 2012 MDP model was converted to the same model versions and the rainfall values were update to NOAA Atlas 14 to better compare the differences in peak flows. The unit discharges were compared to eliminate differences in tributary area. After converting the models, the peak flows in this studied ranged from 5% higher than the updated 2012 MDP to 26% lower than the updated 2012 MDP values. The remaining differences in peak flows can be mostly attributed to the more detailed 2020 LiDAR information that was used to delineate watersheds and flow paths. The 2012 MDP was an update of the 2006 Hydrology, which was based on 10-foot topography. The differences are within 30% and are reasonable and therefore no calibration was completed.

Table 6 - Previous Studies Hydrology Reconciliation

Reference Location	2012 MDP					2012 MDP Update		2024 MDP					Comparisons	
	Design Point	Total Tributary Area (Ac)	Future % Imp	FTR Q100 Peak Discharges (cfs)	Unit Discharge (cfs/ac)	FTR Q100 Peak Discharges (cfs)	Unit Discharge (cfs/ac)	Design Point	Total Tributary Area (Ac)	Future % Imp	FTR Q100 Peak Discharges (cfs)	Unit Discharge (cfs/ac)	% Diff Unit Discharge (2012 MDP vs. 2024 MDP)	% Diff Unit Discharge (2012 MDP Update vs. 2024 MDP)
Helena Circle at S Chambers Rd	J_LW17	153	54	690	4.50	438	2.86	HC102	155	53	327	2.11	-53%	-26%
Woodrim Tributary Confluence with WTGC	OUT_WOOD1	398	55	1,563	3.93	1,012	2.54	W101	353	56	697	1.97	-50%	-23%
Cherry Creek Spillway Confluence with WTGC	O_S1	1,272	41	2,914	2.29	1,978	1.56	C101	1,379	44	1,929	1.40	-39%	-10%
Meadowood Creek Tributary Confluence with WTGC	O_WT1	1,687	53	4,174	2.47	3,052	1.81	MC101	1,670	55	2,424	1.45	-41%	-20%
Summer View Tributary Confluence with WTGC	J_LQ109	362	55	1,347	3.72	859	2.37	SV101	475	54	1,051	2.22	-40%	-7%
Summer Lake Tributary Upstream of Pond 1	J_QR625	62	44	262	4.22	178	2.86	SL305	51	64	155	3.01	-29%	5%
Tower Road Tributary and Marina Park Tributary Upstream of Meadow Point Detention Pond	J_QR645	697	42	1,727	2.48	1,184	1.70	T101	660	52	1,155	1.74	-30%	3%
Smokey Ridge Tributary Confluence with WTGC	Basin QR335	75	34	211	2.83	144	1.93	SR101	66	44	132	2.01	-29%	4%
Park View Tributary Upstream of Pond 19	J_QR623	24	45	109	4.58	71	2.98	P103	20	45	49	2.38	-48%	-20%
Reference Location	2017 OSP					---		2024 MDP					2017 vs 2024	
Meadowood Creek Tributary Confluence with WTGC	Outfall	1,694	47	2,206	1.30	---	---	MC101	1670	55	2424	1.45	11%	---

3.7 Results of Analysis

In general, the peak flows are lower than the 2012 MDP, but similar to the 2017 OSP for Meadowood Creek, as discussed in Section 3.6. A summary of the 100-year peak flows at the downstream end of each tributary is summarized in Table 7. The baseline peak discharges and volumes for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year storm events for all the EPA SWMM 5.2 design points can be found in Table B-4, in Appendix B. The peak discharges and volumes versus channel station for the West Toll Gate Creek Tributaries are shown in Table B-5 and are also shown in Figures B-3A through B-3J, in Appendix B. Select SWMM generated hydrographs are included as Figure B-4, in Appendix B.

Table 7 - Summary of 100-Year Peak Flows

Design Point	Tributary	100-Year Peak Flow at the Downstream End (cfs)
HC101	Helena Circle Tributary	388
W101	Woodrim Tributary	697
C101	Cherry Creek Spillway	1,929 ¹
MC101	Meadowood Creek	2,424
MV101	Mission Viejo Tributary	169
LN101	Los Ninos Tributary	208
SV101	Summer Valley Ranch Tributary	1,051
SL101	Summer Lake Tributary	241
MP101	Marina Park Tributary	525
T101O	Tower Road Tributary	1,031
SR101	Smoky Ridge Tributary	132
H101	Himalaya Tributary	5
P101	Park View Tributary	202

¹Peak flow is only for tributary area downstream of Cherry Creek Reservoir and does not include any reservoir flows.

4.0 HYDRAULIC ANALYSIS

To be included in future submittals.

5.0 ALTERNATIVE ANALYSIS

To be included in future submittals.

6.0 REFERENCES

US Geological Survey. January 2019. *National Land Cover Database – 2019 Dataset*

City of Aurora, Storm Drainage Design and Technical Criteria Manual, Aurora, Colorado, October 11, 2010

Federal Highway Administration. July 28, 2016. *HY-8 7.50*

J3 Engineering Consultants Inc. November 2013. *Toll Gate Creek and East Toll Gate Creek (Downstream of Hampton): Flood Hazard Area Delineation*

Kiowa Engineering Corporation. August 1990. *Upper Toll Gate Creek Basin Outfall Planning Study*.

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Michael Baker International. December, 18 2012. *West Toll Gate Creek Major Drainageway Plan*

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Stantec Consulting Services Inc. September 2016. *City of Aurora Channel Stabilization Study Summary Report*

Turner Collie & Braden Inc. October 1998. *Quincy Reservoir Outfall Systems Planning Alternatives Evaluation Report Phase A*

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US Department of Commerce, National Oceanic and Atmospheric Administration, Atlas 14, Volume 8, Version 2. December 2, 2018. *Point Precipitation Frequency Estimates*.

US Department of Homeland Security. February 5, 2014. *Flood Insurance Rate Map: Map Numbers 08005C0179L, 08005C0183L, 08005C0187K, 08005C0191L, 08005C0189K, 08005C0193L, 08005C0194L, 08005C0481L, 08005C0482M*

US Environmental Protection Agency. July 31, 2018. *EPA SWMM 5.2.1*

WEST TOLL GATE CREEK TRIBUTARIES

Major Drainageway Plan

APPENDIX A

PROJECT CORRESPONDENCE



WEST TOLL GATE CREEK TRIBUTARIES

Major Drainageway Plan

MEETING MINUTES





MEETING MINUTES

Kickoff Meeting

Date:	September 7, 2023 at 11:00 AM via Teams
RE:	West Toll Gate Creek Tributaries MDP Kick-off
Attendees:	Attendees listed below
Project #	022-02231

Attendees:

Name	Company	Email
Colin Haggerty	Mile High Flood District (MHFD)	chaggerty@mhfd.org
Derek Clark	MHFD	dclark@mhfd.org
Jessica Traynor	Southeast Metro Stormwater Authority (SEMSWA)	jtraynor@semswa.org
Tiffany Clark	SEMSWA	tclark@semswa.org
Nicole Harwell	SEMSWA	nharwell@semswa.org
Sam Scorza	City of Aurora (COA)	samiller@auroragov.org
Craig Perl	COA	cperl@aurora.org
Gustav Slovensky	COA	gslovens@auroragov.org
Amy Gabor	Olsson	agabor@olsson.com
Zack DelGrosso	Olsson	zdelgrosso@olsson.com

Discussion Items:

The purpose of this meeting was to discuss the start of the project and better define its scope. Specifically, determine which tributaries should be included in this study. This meeting was only to discuss the hydrology phase of the study. While this summary is not intended to represent a comprehensive account of the meeting, it is intended to reflect the key points raised and issues for further consideration and to identify the action items resulting from the discussions. The non-bold items comprised the meeting agenda. The items in bold resulted from the discussions.

- 1) Introductions
- 2) Project goals
 - a) The main goal of this project is to continue the efforts of the District to update MDPs throughout its boundaries and identify potential issues and maintenance needs.
 - b) This study will help provide an assessment of existing conditions, identify problem areas, and provide guidance on future construction projects for the West Toll Gate Creek tributaries.

- 3) Needed Information
 - a) 2020 LiDAR topo and contours – **MHFD to provide**
 - b) GIS files (storm sewer, other utilities that are available, property lines, ROW, easement, streets, streams, FPs, City limits, SEMSWA limits, future land use or zoning, etc.) – **To be provided by MHFD, SEMSWA, and COA**
 - c) GIS file of WTGC subbasins and overall watershed – **MHFD to provide**
 - d) West Toll Gate Creek hydrology models – **MHFD to provide**
 - e) Crossing structure surveys – **Crossing structure surveys are not needed at this time. Potential survey needs will be discussed in future phases of the study**
 - f) Any plans, reports, or studies in the project area that not available on-line (ie the concrete channel assessment and sediment analysis by Aurora) – **To be provided by MHFD, SEMSWA, and COA**
 - g) Contact information for any additional stakeholders that should be included as the study progresses
- 4) Hydrology
 - a) **Hydrology will be based on NOAA Atlas 14 rainfall, CUHP 2005 Version 2.0.1, and EPA SWMM 5.2.3.**
 - b) **Existing imperviousness determined using 2019 NLCD, with adjustments to change any values less than 2% to 2% and update open water to 100%. Aerial imagery will be used to update any development post-2019. Future imperviousness based on land use and zoning for undeveloped parcels.**
 - c) **Only need to look at local drainage for Cherry Creek Spillway.**
 - d) **Do not include hydrology routing down West Toll Gate Creek.**
 - e) **Match detention in 2012 MDP. No additional detention ponds are anticipated to be included.**
- 5) Previous studies and existing conditions
 - a) **West Toll Gate Creek was studied in 2012, but did not include the smaller tributaries. Other studies have been done that include some of the tributaries. Olsson will review available information on MHFD's website.**
 - b) **COA completed an assessment of concrete channels, but it did not include an evaluation of peak flows. COA will send Olsson the report and it will be referenced as it relates to the existing conditions.**
 - c) **COA completed a sediment analysis on West Toll Gate Creek. The study will be considered as it relates to the tributaries.**
 - d) **At this time, it is anticipated that no effective floodplains will be updated by this study.**
 - e) **Woodrim Tributary has recently been studied as part of a development.**
- 6) Determination of tributaries to be included in MDP
 - a) **Olsson will provide a map to sponsors with recommendations on what tributaries should be included in the study. Generally, tributaries will be included if they have been previously studied and/or are open channels. Piped systems are not anticipated to be included.**
 - b) **The Aurora Mall drainage system was completed recently and has complicated hydrology/hydraulics. Because it was completed recently, it will not be included in the study.**
 - c) **Highline Canal will only be included as it relates to any other tributary crossing it.**
 - d) **Unnamed Tributary was studied as part of the 2012 MDP and will not be included.**
- 7) Deliverables
 - a) **The study will follow the typical PDF submittal and will not be a web-based master plan, but will include GIS files that are compatible with MHFD's Confluence system. MHFD prefers web-based.**

Action Items:

- **Olsson**
 - **Provide a map of tributaries outlining which have old studies/information**
 - **Provide scope and fee for hydrology**
- **MHFD**
 - **Provide 2020 LiDAR**
 - **Provide 2012 hydrology and GIS shapefiles**
 - **Provide any relevant studies and plans not accessible on-line**
- **COA/SEMSWA**
 - **Provide any relevant GIS files not accessible on-line**
 - **Provide any relevant studies and plans not accessible on-line**

Please contact Olsson at 303-237-2072 with changes or questions regarding these meeting minutes. These minutes will be considered final unless comments are received within seven days of distribution. Although comments will be incorporated, as appropriate, only major revisions will be redistributed.

