



MEMORANDUM

To: Teresa Patterson, P.E., CFM
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MHFD
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Date: February 5, 2021

Subject: First Creek MDP and FHAD: Baseline Hydrology Memorandum

OVERVIEW

This memorandum accompanies the digital submittal for the Baseline Hydrology Study for the First Creek (Downstream of Rocky Mountain Arsenal) Major Drainageway Plan (MDP) and Flood Hazard Area Delineation (FHAD). The project is co-sponsored by the Mile High Flood District (MHFD) and the City of Commerce City. RESPEC Consulting and Services completed the hydrology phase of the study in August 2020.

The baseline hydrology digital data that accompanies this memorandum include the following:

- / Project Website (www.firstcreekmdp.com)
- / Colorado Urban Hydrograph Procedure (CUHP) v. 2.0.1 (existing and future conditions)
- / EPA Stormwater Management Model (SWMM) v. 5.1.013
- / GIS Geodatabase (model input and output)
- / Detention stage/storage tables, detention outlet rating curves, and SWMM output hydrographs
- / ArcMap .mxd file along with Microsoft Excel tables showing design point hydrographs

Several drainageway studies have been completed for the upper and lower portions of the First Creek watershed. Additionally, there is rapid ongoing, imminent, and planned development occurring throughout the watershed. Therefore, the objective of this study is to supply an up-to-date and cohesive hydrologic study for the entire watershed. This hydrology will serve as the basis for the peak flows used in the remaining phases of the MDP and FHAD.

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Although the majority of the MDP and FHAD is focused on the reach of First Creek located downstream of the Rocky Mountain Arsenal (RMA), the baseline hydrology covers the entire watershed from the confluence with the South Platte River to the headwaters located southwest of the intersection of E. Jewell Ave. and Watkins Rd. within the City of Aurora.

The baseline hydrology for this study was prepared using CUHP v. 2.0.1 and EPA SWMM v.5.1.013. Input parameters for CUHP were generated by RESPEC using ArcGIS and Python software developed for this study. The input can be found in the associated CUHP files, the project website, and the GIS Geodatabase. The hydrographs developed by CUHP, were then routed through the watershed using EPA SWMM. The EPA SWMM routing can also be found in the associated EPA SWMM files, the project website, and the GIS Geodatabase

PREVIOUS STUDIES

Multiple studies have been completed for portions of the First Creek watershed. Below is a list of former First Creek studies that were consulted as part of this study:

- / The entire First Creek watershed was studied in the report entitled *Major Drainageway Planning – First Creek*, prepared by Engineering Consultants, Inc., dated March 1977. The effective FEMA Flood Insurance Study (FIS) report utilizes future conditions peak flow values from the 1977 study as the basis for the floodplain delineation downstream of the RMA (north of 96th Avenue) and are considered the effective FEMA peak flows for the lower watershed.
- / The lower portion of First Creek was studied in the report entitled *Lower First Creek and Direct Flow Area 0055 Major Drainageway Planning*, prepared by Turner Collie & Braden Inc., dated May 2002. The 2002 peak flows were never adopted by the co-sponsors and are therefore disregarded in this study.
- / The upper portion of First Creek was studied in the report entitled *First Creek (Upstream of Buckley Road) Major Drainageway Plan*, prepared by Moser and Associates, dated August 2010. The 2010 peak flows are considered the effective peak flows for the upper portion of the watershed east of the RMA.
- / Tributaries to First Creek have been recently studied in the report entitled *First Creek Tributaries (Upstream of I-70) Master Drainageway Plan*, prepared by Merrick, dated February 2019. The baseline hydrology models used in the Merrick study were imported directly into the hydrologic modeling for this study.

RAINFALL

The rainfall input into the CUHP model was determined using NOAA Atlas 14, Volume 8, Version 2. The rainfall used in the model is as follows:



Table 1. Point Rainfall Depth (inches)

Return Period	1-hour	6-hour
1	0.691	1.06
2	0.842	1.27
5	1.12	1.67
10	1.38	2.03
25	1.79	2.6
50	2.13	3.07
100	2.5	3.59
500	3.5	4.96

Per the criteria presented in MHFD’s *Urban Storm Drainage Criteria Manual* (USDCM), large watersheds require a Depth Reduction Factor (DRF) adjustment to reduce point precipitation values to area-average precipitation values. Because the First Creek watershed is approximately 49 square miles, a rainfall area correction was applied to all nodes for each storm event. For minor storms (1-year, 2-year, 5-year, 10-year), a DRF was applied to design points (DP) with a contributing drainage area greater than or equal to 2.0 square miles. For major storms (25-year, 50-year, 100-year, 500-year), a DRF was applied to design points with a contributing drainage area greater than or equal to 15 square miles.