**Minutes prepared by: Zack DelGrosso
Distribution List: Attendees**



MEETING MINUTES

Progress Meeting

Date:	June 20, 2024 at 12:00 PM via Teams
RE:	West Toll Gate Creek Tributaries MDP Progress Meeting
Attendees:	Attendees listed below
Project #	022-02231

Attendees:

Attended	Name	Company	Email
x	Colin Haggerty	Mile High Flood District (MHFD)	chaggerty@mhfd.org
x	Jessica Traynor	Southeast Metro Stormwater Authority (SEMSWA)	jtraynor@semswa.org
x	Tarah Hamlyn	SEMSWA	thamlyn@semswa.org
x	Tiffany Clark	SEMSWA	tclark@semswa.org
x	Nicole Harwell	SEMSWA	nharwell@semswa.org
x	Sam Scorza	City of Aurora (COA)	sscorza@auroragov.org
x	Amy Gabor	Olsson	agabor@olsson.com
x	Kiersten Rasmussen	Olsson	krasmussen@olsson.com

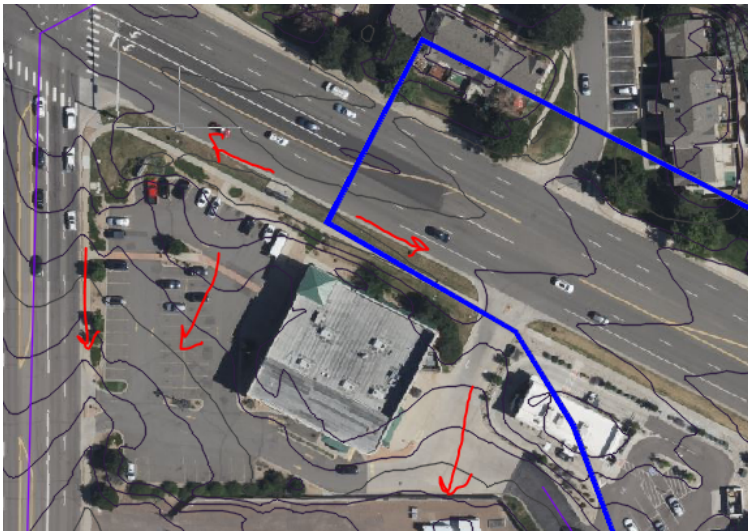
While this summary is not intended to represent a comprehensive account of the meeting, it is intended to reflect the key points raised and issues for further consideration and to identify the action items resulting from the discussions. The non-bold items comprised the meeting agenda. The bold items resulted from the discussions.

Study Goals: Complete a clear and concise study to identify potential issues and maintenance needs along the West Toll Gate Tributaries.

- 1) Hydrology comments
 - a) Overview of results – generally lower peak flows as compared to 2012 MDP
 - b) Interactive map vs. static maps in PDF report
 - i) **Aurora and SEMSWA agree with keeping the interactive figure and adding file links to separate static maps.**
 - c) Percent impervious calculations
 - i) Utilized DRCOG information and assigned percent impervious values based on new MHFD guidance. The approach was reviewed and accepted by MHFD. Percent impervious values using this approach are similar to 2012 MDP land use approach values.

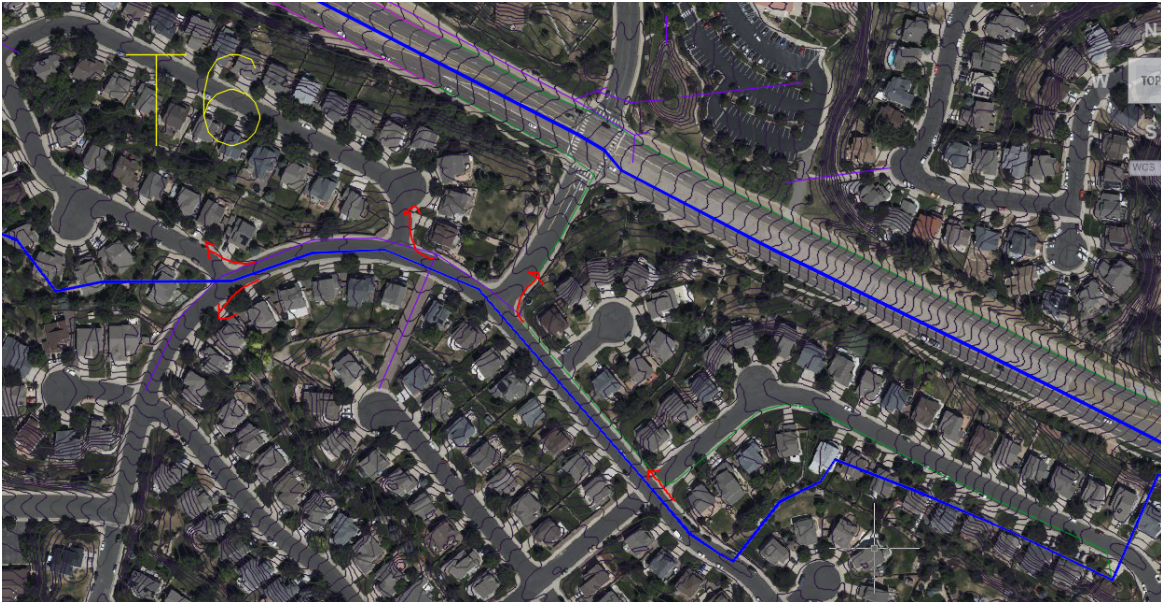
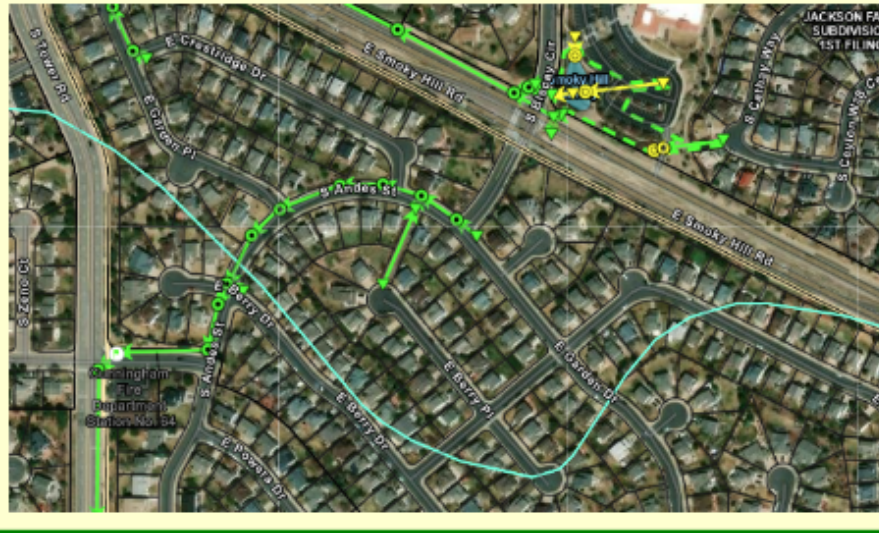
- d) Subbasin boundary comments
 - i) Typically, boundaries assumed storm drains were clogged and followed contours. Adjust boundaries based on storm drain systems in select areas?





- E Smoky Hill Rd & S Richfield St:
 - It would be more conservative to include the pipe drainage area.
 - SEMSWA has concerns regarding leaving the area out and having more issues show up downstream.
 - SEMSWA and Aurora agree to include full area associated with the storm drain, including flows and overflows.

There is a pipe system within this roadway. It appears to direct flows to Piney Creek.

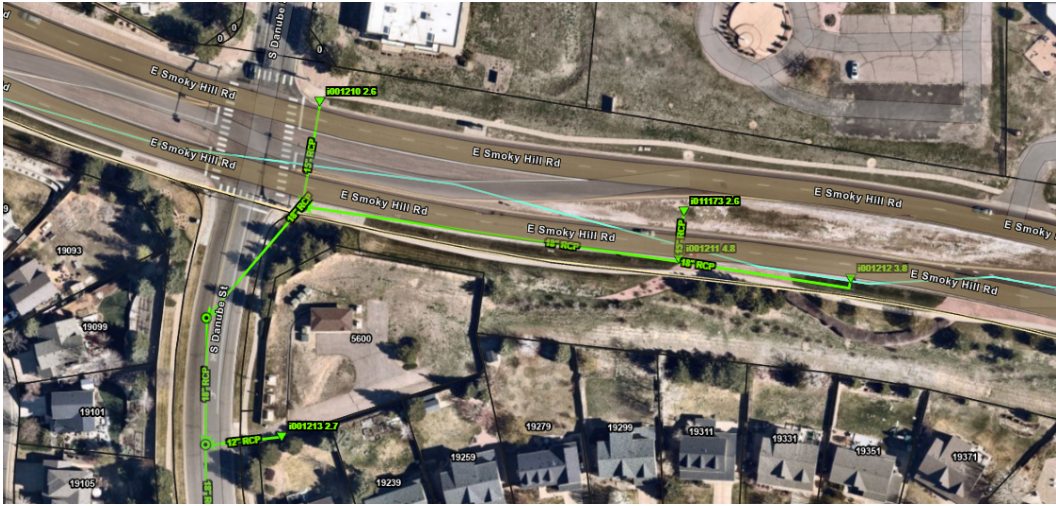


- E Smoky Hill Rd & S Biscay Cir:
 - Storm system flows to Piney Creek, overflows route to WTGC.
 - SEMSWA would like to keep any information regarding different stream drainage consistent.
 - SEMSWA agrees to keep the drainage area and subtract pipe capacity flows, include a map note and documentation regarding the split flow scenario.
 - Accounting for the orphan/overlap areas between Piney Creek and WTGC is not in scope for this study, but is something that will need considered as projects occur.

Double check basin boundary - there appears to be an inlet in this area which directs flows to the south, not north.



- E Smoky Hill Rd & Danube St:
 - Jurisdictional boundary between Arapahoe County and Centennial
 - Storm system flows to Piney Creek, overflows route to WTGC.
 - Arapahoe County storm system at interseciton has a 15” RCP that runs south and turns into an 18” pipe (see screenshot provided by Tarah below)
 - Olsson will use the same plan as Smoky Hill & Biscay- keep tributary area in WTGC Tribs model and remove 18” pipe capacity from the model, include documentation.



- 2) Next steps
 - a) Submit final hydrology
 - b) Identify problem areas: scoping options
 - i) Review existing reports/studies
 - ii) Evaluate problem areas along tributaries from lens of the five elements
 - Hydrology – utilize baseline models
 - Hydraulics – 1D and/or 2D models
 - (a) **SEMSWA & Aurora agree on just a 1D model unless there is an area that makes more sense with 2D**
 - Geomorphology
 - Vegetation
 - Community Values
 - iii) Water quality?
 - iv) **Aurora**
 - On board with considering areas for additional water quality opportunities.
 - Would prefer an approach that outlines characteristics to look for and give a potential design solution.
 - Recommends the analysis doesn’t get too specific with solutions, rather if they are warranted in the future and possible opportunities to include the five elements.
 - v) **SEMSWA**
 - Since the area is already developed, look through areas and solutions with the assumption that nothing is changing unless there is a large issue. Incorporating very small WQ areas would be bonuses.
 - vi) **USAP? MHFD** is looking for one in a developed area.
 - Aurora and SEMSWA don’t think this is the right area to apply one.
 - Likely wouldn’t be much value in this system since it is all piped and could only incorporate smaller, realistic scenarios.
 - vii) **Public Outreach:**
 - SEMSWA will coordinate about any information they have from homeowners or HOA’s regarding problem areas.
 - Public outreach normally occurs after identifying problem areas and some alternatives to then have information to share while getting more information from the public.
 - MHFD have an outreach requirement for MDPs, Olsson will follow up with MHFD about public outreach/public meeting.
 - Aurora has a PIO team for consistency on how they do the outreach, SEMSWA agrees to utilize Auora’s planning process.
 - Aurora can put Olsson in contact with their PIO team after MHFD coordination.
 - Developing the public outreach strategy will start now, to allow time to coordinate formal outreach processes and not delay the study.
 - c) Alternatives analysis
 - i) Scope now, or after problem areas are identified and reviewed?
 - **Alternatives analysis will be scoped at a later date, after the problems are identified.**

- 3) Deliverables
 - a) PDF

- i) **Combined PDF deliverable**
 - **Olsson will adjust the interactive map to include file links for static maps.**
 - **SEMSWA:**
 - (a) **Prefers to keep the pdf as concise as possible and not repeat the same information throughout the document.**
 - (b) **Is open to having a separate meeting to discuss their checklist and which items can be removed.**
 - (c) **Prefers not to follow full checklist of PDF studies. Potential to utilize the MHFD memo template as a guide for the report text.**
 - (i) **Olsson will coordinate with MHFD regarding the template and wait for a final formatting decision before starting on the report.**
 - **Aurora:**
 - (a) **Will likely ask Olsson to populate an alternatives spreadsheet as a part of the final deliverable.**
 - (b) **Spreadsheet is currently in development; Aurora will share content that they will be looking for as a deliverable.**
- b) **Data information/format**
- c) **GIS files**
 - i) **Olsson will meet MHFD Confluence standards for GIS files.**

4. Other:

- **Once the scope is finalized, Olsson can start on the hydraulic analysis while final hydrology is being reviewed.**

Action Items:

Aurora:

- **Send Olsson the content that they will be looking for as part of their alternative's spreadsheet – *Completed***

SEMSWA:

- **Send Olsson any public comments about problem areas that they have received.**

Olsson:

- **Finalize hydrology**
- **Submit problem areas scope and fee, include line item for outreach in the scope.**
- **Coordinate with MHFD about a memo template.**
- **Coordinate with MHFD and Aurora regarding public outreach planning.**

Please contact Olsson at 303-237-2072 with changes or questions regarding these meeting minutes. These minutes will be considered final unless comments are received within seven days of distribution. Although comments will be incorporated, as appropriate, only major revisions will be redistributed.

Minutes prepared by: Kiersten Rasmussen

cc: Attendees, File

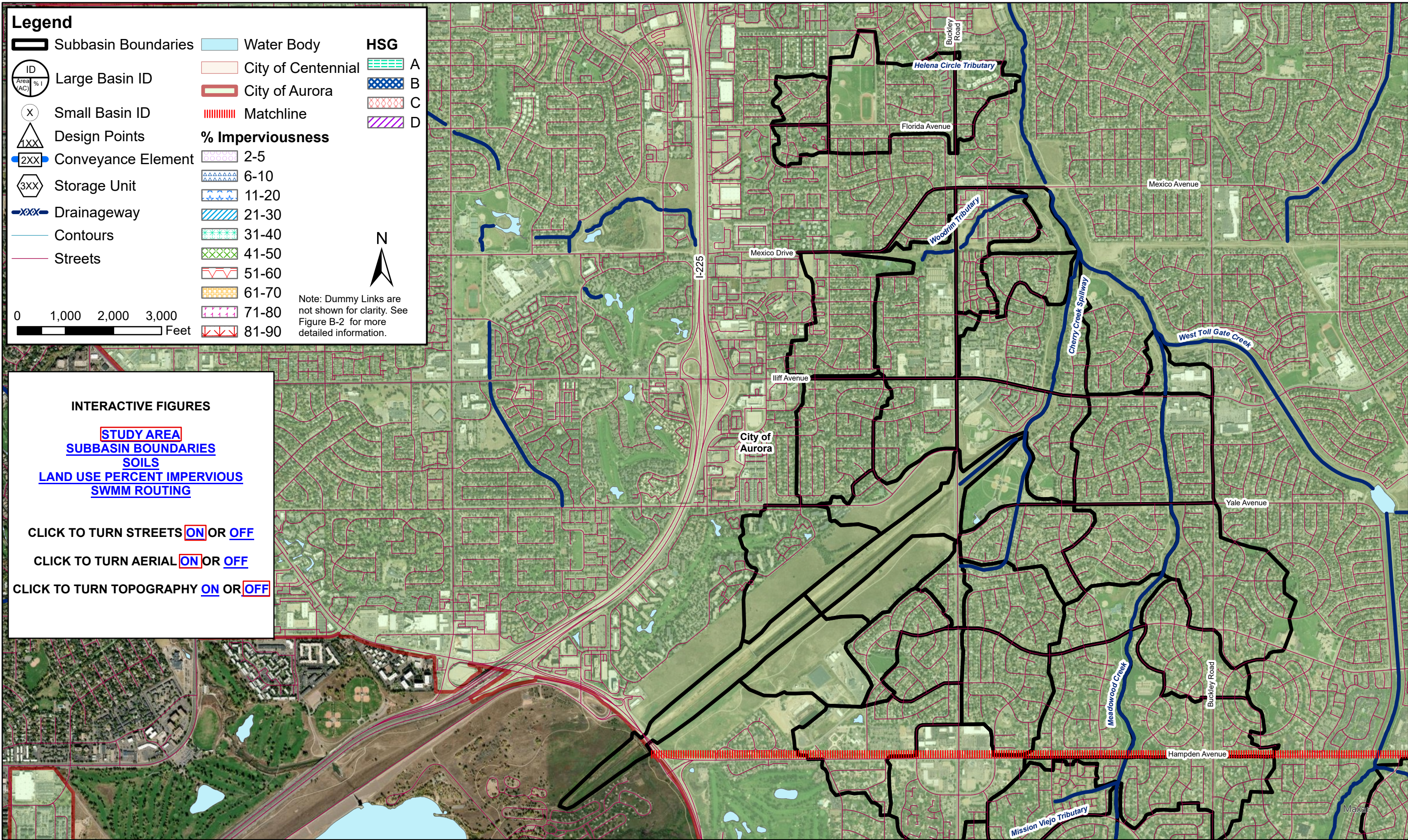
WEST TOLL GATE CREEK TRIBUTARIES

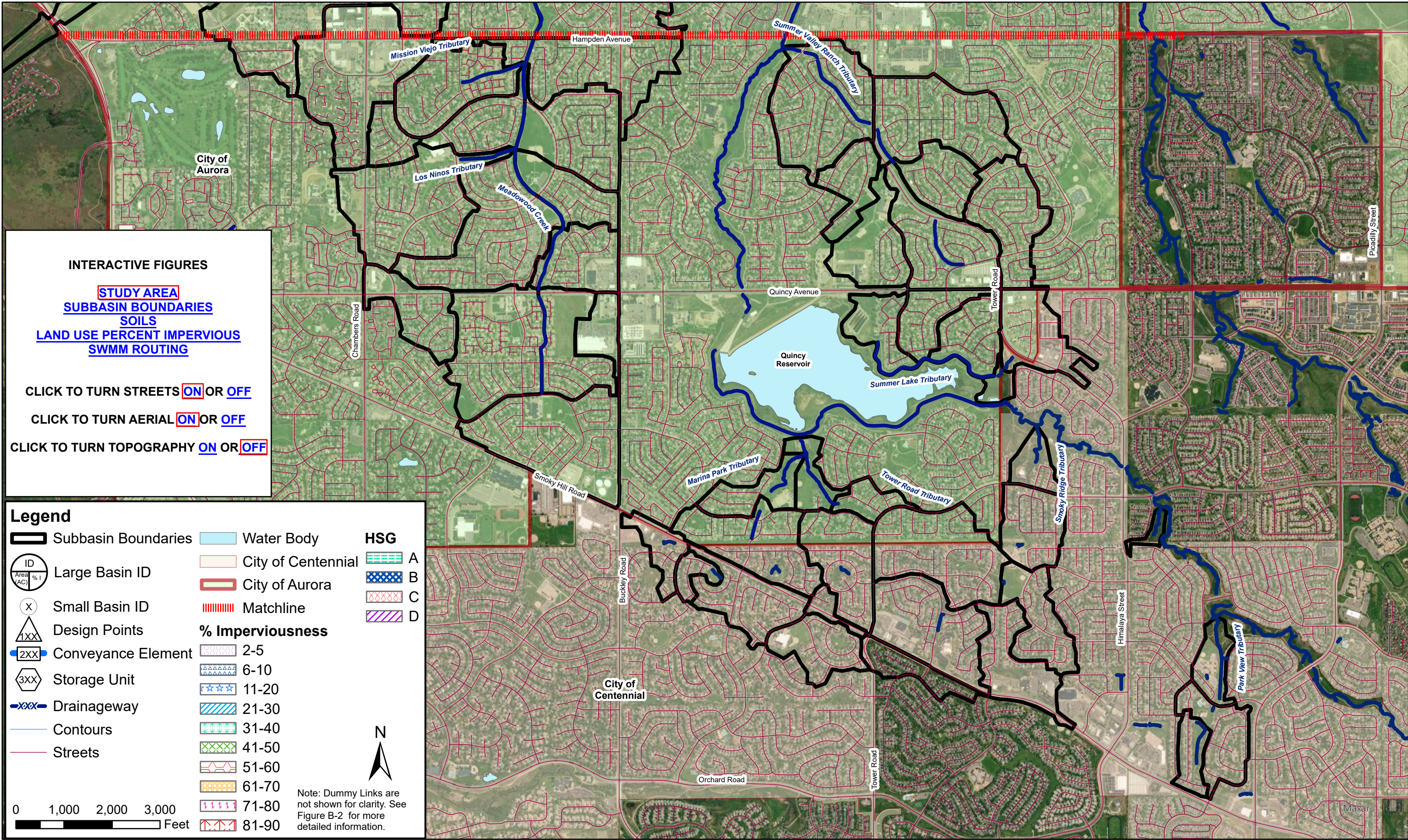
Major Drainageway Plan

APPENDIX B

HYDROLOGIC ANALYSIS







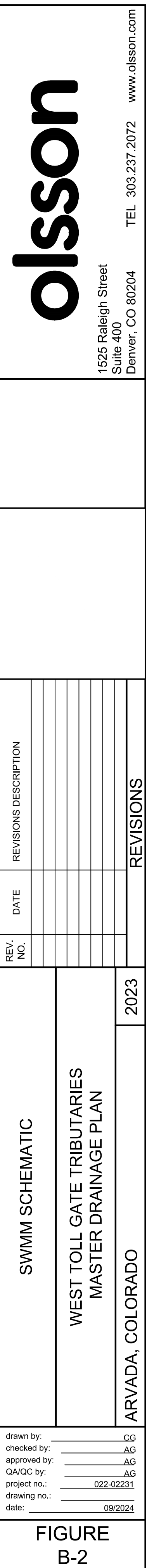


Table B-1 - Unadjusted Rainfall Distributions

1Hr Depth	0.870
Return Period	2
Time	Depth
0:05	0.0174
0:10	0.0348
0:15	0.0731
0:20	0.1392
0:25	0.2175
0:30	0.1218
0:35	0.0548
0:40	0.0435
0:45	0.0261
0:50	0.0261
0:55	0.0261
1:00	0.0261
1:05	0.0261
1:10	0.0174
1:15	0.0174
1:20	0.0174
1:25	0.0174
1:30	0.0174
1:35	0.0174
1:40	0.0174
1:45	0.0174
1:50	0.0174
1:55	0.0087
2:00	0.0087

1Hr Depth	1.14
Return Period	5
Time	Depth
0:05	0.0228
0:10	0.0422
0:15	0.0992
0:20	0.1744
0:25	0.2850
0:30	0.1482
0:35	0.0661
0:40	0.0502
0:45	0.0410
0:50	0.0410
0:55	0.0342
1:00	0.0342
1:05	0.0342
1:10	0.0342
1:15	0.0285
1:20	0.0251
1:25	0.0251
1:30	0.0251
1:35	0.0251
1:40	0.0171
1:45	0.0171
1:50	0.0171
1:55	0.0171
2:00	0.0148

1Hr Depth	1.39
Return Period	10
Time	Depth
0:05	0.0278
0:10	0.0514
0:15	0.1140
0:20	0.2085
0:25	0.3475
0:30	0.1668
0:35	0.0778
0:40	0.0598
0:45	0.0528
0:50	0.0445
0:55	0.0445
1:00	0.0445
1:05	0.0445
1:10	0.0445
1:15	0.0445
1:20	0.0348
1:25	0.0264
1:30	0.0264
1:35	0.0264
1:40	0.0264
1:45	0.0264
1:50	0.0264
1:55	0.0236
2:00	0.0181

1Hr Depth	1.77
Return Period	25
Time	Depth
0:05	0.0230
0:10	0.0619
0:15	0.0885
0:20	0.1416
0:25	0.2655
0:30	0.4425
0:35	0.2124
0:40	0.1416
0:45	0.0885
0:50	0.0885
0:55	0.0566
1:00	0.0566
1:05	0.0566
1:10	0.0425
1:15	0.0425
1:20	0.0319
1:25	0.0319
1:30	0.0248
1:35	0.0248
1:40	0.0248
1:45	0.0248
1:50	0.0248
1:55	0.0248
2:00	0.0248

1Hr Depth	2.08
Return Period	50
Time	Depth
0:05	0.0270
0:10	0.0728
0:15	0.1040
0:20	0.1664
0:25	0.3120
0:30	0.5200
0:35	0.2496
0:40	0.1664
0:45	0.1040
0:50	0.1040
0:55	0.0666
1:00	0.0666
1:05	0.0666
1:10	0.0499
1:15	0.0499
1:20	0.0374
1:25	0.0374
1:30	0.0291
1:35	0.0291
1:40	0.0291
1:45	0.0291
1:50	0.0291
1:55	0.0291
2:00	0.0291

1Hr Depth	2.41
Return Period	100
Time	Depth
0:05	0.0241
0:10	0.0723
0:15	0.1109
0:20	0.1928
0:25	0.3374
0:30	0.6025
0:35	0.3374
0:40	0.1928
0:45	0.1494
0:50	0.1205
0:55	0.0964
1:00	0.0964
1:05	0.0964
1:10	0.0482
1:15	0.0482
1:20	0.0289
1:25	0.0289
1:30	0.0289
1:35	0.0289
1:40	0.0289
1:45	0.0289
1:50	0.0289
1:55	0.0289
2:00	0.0289