The DRF for all events was determined by the CUHP (version 2.0.1) software. Tables 2 and 3 list the range and the correction area applied. Correction factors applied to the minor and major storm events can be found in Appendix 1. Refer to the associated project website and GIS geodatabase to see the area correction applied to each node.

Table 2. Area Correction Factors, Minor Storms (1-year, 2-year, 5-year, 10-year)

Upstream Area (square mi.)	Correction Area Applied
<2	0
2 - 5	2
5 -10	5
10-15	10
15-20	15
20-25	20
25-30	25
30-35	30
35-40	35
> 40	40



Table 3. Area Correction Factors, Major Storms (25-year, 50-year, 100-year, 500-year)

Upstream Area (square mi.)	Correction Area Applied
<15	0
15-20	15
20-25	20
25-30	25
30-35	30
35-40	35
>40	40

SUBCATCHMENTS

The following subsections describe the data used to analyze subcatchments within the CUHP model.

GENERAL DESCRIPTION

The high point in the watershed is approximately 5875ft (NAVD 88) and is located in the upper portion of the watershed. The low point is near the confluence with the South Platte River and is approximately 5025 ft (NAVD 88). The average slope of the watershed is 0.022 ft/ft – with the steeper sections of the watershed near the headwaters and the flatter slopes located in the historic floodplain of the South Platte River downstream of the RMA.

Subcatchments were delineated using the 2010 Upper MDP as the initial basis and then refined using current topography and land use. RESPEC received subcatchments, CUHP, and SWMM files from the 2020 Tributaries MDP. South of I-70, RESPEC used the subcatchments, CUHP, and SWMM files from the 2020 Tributaries MDP without modification to be consistent with the recent study.

SOIL TYPES

The watershed consists of a mixture of A, B, and C soils. Pockets of A soils are located along the First Creek channel in the middle portion of the watershed and near the downstream confluence with the South Platte River. The remainder of the watershed consists of a mixture of B and C soil types. The soils were obtained from the Web Soil Survey and are shown on the project website and in the associated GIS Geodatabase.

IMPERVIOUSNESS

The baseline hydrology includes existing conditions and future conditions land uses. The watershed is currently experiencing rapid development and there are several areas in the watershed currently in the process of being developed, these areas are modeled assuming fully developed conditions, particularly when the detention associated with the development is included in the existing conditions SWMM model. The assumed land uses for existing and future conditions were discussed in detail with the



MHFD and are shown on the land use data provided in the accompanying GIS geodatabase and on the project website.

The following imminent developments are included in the existing conditions model:

- / Denver International Business Center (DIBC):
 - o The existing conditions included Filing 5 of the DIBC. Filing 5 is located on the southern end of the DIBC, west of Tower Road and approximately between 66th Avenue and 68th Avenue. As of the writing of this memorandum, only the lower master planned detention is built, these conditions are reflected in the existing conditions model.
- / Denver Gateway
 - o The existing conditions included Filing 5 of the Denver Gateway development. Bounded by and including a portion of the east half of the Argonne Street right-of-way adjacent to the development, the west half of the N. Dunkirk Street right-of-way between East 60th Avenue and East 62nd Avenue, and the north half of East 60th Avenue right-of-ways between North Dunkirk Street and North Argonne Street.
- / Green Valley Ranch East
 - o The development is located in northeastern Aurora, Colorado. The site is east of Picadilly Road, west of E-470, north of 38th Avenue, and south of 52nd Avenue with the regional detention improvements north of 48th Avenue. The existing conditions model includes 611 acres of Green Valley Ranch East associated with "Green Valley – Amendment 2".
- / Majestic Commerce Center
 - o The existing conditions model included the entire Majestic Commerce Center Site. The Site consists of 528 acres and is bound by Picadilly Road to the West, the alignment of 38th Avenue to the North, the right of way of E-470 to the East, and East 26th Avenue to the South.
- / Aurora Commerce Center
 - o The existing conditions model included the entire Aurora Commerce Center Site. The proposed development is located North of Smith Road, West of E-470, East of Picadilly Road and South of 26th Avenue.
- / The Aurora Highlands
 - o The Aurora Highlands is located in northeastern Aurora, Colorado. The site is located east of E-470, south of 48th Avenue, north of 26th Avenue, and west of Powhaton Road (future alignment). The existing conditions model included the portions of Aurora Highlands tributary to the imminent detention basins including Pond 8507, Pond 8540, Pond 8570, and Pond 8571. Pond 8560 (Stock Pond) is an interim pond, designed to reduce existing peak flows to closely match master planned flows. Pond 8560 was also included in the existing conditions model, but areas tributary to Pond 8560 were assumed to be undeveloped.



- / Adonea
 - The existing conditions model included Adonea Filing No. 7 which is bounded to the south by E. 1st Avenue, to the west by Adonea Filing 1, to the north by E. 6th Avenue and to the east by Powhatan Rd.
- / Harmony
 - Harmony Filing No. 1 (Metro District) is generally located south of I-70, in the southern ½ of Section 9, and a portion of the northern ½ of Section 16, Township 4 South, Range 65 West of the 6th Principal Meridian, in the City of Aurora, Colorado.
- / Sky Ranch
 - The existing conditions model included the first phase of development in Sky Ranch, known as Neighborhood B, which is bounded to the west by the City of Aurora/Arapahoe County boundary, to the east by Monaghan Road, to the north by 10th Avenue, and to the south by 6th Avenue.
- / Painted Prairie
 - The Painted Prairie property covers the entire extent of Section 11 and is bounded by 64th Avenue to the North, Himalaya Road to the West, 56th Avenue to the South, and Picadilly Road to the East. The existing conditions model included Filing No. 1 which is most of Section 11 with the exception of the northern most portion of the property.

The average existing and future conditions imperviousness is 24% and 55%, respectively. In general, the lower portion of the watershed consists of existing and future industrial and commercial uses. The middle section of the watershed is the RMA and some existing residential developments. The upper portion of the watershed is currently open fields and historic farmland but is rapidly developing with additional residential areas.

HYDROGRAPH ROUTING

Hydrographs from CUHP were input into EPA SWMM and routed through the First Creek watershed. The routing elements consist of various geometries of open channel flow with culverts at some major road crossings. Routing elements from the 2020 Tributaries MDP were not revised as part of this study. Routing elements from the 2010 MDP were used as the basis of the SWMM routing and modified as needed. Diversions were used sparingly and only at locations where pipe overtopping elements were modeled at road crossings. These diversions were taken from the 2010 MDP and 2020 Tributaries MDP and were not modified in this study. Manning's n roughness values were taken from the previous studies and modified as needed to reflect existing conditions.

DETENTION

There are several detention features located in the existing and future conditions models. The detention ponds are listed on the project website and in the associated GIS geodatabase. A general description of the detention features is provided in Table 4 below. All detention basins are included in the existing conditions model because they are either currently existing or will be built soon (aka "soon to be built").



Table 4. Detention Basins modeled in the First Creek Watershed

SWMM ID	Detention Name	Status	Owner	Location
8312_IN	Himalaya Pond 808	Existing	Town Center Metro District	N. Dunkirk St. and E. 54 th Pl.
8507_IN	Aurora Highlands Pkwy Pond 8507	Soon to be built	Green Valley Ranch East LLC	Aurora Highlands (Gun Club Rd.)
8537_IN	TAH Mainstreet Pond 8540	Soon to be built	Aurora Highlands Holdings LLC	E. 26 th Ave and E-470 (East Side)
8513_IN	TAH Stock Pond 8560	Soon to be built	Green Valley Ranch East LLC	Aurora Highlands
8570_IN	TAH Pond 8570	Soon to be built	Green Valley Ranch East LLC	Aurora Highlands (Aurora Highlands Pkwy)
8509_IN	TAH Pond 8571	Soon to be built	Gvr King LLC	Aurora Highlands
8413_IN	High Point Pond 800	Existing	AMC High Point VI LLC	Tower Rd. and E. 66 th Ave.
8404_IN	High Point Pond 801	Existing	City of Aurora	N. Dunkirk St. and E. 60 th Ave.
8812_IN*	DIBC Pond 812, Ph 1	Soon to be built	Denver International Business Center	Denver International Business Center
8338_IN	First Creek Sub F1 Pond 826	Existing	Dunkirk Place LLC	E. 60 th Ave. and Argonne St.
8419_IN	Majestic 26th Ave Detention	Soon to be built	Majestic Commerce Center II LLC	E. 26 th Ave and E-470 (West Side)
8803_IN	Denver Gateway Pond 8405	Soon to be built	BBF Gateway LLC	Denver Gateway
8503C_IN	Green Valley Ranch East Pond 8503C	Soon to be built	Clayton Properties Group II Inc	Green Valley Ranch Blvd. and Picadilly Rd.
8406_IN	Painted Prairie Pond 816	Existing	WF Prairie LLC	Painted Prairie



8410_IN	Blue Grama Pond	Existing	City and County of Denver	E. 64 th Ave. and Pena Blvd.
8602_IN	Sky Ranch Pond D	Existing	Pure Cycle Corporation	Sky Ranch
8503B_IN	Green Valley Ranch East Pond 8503B	Soon to be built	Clayton Properties Group II Inc	Green Valley Ranch Blvd. and Picadilly Rd.