1Hr Depth	3.28
Return Period	500
Time	Depth
0:05	0.0328
0:10	0.0984
0:15	0.1509
0:20	0.2624
0:25	0.4592
0:30	0.8200
0:35	0.4592
0:40	0.2624
0:45	0.2034
0:50	0.1640
0:55	0.1312
1:00	0.1312
1:05	0.1312
1:10	0.0656
1:15	0.0656
1:20	0.0394
1:25	0.0394
1:30	0.0394
1:35	0.0394
1:40	0.0394
1:45	0.0394
1:50	0.0394
1:55	0.0394
2:00	0.0394

Table B-2 - Detention Basin Stage-Storage-Discharge Information

Design Point SL305 - Summer Lake Tributary (Pond 1)	
Storage (ac-ft)	Discharge (cfs)
0	0
0.1	3
0.2	5
0.6	6
1.3	7
2.2	8
2.7	9
3.2	9
4.9	24
5.5	43
5.7	500

Values from *West Toll Gate Creek Major Drainageway Plan (2012)* - Outlet O_QRET_805

Design Point T301 - Tower Road Tributary (Meadow Point Pond)	
Storage (ac-ft)	Discharge (cfs)
0	0
3.8	30
12.1	80
23.7	130
37.8	4125
54.5	11398

Values from *West Toll Gate Creek Major Drainageway Plan (2012)* - Outlet O_QRET_802

Design Point T308- Tower Road Tributary (Smokey Ridge Pond)	
Storage (ac-ft)	Discharge (cfs)
0	0
0.12	9.9
1.3	14.3
3.3	18
4.3	40.5
5.6	64
6.5	69
6.6	100

Values from *West Toll Gate Creek Major Drainageway Plan (2012)* - Outlet O_QRET_809

Table B-3 - Diversion Flows to Piney Creek: Existing Pipe Capacity

Design Point	Type	No. of Barrels	Dia. (in)	Hyd. Radius (in)	n	Slope (ft/ft)	Pipe Capacity (cfs)
T106	RCP	1	24	6	0.015	0.016	25
T107	RCP	1	18	4.50	0.015	0.040	18

Rating Curve - Design Point T106

Total Flow (cfs)	Pipe Flow (cfs)	Overflow (cfs)
0	0	0
25	12.5	12.5
50	25	25
500	25	475

Rating Curve - Design Point T107

Total Flow (cfs)	Pipe Flow (cfs)	Overflow (cfs)
0	0	0
18	9	9
36	18	18
500	18	482

WEST TOLL GATE CREEK TRIBUTARIES

Major Drainageway Plan

CUHP INPUT TABLE

CUHP SUBCATCHMENTS

								Maximum Depression Storage (Watershed inches)		Horton's Infiltration Parameters			DCIA
Subcatchment Name	EPA SWMM Target Node	Raingage	Area (ft²)	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)	Level 0, 1, or 2
HC1	HC101	Rainfall	1262297	991	2611	0.0157	58.03	0.35	0.08	3.0000	0.00180	0.500	0
HC2	HC102	Rainfall	4904793	2010	3502	0.0166	50.74	0.35	0.08	3.0003	0.00180	0.500	0
HC3	HC103	Rainfall	1067353	788	1434	0.0133	56.86	0.35	0.07	4.5346	0.00157	0.679	0
HC4	HC104	Rainfall	780766	755	1546	0.0055	59.04	0.35	0.07	4.2161	0.00177	0.590	0
W1	W101	Rainfall	1053402	1872	2985	0.0087	20.32	0.39	0.09	3.0000	0.00180	0.500	0
W2	W102	Rainfall	1620871	1437	2507	0.0157	44.85	0.37	0.08	3.1349	0.00179	0.511	0
W3	W103	Rainfall	2793204	1505	3327	0.0109	70.36	0.35	0.08	3.1111	0.00180	0.507	0
W4	W104	Rainfall	1021730	936	2129	0.0122	57.32	0.35	0.07	3.4455	0.00180	0.530	0
W5	W105	Rainfall	216921	338	1327	0.0133	75.33	0.35	0.09	4.3407	0.00180	0.589	0
W6	W106	Rainfall	4526800	1439	3955	0.0128	57.83	0.36	0.08	4.0204	0.00180	0.568	0
W7	W107	Rainfall	4067005	1742	4200	0.0119	54.57	0.36	0.08	4.3592	0.00161	0.653	0
W8	W108	Rainfall	91636	623	1566	0.0116	84.14	0.35	0.1	4.6158	0.00155	0.693	0
C1	C101	Rainfall	4724751	2343	4909	0.0103	50.10	0.37	0.08	3.9867	0.00164	0.620	0
C2	C102	Rainfall	2090637	1242	2682	0.0167	47.34	0.37	0.08	3.6980	0.00146	0.660	0
C3	C103	Rainfall	2333691	880	2677	0.0114	53.85	0.37	0.09	4.6006	0.00133	0.764	0
C4	C104	Rainfall	2892885	1562	3366	0.0104	57.23	0.35	0.08	4.6776	0.00141	0.742	0
C5	C105	Rainfall	4007617	2276	3755	0.0129	54.87	0.35	0.07	4.9038	0.00091	0.923	0
C6	C106	Rainfall	1599639	1283	2619	0.0107	32.77	0.37	0.1	4.9456	0.00081	0.960	0
C7	C107	Rainfall	2806954	3178	5949	0.0010	10.51	0.4	0.1	3.3415	0.00166	0.571	0
C8	C108	Rainfall	3047923	3037	6796	0.0004	6.05	0.4	0.1	3.0229	0.00179	0.506	0
C9	C109	Rainfall	2225515	1595	3248	0.0197	27.86	0.39	0.09	4.8576	0.00085	0.941	0
C10	C110	Rainfall	4300731	1633	2551	0.0109	27.72	0.38	0.09	4.5379	0.00139	0.741	0
C11	C111	Rainfall	3225578	1589	3232	0.0103	51.90	0.35	0.07	4.7777	0.00119	0.822	0
C12	C112	Rainfall	3053873	1005	2976	0.0135	50.34	0.35	0.07	4.5000	0.00180	0.600	0
C13	C113	Rainfall	892870	592	1658	0.0110	56.40	0.35	0.07	4.5163	0.00176	0.613	0
C14	C114	Rainfall	2083016	1210	3010	0.0130	7.83	0.4	0.09	4.2111	0.00166	0.626	0
C15	C115	Rainfall	3161784	1489	3104	0.0067	28.67	0.39	0.1	4.2981	0.00179	0.590	0
C16	C116	Rainfall	2069144	1208	3394	0.0146	52.84	0.35	0.07	4.4682	0.00180	0.598	0
C17	C117	Rainfall	1799951	1480	2596	0.0116	54.51	0.35	0.07	4.4998	0.00180	0.600	0
C18	C118	Rainfall	4442857	2963	4993	0.0094	56.17	0.35	0.08	4.6324	0.00151	0.706	0
C19	C119	Rainfall	5562889	1434	4103	0.0154	71.76	0.35	0.08	4.6403	0.00149	0.712	0
C20	C120	Rainfall	3749615	1334	3156	0.0096	53.05	0.35	0.07	4.5263	0.00174	0.621	0
MC1	MC101	Rainfall	1081361	947	2386	0.0084	55.09	0.38	0.1	3.0743	0.00177	0.514	0
MC2	MC102	Rainfall	4169830	2251	3792	0.0155	53.54	0.35	0.07	3.4037	0.00180	0.527	0
MC3	MC103	Rainfall	2227422	1244	3214	0.0056	62.82	0.35	0.08	3.3969	0.00158	0.599	0
MC4	MC104	Rainfall	3158723	1433	3086	0.0126	49.64	0.36	0.07	4.2122	0.00180	0.582	0
MC5	MC105	Rainfall	5561641	2366	4758	0.0135	53.44	0.36	0.07	4.9933	0.00071	0.995	0
MC6	MC106	Rainfall	3241824	1507	4127	0.0121	55.44	0.35	0.07	4.9996	0.00070	1.000	0
MC7	MC107	Rainfall	2047611	1646	3301	0.0136	43.26	0.36	0.08	4.5127	0.00177	0.610	0
MC8	MC108	Rainfall	3992537	1584	4880	0.0100	49.80	0.37	0.07	4.2576	0.00157	0.660	0
MC9	MC109	Rainfall	4143915	2634	5635	0.0073	52.57	0.37	0.08	4.6064	0.00149	0.711	0
MC10	MC110	Rainfall	501942	786	2264	0.0163	61.76	0.35	0.08	4.5000	0.00180	0.600	0
MC11	MC111	Rainfall	3668805	2576	3982	0.0096	57.86	0.35	0.07	4.5672	0.00165	0.654	0
MC12	MC112	Rainfall	1847030	2242	3792	0.0070	57.21	0.35	0.07	4.5000	0.00180	0.600	0
MC13	MC113	Rainfall	975403	830	1675	0.0127	57.35	0.35	0.07	4.5000	0.00180	0.600	0
MC14	MC114	Rainfall	3408782	1699	3852	0.0065	54.01	0.35	0.08	4.6376	0.00150	0.710	0
MC15	MC115	Rainfall	5084672	2707	5467	0.0118	58.92	0.35	0.07	4.7691	0.00121	0.815	0
MC16	MC116	Rainfall	1856756	2146	3640	0.0083	52.27	0.35	0.08	4.7103	0.00134	0.768	0
MC17	MC117	Rainfall	2137883	851	2624	0.0069	61.57	0.35	0.08	3.5899	0.00148	0.647	0
MC18	MC118	Rainfall	1058618	794	2131	0.0184	80.67	0.35	0.1	3.2332	0.00180	0.516	0
MC19	MC119	Rainfall	2354890	2077	3520	0.0095	46.73	0.35	0.07	3.5769	0.00180	0.538	0
MC20	MC120	Rainfall	4445128	1625	4052	0.0112	55.33	0.35	0.08	4.5980	0.00142	0.735	0

CUHP SUBCATCHMENTS

								Maximum Depression Storage (Watershed inches)		Horton's Infiltration Parameters			DCIA
Subcatchment Name	EPA SWMM Target Node	Raingage	Area (ft²)	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)	Level 0, 1, or 2
MC21	MC121	Rainfall	2063274	842	2012	0.0075	61.98	0.35	0.08	4.9758	0.00075	0.981	0
MC22	MC122	Rainfall	5150094	1906	3929	0.0163	52.40	0.35	0.08	4.5000	0.00180	0.600	0
MV1	MV101	Rainfall	3230515	1617	3278	0.0130	58.93	0.35	0.07	4.5084	0.00178	0.607	0
LN1	LN101	Rainfall	5351940	3119	4898	0.0152	54.21	0.36	0.08	4.7072	0.00134	0.766	0
SV1	SV101	Rainfall	4697999	2022	3690	0.0138	53.04	0.35	0.07	3.8466	0.00144	0.677	0
SV2	SV102	Rainfall	1506012	1110	2586	0.0177	49.30	0.36	0.08	3.0000	0.00180	0.500	0
SV3	SV103	Rainfall	4215088	1328	3447	0.0302	55.48	0.35	0.07	3.0000	0.00180	0.500	0
SV4	SV104	Rainfall	1737962	1245	2368	0.0165	52.17	0.35	0.07	3.0000	0.00180	0.500	0
SV5	SV105	Rainfall	2831558	912	3277	0.0194	57.60	0.35	0.07	3.0000	0.00180	0.500	0
SV6	SV106	Rainfall	3383892	1824	3832	0.0234	59.62	0.36	0.08	3.0000	0.00180	0.500	0
SV7	SV107	Rainfall	2299081	1501	2761	0.0235	42.41	0.38	0.09	3.0000	0.00180	0.500	0
SL1	SL101	Rainfall	432600	478	1203	0.0153	13.32	0.4	0.08	3.0000	0.00180	0.500	0
SL2	SL102	Rainfall	1754962	1692	3042	0.0144	47.93	0.36	0.07	3.0000	0.00180	0.500	0
SL3	SL103	Rainfall	1457776	1071	3016	0.0114	55.25	0.35	0.07	3.0000	0.00180	0.500	0
SL4	SL104	Rainfall	1485485	1827	3070	0.0066	44.63	0.37	0.08	3.0000	0.00180	0.500	0
SL5	SL105	Rainfall	2240726	798	2696	0.0155	64.12	0.35	0.08	3.0000	0.00180	0.500	0
MP1	MP101	Rainfall	1413128	1495	3100	0.0132	43.29	0.37	0.08	4.5404	0.00157	0.679	0
MP2	MP102	Rainfall	3256496	724	2999	0.0154	50.27	0.36	0.07	4.5868	0.00161	0.669	0
MP3	MP103	Rainfall	2433441	627	2987	0.0101	53.50	0.35	0.07	4.5000	0.00180	0.600	0
MP4	MP104	Rainfall	552296	1091	1795	0.0050	50.47	0.35	0.07	4.5087	0.00178	0.607	0
MP5	MP105	Rainfall	990151	432	1414	0.0063	58.51	0.36	0.09	4.8415	0.00105	0.873	0
MP6	MP106	Rainfall	425741	460	1436	0.0140	56.64	0.35	0.08	4.5494	0.00169	0.639	0
MP7	MP107	Rainfall	1823597	865	2273	0.0146	50.30	0.36	0.08	4.5000	0.00180	0.600	0
T1	T101	Rainfall	996494	855	1770	0.0101	20.65	0.39	0.07	4.1979	0.00180	0.580	0
T2	T102	Rainfall	795962	648	2048	0.0174	52.74	0.36	0.07	4.5000	0.00180	0.600	0
T3	T103	Rainfall	2720442	1596	3307	0.0118	51.70	0.36	0.07	4.5770	0.00163	0.662	0
T4	T104	Rainfall	4148240	2201	4099	0.0095	53.90	0.36	0.07	4.4917	0.00180	0.601	0
T5	T105	Rainfall	3696735	2121	3888	0.0253	61.19	0.35	0.08	4.5459	0.00170	0.637	0
T6	T106	Rainfall	1155481	1160	3104	0.0194	54.99	0.35	0.07	4.5000	0.00180	0.600	0
T7	T107	Rainfall	2336550	1210	3864	0.0203	58.70	0.36	0.08	4.4546	0.00175	0.614	0
T8	T108	Rainfall	2088597	1146	2748	0.0213	48.21	0.35	0.07	4.4727	0.00180	0.598	0
SR1	SR101	Rainfall	873633	928	1926	0.0242	33.20	0.37	0.08	3.0000	0.00180	0.500	0
SR2	SR102	Rainfall	2000837	1151	2644	0.0205	49.11	0.35	0.08	3.2837	0.00180	0.519	0
H1	H101	Rainfall	258649	589	1547	0.0172	17.41	0.4	0.07	3.0000	0.00180	0.500	0
P1	P101	Rainfall	1018887	1061	2359	0.0210	38.79	0.37	0.09	3.0389	0.00180	0.503	0
P2	P102	Rainfall	1856719	625	2208	0.0225	51.17	0.35	0.07	3.1837	0.00180	0.512	0
P3	P103	Rainfall	886751	640	1789	0.0292	45.00	0.35	0.07	3.0261	0.00180	0.502	0