*Detention 8812 is partially built as of the writing of this report, only the lower detention pond is included in the existing conditions.

RESULTS OF ANALYSIS

The shape of the First Creek watershed impacts the transformation of the hydrograph as it progresses downstream. Because the watershed is relatively long and narrow, the hydrograph peaks in the middle portion of the watershed and is relatively flat as it progresses to the confluence with the South Platte River. This hydrologic response is consistent with the results from the 2010 MDP. However, as shown below in Table 5, the overall peak flows from this study are significantly less than the 2010 MDP. Since the completion of the 2010 study, CUHP, SWMM, and point rainfall depths have been revised. The differences in model versioning and point rainfall is in part the reason for the reduction in peak flow from the 2010 MDP. Additionally, this study incorporates several detention ponds throughout the upper portion of the watershed that did not exist at the time of the 2010 MDP. The detention combined with the model revisions are the reasons for the decrease in peak flow to the 2010 MDP. The resulting peak flows from this study are very similar to those from the original 1977 MDP.

Table 5. Comparison of 100-year Peak Flows to Previous Studies

Location	First Creek MDP ECI (1977)		First Creek (u/s Buckley Rd.) MDP Moser (2010)		First Creek MDP RESPEC (2020)	
	Existing (cfs)	Future (cfs)	Existing (cfs)	Future (cfs)	Existing (cfs)	Future (cfs)
South Platte River	5,570	7,380*	6,230	11,100	4,310	7,517
U.S. Highway 85	5,570	7,380*	6,090	11,000	4,307	7,496
I-76	5,570	7,380*	5,810	11,000	4,301	7,468
East 96th Ave.	5,570	7,380*	5,710	11,000	4,300	7,503
North Chambers Rd.	---	---	5,200	11,300	4,385	8,011
Buckley Rd.	4,900	6,720	5,200*	11,400	4,289	8,012
Conf. with Trib T.	4,820	6,420	7,100*	13,500	5,309	8,685
Picadilly Rd.	3,000	4,040	5,490*	10,700	4,124	7,265



I-70	2,950	3,690	4,790*	9,990	5,417	8,929
East 6th Ave.	---	---	2,270*	4,050	1,881	2,756
Trib T at Picadilly Rd.	2,330	3,170	2,530*	6,100	2,921	3,757

*FEMA Effective 100-year peak flows

Detailed CUHP and SWMM output is included in the project website, model files, and GIS geodatabase. Hydrographs at every design point for the 1-, 2-, 5-, 10-, 25-, 50-, 100, and 500-year storm events are included in the GIS geodatabase for both the existing and future conditions.

REFERENCES

ADONEA FILING 7 FINAL DRAINAGE REPORT, prepared by CVL Consultants of Colorado, Inc., September 2017.

Aurora Commerce Center Subdivision Filing No. 3 Aurora, Colorado, Prepared By: Kimley-Horn and Associates, Inc. November 2019.

The Aurora Highlands Master Drainage Report – Amendment 1, prepared by HR Green Development, LLC. August 2019.

Colorado Urban Hydrograph Procedure (CUHP) 2005 User Manual – Version 2.0.0, Urban Drainage and Flood Control District, September 9, 2016.

FINAL DRAINAGE REPORT FOR DENVER GATEWAY CENTER, prepared by Harris Kocher Smith, June 7, 2019.

First Creek Tributaries (Upstream of I-70) Master Drainageway Plan, prepared by Merrick, dated February 2019.

First Creek (Upstream of Buckley Road) Major Drainageway Plan, prepared by Moser and Associates, dated August 2010.

GREEN VALLEY - AMENDMENT 2 MASTER DRAINAGE REPORT, prepared by Calibre Engineering Inc. September 2019.

HARMONY FILING NO. 1 METRO DISTRICT FINAL DRAINAGE REPORT, prepared by CVL Consultants of Colorado, Inc. May 2017.

Lower First Creek and Direct Flow Area 0055 Major Drainageway Planning, prepared by Turner Collie & Braden Inc., dated May 2002.

Major Drainageway Planning – First Creek, prepared by Engineering Consultants, Inc., dated March 1977.

MASTER DRAINAGE REPORT MAJESTIC COMMERCENTER II 528 AC., prepared by Ware Malcomb, 10/28/2019.

National Oceanic and Atmospheric Administration, Atlas 14 Precipitation-Frequency Atlas of the United States, Volume 8, Version 2.0.



National Resources Conservation Service, Web Soil Survey 2019: <https://websoilsurvey.nrcs.usda.gov>.

PAINTED PRAIRIE MASTER DRAINAGE REPORT FIRST CREEK BASIN, prepared by CVL Consultants of Colorado, Inc. October 2018.

PRELIMINARY/FINAL DRAINAGE REPORT FOR DENVER INTERNATIONAL BUSINESS CENTER FILING 5, prepared by JR ENGINEERING, LLC, September 22, 2015.

SKY RANCH NEIGHBORHOOD B PHASE III DRAINAGE REPORT (E 6th Ave. and Monaghan Rd.), prepared by CVL Consultants of Colorado, Inc. July 18, 2018.

U.S. Geological Survey, NLCD 2016 Percent Developed Imperviousness - National Geospatial Data Asset (NGDA) Land Use Land Cover: None, U.S. Geological Survey, Sioux Falls, SD.

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APPENDIX 1

RAINFALL DEPTH REDUCTION FACTORS

CUHP rainfall depth reduction factors used in this modeling are shown in the tables below. These figures are taken from UDSCM Volume 1, Chapter 5, Section 3.2.



Table 5-3. DRFs for design rainfall distributions 2-, 5-, and 10-year design rainfall

Time (minutes)	Correction Factor by Watershed Area in Square Miles ¹								
	2	5	10	15	20	30	40	50	75
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
15	1.00	0.97	0.94	0.91	0.90	0.85	0.75	0.65	0.56
20	1.00	0.86	0.75	0.68	0.61	0.55	0.48	0.42	0.35
25	1.00	0.86	0.75	0.68	0.61	0.55	0.48	0.42	0.35
30	1.00	0.86	0.75	0.68	0.61	0.55	0.48	0.42	0.42
35	1.00	0.97	0.94	0.91	0.90	0.90	0.90	0.90	0.89
40	1.00	0.97	0.94	0.91	0.90	0.90	0.90	0.90	0.89
45	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
50	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
55	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
60	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
65	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
70	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
75	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
80	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
85	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
90	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
95	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
100	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
105	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
110	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
115	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
120	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
125-180	N/A	N/A	N/A	1.00	1.00	1.00	1.00	1.00	1.00
185-360	N/A	N/A	N/A	1.23	1.28	1.30	1.32	1.33	1.33

¹For areas between the values listed in the table, correction factors can be obtained through linear interpolation between columns.



Table 5-4. DRFs for design rainfall distributions 25-, 50-, 100-, and 500-year design rainfall

Time (minutes)	Correction Factor by Watershed Area in Square Miles ¹					
	15	20	30	40	50	75
5	1.15	1.15	1.15	1.15	1.15	1.10
10	1.15	1.15	1.15	1.15	1.15	1.10
15	1.15	1.15	1.15	1.15	1.15	1.10
20	1.25	1.18	1.10	1.05	1.00	0.90
25	0.73	0.69	0.64	0.60	0.58	0.55
30	0.73	0.69	0.64	0.60	0.58	0.55
35	0.73	0.69	0.64	0.60	0.58	0.55
40	1.05	1.02	0.95	0.90	0.85	0.80
45	1.20	1.20	1.20	1.15	1.05	0.95
50	1.15	1.15	1.15	1.15	1.05	0.95
55	1.15	1.15	1.15	1.15	1.15	1.15
60	1.15	1.15	1.15	1.15	1.15	1.15
65	1.08	1.10	1.13	1.15	1.15	1.15
70	1.08	1.10	1.13	1.15	1.15	1.15
75	1.08	1.10	1.13	1.15	1.15	1.15
80	1.08	1.10	1.13	1.15	1.15	1.15
85	1.08	1.10	1.13	1.15	1.15	1.15
90	1.08	1.10	1.13	1.15	1.15	1.15
95	1.08	1.10	1.13	1.15	1.15	1.15
100	1.08	1.10	1.13	1.15	1.15	1.15
105	1.08	1.10	1.13	1.15	1.15	1.15
110	1.08	1.10	1.13	1.15	1.15	1.15
115	1.08	1.10	1.13	1.15	1.15	1.15
120	1.08	1.10	1.13	1.15	1.15	1.15
125-180	1.08	1.10	1.13	1.15	1.25	1.25
185-360	1.05	1.10	1.10	1.10	1.10	1.13

¹For areas between the values listed in the table, correction factors can be obtained through linear interpolation between columns.