WEST TOLL GATE CREEK TRIBUTARIES

Major Drainageway Plan

EPA SWMM 5.2

INPUT PARAMETERS



WEST TOLL GATE CREEK TRIBUTARIES

Major Drainageway Plan

EPA SWMM 5.2

100-YEAR FUTURE CONDITIONS OUTPUT



Table B-4 - Baseline Peak Flows and Volumes

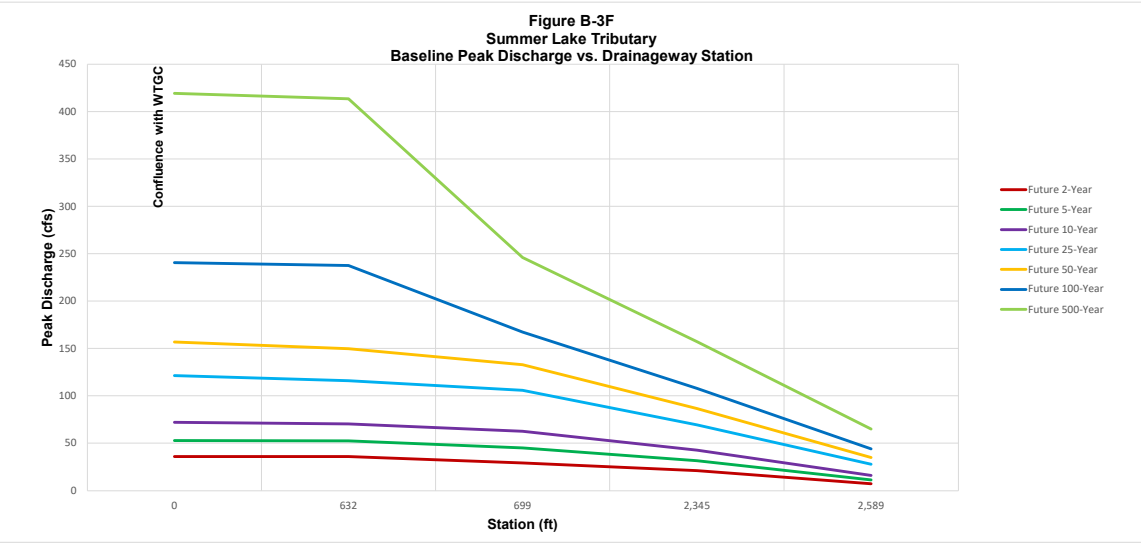
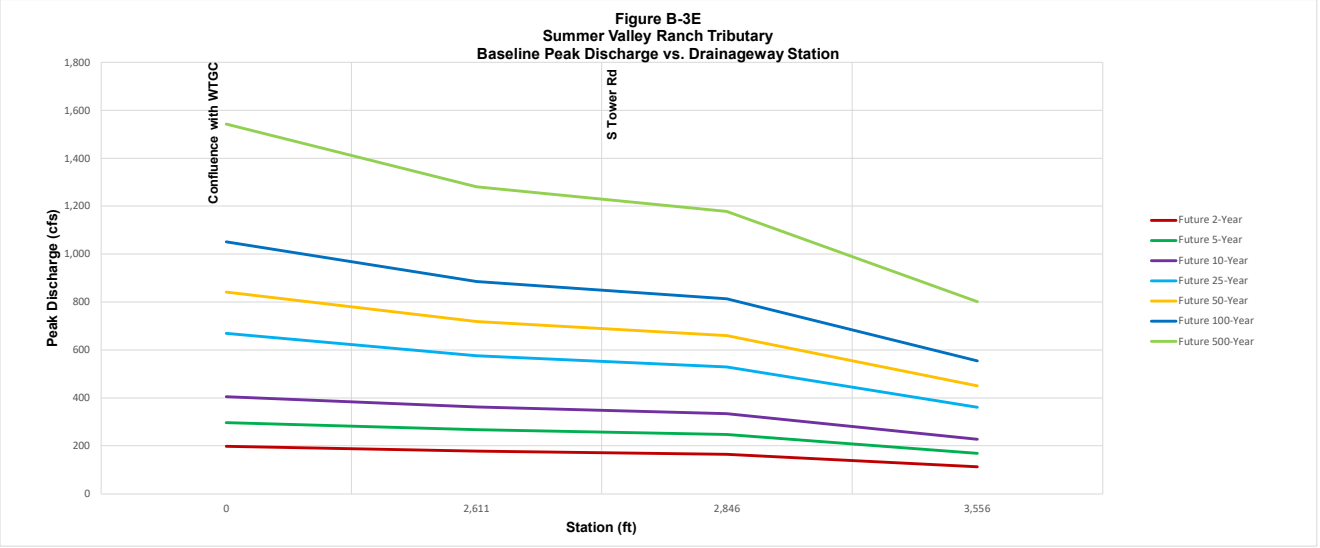
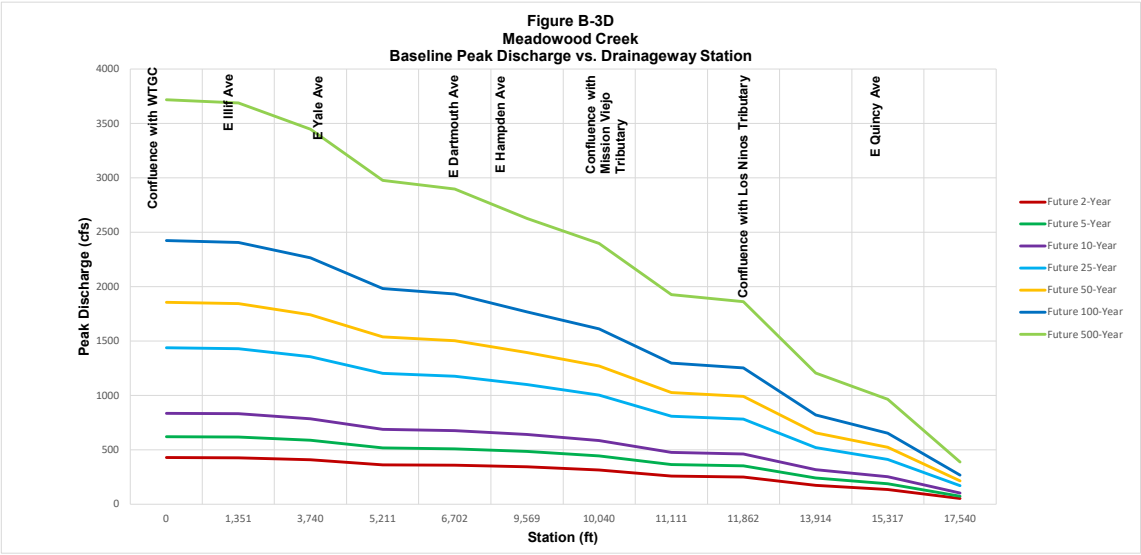
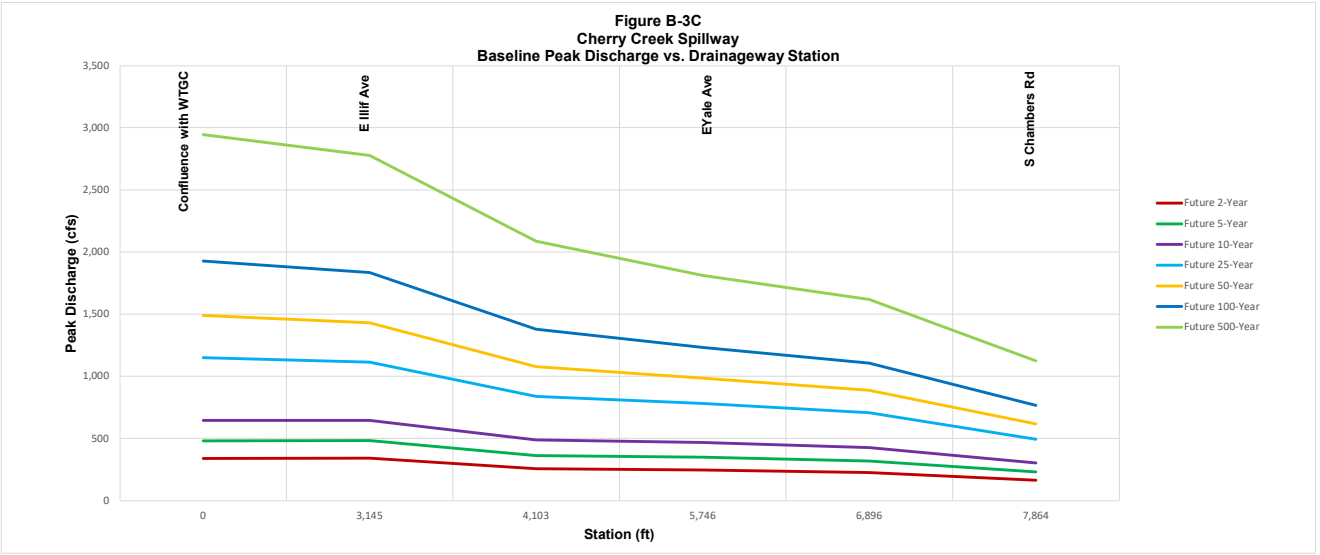
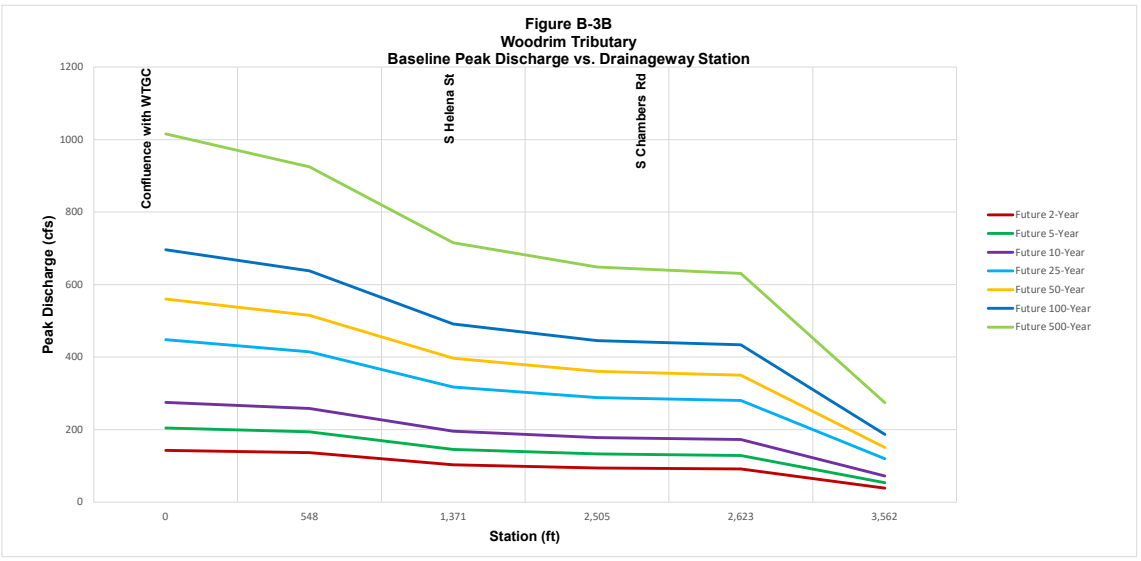
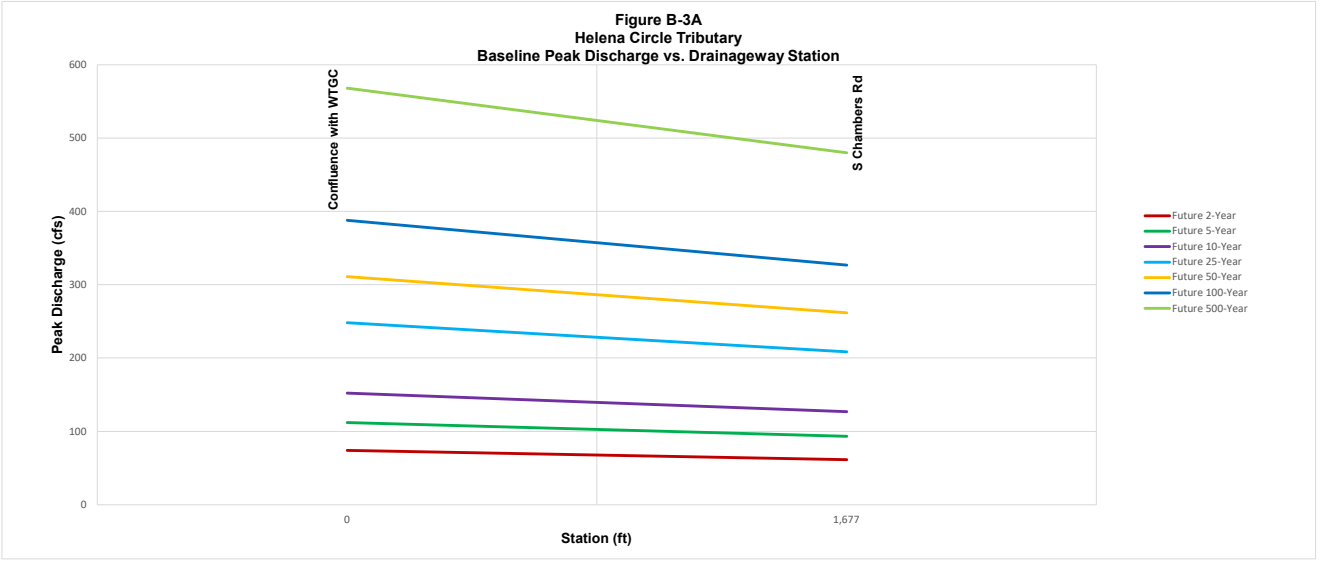
Drainagway	Design Point	Drainage Area (acres)	Drainage Area (sm)	Future Percent Imperviousness	Future Conditions Peak Flow (cfs)							Future Conditions Runoff Volume (acre-feet)						
					Q ₂	Q ₅	Q ₁₀	Q ₂₅	Q ₅₀	Q ₁₀₀	Q ₅₀₀	V ₂	V ₅	V ₁₀	V ₂₅	V ₅₀	V ₁₀₀	V ₅₀₀
Helena Circle Tributary	HC101	184	0.3	54	74	112	152	248	311	388	568	7	10	13	20	25	31	45
	HC102	155	0.2	53	62	93	127	209	262	327	480	6	8	11	17	21	26	37
	HC103	25	0.0	57	14	19	25	39	49	61	90	1	1	2	3	3	4	6
	HC104	18	0.0	59	8	12	15	25	30	37	54	1	1	1	2	2	3	4
Woodrim Tributary	W101	353	0.6	56	143	205	276	449	560	697	1,016	14	19	26	38	48	59	86
	W102	37	0.1	45	11	18	25	42	53	66	97	1	2	2	4	5	6	9
	W103	292	0.5	60	137	194	258	414	516	638	925	12	17	22	33	40	49	72
	W104T	228	0.4	57	103	146	196	318	397	492	715	9	12	16	24	30	37	55
	W104	23	0.0	57	11	16	21	33	41	50	73	1	1	2	3	3	4	6
	W105T	204	0.3	57	94	133	178	288	360	446	648	8	11	15	22	27	33	49
	W105	5	0.0	75	3	5	6	9	10	13	18	0	0	0	1	1	1	1
	W106	199	0.3	57	91	129	173	280	350	434	631	8	11	14	21	26	33	48
Cherry Creek Spillway	W107	93	0.1	55	39	54	73	120	151	188	275	3	5	6	9	12	15	22
	W108	2	0.0	84	1	1	2	2	3	3	5	0	0	0	0	0	0	1
	C101	1379	2.2	44	339	481	646	1,152	1,492	1,929	2,946	40	56	76	122	155	199	301
	C102T	1271	2.0	44	342	483	645	1,113	1,432	1,834	2,778	36	51	69	110	141	181	275
	C102	48	0.1	47	17	24	33	59	75	95	141	1	2	3	4	6	7	11
	C103	54	0.1	54	24	35	44	73	93	118	177	2	3	3	5	6	8	12
	C104	158	0.2	56	59	79	101	167	215	276	419	6	8	10	15	18	23	35
	C105	92	0.1	55	35	47	59	94	122	154	236	3	4	6	8	10	13	19
	C106T	1011	1.6	41	256	363	489	839	1,077	1,378	2,086	27	38	52	86	111	143	218
	C106	37	0.1	33	4	6	8	15	22	32	55	1	1	1	2	2	3	6
	C107	64	0.1	11	1	1	4	11	15	21	35	0	1	1	4	5	7	12
	C108	70	0.1	6	0	1	4	10	14	20	32	0	1	2	4	6	8	13
	C109	150	0.2	28	13	21	29	73	107	151	256	2	3	4	8	12	16	27
	C110	99	0.2	28	13	20	26	66	92	125	201	1	2	3	6	8	11	19
	C111	690	1.1	51	247	348	467	782	984	1,232	1,813	24	33	44	68	85	107	159
	C112	616	1.0	51	225	317	427	707	886	1,105	1,618	21	29	40	61	77	96	143
	C113	459	0.7	51	166	231	304	495	618	768	1,125	16	22	29	45	57	72	106
	C114	120	0.2	20	6	11	20	52	74	107	177	2	2	4	8	11	15	24
	C115	73	0.1	29	9	13	22	48	64	85	130	1	2	3	5	7	10	15
	C116T	319	0.5	62	157	218	283	448	556	684	989	13	18	24	35	43	53	77
Meadowood Creek	C116	48	0.1	53	19	27	38	62	78	96	140	2	2	3	5	6	8	11
	C117	271	0.4	63	140	193	248	388	481	591	852	12	16	21	30	37	45	66
	C118	230	0.4	65	128	174	220	340	419	514	739	10	14	18	26	32	39	56
	C119	128	0.2	72	98	134	169	249	305	370	530	6	9	11	15	19	23	32
	C120	86	0.1	53	39	55	75	124	156	194	282	3	4	6	9	11	14	20
	MC101	1670	2.6	55	428	621	836	1,438	1,856	2,424	3,719	63	87	113	167	209	261	387
	MC102T	1646	2.6	55	427	617	830	1,429	1,844	2,406	3,687	62	85	111	164	206	256	381
	MC102	96	0.1	54	41	61	82	130	162	199	288	4	5	7	10	13	16	23
	MC103	51	0.1	63	24	34	44	69	85	104	149	2	3	4	6	7	9	13
	MC104T	1499	2.3	55	409	587	783	1,354	1,741	2,263	3,447	56	76	100	148	185	231	344
	MC104	73	0.1	50	29	42	58	98	123	153	224	2	3	5	7	9	11	17
	MC105	128	0.2	53	47	61	76	113	150	195	305	4	6	7	10	13	16	25
	MC106	74	0.1	55	30	38	48	71	94	122	189	3	4	4	6	8	10	15
	MC107	1224	1.9	55	362	516	688	1,202	1,538	1,981	2,976	46	64	83	124	155	194	285
	MC108T	1177	1.8	56	357	508	675	1,177	1,503	1,932	2,896	44	62	80	120	150	187	275
	MC108	92	0.1	50	31	43	58	101	128	162	239	3	4	6	9	11	14	21
	MC109	95	0.1	53	26	36	46	82	104	133	197	3	5	6	9	11	14	22
	MC110T	990	1.5	56	342	485	640	1,098	1,393	1,766	2,626	38	52	68	101	126	157	231
	MC110	12	0.0	62	5	7	9	15	18	22	32	0	1	1	1	2	2	3
	MC111	84	0.1	58	32	44	58	96	120	149	217	3	5	6	9	11	14	20
	MC112T	895	1.4	56	313	443	585	1,001	1,270	1,610	2,395	34	47	61	91	114	141	208
	MC112	42	0.1	57	13	18	24	39	49	61	88	2	2	3	5	6	7	10
	MC113T	700	1.1	56	258	363	477	809	1,026	1,297	1,926	26	37	47	71	88	110	162
	MC113	22	0.0	57	11	16	22	34	42	52	75	1	1	2	2	3	4	5
	MC114	78	0.1	54	27	38	50	85	108	136	200	3	4	5	8	10	12	18
	MC115T	677	1.1	56	250	352	461	782	991	1,253	1,860	25	35	46	68	85	106	157
	MC115	117	0.2	59	45	61	76	127	159	201	298	5	6	8	12	14	18	27
	MC116	43	0.1	52	11	15	19	34	44	56	84	1	2	3	4	5	6	9
	MC117	395	0.6	56	171	240	318	521	655	820	1,205	15	21	28	41	51	63	93
	MC118	24	0.0	81	21	29	36	51	61	74	103	1	2	2	3	4	5	7
	MC119T	322	0.5	54	135	189	251	412	521	652	964	12	16	21	32	40	50	74
	MC119	54	0.1	47	15	22	30	52	65	81	120	2	3	3	5	7	9	13
	MC120	102	0.2	55	45	62	80	135	171	213	315	4	5	7	10	13	16	23
	MC121	47	0.1	62	28	37	46	66	85	108	163	2	3	3	4	5	7	10
	MC122	118	0.2	52	53	75	104	171	215	267	388	4	6	8	12	15	19	28

Table B-4 - Baseline Peak Flows and Volumes

Drainagway	Design Point	Drainage Area (acres)	Drainage Area (sm)	Future Percent Imperviousness	Future Conditions Peak Flow (cfs)							Future Conditions Runoff Volume (acre-feet)						
					Q ₂	Q ₅	Q ₁₀	Q ₂₅	Q ₅₀	Q ₁₀₀	Q ₅₀₀	V ₂	V ₅	V ₁₀	V ₂₅	V ₅₀	V ₁₀₀	V ₅₀₀
Mission Viejo Tributary	MV101	74	0.1	59	38	52	70	111	137	169	244	3	4	6	8	10	12	18
Los Ninos Tributary	LN101	123	0.2	54	42	59	74	129	164	208	310	4	6	8	12	15	19	28
Summer Valley Tributary	SV101	475	0.7	54	199	297	405	670	842	1,051	1,543	18	26	34	51	64	79	115
	SV102T	367	0.6	54	178	267	362	575	718	885	1,281	14	20	27	40	50	61	90
	SV102	35	0.1	49	14	21	29	46	58	72	104	1	2	2	4	5	6	8
	SV103	332	0.5	54	165	247	334	529	660	814	1,177	12	18	25	37	45	56	81
	SV104T	235	0.4	54	113	168	228	362	451	555	802	9	13	17	26	32	39	57
	SV104	40	0.1	52	18	27	36	58	72	88	128	1	2	3	4	5	7	10
	SV105	65	0.1	58	41	60	80	120	149	183	262	3	4	5	7	9	11	16
	SV106	78	0.1	60	42	61	80	124	153	186	267	3	5	6	9	11	13	19
Summer Lake Tributary	SV107	53	0.1	42	17	26	38	65	83	103	152	1	2	3	5	6	8	12
	SL101	169	0.3	52	36	53	72	121	157	241	419	6	9	12	18	23	28	41
	SL102T	159	0.2	54	36	52	70	116	150	237	413	6	9	12	17	22	27	39
	SL102	108	0.2	49	29	45	62	106	133	167	246	4	5	8	11	14	18	26
	SL103	68	0.1	50	21	31	43	69	86	108	157	2	3	5	7	9	11	16
	SL104	34	0.1	45	7	11	16	28	35	44	65	1	2	2	3	4	5	8
	SL105O	51	0.1	64	7	8	9	19	31	82	177	2	3	4	6	8	9	13
	SL305	51	0.1	64	38	54	71	103	127	155	220	2	3	4	6	8	9	13
Marina Park Tributary	SL105	51	0.1	64	38	54	71	103	127	155	220	2	3	4	6	8	9	13
	MP101	250	0.4	51	91	130	181	321	412	525	787	9	12	16	24	31	39	57
	MP102	218	0.3	52	88	125	174	302	386	490	732	8	11	14	22	27	34	50
	MP103	143	0.2	53	60	84	116	195	249	314	467	5	7	10	14	18	22	33
	MP104	13	0.0	50	3	5	6	11	14	17	25	0	1	1	1	2	2	3
	MP105	23	0.0	59	13	18	22	34	44	56	84	1	1	1	2	3	3	5
	MP106	10	0.0	57	5	7	9	14	18	22	32	0	1	1	1	1	2	2
Tower Road Tributary	MP107	42	0.1	50	19	27	38	61	77	97	142	1	2	3	4	5	7	10
	T101O	662	1.0	52	75	97	124	513	744	1,031	1,643	22	31	41	63	79	100	149
	T301	662	1.0	52	212	298	411	716	911	1,155	1,728	22	31	41	63	80	100	149
	T101	662	1.0	52	212	298	411	716	911	1,155	1,728	22	31	41	63	80	100	149
	T102	389	0.6	55	124	171	234	396	500	628	938	13	18	24	37	47	59	87
	T103	62	0.1	52	23	32	44	74	94	117	172	2	3	4	6	8	10	14
	T104	308	0.5	56	97	133	181	304	384	482	720	10	14	19	29	37	46	68
	T105	111	0.2	60	50	68	91	144	179	221	328	4	6	7	11	13	16	24
	T106O	27	0.0	55	5	7	10	16	20	25	25	0	1	1	1	2	2	3
	T106	27	0.0	55	10	15	20	32	41	50	73	1	1	2	3	3	4	6
	T107T	102	0.2	54	23	29	42	74	94	118	175	3	4	5	8	11	14	21
	T107O	54	0.1	59	13	18	18	18	18	18	18	1	1	2	2	2	2	3
	T107	54	0.1	59	27	37	49	79	98	121	175	2	3	4	6	7	9	13
	T108O	48	0.1	48	11	12	14	17	23	39	65	2	2	3	5	6	7	11
	T308	48	0.1	48	19	28	39	66	83	104	152	2	2	3	5	6	7	11
	T108	48	0.1	48	19	28	39	66	83	104	152	2	2	3	5	6	7	11
Smokey Ridge Tributary	SR101	66	0.1	44	22	35	50	84	106	132	195	2	3	4	7	8	10	15
	SR102	46	0.1	49	19	30	41	67	83	103	149	2	2	3	5	6	7	11
Himalaya Tributary	H101	6	0.01	17	0	1	1	3	4	5	8	0	0	0	0	1	1	1
Park View Tributary	P101	86	0.1	46	36	56	78	129	162	202	296	3	4	6	9	11	14	20
	P102	63	0.1	49	33	51	70	110	138	171	249	2	3	4	7	8	10	15
	P103	20	0.0	45	9	14	19	31	39	49	71	1	1	1	2	3	3	5

Table B-5 - Baseline Peak Flows and Volumes Along the Drainageways

Design Point	Location	Total Drainage Area (acres)	Total Drainage Area (mi ²)	Length (feet)	Future Peak Flows (cfs)							Future Runoff Volumes (acre-feet)						
					Q ₂	Q ₅	Q ₁₀	Q ₂₅	Q ₅₀	Q ₁₀₀	Q ₅₀₀	V ₂	V ₅	V ₁₀	V ₂₅	V ₅₀	V ₁₀₀	V ₅₀₀
Helena Circle Tributary																		
HC101	Confluence with WTGC	184	0.3	0	74	112	152	248	311	388	568	7	10	13	20	25	31	45
HC102	S Chambers Rd	155	0.2	1,677	62	93	127	209	262	327	480	6	8	11	17	21	26	37
Woodrim Tributary																		
W101	Confluence with WTGC	353	0.6	0	143	205	276	449	560	697	1,016	14	19	26	38	48	59	86
W103		292	0.5	548	137	194	258	414	516	638	925	12	17	22	33	40	49	72
W104T	S Helena Street	228	0.4	1,371	103	146	196	318	397	492	715	9	12	16	24	30	37	55
W105T	Downstream of S Chambers Rd	204	0.3	2,505	94	133	178	288	360	446	648	8	11	15	22	27	33	49
W106	Upstream of S Chambers Rd	199	0.3	2,623	91	129	173	280	350	434	631	8	11	14	21	26	33	48
W107		93	0.1	3,562	39	54	73	120	151	188	275	3	5	6	9	12	15	22
Cherry Creek Spillway																		
C101	Confluence with WTGC	1,379	2.2	0	339	481	646	1,152	1,492	1,929	2,946	40	56	76	122	155	199	301
C102T	E Illif Ave	1,271	2.0	3,145	342	483	645	1,113	1,432	1,834	2,778	36	51	69	110	141	181	275
C106T		1,011	1.6	4,103	256	363	489	839	1,077	1,378	2,086	27	38	52	86	111	143	218
C111	E Yale Ave	690	1.1	5,746	247	348	467	782	984	1,232	1,813	24	33	44	68	85	107	159
C112		616	1.0	6,896	225	317	427	707	886	1,105	1,618	21	29	40	61	77	96	143
C113	S Chambers Road	459	0.7	7,864	166	231	304	495	618	768	1,125	16	22	29	45	57	72	106
Meadowood Creek																		
MC101	Confluence with WTGC	1,670	2.6	0	428	621	836	1,438	1,856	2,424	3,719	63	87	113	167	209	261	387
MC102T	E Illif Ave	1,646	2.6	1,351	427	617	830	1,429	1,844	2,406	3,687	62	85	111	164	206	256	381
MC104T	E Yale Ave	1,499	2.3	3,740	409	587	783	1,354	1,741	2,263	3,447	56	76	100	148	185	231	344
MC107		1,224	1.9	5,211	362	516	688	1,202	1,538	1,981	2,976	46	64	83	124	155	194	285
MC108T	E Dartmouth Ave	1,177	1.8	6,702	357	508	675	1,177	1,503	1,932	2,896	44	62	80	120	150	187	275
MC110T	E Hampden Ave	990	1.5	9,569	342	485	640	1,098	1,393	1,766	2,626	38	52	68	101	126	157	231
MC112T	Confluence with Mission Viejo Tributary	895	1.4	10,040	313	443	585	1,001	1,270	1,610	2,395	34	47	61	91	114	141	208
MC113T		700	1.1	11,111	258	363	477	809	1,026	1,297	1,926	26	37	47	71	88	110	162
MC115T	Confluence with Los Ninos Tributary	677	1.1	11,862	250	352	461	782	991	1,253	1,860	25	35	46	68	85	106	157
MC117		395	0.6	13,914	171	240	318	521	655	820	1,205	15	21	28	41	51	63	93
MC119T	E Quincy Ave	322	0.5	15,317	135	189	251	412	521	652	964	12	16	21	32	40	50	74
MC122		118	0.2	17,540	53	75	104	171	215	267	388	4	6	8	12	15	19	28
Mission Viejo Tributary																		
MV101	Confluence with Meadowood Creek	74	0.1	0	38	52	70	111	137	169	244	3	4	6	8	10	12	18
Los Ninos Tributary																		
LN101	Confluence with Meadowood Creek	123	0.2	0	42	59	74	129	164	208	310	4	6	8	12	15	19	28
Summer Valley Ranch Tributary																		
SV101	Confluence with WTGC	475	0.7	0	199	297	405	670	842	1,051	1,543	18	26	34	51	64	79	115
SV102T	Downstream of S Tower Rd	367	0.6	2,611	178	267	362	575	718	885	1,281	14	20	27	40	50	61	90
SV103	Upstream of S Tower Rd	332	0.5	2,846	165	247	334	529	660	814	1,177	12	18	25	37	45	56	81
SV104T		235	0.4	3,556	113	168	228	362	451	555	802	9	13	17	26	32	39	57
Summer Lake Tributary																		
SL101	Confluence with WTGC	169	0.3	0	36	53	72	121	157	241	419	6	9	12	18	23	28	41
SL102T		159	0.2	632	36	52	70	116	150	237	413	6	9	12	17	22	27	39
SL102		108	0.2	699	29	45	62	106	133	167	246	4	5	8	11	14	18	26
SL103		68	0.1	2,345	21	31	43	69	86	108	157	2	3	5	7	9	11	16
SL104		34	0.1	2,589	7	11	16	28	35	44	65	1	2	2	3	4	5	8
Marina Park Tributary																		
MP101	Confluence with Tower Road Tributary	250	0.4	0	91	130	181	321	412	525	787	9	12	16	24	31	39	57
MP102		218	0.3	1,430	88	125	174	302	386	490	732	8	11	14	22	27	34	50
MP103	E Smoky Hill Rd	143	0.2	3,135	60	84	116	195	249	314	467	5	7	10	14	18	22	33
Tower Road Tributary																		
T101O	Confluence with WTGC	662	1.0	0	75	97	124	513	744	1,031	1,643	22	31	41	63	79	100	149
T301	Meadow Point Pond	662	1.0	0	212	298	411	716	911	1,155	1,728	22	31	41	63	80	100	149
T101	Confluence with Marina Park Tributary	662	1.0	0	212	298	411	716	911	1,155	1,728	22	31	41	63	80	100	149
T102		389	0.6	1,609	124	171	234	396	500	628	938	13	18	24	37	47	59	87
T104	S Tower Rd	308	0.5	2,655	97	133	181	304	384	482	720	10	14	19	29	37	46	68
T107T	S Danube St	102	0.2	6,003	23	29	42	74	94	118	175	3	4	5	8	11	14	21
T108O		48	0.1	6,317	11	12	14	17	23	39	65	2	2	3	5	6	7	11
T308	Smokey Ridge Pond	48	0.1	6,317	19	28	39	66	83	104	152	2	2	3	5	6	7	11
T108		48	0.1	6,317	19	28	39	66	83	104	152	2	2	3	5	6	7	11
Smokey Ridge Tributary																		
SR101	Confluence with WTGC	66	0.1	0	22	35	50	84	106	132	195	2	3	4	7	8	10	15
SR102	E Chenango Dr	46	0.1	1,413	19	30	41	67	83	103	149	2	2	3	5	6	7	11
Himalaya Tributary																		
H101	Confluence with WTGC	6	0.0	0	0	1	1	3	4	5	8	0	0	0	0	1	1	1
Park View Tributary																		
P101	Confluence with WTGC	86	0.1	0	36	56	78	129	162	202	296	3	4	6	9	11	14	20
P102	E Berry Dr	63	0.1	2,016	33	51	70	110	138	171	249	2	3	4	7	8	10	15



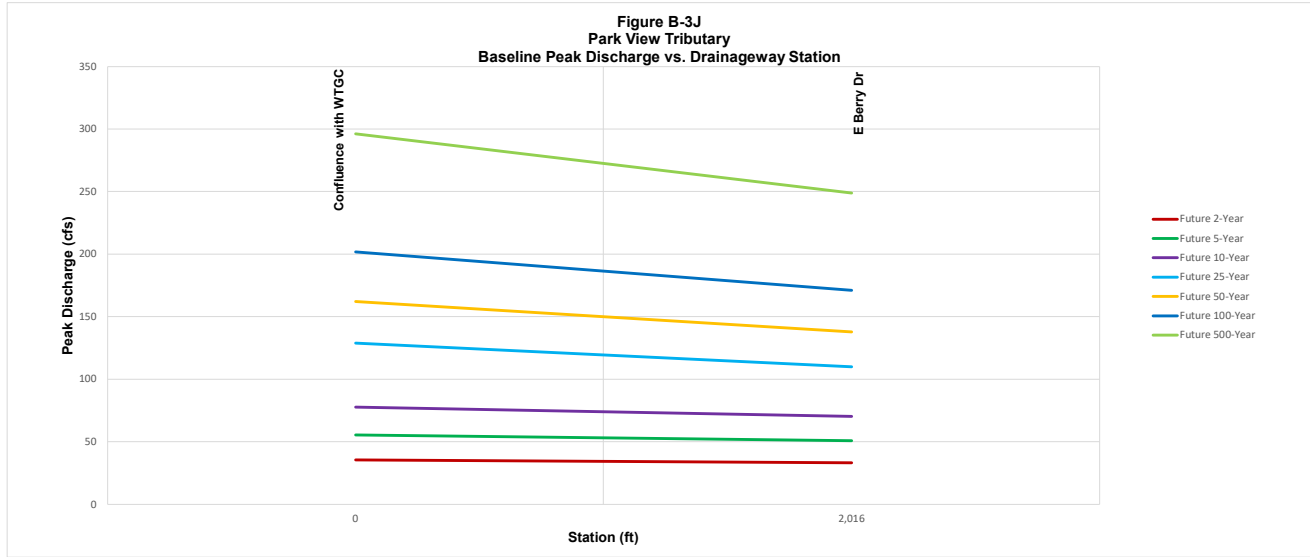
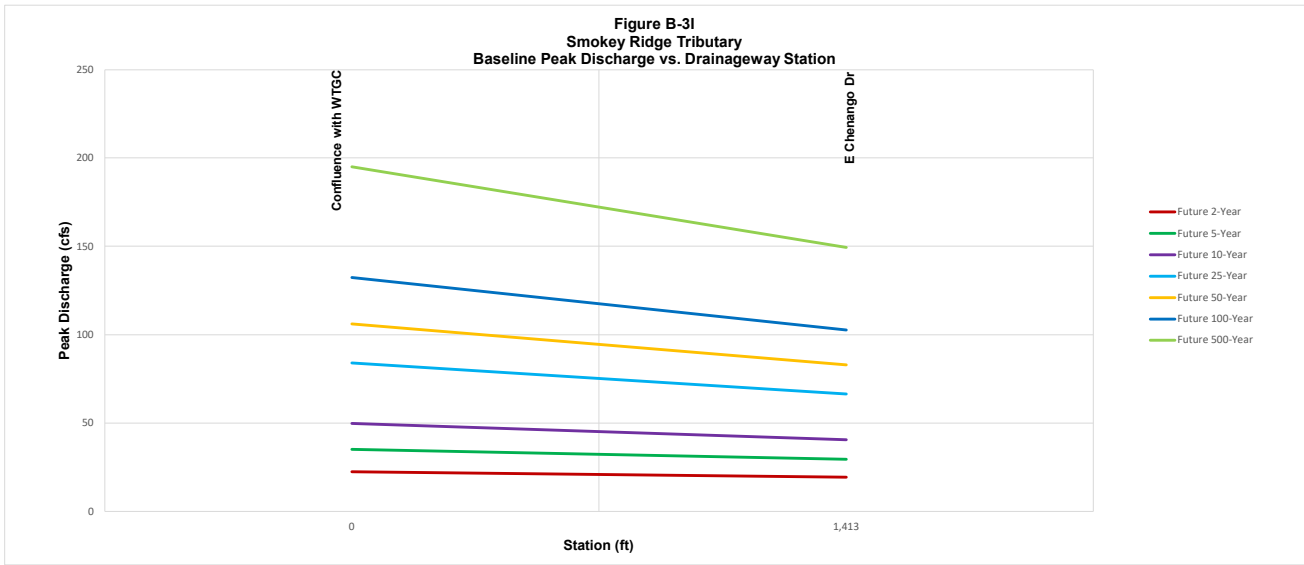
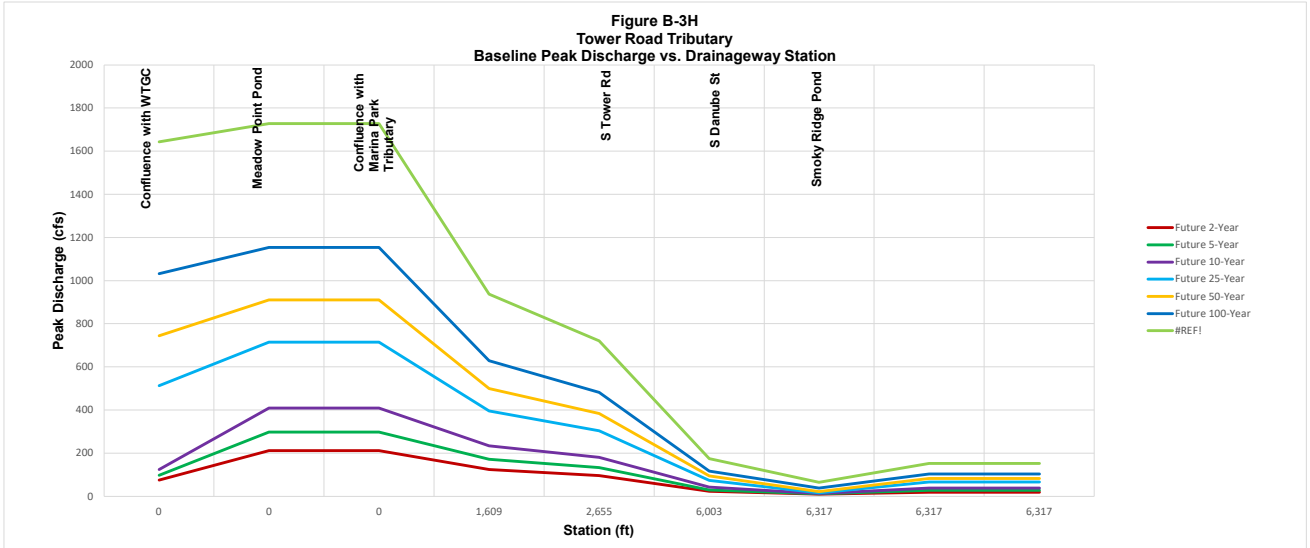
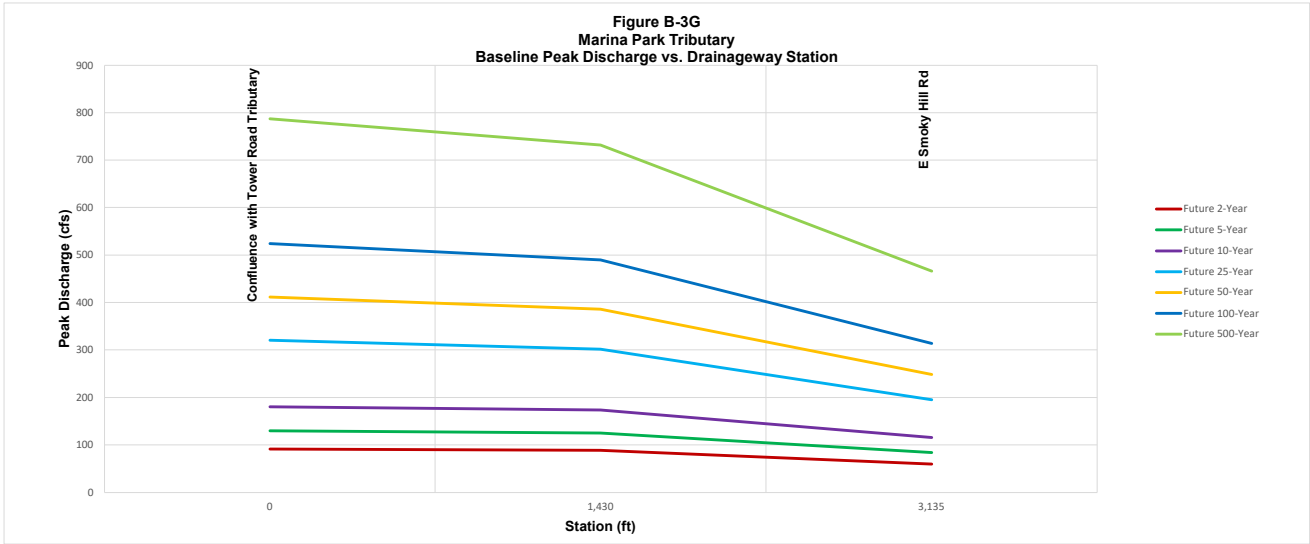


Figure B-4 - Baseline Hydrographs

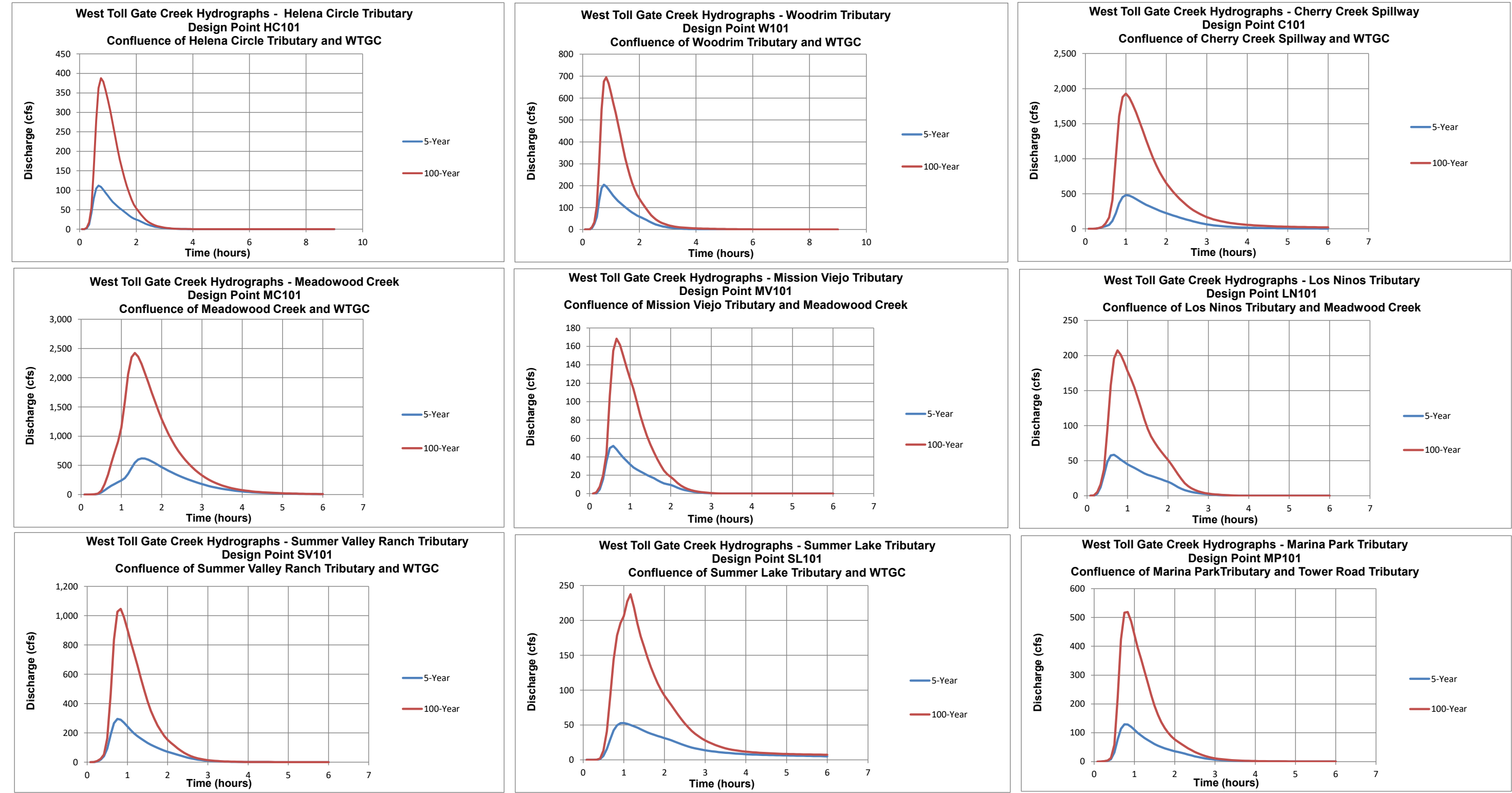


Figure B-4 - Baseline Hydrographs

